Clarence F. Klamm, Jr.

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

☆

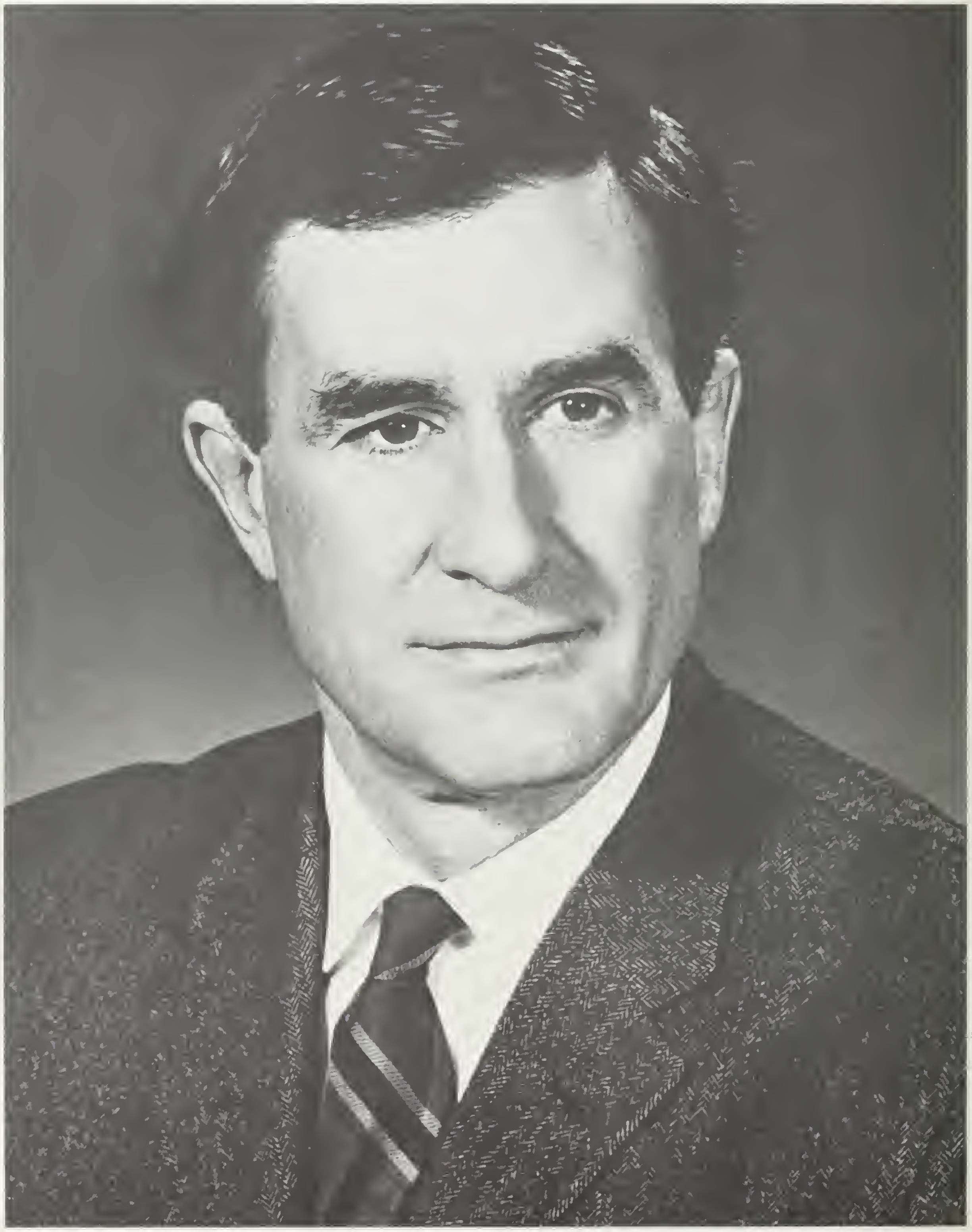
CATALOGUE FOR 1970-1972

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

☆

CATALOGUE FOR 1970-1972



The Honorable
JOHN H. CHAFEE
Secretary of the Navy

MISSION

The Secretary of the Navy has defined the mission of the Naval Postgraduate School as follows:

"To conduct and direct the Advanced Education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence."

Superintendent

ROBERT WARING McNITT

Rear Admiral, U.S. Navy

B.S., Naval Academy, 1938; Naval Postgraduate School, 1945;

M.S., Massachusetts Institute of Technology, 1947

Academic Dean

MILTON U. CLAUSER

B.S., California Institute of Technology, 1934;
M.S. 1935; Ph.D 1937

NAVAL POSTGRADUATE SCHOOL

Deputy Superintendent for Programs
FLETCHER HARRIS BURNHAM
Captain, U.S. Navy
B.S., Naval Academy, 1943;
B.S. in Operations Analysis, Naval Postgraduate School, 1954;
M.S., 1954

Deputy Superintendent for Logistics
ROBERT YANTIS GAINES
Captain, U.S. Navy
B.S.E.E., Univ. of California at Los Angeles, 1948;
M.S., George Washington Univ., 1963

Dean of Programs
WILBERT FREDERICK KOEHLER
B.S., Allegheny College, 1933; M.A.,
Cornell Univ., 1934; Ph.D., Johns Hopkins Univ., 1948

Executive Assistant to the Deputy Superintendent for Programs
ORRIE ANDREW HAHS
Captain, U.S. Navy
B.S., Naval Postgraduate School, 1952;
M.S. in Physics, Univ. of California
at Los Angeles, 1953

Dean of Curricula
BROOKS JAVINS LOCKHART
B.A., Marshall Univ., 1937; M.S., West
Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943

Dean of Research Administration
CARL ERNEST MENNEKEN
B.S., Univ. of Florida, 1932;
M.S., Univ. of Michigan, 1936

Registrar
MISS JEAN WARRINER
B.A., Occidental College, 1947

Superintendent's Staff Assistants

Aide to the Superintendent	LTJG Jerry M. Monroe, USNR
Comptroller	CAPT Robert E. Graham, SC, USN
Civilian Personnel Officer	Mr. Weston B. Lockwood
Officer in Charge (NALF)	CAPT Robert N. Miller, USN
Senior Medical Officer (NALF)	CAPT Ronald A. Cummings, MC, USN

Operations and Programs Administrative Staff

Plans Officer	CDR Warren A. Higley, USN
Flight Officer	CDR Claude F. Giles, USN
Administrative Officer	LCDR Evelyn C. Wadsworth, USN
Academic Assistant	CDR Nadene LaBonte, USN
Foreign Training Officer	LCDR Francis W. Borst, Jr., USN
Marine Corps Representative	LTCOL James P. Connolly, USMC
Submarine Liaison Officer	LCDR Peter B. Boyne, USN

Administration and Logistics Staff

Director, Administration Dept.	CDR Donald T. Fitzgerald, USN
Director, Supply Dept.	CDR G.M. Durham, SC, USN
Director, Public Works Dept.	CDR James F. Schumann, CEC, USN
Director, Dental Dept.	CAPT J.F. Keenan, DC,USN
Assistant for Special Projects	LCDR Eugene M. Toscano, USN
Catholic Chaplain	CAPT Joseph F. Cloonan, CHC, USN
Protestant Chaplain	CAPT Samuel D. Chambers, CHC, USN
Legal Officer	LT Larry J. Lichtenegger, JAGC, USNR
Communications Officer	ENS W.H. Griffith, USN

CALENDAR FOR 1970-71 ACADEMIC YEAR

1970

Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula	Monday, 29 June
Fourth of July (holiday)	Friday, 3 July
Quarter I Begins (1970-71)	Monday, 6 July
Language Examination in French, German, Russian, for Ph.D. Candidates	Monday, 10 August
Refresher Course Begins	Monday, 17 August
Labor Day (holiday)	Monday, 7 September
Date for Final Completion of Thesis for September Graduation	Wednesday, 16 September
Registration for all Curricula except BS/BA, Management, Meteorology, Nuclear Engineering (Effects)	Monday, 21 September
Examination Week for Quarter I	21-25 September
Quarter I Ends	Friday, 25 September
Quarter II Begins	Monday, 28 September
Graduation	Wednesday, 30 September
Language Examinations in French, German, Russian, for Ph.D. Candidates	Monday, 19 October
Veterans Day (holiday)	Wednesday, 11 November
Refresher Course Begins	Monday, 23 November
Thanksgiving Day (holiday)	Thursday, 26 November
Date for Final Completion of Thesis for December Graduation	Tuesday, 8 December
Examination Week for Quarter II	14-18 December
Quarter II Ends	Friday, 18 December
Graduation	Tuesday, 22 December
Christmas (holiday)	Friday, 25 December
Registration for Management, IGEP, Meteorology, BS/BA Curricula	Monday, 28 December

1970

S	M	T	W	T	F	S	S	M	T	W	T	F	S
JANUARY							JULY						
				1	2	3				1	2	3	4
4	5	6	7	8	9	10	5	6	7	8	9	10	11
11	12	13	14	15	16	17	12	13	14	15	16	17	18
18	19	20	21	22	23	24	19	20	21	22	23	24	25
25	26	27	28	29	30	31	26	27	28	29	30	31	
FEBRUARY							AUGUST						1
1	2	3	4	5	6	7	2	3	4	5	6	7	8
8	9	10	11	12	13	14	9	10	11	12	13	14	15
15	16	17	18	19	20	21	16	17	18	19	20	21	22
22	23	24	25	26	27	28	23	24	25	26	27	28	29
							30	31					
MARCH							SEPTEMBER						
1	2	3	4	5	6	7			1	2	3	4	5
8	9	10	11	12	13	14	6	7	8	9	10	11	12
15	16	17	18	19	20	21	13	14	15	16	17	18	19
22	23	24	25	26	27	28	20	21	22	23	24	25	26
29	30	31					27	28	29	30			
APRIL							OCTOBER						
			1	2	3	4					1	2	3
5	6	7	8	9	10	11	4	5	6	7	8	9	10
12	13	14	15	16	17	18	11	12	13	14	15	16	17
19	20	21	22	23	24	25	18	19	20	21	22	23	24
26	27	28	29	30			25	26	27	28	29	30	31
MAY					1	2	NOVEMBER						
3	4	5	6	7	8	9	1	2	3	4	5	6	7
10	11	12	13	14	15	16	8	9	10	11	12	13	14
17	18	19	20	21	22	23	15	16	17	18	19	20	21
24	25	26	27	28	29	30	22	23	24	25	26	27	28
31							29	30					
JUNE							DECEMBER						
	1	2	3	4	5	6			1	2	3	4	5
7	8	9	10	11	12	13	6	7	8	9	10	11	12
14	15	16	17	18	19	20	13	14	15	16	17	18	19
21	22	23	24	25	26	27	20	21	22	23	24	25	26
28	29	30					27	28	29	30	31		

1971

S	M	T	W	T	F	S	S	M	T	W	T	F	S
JANUARY					1	2	JULY						
3	4	5	6	7	8	9					1	2	3
10	11	12	13	14	15	16	4	5	6	7	8	9	10
17	18	19	20	21	22	23	11	12	13	14	15	16	17
24	25	26	27	28	29	30	18	19	20	21	22	23	24
31							25	26	27	28	29	30	31
FEBRUARY							AUGUST						
	1	2	3	4	5	6	1	2	3	4	5	6	7
7	8	9	10	11	12	13	8	9	10	11	12	13	14
14	15	16	17	18	19	20	15	16	17	18	19	20	21
21	22	23	24	25	26	27	22	23	24	25	26	27	28
28							29	30	31				
MARCH							SEPTEMBER						
	1	2	3	4	5	6				1	2	3	4
7	8	9	10	11	12	13	5	6	7	8	9	10	11
14	15	16	17	18	19	20	12	13	14	15	16	17	18
21	22	23	24	25	26	27	19	20	21	22	23	24	25
28	29	30	31				26	27	28	29	30		
APRIL							OCTOBER					1	2
				1	2	3	3	4	5	6	7	8	9
4	5	6	7	8	9	10	10	11	12	13	14	15	16
11	12	13	14	15	16	17	17	18	19	20	21	22	23
18	19	20	21	22	23	24	24	25	26	27	28	29	30
25	26	27	28	29	30		31						
MAY						1	NOVEMBER						
2	3	4	5	6	7	8		1	2	3	4	5	6
9	10	11	12	13	14	15	7	8	9	10	11	12	13
16	17	18	19	20	21	22	14	15	16	17	18	19	20
23	24	25	26	27	28	29	21	22	23	24	25	26	27
30	31						28	29	30				
JUNE							DECEMBER						
		1	2	3	4	5				1	2	3	4
6	7	8	9	10	11	12	5	6	7	8	9	10	11
13	14	15	16	17	18	19	12	13	14	15	16	17	18
20	21	22	23	24	25	26	19	20	21	22	23	24	25
27	28	29	30				26	27	28	29	30	31	

1971

New Years Day (holiday)	Friday, 1 January
Quarter III Begins	Monday, 4 January
Language Examinations in French, German, Russian for Ph.D. Candidates	Monday, 18 January
Washington's Birthday (holiday)	Monday, 15 February
Refresher Course Begins	Tuesday, 16 February
Date for Final Completion of Thesis for March Graduation	Wednesday, 17 March
Registration for all Curricula except BS/BA, Management, Meteorology, Nuclear Engineering (Effects), Underwater Physics Systems	Monday, 22 March
Examination Week for Quarter III	22-26 March
Quarter III Ends	Friday, 26 March
Quarter IV Begins	Monday, 29 March
Graduation	Wednesday, 31 March
Language Examinations in French, German, Russian for Ph.D. Candidates	Monday, 19 April
Refresher Course Begins	Monday, 24 May
Memorial Day (holiday)	Monday, 31 May
Date for Final Completion of Thesis for June Graduation	Friday, 11 June
Examination Week for Quarter IV	14-18 June
Quarter IV Ends (1970-71)	Friday, 18 June
Graduation	Friday, 25 June

CALENDAR FOR 1971-72 ACADEMIC YEAR

1971

Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula	Monday, 28 June
Fourth of July (holiday)	Monday, 5 July
Quarter I Begins (1971-72)	Tuesday, 6 July
Refresher Course Begins	Monday, 16 August
Labor Day (holiday)	Monday, 6 September
Date for Final Completion of Thesis for September Graduation	Wednesday, 15 September
Registration for all Curricula except BS/BA, Management, Meteorology, Nuclear Engineering (Effects)	Monday, 20 September
Examination Week for Quarter I	20-24 September
Quarter I Ends	Friday, 24 September
Quarter II Begins	Monday, 27 September
Graduation	Wednesday, 29 September
Columbus Day (holiday)	Monday, 11 October
Language Examinations in French, German, Russian for Ph.D. Candidates	Monday, 18 October
Veterans Day (holiday)	Monday, 25 October
Refresher Course Begins	Monday, 22 November
Thanksgiving Day (holiday)	Thursday, 25 November
Date for Final Completion of Thesis for December Graduation	Wednesday, 8 December
Exam Week for Quarter II	13-17 December
Quarter II Ends	Friday, 17 December
Graduation	Wednesday, 22 December
Christmas (holiday)	Friday, 24 December
Registration for Management, IGEP, Meteorology, BS/BA Curricula	Monday, 27 December
New Years Day (holiday)	Friday, 31 December

1971

S	M	T	W	T	F	S	S	M	T	W	T	F	S
JANUARY					1	2	JULY						
3	4	5	6	7	8	9					1	2	3
10	11	12	13	14	15	16	4	5	6	7	8	9	10
17	18	19	20	21	22	23	11	12	13	14	15	16	17
24	25	26	27	28	29	30	18	19	20	21	22	23	24
31							25	26	27	28	29	30	31
FEBRUARY							AUGUST						
	1	2	3	4	5	6	1	2	3	4	5	6	7
7	8	9	10	11	12	13	8	9	10	11	12	13	14
14	15	16	17	18	19	20	15	16	17	18	19	20	21
21	22	23	24	25	26	27	22	23	24	25	26	27	28
28							29	30	31				
MARCH							SEPTEMBER						
	1	2	3	4	5	6				1	2	3	4
7	8	9	10	11	12	13	5	6	7	8	9	10	11
14	15	16	17	18	19	20	12	13	14	15	16	17	18
21	22	23	24	25	26	27	19	20	21	22	23	24	25
28	29	30	31				26	27	28	29	30		
APRIL							OCTOBER					1	2
				1	2	3	3	4	5	6	7	8	9
4	5	6	7	8	9	10	10	11	12	13	14	15	16
11	12	13	14	15	16	17	17	18	19	20	21	22	23
18	19	20	21	22	23	24	24	25	26	27	28	29	30
25	26	27	28	29	30		31						
MAY						1	NOVEMBER						
2	3	4	5	6	7	8		1	2	3	4	5	6
9	10	11	12	13	14	15	7	8	9	10	11	12	13
16	17	18	19	20	21	22	14	15	16	17	18	19	20
23	24	25	26	27	28	29	21	22	23	24	25	26	27
30	31						28	29	30				
JUNE							DECEMBER						
		1	2	3	4	5				1	2	3	4
6	7	8	9	10	11	12	5	6	7	8	9	10	11
13	14	15	16	17	18	19	12	13	14	15	16	17	18
20	21	22	23	24	25	26	19	20	21	22	23	24	25
27	28	29	30				26	27	28	29	30	31	

1972

Quarter III Begins	Monday, 3 January
Language Examinations in French, German, Russian for Ph.D. Candidates	Monday, 17 January
Refresher Course Begins	Monday, 14 February
Washington's Birthday (holiday)	Monday, 21 February
Date for Final Completion of Thesis for March Graduation	Wednesday, 15 March
Registration for all Curricula except BS/BA, Management, Meteorology, Nuclear Engineering (Effects), Underwater Physics Systems	Monday, 20 March
Examination Week for Quarter III	20-24 March
Quarter III Ends	Friday, 24 March
Quarter IV Begins	Monday, 27 March
Graduation	Wednesday, 29 March
Language Examinations in French, German, Russian for Ph.D. Candidates	Monday, 17 April
Refresher Course Begins	Monday, 22 May
Memorial Day (holiday)	Monday, 29 May
Date for Final Completion of Thesis for June Graduation	Friday, 9 June
Examination Week for Quarter IV	12-16 June
Quarter IV Ends (1971-72)	Friday, 16 June
Graduation	Friday, 23 June
Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula	Monday, 26 June
Quarter I Begins (1972-73)	Monday, 3 July
Fourth of July (holiday)	Tuesday, 4 July
Language Examination in French, German, Russian for Ph.D. Candidates	Monday, 10 August
Refresher Course Begins	Monday, 14 August
Labor Day (holiday)	Monday, 4 September
Date for Final Completion of Thesis for September Graduation	Wednesday, 13 September
Registration for all Curricula except BS/BA, Management, Meteorology, Nuclear Engineering (Effects)	Monday, 18 September
Examination Week for Quarter I	18-22 September
Quarter I Ends	Friday, 22 September
Quarter II Begins	Monday, 25 September
Graduation	Wednesday, 27 September

1972

S	M	T	W	T	F	S	S	M	T	W	T	F	S
JANUARY						1	JULY						1
2	3	4	5	6	7	8	2	3	4	5	6	7	8
9	10	11	12	13	14	15	9	10	11	12	13	14	15
16	17	18	19	20	21	22	16	17	18	19	20	21	22
23	24	25	26	27	28	29	23	24	25	26	27	28	29
30	31						30	31					
FEBRUARY							AUGUST						
		1	2	3	4	5			1	2	3	4	5
6	7	8	9	10	11	12	6	7	8	9	10	11	12
13	14	15	16	17	18	19	13	14	15	16	17	18	19
20	21	22	23	24	25	26	20	21	22	23	24	25	26
27	28	29					27	28	29	30	31		
MARCH							SEPTEMBER						
			1	2	3	4						1	2
5	6	7	8	9	10	11	3	4	5	6	7	8	9
12	13	14	15	16	17	18	10	11	12	13	14	15	16
19	20	21	22	23	24	25	17	18	19	20	21	22	23
26	27	28	29	30	31		24	25	26	27	28	29	30
APRIL						1	OCTOBER						
2	3	4	5	6	7	8	1	2	3	4	5	6	7
9	10	11	12	13	14	15	8	9	10	11	12	13	14
16	17	18	19	20	21	22	15	16	17	18	19	20	21
23	24	25	26	27	28	29	22	23	24	25	26	27	28
30							29	30	31				
MAY							NOVEMBER						
	1	2	3	4	5	6				1	2	3	4
7	8	9	10	11	12	13	5	6	7	8	9	10	11
14	15	16	17	18	19	20	12	13	14	15	16	17	18
21	22	23	24	25	26	27	19	20	21	22	23	24	25
28	29	30	31				26	27	28	29	30		
JUNE							DECEMBER					1	2
				1	2	3	3	4	5	6	7	8	9
4	5	6	7	8	9	10	10	11	12	13	14	15	16
11	12	13	14	15	16	17	17	18	19	20	21	22	23
18	19	20	21	22	23	24	24	25	26	27	28	29	30
25	26	27	28	29	30		31						

DISTINGUISHED ALUMNI

Among those who have completed a Naval Postgraduate School curriculum who attained flag (USN) or general (USMC) rank on the active list are the following: (The asterisk (*) indicates those on active list as of 1 January 1970).

Admiral Walter F. Boone
Admiral Arleigh A. Burke
General Clifton B. Cates
Admiral Maurice E. Curts
Admiral Robert L. Dennison
Admiral Donald B. Duncan
Admiral Frank G. Fahrion
Admiral Cato D. Glover, Jr.
Admiral Roscoe F. Good
Admiral Charles D. Griffin
Admiral Byron H. Hanlon
Admiral Ephraim P. Holmes*
Admiral Royal E. Ingersoll
Admiral Albert G. Noble
Admiral Alfred M. Pride
Admiral James O. Richardson
Admiral Horacio Rivero, Jr.*
Admiral Samuel M. Robinson
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.
Admiral Felix B. Stump
General Merrill B. Twining
Admiral Alfred G. Ward
Admiral John M. Will
Vice Admiral Walter S. Anderson
Vice Admiral Harold D. Baker
Vice Admiral Wallace M. Beakley
Vice Admiral George F. Beardsley
Vice Admiral Frank E. Beatty
Vice Admiral Robert E. Blick, Jr.
Vice Admiral Charles T. Booth, II
Vice Admiral Carleton F. Bryant
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral John L. Chew*
Vice Admiral Ralph W. Christie
Vice Admiral Oswald S. Colclough
Vice Admiral John B. Colwell
Vice Admiral Thomas F. Connolly*
Vice Admiral William G. Cooper
Vice Admiral John C. Daniel
Vice Admiral Glenn B. Davis
Vice Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho
Vice Admiral James H. Doyle
Vice Admiral Irving T. Duke
Vice Admiral Ralph Earle, Jr.
Vice Admiral Clarence E. Ekstrom
Vice Admiral Emmet P. Forrestel
Vice Admiral Roy A. Gano
Vice Admiral William E. Gentner, Jr.
Vice Admiral Elton W. Grenfell
Vice Admiral Robert W. Hayler
Lieutenant General Geo. D. Hermle
Vice Admiral Ira E. Hobbs
Vice Admiral George F. Hussey, Jr.
Vice Admiral Olaf M. Hustvedt
Vice Admiral Thomas B. Inglis
Vice Admiral Andrew M. Jackson, Jr.
Vice Admiral Albert E. Jarrell
Vice Admiral Tarry B. Jarrett
Lieutenant General Clayton C. Jerome
Vice Admiral Robert T. S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Fred P. Kirtland
Vice Admiral Harold O. Larson
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance
Vice Admiral William J. Marshall
Vice Admiral Charles B. Martell
Vice Admiral Kleber S. Masterson
Vice Admiral John L. McCrea
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson
Vice Admiral Arthur C. Miles
Vice Admiral Marion E. Murphy
Vice Admiral Lloyd M. Mustin*
Vice Admiral Frank O'Beirne
Vice Admiral Francis P. Old
Vice Admiral Howard E. Orem
Vice Admiral Harvey E. Overesch
Vice Admiral Edward N. Parker
Vice Admiral Frederick W. Pennoyer, Jr.
Vice Admiral Charles A. Pownall
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage*
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Hyman G. Rickover*
Vice Admiral Rufus E. Rose
Vice Admiral Richard W. Ruble
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin, Jr.
Vice Admiral Harry Sanders
Vice Admiral Walter G. Schindler
Vice Admiral William A. Schoech
Vice Admiral Harry E. Sears
Vice Admiral Thomas G. W. Settle
Vice Admiral William B. Smedberg, III
Vice Admiral Allan E. Smith
Vice Admiral Chester C. Smith
Vice Admiral Roland N. Smoot
Lieutenant General Edward W. Snedeker
Vice Admiral Selden B. Spangler
Vice Admiral Thomas M. Stokes
Vice Admiral Paul D. Stroop
Vice Admiral Wendell G. Switzer
Vice Admiral John Sylvester
Vice Admiral John Sylvester
Vice Admiral Aurelius B. Voseller
Vice Admiral Homer N. Wallin
Vice Admiral James H. Ward
Vice Admiral Charles E. Weakley
Vice Admiral Charles Wellborn, Jr.
Vice Admiral George L. Weyler
Vice Admiral Charles W. Wilkins
Vice Admiral Ralph E. Wilson
Rear Admiral James L. Abbot, Jr.*
Rear Admiral Robert E. Adamson*
Rear Admiral John W. Ailes, III
Rear Admiral Herbert S. Ainsworth*
Rear Admiral Frank Akers
Rear Admiral Herbert H. Anderson*
Rear Admiral Roy G. Anderson*
Rear Admiral Burton H. Andrews*
Rear Admiral Parker B. Armstrong*
Rear Admiral Jackson D. Arnold*
Rear Admiral Frederick L. Ashworth
Rear Admiral Edgar H. Batcheller
Rear Admiral Richard W. Bates
Rear Admiral Robert L. Baughan, Jr.*
Rear Admiral Marmaduke G. Bayne*
Rear Admiral Frederick J. Becton
Rear Admiral John K. Beling*
Rear Admiral David B. Bell*
Rear Admiral Fred G. Bennett*
Rear Admiral Philip A. Beshany*
Rear Admiral Abel T. Bidwell
Major General Arthur F. Binney
Rear Admiral Calvin M. Bolster
Rear Admiral John L. Boyes*
Rear Admiral Frank A. Braisted
Rear Admiral Harold M. Briggs
Rear Admiral William A. Brockett
Rear Admiral James A. Brown*
Rear Admiral Henry C. Brutton
Rear Admiral Charles A. Buchanan
Rear Admiral Thomas Burrowes
Rear Admiral Robert L. Campbell
Rear Admiral Milton O. Carlson
Rear Admiral Worrall R. Carter
Rear Admiral George L. Cassell*
Rear Admiral Robert W. Canenagh
Rear Admiral Lester S. Chambers
Rear Admiral John D. Chase*
Rear Admiral Kenan C. Childers, Jr.*
Rear Admiral Ernest E. Christensen*
Rear Admiral Thomas J. Christman*
Rear Admiral Albert H. Clancy, Jr.*
Rear Admiral David H. Clark
Rear Admiral Henry G. Clark, CEC
Rear Admiral Sherman R. Clark
Rear Admiral Leonidas D. Coates, Jr.
Rear Admiral Philip P. Cole*
Rear Admiral Howard L. Collins
Rear Admiral Damon C. Cooper*
Rear Admiral Joshua W. Cooper
Rear Admiral Roy T. Cowdrey
Rear Admiral Donald V. Cox*
Rear Admiral Richard S. Craighill
Rear Admiral Frederick G. Crisp
Rear Admiral Robert E. Cronin
Rear Admiral Robert R. Crutchfield*
Rear Admiral Charles A. Curtze

Rear Admiral John E. Dacey*
Rear Admiral James A. Dare*
Rear Admiral Lawrence R. Daspit
Rear Admiral James R. Davis, CEC
Rear Admiral James W. Davis
Rear Admiral John B. Davis, Jr.*
Rear Admiral James C. Dempsey*
Rear Admiral Vincent P. de Poix*
Rear Admiral John H. Dick*
Rear Admiral Ernest W. Dobie, Jr.*
Rear Admiral Joseph E. Dodson
Rear Admiral William A. Dolan, Jr.
Rear Admiral James C. Donaldson, Jr.*
Rear Admiral Marshall E. Dornin*
Rear Admiral Jack S. Dorsey
Rear Admiral Jennings B. Dow
Rear Admiral Louis Dreller
Rear Admiral Norman J. Drustrup, CEC
Rear Admiral Clifford H. Duerfeldt
Rear Admiral Donald T. Eller
Rear Admiral Robert B. Ellis
Rear Admiral Edward J. Fahy
Rear Admiral James M. Farrin, Jr.
Rear Admiral Emerson E. Fawkes
Rear Admiral John J. Fee
Rear Admiral William E. Ferrall
Rear Admiral Charles W. Fisher
Rear Admiral Francis J. Fitzpatrick*
Rear Admiral Eugene B. Fluckey*
Rear Admiral Norbert Frankenberger*
Rear Admiral Mason B. Freeman*
Rear Admiral Laurence H. Frost
Rear Admiral Robert B. Fulton, II*
Rear Admiral Walter D. Gaddis*
Rear Admiral DAniel V. Gallery
Rear Admiral Fillmore B. Gilkeson*
Rear Admiral Robert O. Glover
Rear Admiral Alexander S. Goodfellow, Jr.*
Rear Admiral Willard K. Goodney
Rear Admiral Arthur R. Gralla*
Rear Admiral Lucien McK. Grant
Rear Admiral Edward E. Grimm
Rear Admiral Peter W. Haas, Jr.
Rear Admiral Mayo A. Hadden, Jr.*
Rear Admiral Ira F. Haddock, SC*
Rear Admiral Frederick E. Haeberle
Rear Admiral Wesley M. Hague
Rear Admiral Grover B. H. Hall
Rear Admiral William M. Harnish*
Rear Admiral Lloyd Harrison
Rear Admiral Hugh E. Haven
Rear Admiral Vincent P. Healey*
Rear Admiral James B. Hildreth*
Rear Admiral Wellington T. Hines
Rear Admiral Morris A. Hirsch
Rear Admiral George A. Holderness, Jr.
Rear Admiral Paul A. Holmberg*
Rear Admiral Ernest C. Holtzworth
Rear Admiral Leroy V. Honsinger
Rear Admiral Edwin B. Hooper*
Rear Admiral Harold A. Houser
Rear Admiral Herbert S. Howard
Rear Admiral Miles H. Hubbard
Rear Admiral Harry Hull
Rear Admiral James McC. Irish
Rear Admiral William D. Irvin
Rear Admiral Joseph A. Jaap
Major General Samuel S. Jack
Rear Admiral David H. Jackson*
Major General Arnold W. Jacobsen
Rear Admiral Jack M. James*
Rear Admiral Ralph K. James
Rear Admiral Frank L. Johnson
Rear Admiral Horace B. Jones, CEC
Rear Admiral Jerome H. King, Jr.*
Rear Admiral Denys W. Knoll
Rear Admiral Paul L. Lacy, Jr.*
Rear Admiral David Lambert
Major General Frank H. Lamson-Scribner
Rear Admiral Martin J. Lawrence
Rear Admiral William H. Leahy
Rear Admiral Kent L. Lee*
Rear Admiral William E. Lemos*
Rear Admiral Joseph W. Leverton, Jr.
Rear Admiral John K. Leydon
Rear Admiral William H. Livingston*
Rear Admiral James C. Longino, Jr.*
Rear Admiral Theodore C. Lonnquest
Rear Admiral Almon E. Loomis
Rear Admiral Wayne R. Loud
Rear Admiral Charles H. Lyman, III
Major General William G. Manley
Rear Admiral Charles F. Martin
Rear Admiral Thomas R. McClellan*
Rear Admiral William R. McClendon*
Major General Keith B. McCutcheon
Rear Admiral John B. McGovern
Rear Admiral Eugene B. McKinney
Rear Admiral William R. McKinney*
Rear Admiral Kenmore M. McManes
Rear Admiral Philip S. McManus*
Rear Admiral Robert W. McNitt*
Rear Admiral John H. McQuilken
Rear Admiral Wm. K. Mendenhall, Jr.
Major General Lewie G. Merritt
Rear Admiral Frederick H. Michaelis*
Rear Admiral Roderick O. Middleton*
Rear Admiral William Miller
Rear Admiral Benjamin E. Moore
Rear Admiral Robert L. Moore, Jr.
Rear Admiral Armand M. Morgan
Rear Admiral Thomas H. Morton
Rear Admiral Albert G. Mumma
Rear Admiral William T. Nelson
Rear Admiral Charles A. Nicholson, II
Rear Admiral Robert H. Northwood, SC
Rear Admiral Ira H. Nunn
Rear Admiral Emmet O'Beirne
Rear Admiral Edward J. O'Donnell
Rear Admiral Clarence E. Olsen
Rear Admiral James B. Osborn*
Rear Admiral Charles J. Palmer
Rear Admiral Lewis S. Parks
Rear Admiral Goldsborough S. Patrick
Rear Admiral John B. Pearson, Jr.
Rear Admiral Raymond E. Peet*
Rear Admiral Henry S. Persons
Rear Admiral William F. Petrovie*
Rear Admiral Carl J. Pfingstag
Rear Admiral Richard H. Phillips
Rear Admiral Ben B. Pickett*
Rear Admiral Paul E. Pihl
Rear Admiral Frank L. Pinney, Jr.
Rear Admiral Walter H. Price
Rear Admiral Schuyler N. Pyne
Rear Admiral James D. Ramage*
Rear Admiral Harry L. Reiter, Jr.
Rear Admiral Henry A. Renken*
Rear Admiral Joseph E. Rice*
Rear Admiral Basil N. Rittenhouse, Jr.
Rear Admiral Walter F. Rodee
Rear Admiral William K. Romoser
Rear Admiral Gordon Rowe
Rear Admiral Donald Royce
Rear Admiral Edward A. Ruckner*
Rear Admiral Thomas J. Rudden, Jr.*
Rear Admiral George L. Russell
Rear Admiral Ben W. Sarver
Rear Admiral Raymond J. Schneider*
Rear Admiral Malcolm F. Schoeffel
Rear Admiral Floyd B. Schultz
Rear Admiral John N. Shaffer*
Rear Admiral Leslie H. Sell*
Rear Admiral Tazewell T. Shepard, Jr.*
Rear Admiral William B. Sieglaff
Rear Admiral Harry Smith
Rear Admiral James H. Smith, Jr.*
Rear Admiral John V. Smith*
Rear Admiral Levering Smith*
Rear Admiral John A. Snackenberg
Rear Admiral Philip W. Snyder
Rear Admiral Edward A. Solomons
Rear Admiral Robert H. Speck
Rear Admiral Roger E. Spreen*
Rear Admiral Frederick C. Stelter, Jr.
Rear Admiral Edward C. Stephan
Rear Admiral Earl E. Stone
Rear Admiral Charles W. Styer
Rear Admiral Robert L. Swart
Rear Admiral William E. Sweeney
Rear Admiral Frank R. Talbot
Rear Admiral Raymond D. Tarbuck
Rear Admiral Arthur H. Taylor
Rear Admiral John McN. Taylor
Rear Admiral Theodore A. Torgerson
Rear Admiral George C. Towner
Rear Admiral Robert L. Townsend*
Rear Admiral David M. Tyree
Rear Admiral Frank Virden
Rear Admiral John R. Wadleigh*
Rear Admiral George H. Wales
Rear Admiral Thomas J. Walker, III*
Rear Admiral Kenneth C. Wallace*
Rear Admiral Frederick B. Warder
Rear Admiral William W. Warlick
Rear Admiral Odale D. Waters, Jr.*
Rear Admiral David F. Welch*
Rear Admiral Thomas R. Weschler*
Rear Admiral Ralph Weymouth*
Rear Admiral Charles D. Wheelock
Rear Admiral Francis T. Williamson
Rear Admiral Frederick S. Withington
Rear Admiral Narvin O. Wittman*
Rear Admiral Mark W. Woods*
Rear Admiral Edward A. Wright
Rear Admiral Earl P. Yates*
Rear Admiral Elmer E. Yeomans
Brigadier General George C. Axtell, Jr.*
Brigadier General Edward C. Dyer
Brigadier General Jacob E. Glick
Commodore Stanley D. Jupp
Brigadier General Ivan W. Miller
Commodore Robert E. Robinson, Jr.
Commodore Henry A. Schade
Commodore Oscar Smith
Commodore Ralph S. Wentworth

HISTORY

The Naval Postgraduate School had a modest beginning at the Naval Academy at Annapolis in 1909, at which time the first class of ten officers enrolled in a Marine Engineering curriculum. The need for technically educated officers had become evident at the turn of the century. The idea of a naval graduate school had its inception in a course of instruction in Marine Engineering which the Bureau of Engineering instituted in 1904. The results of this course were so encouraging that in 1909 the Secretary of the Navy established a School of Marine Engineering at the Naval Academy in Annapolis. In 1912 the School was designated the Postgraduate Department of the Naval Academy.

The operation of the school was temporarily suspended during World War 1, but in 1919 classes were resumed in converted Marine Barracks on the Naval Academy grounds. At this time curricula in Mechanical Engineering and Electrical Engineering were added. With the passing years other curricula – Ordnance Engineering, Radio Engineering, Aerological Engineering and Aeronautical Engineering – were added as the Navy's need for officers with technical knowledge in these fields became evident.

In 1921 it again became a "School," changing its name from "Postgraduate Department" to "Postgraduate School," but remaining under the command of the Superintendent of the Naval Academy.

In 1927 the General Line Curriculum was established within the Postgraduate School to provide courses of instruction to acquaint junior line officers returning from sea duty with modern developments taking place in the Navy. The courses dealt with naval and military subjects for the most part. The General Line Curriculum remained as an integral part of the Postgraduate Department until the declaration of the emergency prior to the outbreak of World War II, at which time it was discontinued because of the need for officers in the growing fleet.

The enrollment in the Postgraduate School increased rapidly in the war years both in the several engineering curricula and in the communications curriculum which was added to meet the need for trained communication officers in the naval establishment. The School outgrew its quarters necessitating the building of an annex to house the additional classrooms and laboratories required, but even with this addition, the space requirements of the expanded school were not met.

The post-war program called for still further expansion and the re-establishment of the General Line Curriculum with a greatly increased enrollment. In 1946 the General Line School was established at Newport, Rhode Island, as an outlying element of the Postgraduate School and continued until disestablished in 1952; in 1948 an additional General Line School was established at Monterey, California. The objective of the General Line School program – that of providing an integrated course in naval science to broaden the professional knowledge of unrestricted line officers of the Regular Navy – continued in effect as it had since the inception of this program. During the period 1946 to 1955 the School served to provide such education primarily to Reserve and ex-Temporary officers who had transferred to Regular status.

The physical growth of the School and its increase in scope and importance were recognized in Congressional action which resulted in legislation during the years of 1945 to 1951 emphasizing the academic stature of the School, and providing for continued growth in a new location with modern buildings and equipment. This legislation authorized the Superintendent to confer Bachelor's, Master's, and Doctor's degrees in engineering and related subjects; created the position of Academic Dean to insure continuity in academic policy; established the School as a separate naval activity to be known as the Naval Postgraduate School; authorized the establishment of the School at Monterey, California; provided funds to initiate the construction of buildings to house modern laboratories and classrooms at that location.

On 22 December 1951, by order of the Secretary of the Navy, the Naval Postgraduate School was officially disestablished at Annapolis, Maryland, and established at Monterey, California. This completed the transfer of the School from the East to the West Coast, which had begun in 1948 when the Aerology Department and Curricular office were moved to the new location. Concurrently with this relocation the Naval School (General Line) at Monterey was disestablished as a separate military command and it became a component of the Naval Postgraduate School. At the same time, there was established the Naval Administrative Command, Naval Postgraduate School, Monterey, to provide logistic support, including supply, public works, medical and dental functions, for the Naval Postgraduate School and its components.

In June, 1956, by direction of the Chief of Naval Personnel, the Navy Management School was established as an additional component of the Postgraduate School. Its mission was to provide an educational program for officers in the application of sound scientific management practice to the complex organizational sturcture and operation of the Navy with a view to increasing efficiency and economy of operation. The first class included only Supply and Civil Engineering Corps officers and emphasis was placed on general management theory, financial management, and inventory management. In August, 1957, this school was expanded to include input of both Line and Staff Corps officers. Since that time the curriculum has been under constant revision to include new areas of import to, and changes of concept in, the field of management. Subsequently the curriculum was lengthened and led to a master's degree for those who could meet the requirements for such a degree.

Discussions commenced in mid-1957 resulted in the establishment in August, 1958, of a Bachelor of Science curriculum in the General Line School and a change in the name of that school, effective 1 July 1958, to the General Line and Naval Science School.

The curriculum included subjects taught in the General Line curriculum plus new courses adequate in number, level, and scope to support a degree of bachelor of science, no major designated. The success of the program through the early classes led to the addition of an Arts program in August, 1961, to provide for those officers whose previous education emphasized the humanities rather than science and mathematics.

These baccalaureate curricula eventually replaced the Navy's Five-Term program which had been conducted in civilian universities and, except for the College Degree Program, now constitute the only programs available to naval officers to complete their undergraduate education.

In August, 1960, the Engineering Science Curriculum was initiated with a concurrent reduction in the number of U.S. officers enrolled in the General Line Curriculum. In August, 1962, input of U.S. officers into the General Line Curriculum was terminated; however, the program was continued for foreign officers.

The continuing growth and projected expansion of the School led to a major reorganization in 1962. In June, the Administrative Command was disestablished as a separate command, its functions continuing to be performed by personnel reporting to a new Director of Administrative and Logistic Services. In August, the three component schools were disestablished and a completely new organization became effective. There is now but one School – the Naval Postgraduate School – with unified policy, procedure and purpose. The position of Chief of Staff was replaced by Deputy Superintendent and responsibility for the operation of all academic programs was placed under the dual control of a naval officer Director of Programs and civilian Dean of Programs.

A subsequent reorganization in 1966 resulted in the disestablishment of the position of Deputy Superintendent and the retitling of the positions of the principle military assistants as will be noted in the following section.

In January, 1967, after a thorough re-evaluation and revision of curricula in the light of curricular objectives, plans were approved to shift the operations of the School from a five-term to a four-quarter academic calendar effective 1 July 1967. This resulted in certain personnel economies, and in the overall strengthening of curricula by the elimination of obsolete and unnecessary material and realignment of course content into more logical sequence.

In connection with the foregoing, the General Line Curriculum for foreign officers and the Naval Warfare Department were disestablished. Foreign officers continue to be enrolled in the technical and management curricula.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are an Academic Dean who is the senior member of the civilian faculty and two captains of the line, the Deputy Superintendent for Operations and Programs, and the Deputy Superintendent for Administration and Logistics.

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices and Academic Departments. The former are staffed by naval officers whose primary functions are three-fold: (1) academic and military supervision and direction of officer students; (2) coordinating, in conjunction with Academic Associates, the elements of each curriculum within their program areas; and (3) conducting liaison with curricula sponsor representatives. Officer students are grouped into the following curricular programs areas:

- Aeronautical Engineering
- Electronics and Communications Engineering
- Ordnance Engineering
- Naval Engineering
- Environmental Sciences
- Management and Computer Science
- Operations Analysis
- Engineering Science
- Baccalaureate

Officer students in each curricula group pursue similar or closely related curricula. With most of these areas a common core program of study is followed for at least half the period of residency.

Objectives and details of curricula are contained elsewhere in this catalogue.

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into eleven academic departments:

Aeronautics
Business Administration and Economics
Electrical Engineering
Government and Humanities
Material Science and Chemistry
Mathematics
Mechanical Engineering
Meteorology
Oceanography
Operations Analysis
Physics

Over four-fifths of the teaching staff are civilians of varying professorial rank and the remainder naval officers.

Detailed listings of faculty members and course offerings are contained in later sections of the catalogue.

The Academic Program organization described is supervised by the Deputy Superintendent for Operations and Programs and a civilian Dean of Programs who collaborate to share jointly the responsibilities for planning, conduct and administration of the several educational programs. An Executive Assistant to the Deputy Superintendent for Operations and Programs, similarly shares curricular responsibilities with a Dean of Curricula in a position just above the Curricular Officers.

The close tie between elements of this dual organization is further typified by the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula – the Navy's needs being the responsibility of the Curricular Officer, and academic soundness being the responsibility of the Academic Associate.

The educational programs conducted at Monterey fall into several general categories:

a. Engineering and scientific education leading to designated baccalaureate and/or advanced degrees.

b. Management education to the Master's level.

c. Undergraduate education leading to a first baccalaureate degree, either B.S. or B.A.

Supplementing category a. above is the Engineering Science program. The major portion of the officers selected for this program undergo two terms of refresher and prerequisite study. Those who are so motivated and available for the requisite time may be selected by the Superintendent for a two or three year engineering or science curriculum. Those not selected continue in a non-degree program with the primary objective of basic scientific education which will better prepare them for advanced functional training and/or general updating in technical areas.

Logistic service support is rendered by conventional departments such as Supply and Disbursing, Public Works, Dental, Public Affairs and Visit Liaison, etc., grouped organizationally under a Deputy Superintendent for Administration and Logistics. Certain other offices such as that of the Comptroller are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fishermen's Wharf. The site of the School is the former luxury Del Monte Hotel of pre-World II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research, a nearby laboratory and recreation area, and the La Mesa housing area.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its old Spanish architecture.

Most of the academic classrooms, laboratories, and offices are located in Spanagel, Bullard, Halligan, Root and Ingersoll Halls. The construction of a new building, to be called the Dudley Knox Library, has been approved and final plans are prepared. Its completion is dependent on the release of funds for government construction. About one-third of Root Hall is now occupied by the Library and Reference Center. Adjacent to the main academic buildings is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

The Laboratory and Recreation area adjacent to the Naval Auxiliary Landing Field contain many laboratories associated with the aeronautical engineering curricula. In addition this area has a nine-hole golf course and a picnic area.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the officers of the Postgraduate School.

La Mesa Village, located 3 miles from the School, consisting of former Wherry Housing and new Capehart Housing, contains 877 units of public quarters for naval personnel. An elementary school is located within the housing area.

The Naval Auxiliary Landing Field is located about one mile from the School. Aircraft are available for maintaining flight proficiency. Cross-country flights up to 1200 miles are now permitted. One half-day each week is scheduled for flying as part of the aviator student's work-week.

On the main School grounds are 149 BOQ rooms, an Open Mess, a Navy Exchange, 4 tennis courts, a large swimming pool and 6 lane bowling alley. An eighteen-tee nine-hole Navy golf course is located near the main campus.

Medical facilities include a Dispensary at the Naval Auxiliary Landing Field, Monterey, supported by the U.S. Army Hospital, Fort Ord (7 miles away) and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

TEXTBOOKS

The Naval Postgraduate School expects to open a bookstore in early 1971. The store will stock textbooks and related school supplies. Students will be required to purchase all necessary books and supplies either from the school bookstore, local civilian bookstores or other students in the school. It is planned to partially reimburse each student for some of the cost. The net cost to each student will depend on the curriculum in which he is enrolled and on the extent to which he retains his textbooks for a personal library.

ADMISSIONS PROCEDURES

U.S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to BuPers Notice 1520, Subject: Postgraduate Educational Programs, which is published annually by the Chief of Naval Personnel. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Chief of Naval Personnel to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by a BuPers Notice at the earliest feasible date after the meeting of the selection board, or by official correspondence.

The curriculum numbers as assigned in the annual BuPers Notice 1520 are repeated in the title of each curriculum and are also included in the list of curricula at the Postgraduate School on page 27 and the list of curricula conducted at civilian institutions on page 59.

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U.S. Marine Corps, or the Commandant U.S. Coast Guard, as appropriate.

Military officers from Allied Countries may be admitted to certain curricula at the Postgraduate School. Such admission is subject to availability of quotas assigned to each country. Applications must be made through normal channels of communication and not sent directly to the Naval Postgraduate School. The academic standards described in this Catalogue for admission to each curricula must be met.

Civilian students are not eligible to attend the Postgraduate School.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. This authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School was accredited in 1962 as a full member of the Western Association of Schools and Colleges. Initial accreditation as an associate member was given in 1955. Specific engineering curricula have been accredited by the Engineers' Council for Professional Development (ECPD) since 1949.

Beginning with the 1967-68 academic year, the Postgraduate School began operation on a 12-week quarter calendar, with the last week of each quarter set aside for final examinations. Prior to this year, the academic schedule was based on 10-week terms.

Students' performance is evaluated on the basis of a qualify point number assigned to the letter grade achieved in a course as follows.

Performance	*Grade*	*Quality Point Number*
Excellent	A	3.0
Good	B	2.0
Fair	C	1.0
Barely Passing	D	0.0
Failure	X	−1.0

When the quarter hours value of a course is multiplied by the quality point number of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the quarter hour value of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 2.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours. Satisfactory academic proficiency at the Naval Postgraduate School has been established at a QPR of 1.0 for all courses of a curriculum.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for this purpose between classes.

The courses listed in this Catalogue are assigned a level of academic credit by the numbers assigned.

0001 - 0999	No credit
1000 - 1999	Lower division credit
2000 - 2999	Upper division credit
3000 - 3999	Upperdivision or graduate credit
4000 - 4999	Graduate credit

The two numbers in parenthesis (separated by hyphens) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating quarter hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned a credit value of 4 quarter hours.

ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include the American Meteorological Society, Association for Computing Machinery, American Society of Mechanical Engineers, The Institute of Electrical and Electronics Engineers, Inc.

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 2.65, or higher, while carrying a minimum academic load of 12 quarter hours.

GRADUATION WITH HONORS. The award of the Master of Science Degree may be made "With Distinction" when a student completes the degree requirements with a minimum of 32-quarter hours earned in residence and a final Quality Point Rating of 2.75, or higher. The award of a Bachelor's Degree may be made "Cum Laude" when a student completes the degree requirements with a minimum of 60-quarter hours in residence and a final Quality Point Rating of 2.50, or higher.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma Xi, an honorary society founded to recognize excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J. C. WOELFEL AWARD. This award is given annually to the United States Naval officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

DIPLOMAS OF COMPLETION

Diplomas of Completion are issued to students completing programs which do not offer a degree. To establish eligibility for a Diploma of Completion, a student must obtain an overall QPR of 1.0 or better. Where applicable, students obtaining a QPR of 2.75 or better will receive Diplomas of Completion "With Distinction."

REQUIREMENTS FOR THE BACCALAUREATE DEGREE

1. The Bachelor of Science or the Bachelor of Arts Degree may be awarded for successful completion of a curriculum which has been approved by the Academic Council as meriting the degree. Such curricula shall conform to current practice in other accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Baccalaureate Degree are as follows:

a. 180 quarter hours of which at least 72 hours must be at the upper division level from course numbered at or above 2000.

b. One academic year in residence.

c. 36 quarter hours in the Humanities and the Social Sciences.

d. 36 quarter hours in Mathematics and the Physical Sciences.

e. Completion of the departmental requirements for a well-defined major.

f. A quality point rating of at least 1.00 in all courses taken at the Postgraduate School as well as in the courses in the major.

REQUIREMENTS FOR THE MASTER OF ARTS AND MASTER OF SCIENCE DEGREES

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Master's Degree are as follows:

a. 32 quarter hours of graduate level credits.

b. A thesis or its equivalent is required. If the thesis is waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.

c. One academic year in residence.

d. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master of Science degree requires a baccalaureate degree with appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.

4. In order to qualify for a Master's Degree, a student first must be admitted to candidacy for the degree. Application for admission to candidacy must be made subsequent to completion of 50% of his curriculum, and prior to completion of 75% of the curriculum. Students having a quality point rating of 2.00 or greater in all courses of their curricula are qualified for admission to candidacy. Students having a total quality point rating from 1.50 to 1.99, inclusive, may be admitted to candidacy by the Academic Council upon recommendation of the Chairman of the Department of the major. Students with a total quality point rating below 1.50 will be ineligible for admission to candidacy.

5. To be eligible for the Master's Degree, the student must attain a minimum average quality point rating of 2.00 in all the graduate level courses in his curriculum and either 1.50 in the remaining courses or 1.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DEGREE: ENGINEER

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.

b. An acceptable thesis.

c. One academic year in residence.

d. Departmental requirements for the degree in a specified Engineering field.

e. A quality point rating of at least 2.00 in all graduate courses in the curriculum and either 1.50 in the remaining courses or 1.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DOCTOR'S DEGREE

1. The Doctor's Degree (in engineering and related fields) is awarded as a result of very meritorious and scholarly achievement in a particular field of study which has been approved by the Academic Council as within the purview of the Naval Postgraduate School. A candidate must exhibit faithful and scholarly application to all prescribed courses of study, achieve a high level of scientific advancement and establish his ability for original investigation. He shall further meet the requirements described in the following paragraphs.

2. Any program leading to the Doctor's Degree shall require the equivalent of at least three academic years of study beyond the undergraduate level with at least one academic year being spent at the Naval Postgraduate School.

3. A student seeking to become a candidate for the Doctorate shall hold a Bachelor's degree from a college or university, based on a curriculum that included the prerequisites for full graduate status in the department of his major study, or he shall have pursued successfully an equivalent course of study. The student shall submit his previous record to the Chairman of the Department of his proposed major subject for determination of his acceptability as a Doctoral student.

4. This chairman will consult with two or more selected department chairmen to nominate a doctoral committee for the student. The committee will consist of five or more members with at least one representative from each of the selected departments. The Department Chairman of the student's major will submit the proposed committee names to the Academic Council for its approval.

5. The Doctoral Committee has full responsibility for prescribing a program of study, which shall include one or more minor fields, suitable to the needs of the student and the requirements for award of the Doctorate.

6. When the program of study in his major and minor field is essentially complete, the student shall be given qualifying examinations, including those associated with the foreign language requirement. The qualifying examinations in the major and minor fields will be both written and oral and will be conducted by the Doctoral Committee. The members of the Academic Council or their delegates will be invited to attend the oral examinations.

7. The foreign language requirement is to be satisfied by the student demonstrating before an examiner appointed by the Academic Dean that he possesses a satisfactory ability to read work related to his special field of study in at least two foreign languages. The accepted languages are French, German and Russian. If the student can demonstrate that enough current technical literature in his major field exists in another foreign language, the Doctoral Committee may substitute this for one of the accepted languages. Preparations for meeting this requirement should begin early in the student's program.

8. Upon successful completion of the qualifying examinations, and the fulfillment of the foreign language requirements, the student becomes a candidate for the Doctorate. The Doctoral Committee will report to the Academic Council the student's advancement to candidacy. After advancement, the candidate must devote at least six months to research before he may expect to present himself for the final examination. All requirements must be satisfied within a maximum period of five years after advancement to candidacy.

9. The distinct requirement of the Doctorate is a successful completion of a scholarly investigation leading to an original and significant contribution to knowledge in the candidate's major area of study. The subject of the investigation must be approved in advance, by the Doctoral Committee. When the results of the investigation are completed, a copy of the dissertation shall be submitted to each member of the Doctoral Committee. The Committee will make the final decision on the acceptance of the dissertation.

10. After the approval of the dissertation, and not later than two weeks prior to the award of the degree, the Committee will conduct a final oral examination of the candidate. The members of the Academic Council or their delegates will be invited to attend the examination. In this final examination, the candidate will be asked to defend his Dissertation and in addition shall be questioned on any subject deemed important to the Committee. Upon completion of the final examination the Committee will nominate the successful candidate to the Academic Council for the award of the Doctor's degree. The Committee will supply to the Council such information concerning the candidate as may be requested by the Council Secretary.

11. With due regard for all the requirements for awarding the Doctorate and the recommendations of the Doctoral Committee, the Academic Council will make the final decision to recommend the candidate to the Superintendent of the Naval Postgraduate School for the award of the degree.

SUPERINTENDENT'S GUEST LECTURE PROGRAM

Throughout the Academic Year lectures will be presented on Tuesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international, governmental, sociological, and military affairs. Occasionally speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

IBM 360/67 computer system in the Computer Center.

W. R. CHURCH COMPUTER CENTER

STAFF

DOUGLAS GEORGE WILLIAMS, Professor and Director (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

ROGER RENE HILLEARY, Manager, User Services (1962); B.A., Pomona College, 1953.

EDWARD NORTON WARD, Supervisor, Systems Programming, (1962), B.A., Univ. of California at Lost Angeles, 1952.

DAVID FREDRIC NORMAN, Manager, Operations (1969).

LOIS MAY BRUNNER (1961); B.S., Naval Postgraduate School, 1968.

RICHARD EUGENE DONAT (1968); B.S., California State Polytechnic College, 1967.

KATHLEEN MARIE EISENHARDT (1969); B.S.M.E., Brown University, 1969.

WILLIAM DAVID EHRMAN (1968); B.S., Colorado State University, 1965; M.S., Colorado State University, 1968.

CLARENCE WILLIAM KELLOGG (1968); A.A., Monterey Peninsula College, 1969.

GERARD PAUL LEARMONTH (1969); B.S., New York University, 1966.

WILLIAM LEO MOLL (1969); B.B.A., Univ. of Texas, 1965.

BERNADETTE REQUIRO PEAVEY (1967); B.A., Univ. of California at Berkeley, 1963.

SHARON DILL RANEY (1964); B.S., California State Polytechnic College, 1964.

KATHRYN BETTY STRUTYNSKI (1967); B.S., Brigham Young University, 1953.

ROBERT STEPHEN WALTON (1961); B.S., Massachusetts Institute of Technology, 1949.

PIMPORN CHAVASANT ZELENY (1968); B.S. (Honours), Chulalongkorn University, Bangkok, 1955; M.S., Syracuse University, 1958.

* The year of joining the Postgraduate School is indicated in parentheses.

The Naval Postgraduate School was one of the first insitutions to use digital computers in their educational programs. The first machine, an NCR 102A, was installed in 1954 and operated by the Department of Mathematics. A central Computer Facility was created in 1960 as an organizational unit separate from the academic departments. In December, 1969, the Facility was renamed the "W. R. Church Computer Center" in memory of Professor Church, Chairman of the Department of Mathematics (1947-66), who recognized very early the value of computers in education and was instrumental in obtaining the early computers at the School.

The many services of the Center are available to all faculty, staff, and students of the School for use in connection with instruction, research, or administrative activities.

These services are based on an IBM 360, Model 67 computer system which was installed in April, 1967. The present hardware complement includes two Model 67 processing units; four different levels of storage, including 786 thousand bytes of core, four million bytes on a drum, approximately 291 million bytes on disk devices, and four magnetic tape units; normal peripheral devices; two high-speed plotters, thirty remote typewriter terminals, and an IBM 2250 Graphical Display Unit with light-pen and programmed function keyboard. The two processors are identical and can access directly, or control, all components of the system including core storage modules, input/output controllers and devices. The resources of the system can be allocated easily to create different operational environments.

The Center offers users two modes of operational services, viz., batch processing and multi-access time-sharing. Both operating systems support a great variety of programming languages, library of subroutines and other software facilities. Languages provided include FORTRAN IV, Assembler, PL/1, COBOL, GPSS, and SNOBOL.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the academic curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in computer science. They are introduced to the computer early in their curricula at the Naval Postgraduate School and encouraged to use it in subsequent course work and research.

The Computer Center supports a wide variety of specialist courses in computer science offered in the Departments of Business Administration and Economics, Electrical Engineering, Mathematics, and Operations Analysis. The School offers two graduate degrees in the data processing field, viz., M.S. (Computer Systems Management) since 1963, and M.S. (Computer Science) since 1967.

The Center has a staff of 32 people of whom 15 are mathematician/programmers. The professional staff provides a consulting service in applications programming, systems programming and problem formulation to students and faculty members. They participate in an active research and development program directed primarily towards improving the present operational environment or introducing new programming facilities to users. Current projects include work on systems measurement, improvement of operating systems, graphical data processing, time-sharing facilities, and numerical analysis.

Library

THE LIBRARIES

STAFF

GEORGE RIDGELY LUCKETT, Professor and Director of Libraries (1950)*; B.S., Johns Hopkins Univ., 1949; M.S., Catholic Univ., 1951.

PAUL SPINKS, Associate Professor and Associate Director of Libraries (1959); B.A., Univ. of Oklahoma, 1958; M.S., 1959.

EDGAR RAYMOND LARSON, Assistant Professor and Reader Services Librarian (1959); B.A., University of Washington, 1939; B.S., 1950.

GEORGIA PLUMMER LYKE, Reference Librarian (1952); A.A., Hartnell College, 1940.

DIANE SHIRLEY NIXON, Reference Librarian (1969); B.A., California State College, 1968; M.S., Univ. of Southern California, 1969.

JANUSZ I. KODREBSKI, Assistant Professor and Head Catalog Librarian (1956); Diplomat of the National War College, Warsaw, Poland, 1938; M.S., Univ. of Southern California, 1955.

ELSA MARIE KUSWALT, Catalog Librarian (1958); B.A., Univ. of California at Berkeley, 1957; M.L.S., Univ. of Southern California, 1966.

LOUIS OVEN, Catalog Librarian (1969); B.A., Monterey Institute of Foreign Studies, 1964; M.A., 1968; M.A., Univ. of California at Berkeley, 1968.

SYLVIA K. SHEINGOLD, Catalog Librarian (1969); B.A., Hunter College, 1936; M.A., San Jose State College, 1968.

ALICE MARIE STUDE, Catalog Librarian (1957); B.A., Univ. of Minnesota, 1930; M.S., Univ. of California at Berkeley, 1961.

ROBERT MORAN TIERNEY, Head Technical Reports Librarian (1957); B.A., Columbia Univ., 1937; M.A., San Jose State College, 1962.

CHRISTOPHER KASPAREK-OBST, Technical Reports Librarian (1967); B.S., Univ. of California at Berkeley, 1966; M.S., 1967.

CLEO ELIZABETH PETERSON, Technical Reports Librarian (1958); A.A., Red Oak College, 1938.

MABEL CHARLOTTE VAN VORHIS, Technical Reports Librarian (1955); B.A., Univ. of California at Berkeley, 1926.

MARY THERESE BRITT, Acquisitions Librarian (1966); B.S., College of St. Catharine, 1947.

* The year of joining the Postgraduate School is indicated in parentheses.

DESCRIPTION

The Library system serves the research and instructional needs of the community comprising students, faculty, and staff of all departments of the School. It embraces an active collection of 123,000 books, bound periodicals and pamphlets, 144,000 technical documents, over 2500 periodical works currently received, and 65,000 abstract cards, microcards, and microfiche. These materials parallel the School's curricular fields of engineering, physical sciences, industrial engineering, management, naval sciences, government and humanities.

The Reference Library provides the open literature sources such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It also furnishes facilities for microfilming and microfilm reading, for photographic and contact reproduction of printed matter, and for borrowing, from other libraries, publications not held in its collection.

The Technical Reports and Classified Materials Section is the principal repository for technical research documents received by the School. It houses 144,000 documents, 70,000 of which are classified, and exercises control over the microcard and microfiche collection. A machine information storage and retrieval system that utilizes the School's computer facilities is available for literature searches of documents received since November, 1960. An SDI (Selective Dissemination of Information) service, designed to broaden the scope of the Library's automated services to the Postgraduate School, is also available. Future plans include the installation in the Library of a remote terminal unit, which will facilitate the generation of rapid literature searches.

The Christopher Buckley, Jr., Library is a branch of the Reference Library and is located on the first floor adjacent to the lobby. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who began donating books to the School for this Library in 1949. An additional 2,000 volumes are held at Mr. Buckley's residence pending the construction of the new Library building.

In 1954, the Reference Library was assigned space in an area originally designed to house classrooms and offices, but modified to temporarily serve as a Library. The sixteen years since have witnessed considerable expansion of the Postgraduate School's curricular and research interests, its faculty, military staff, and student body, together with a corresponding expansion of the Library's collections and services. This growth has created a compelling need for more library space and more adequate reference and research facilities – a need recognized during Fiscal Year 1969, when funds for a new reference center, The Dudley Knox Library, were appropriated and complete plans later reached their final stage of approval. Construction is scheduled to commence in July, 1970, and occupancy is expected during the summer of 1971.

Hermann Hall, Administration Building

CURRICULAR OFFICES and PROGRAMS

Lobby of Administration Building

CURRICULA AT THE POSTGRADUATE SCHOOL

Curriculum	*Curriculum Number*	*Length*	*Convening Dates*
Advanced Science			
Chemistry	380	33 mo.	March, September
Hydrodynamics	380	33 mo.	March, September
Mathematics (Applied)	380	33 mo.	March, September
Material Science	380	33 mo.	March, September
Physics (General)	380	33 mo.	March, September
Physics (Nuclear)	380	33 mo.	March, September
Aeronautical Engineering			
General	610	24 mo.	March, September
Advanced	610	24-33 mo.	March, September
Baccalaureate			
Bachelor of Science	461	24 mo.	January, July
Bachelor of Arts	461	24 mo.	January, July
Electronics and Communications Engineering			
Communications Engineering			
Basic	600	21 mo.	March, September
Advanced	600	27-36 mo.	March, September
Engineering Electronics			
Basic	590	21 mo.	March, September
Advanced	590	27-36 mo.	March, September
Information and Control	590	27-36 mo.	March September
Special (CEC)	472	12-18 mo.	March, September
Communications Management	620	18 mo.	March, September
Engineering Science	460	9 mo.	March, September
Environmental Sciences			
Meteorology	371	12 mo.	January, July
Advanced Meteorology	372	24 mo.	March, September
General Meteorology	372	21 mo.	March, September
Oceanography	440	24 mo.	March, September
Management and Computer Science			
Computer Science	368	21 mo.	March, September
Computer Systems Management	367	15 mo.	March, September
Management	814 and 817	12 mo.	January, July
Naval Engineering			
Mathematics	430	12 mo.	July
Naval Engineering (Mechanical)	570	21 mo.	March, September
Naval Engineering (Electrical)	570	21 mo.	March, September
Mechanical Engineering (Advanced)	570	27-36 mo.	March, September
Electrical Engineering (Advanced)	570	27-36 mo.	March, September
Operations Research/Systems Analysis			
Operations Research/Systems Analysis	360	24 mo.	March, September
Ordnance Engineering			
Nuclear Engineering (Effects)	521	24 mo.	July
Underwater Physics Systems	535	21-36 mo.	September
Ordnance Systems Engineering	530	21-36 mo.	March, September

ADVANCED SCIENCE PROGRAMS CURRICULUM NUMBER 380

Chemistry
Hydrodynamics
Material Science
General Physics
Nuclear Physics
Applied Mathematics

OBJECTIVE – To prepare selected officer personnel to deal with the problem of fundamental and applied research in the fields of general physics, nuclear physics, hydrodynamics, chemistry, material science, and applied mathematics.

QUALIFICATIONS FOR ADMISSION – Officers nominated for Advanced Science Curricula are selected from among those first-year students enrolled in technical curricula at the Postgraduate School who apply for the Advanced Science Program. Applicants are carefully screened and only those having a very good academic background and who appear to have an excellent chance of succeeding in their chosen field are nominated to the Chief of Naval Personnel.

DESCRIPTION – Officers selected for Advanced Science Curricula complete their first year at the Naval Postgraduate School, and may spend their second and third years of study either at the Naval Postgraduate School or a civilian university. The curriculum for each officer is arranged from courses selected to suit the needs of the Navy, to develop the capabilities of the individual student, and to meet the ultimate objective of his specialty.

The Advanced Science Curricula normally lead to the Master of Science degree for those officers meeting the requirements for that degree.

Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a Master's degree upon completion of four quarters course work, including an acceptable thesis.

Computer Applications Laboratory

AERONAUTICAL ENGINEERING PROGRAMS CURRICULUM NUMBER 610

GEORGE WILLIAM EAST, Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy 1950; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1957; M.S. in Aeronautical Engineering, Massachusetts Institute of Technology, 1958; Navy Test Pilot School Class XXXV, 1963.

ROBERT DIEFENDORF ZUCKER, Academic Associate; B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., University of Louisville, 1958; Ph.D., University of Arizona, 1966.

DONALD WILLIAM MATHEWS, Commander, U.S. Navy; Assistant Curricular Officer; B.S. in Engineering, Univ. of California at Berkeley, 1953; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1960; Ae.E., Stanford University, 1961; Armed Forces Staff College, 1966.

OBJECTIVE – To provide officers with advanced aeronautical education to meet Navy technical requirements in flight vehicles and their environmental fields. Curricula are designed to provide majors in support of specific Naval Air Systems Command requirements. A basic foundation in broad areas of Operations Analysis, Management and Engineering Materials is also provided.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with a grade average of B or better in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics, and one year of mechanics is considered minimal preparation. Additional undergraduate coverage in basic engineering, electrical engineering, mathematics and chemistry is desirable.

DESCRIPTION – Classes convene twice yearly in March and September. Officers are ordered in six weeks in advance of convening dates to take calculus and aeromechanics refresher courses. All students will take a common core program for the first three academic quarters in residence. Selection is then made to continue graduate or undergraduate study based on academic performance, availability, and results of a comprehensive examination. Those officers selected for the undergraduate program will continue in either the General or the Flight Performance option leading to the award of the Bachelor of Science in Aeronautical Engineering degree. Officers admitted to graduate status will complete either five additional quarters leading to a Master of Science in Aeronautical Engineering degree or eight additional quarters leading to the degree of Aeronautical Engineer. Officers particularly well qualified may apply for the Ph.D. program. All graduate students must submit a thesis as part of their degree requirements.

September input graduate students may complete their third year at the Postgraduate School or continue their studies at one of the civilian institutions listed at the end of this section. March input graduate students must complete their graduate studies at the Postgraduate School.

Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a Master's degree upon completion of four quarters course of work, including an acceptable thesis.

All Aeronautical Engineering graduates will be recommended for subspecialty qualification codes 81XX as listed in current BUPERS INST 1210.13 series.

The below listed curricula are representative of current Aeronautical Engineering options. All options are not offered to each input, but students are provided with several areas from which to choose. Changes in the basic program are necessary in some options to accommodate the additional specialized courses.

SUMMARY OF PROGRAMS OFFERED IN AERONAUTICAL ENGINEERING CURRICULA

Curricular Title	*Duration*	*Degree Level*
Aeronautical Engineering (. . . . .)		
(Aerodynamics (Flight Dynamics))	2 years (8 qtrs)	M.S. (A.E.)
(Aerodynamics (Flight Dynamics))	3 years (11 qtrs)	Ae.E.
(Aerodynamics (Gasdynamics))	2 years (8 qtrs)	M.S. (A.E.)
(Aerodynamics (Gasdynamics))	3 years (11 qtrs)	Ae.E.
(Information and Control)	2 years (8 qtrs)	M.S. (A.E.)
(Aero/Space Physics)	3 years (11 qtrs)	Ae.E.
(Flight Propulsion (Rockets))	2 years (8 qtrs)	M.S. (A.E.)
(Flight Propulsion (Rockets))	3 years (11 qtrs)	Ae.E.
(Flight Structures)	2 years (8 qtrs)	M.S. (A.E.)
(Flight Structures)	3 years (11 qtrs)	Ae.E.
(Flight Propulsion (Turbomachinery))	2 years (8 qtrs)	M.S. (A.E.)
(Flight Propulsion (Turbomachinery))	3 years (11 qtrs)	Ae.E.
(Air Weapons Systems (Explosive Ordnance))	2 years (8 qtrs)	M.S. (A.E.)
(Air Weapons Systems (Explosive Ordnance))	3 years (11 qtrs)	Ae.E.
(Aeroelectronics)	2 years (8 qtrs)	M.S. (A.E.)
(Aeroelectronics)	3 years (11 qtrs)	Ae.E.
(Aeronautical Engineering)	4 years (16 qtrs)	Ph.D.
(Aeronautical Engineering (Immediate Graduate Education Program))	1 year (4 qtrs)	M.S. (A.E.)

AERONAUTICAL ENGINEERING

First Three Quarters
Common Core

First Quarter

AE 2021	Aero-Structures I	3- 2
AE 2031	Vehicle Aerodynamics I	3- 2
AE 2041	Basic Fluid Mechanics	3- 2
MA 2047	Linear Algebra and Vector Analysis	4- 0
CS 0110	FORTRAN Programming	3- 0
		16- 6

Second Quarter

AE 2022	Aero-Structures II	3- 2
AE 2032	Vehicle Aerodynamics II	3- 2
AE 2042	Engineering Thermodynamics	3- 2
AE 2801	Introduction to Aero Laboratories	0- 3
MA 3130	Differential Equations	4- 0
		13- 9

Third Quarter

AE 3015	Engineering Dynamics	3- 2
AE 3033	Vehicle Aerodynamics III	3- 2
AE 3043	Fundamental Concepts of Gasdynamics	3- 2
AE 3811	Solid Mechanics Laboratory	0- 3
MA 3173	Laplace Transform and Complex Variable	4- 0
		13- 9

After three quarters on board, students are selected for either graduate or undergraduate sequences.

M.S. (A.E.) PROGRAMS – Eight Quarters
(Groups AA, AD, AI, AR, AS, AT, AW, AX)

Master of Science in Aeronautical Engineering programs may lead to specialization in Aerodynamics (Flight Dynamics), Aerodynamics (Gasdynamics), Information and Control, Flight Propulsion (Rockets), Flight Structures, Flight Propulsion (Turbomachinery), Air Weapons Systems (Explosive Ordnance), or Aeroelectronics.

Upon completion of the core, officers qualifying for the M.S. (A.E.) program take the following courses:

Fourth Quarter

MA 3232	Numerical Analysis	4- 0
EE 2222	Electronic Fundamentals I	3- 2
AE 3851	Gasdynamics Laboratory	0- 3
AE 4XXX	Specialty Course	4- 0
AE 4XXX	Speciality Course	4- 0
		15- 5

Fifth Quarter

AE 4632	Computer Methods in Aerodynamics	3- 2
AE 4XXX	Specialty Course	4- 0
AE 4XXX	Specialty Course	4- 0
AE 0810	Thesis Research	0- 0
		11- 2

Sixth Quarter

PS 3411	Probability Theory I	4- 0
AE 4XXX	Specialty Course	4- 0
AE 4XXX	Specialty Course	4- 0
AE 0810	Thesis Research	0- 0
		12- 0

Seventh Quarter

MS 2218	Elements of Engineering Materials	3- 2
AE 4XXX	Specialty Course	4- 0
AE 4XXX	Specialty Course	4- 0
AE 0810	Thesis Research	0- 0
		11- 2

Eighth Quarter

MS 3218	Mechanical Properties of Aerospace Materials I	2- 2
MN 3171	Resource Management for Defense	4- 0
OA 3203	Survey of Operations Analysis/Systems Analysis	4- 0
	Graduate Level Elective	4- 0
		14- 2

SPECIALIZATION COURSES

Aerodynamics (Flight Dynamics)
(Group AA)

This specialty includes coverage of the stability and control parameters of a flight vehicle in both the pilot-controlled and automatic-controlled modes. Both manned and unmanned vehicles are investigated. Topics include automatic landing systems, missile control, and optimal design.

AE 3331 Flight Evaluation Techniques I
AE 3332 Flight Evaluation Techniques II
AE 3831 Flight Evaluation Techniques Laboratory I
AE 3832 Flight Evaluation Techniques Laboratory II
AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4316 Sturctural Dynamics
AE 4317 Aeroelasticity
AE 4341 Guidance and Control for Aerospace Systems I
AE 4342 Guidance and Control for Aerospace Systems II

Aerodynamics (Gasdynamics)
(Group AD)

Operation of flight vehicles in the broad spectrum ranging from hovering flight to hypersonic reentry is investigated, with particular emphasis being placed on the behavior of the gas (air or near-space) in which the vehicle is operating. Subsonic, transonic, supersonic, hypersonic, and plasma flows are covered in detail.

AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4511 Boundary Layer Theory
AE 4512 Convective Heat and Mass Transfer

Information and Control
(Group AI)

This specialty provides knowledge in depth in computer-flight vehicle interface in operation of modern and projected air weapons systems. Computer technology, capability, and applications to the flight vehicle and its mission are stressed.

AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4341 Guidance and Control for Aerospace Systems I
AE 4342 Guidance and Control for Aerospace Systems II
CS 2100 Introduction to Computers and Programming
CS 3111 Programming Languages
CS 3112 Operating Systems
CS 3200 Logical Design of Digital Computers
CS 4202 Interactive Computation Systems
CS 4900 Advanced Topics in Computer Science

Flight Propulsion (Rocket/Turbomachinery)
(Group AR/AT)

Fundamentals of fluid dynamics, thermodynamics, and turbomachinery are developed to provide a generalized flight propulsion background. Emphasis on thesis work provides the basic difference in the assigned specialty of rockets or turbomachinery.

AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4431 Aerothermodynamics of Turbomachines
AE 4432 Advanced Theory of Turbomachines
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4511 Boundary Layer Theory
AE 4512 Convective Heat and Mass Transfer
AE 4831 Turbomachinery Laboratory I
AE 4832 Turbomachinery Laboratory II

Flight Structures
(Group AS)

A study in depth of the mechanics of solids is followed by investigations of the behavior of structural components under conditions of static and dynamic (including aero-elastic) loads (both steady and non-steady). Free, forced, and self-excited vibrations; flutter, gusts, buffet, and stall effects; and wing divergence and control reversal are typical of the topical coverage.

AE 4101 Flight Vehicle Structural Analysis I
AE 4102 Flight Vehicle Structural Analysis II
AE 4131 Solid Mechanics for Aeronautical Engineers I
AE 4132 Solid Mechanics for Aeronautical Engineers II
AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4316 Structural Dynamics
AE 4317 Aeroelasticity

Air Weapons Systems (Explosive Ordnance)
(Group AW)

The studies of chemical explosives and blast and shock effects are emphasized and supplement coverage of core aeronautics courses to prepare the graduate to work in the sub-area of conventional ordnance in air weapons systems.

AE 4301 Flight Vehicle Response
AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
CH 2001 General Principles of Chemistry
CH 2402 Introduction to Physical Chemistry
CH 3709 Explosives Chemistry
CH 3713 Blast and Shock Effects

Aeroelectronics
(Group AX)

Building upon a background of aeronautics core courses, in-depth studies in electrical and electromagnetic fundamentals and applications prepare the graduate to serve as a specialist in avionics of both manned and unmanned flight vehicles in Naval air weapons systems programs. The two-year aeroelectronics program is only available for officers with a previous B.S. degree in Electrical Engineering.

AE 4301 Flight Vehicle Response
AE 4302 Low Speed Aerodynamics
AE 4341 Guidance and Control for Aerospace Systems I
AE 4342 Guidance and Control for Aerospace Systems II
EE 2103 Linear Systems Analysis
EE 2114 Communication Theory
EE 2212 Electronic Engineering Fundamentals
EE 2411 Control Systems
EE 3215 Microwave Devices
EE 4433 Radar Systems
EE 4461 Systems Engineering
EE 4473 Missile Guidance Systems
EE 4481 Electronic Warfare Techniques and Systems
EE 4571 Statistical Communications Theory

Ae.E. PROGRAMS — Eleven Quarters
(Groups AA, AD, AP, AR, AS, AT, AW, AX)

Upon completion of the core, those officers qualifying for the Engineer's degree program take the following courses:

Fourth Quarter

MA 3232	Numerical Analysis	4-0
AE 3851	Gasdynamics Laboratory	0-3
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
		16-3

Fifth Quarter

AE 4632	Computer Methods in Aeronautics	3-2
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
		15-2

Sixth Quarter

PS 3411	Probability Theory I	4-0
EE 2222	Electronic Fundamentals I	3-2
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
		15-2

Seventh Quarter

EE 2223	Electronic Fundamentals II	3-3
AE 4XXX	Specialty Course	4-0
AE 4XXX	Specialty Course	4-0
AE 0810	Thesis	0-0
		11-3

Eighth Quarter

*Industrial Tour		6 wks
AE 0810	Thesis	6 wks

Ninth Quarter

MN 3171	Resource Management for Defense	4-0
MS 2218	Elements of Engineering Materials	3-2
AE 0810	Thesis	0-0
**MA 4611	Calculus of Variations	3-0
		10-2

Tenth Quarter

AE 4XXX	Specialty Course	4-0
AE 4271	Design Problems in Aeronautics I	3-3
MS 3218	Mechanical Properties of Aeropsace Materials	2-2
AE 0810	Thesis	0-0
		9-5

Eleventh Quarter

AE 4XXX	Specialty Course	4-0
AE 4272	Design Problems in Aeronatuics II	3-3
OA 3203	Survey of Operations Analysis/Systems Analysis	4-0
	Graduate Level Elective	4-0
		15-3

*Not included in AX and AP options.

**Selection of other graduate level mathematics course to complement research permitted.

Aerodynamics (Flight Dynamics)
(Group AA)

AE 3331 Flight Evaluation Techniques I
AE 3332 Flight Evaluation Techniques II
AE 3831 Flight Evaluation Techniques Laboratory I
AE 3832 Flight Evaluation Techniques Laboratory II
AE 4131 Solid Mechanics for Aeronautical Engineers I
AE 4132 Solid Mechanics for Aeronautical Engineers II
AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4316 Structural Dynamics
AE 4317 Aeroelasticity
AE 4341 Guidance and Control for Aerospace Systems I
AE 4342 Guidance and Control for Aerospace Systems II
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics

Aerodynamics (Gasdynamics)
(Group AD)

AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4509 Special Topics in Gasdynamics
AE 4511 Boundary Layer Theory
AE 4512 Convective Heat and Mass Transfer
AE 4519 Special Topics in Heat and Mass Transfer
AE 4831 Turbomachinery Laboratory I

Aero/Space Physics
(Group AP)

This program, leading to the degree of Aeronautical Engineer, includes the study of electromagnetics, quantum mechanics, and space and near-space physics. These, together with the core aeronautics courses in gasdynamics and engineering dynamics, and sequences in material science and operations analysis prepare the graduate to participate in any of several areas in Navy programs involving missile and space technology. A two-year Aero/Space Physics program is not available.

AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4509 Special Topics in Gasdynamics
AE 4511 Boundary Layer Theory
PH 2251 Waves and Particles
PH 2351 Electromagnetism I
PH 2352 Electromagnetism II
PH 3561 Introductory Statistical Physics
PH 3651 Atomic Physics
PH 3652 Elements of Molecular, Solid State, and Nuclear Physics
PH 3951 Introduction to Quantum Mechanics
PH 4353 Electromagnetism III
PH 4630 Space Physics I
PH 4631 Space Physics II
PH 4790 Theory of Quantum Devices

Flight Propulsion (Rockets)
(Group AR)

AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4409 Advanced Topics in Combustion
AE 4431 Aerothermodynamics of Turbomachines
AE 4432 Advanced Theory of Turbomachines

AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4509 Special Topics in Gasdynamics
AE 4511 Boundary Layer Theory
AE 4512 Convective Heat and Mass Transfer
AE 4831 Turbomachinery Laboratory I
AE 4832 Turbomachinery Laboratory II

Flight Structures
(Group AS)

AE 4101 Flight Vehicle Structural Analysis I
AE 4102 Flight Vehicle Structural Analysis II
AE 4131 Solid Mechanics for Aeronautical Engineers I
AE 4132 Solid Mechanics for Aeronautical Engineers II
AE 4139 Special Topics in Solid Mechanics
AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4316 Structural Dynamics
AE 4317 Aeroelasticity
AE 4431 Aerothermodynamics of Turbomachines
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4831 Turbomachinery Laboratory I

Flight Propulsion (Turbomachinery)
(Group AT)

AE 4131 Flight Vehicle Structural Analysis I
AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4431 Aerothermodynamics of Turbomachines
AE 4432 Advanced Theory of Turbomachines
AE 4439 Turbopropulsion Systems
AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
AE 4511 Boundary Layer Theory
AE 4512 Convective Heat and Mass Transfer
AE 4831 Turbomachinery Laboratory I
AE 4832 Turbomachinery Laboratory II

Air Weapons Systems (Explosive Ordnance)
(Group AW)

AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4401 Advanced Thermodynamics
AE 4402 Combustion
AE 4501 Advanced Gasdynamics
AE 4502 Hypersonic Flow and Real Gas Effects
AE 4503 Aerodynamics of Wings and Bodies
AE 4504 Magneto/Electrofluiddynamics
CH 2001 General Principles of Chemistry
CH 2402 Introduction to Physical Chemistry
CH 3709 Explosives Chemistry
CH 3713 Blast and Shock Effects
CH 4800 Special Topics

Aeroelectronics
(Group AX)

AE 4301 Flight Vehicle Response
AE 4302 Low Speed Vehicle Aerodynamics
AE 4341 Guidance and Control for Aerospace Systems I
AE 4342 Guidance and Control for Aerospace Systems II
EE 2102 Circuit Analysis
EE 2103 Linear Systems Analysis
EE 2114 Communication Theory
EE 2211 Electronic Engineering Fundamentals I
EE 2212 Electronic Engineering Fundamentals II
EE 2411 Control Systems
EE 2621 Introduction to Fields and Waves
EE 3215 Micro Wave Devices
EE 3622 Electromagnetic Theory
EE 4433 Radar Systems
EE 4461 Systems Engineering
EE 4473 Missile Guidance Systems
EE 4481 Electronic Warfare Techniques and Systems
EE 4571 Statistical Communication Theory
EE 4631 Antenna Engineering

Civilian universities used in third year work and the fields in which they provide the strongest competence for advanced study are as follows:

CALIFORNIA INST. OF TECHNOLOGY, Pasadena, Calif.
- Gasdynamics
- Structures
- Jet Propulsion

MASSACHUSETTS INST. OF TECHNOLOGY, Cambridge, Mass.
- Astronautics
- Airborne Weapons Systems

PRINCETON UNIVERSITY, Princeton, N.J.
- Flight Mechanics
- Gasdynamics
- Propulsion

COLLEGE OF AERONAUTICS, Cranfield, England
- Aerodynamics
- Aircraft Design
- Aircraft Electronics
- Guidance and Control

STANFORD UNIVERSITY, Palo Alto, Calif.
- Aero- and Gasdynamics
- Structures
- Guidance and Control

BACCALAUREATE PROGRAMS

Curriculum Number 461

LLOYD THOMAS ZUEHLKE, Commander, U.S. Navy Curricular Officer; B.S., Stanford University, 1958; M.A., International Affairs, George Washington University, 1963.

RAYMOND KENNETH HOUSTON, Academic Associate; B.S., Worcester Polytechnic Institute, 1933; M.S., 1939.

GEORGE WILLIAM CROWNINSHIELD, Lieutenant Commander, U.S. Navy, Assistant Curricular Officer; B.S., Massachusetts Maritime Academy, 1958; B.S. in Engineering Science, Naval Postgraduate School, 1964.

OBJECTIVE – To raise the educational level, broaden the mental outlook, and increase the professional and scientific knowledge of naval officers who do not have a baccalaureate degree.

QUALIFICATION FOR ADMISSION – Applicants must have an advanced undergraduate standing of at least 45 semester hours of acceptable credit, and have earned a C average in all previous college courses. Acceptable undergraduate work must include mathematics through College Algebra. A minimum of 15 semester hours is required from an accredited educational institution since a maximum of 30 semester hours credit will be allowed for service schools.

DESCRIPTION – The Baccalaureate curricula provide specialized study to meet the professional needs of the commissioned officer. The different educational backgrounds and personal needs of the students are accommodated by providing two curricula.

The Bachelor of Science curriculum emphasizes the physical environment without neglecting the social. It consists of 180 quarter hours distributed as follows: 100 in Science and Engineering; 36 in Government and Humanities; and 44 in electives and/or transfer credit. Successful completion leads to the award of the degree Bachelor of Science in Engineering Science.

The Bachelor of Arts curriculum emphasizes the social environment without neglecting the physical. It consists of 180 quarter hours distributed as follows: 100 in Government and Humanities; 36 in the Physical Sciences; and 44 in electives and/or transfer credit. Successful completion leads to the award of the degree Bachelor of Arts with a major in Government (International Relations).

Classes for both curricula convene in January and July. From one to two calendar years are allowed to complete the program. Students pursuing these curricula carry an average load of 17 credit hours per quarter.

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

First Quarter

CH 1001	Introductory General Chemistry I	4-2
MA 1021	College Algebra and Trigonometry	4-0
GV 1060	U.S. Government	4-0
LT 1040	Appreciation of Literature	3-0
		15-2

Second Quarter

CH 1002	Introductory General Chemistry II	3-2
MA 1105	Calculus and Analytic Geometry I	5-0
SP 1020	Public Speaking	3-0
HI 2032	U.S. History (1865–present)	3-0
EN 1010	Fundamentals of Writing	3-0
		17-2

Third Quarter

MS 1021	Elements of Materials Science I	3-2
MA 1106	Calculus and Analytic Geometry II	5-0
PH 1015	Basic Physics I	5-3
OC 2110	Introduction to Oceanography	3-0
		16-5

Fourth Quarter

MS 1022	Elements of Materials Science II	2-2
MA 1107	Calculus and Analytic Geometry III	3-0
PH 1016	Basic Physics II	4-3
HI 2030	European History (1914–1950)	3-0
PS 2501	Introduction to Probability and Statistics I	4-0
		16-5

Fifth Quarter

ME 2120	Elements of Engineering Thermodynamics	3-2
PH 2017	Basic Physics III	4-2
EE 2222	Electronic Fundamentals I	3-2
GV 2061	National Security	3-0
		13-6

Sixth Quarter

EE 2223	Electronic Fundamentals II	3-3
MN 3941	Engineering Economics	4-0
ME 2561	Statics	3-0
CS 2100	Introduction to Computers and Programming	4-0
		14-3

Seventh Quarter

ME 2562	Dynamics	4-0
EE 2224	Communication and Digital Electronics	4-3
OA 2201	Elements of Operations Research/ Systems Analysis	4-0
	Elective	3-0
		15-3

Eighth Quarter

AO 2302	Aviation Accident Prevention and Crash Investigation (Aviators)	3-2
AO 2303	Aeronautical Engineering for Aviators	4-2
PY 2050	General Psychology	3-0
	Electives (Science and Engineering/ Government and Humanities)	5-0
		15-4

BACHELOR OF ARTS WITH MAJOR IN GOVERNMENT (INTERNATIONAL RELATIONS)

First Quarter

EN 1010	Fundamentals of Writing	3-0
GV 1060	U.S. Government	4-0
HI 2131	U.S. History (1763–1865)	3-0
MA 1010	Intermediate Algebra	4-0
		14-0

Second Quarter

SP 1020	Public Speaking	3-0
HI 2032	U.S. History (1865–present)	3-0
LT 1040	Appreciation of Literature	3-0
MA 1021	College Algebra and Trigonometry	4-0
OC 2110	Introduction to Oceanography	3-0
		16-0

Third Quarter

HI 2130	European History (1815–1914)	3-0
GV 2160	Comparative Government	4-0
MN 3030	Introduction to Economics	4-0
PS 2000	Elementary Probability and Statistics	4-0
		15-0

Fourth Quarter

PH 1005	Elementary Physics I	4-2
GV 2161	Introduction to International Relations	3-0
HI 2030	European History (1914–1950)	3-0
MN 3141	Microeconomics	4-0
		14-2

Fifth Quarter

GV 2061	National Security	3-0
GV 2163	Political Thought	4-0
PH 1006	Elementary Physics II	3-2
	Electives (Government/Humanities)	8-0
		18-2

Sixth Quarter

CS 2100	Introduction to Computers and Programming	4-0
GV 2164	Comparative Ideologies	3-0
PH 1007	Elementary Physics III	4-2
	Electives (Government/Humanities)	7-0
		18-2

Seventh Quarter

PY 2050	General Psychology	3-0
AO 2301	Aeronautical Engineering for Aviators	4-2
AO 2302	Aviation Accident Prevention and Crash Investigation (Aviators)	3-2
	Elective (Government/Humanities)	4-0
		14-4

Eighth Quarter

GU 2272	American Tradition and Ideals	4-0
	Electives (Government/Humanities)	12-0
		16-0

Spanagel Hall Patio

ELECTRONICS/COMMUNICATIONS ENGINEERING AND COMMUNICATIONS MANAGEMENT PROGRAMS CURRICULA NUMBERS 590, 600 and 620

FRANCIS L. ROACH, Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1953; M.S. in Eng. Electronics, Naval Postgraduate School, 1964.

ABRAHAM SHEINGOLD, Academic Associate; B.S., College of the City of New York, 1936; M.S., 1937.

RONALD JACK McAFEE, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S. in Communications Eng., Naval Postgraduate School, 1966.

QUALIFICATIONS FOR ADMISSION TO ENGINEERING PROGRAMS – A Baccalaureate degree is required for admission. Inasmuch as the first four to five quarters constitute a review and rebuilding of the basic science-engineering disciplines, a background with above average grades in differential and integral calculus and physics is considered essential.

DESCRIPTION – Classes start twice a year in September and March. Refresher work in mathematics and physics is available for early arrivals (see academic calendar). Occasionally officers report sufficiently in advance of convening dates to be enrolled in formal courses preceding the normal convening quarters. This has proven to be a very effective opportunity for review work.

The typical officer who did not major in Electrical Engineering in his undergraduate work and who has been away from formal studies from four to six years normally enters an undergraduate curriculum for the first five quarters. This work is common to both the Engineering Electronics (590) and Communications Engineering (600) Curricula and consists of build-up courses in mathematics and physics and the initial circuits and fundamental courses in Electrical Engineering at the undergraduate level. Those officers with appropriate academic backgrounds such as a recent BSEE degree may by-pass two or more of the initial quarters. Each enrolling officer is individually reviewed, counseled, and programmed by the Curricular Officer/Academic Associate team.

Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a Master's degree upon completion of four quarters course work, including an acceptable thesis.

The officer enrolled in Electronics or Communications Engineering may pursue an Electrical Engineering degree to the Bachelor of Science, Master of Science, Electrical Engineer, or Doctor of Philosophy level. Success in this endeavor will be determined by academic performance and approval of requests to the service sponsor and BuPers for any necessary extension of tour beyond the basic availability. Nominations for the advanced programs are normally made near the end of the first year of study. Upon successful completion of any of the BS, MS, EE or PhD programs, the unrestricted line officers of the Navy are subsequently assigned appropriate subspecialty codes by the Chief of Naval Personnel.

The typical length of time required for pursuit of these degrees is as follows, keeping in mind that, as mentioned above, suitably qualified officers may by-pass up to four quarters of undergraduate work thereby reducing the time requirements:

BS in Electrical Engineering . .	5 quarters undergraduate work + 2 quarters sponsors requirements
MS in Electrical Engineering . .	5 quarters undergraduate work + 4 quarters Graduate Course
Electrical Engineer .	5 quarters undergraduate work + 7 quarters Graduate Course

ENGINEERING ELECTRONICS (590)

OBJECTIVE – To provide instruction to officers who will perform in a position in one of the following general categories:

a. Project Manager to one of the electronics projects sponsored by NAVELEX, NAVSHIPS, NAVSHIPENGCEN and other associated naval material branch activities.

b. Project Manager at Navy Fleet Test and Evaluation Force Centers, research labs, experimental centers or similar naval establishments.

c. Electronics Engineering Advisor to major fleet-type commanders.

d. System Superintendent or related system assistant at Naval shipyards.

e. Superintendent shipbuilding-conversion representative in naval districts.

f. Staff/faculty at Naval Academy, Annapolis, or Postgraduate School, Monterey.

g. Staff CNO OP 03/07/94 as technical advisors.

DESCRIPTION – This program of study is designed to provide the officer graduate with a sound understanding of engineering electronic principles and applications. To achieve this the following arrangement has been established:

(1) Electrical Engineering
These courses include the study of electronic devices and circuits, information processing and transmission, and computation and control techniques. These fundamentals are then applied to the engineering study and analysis of modern electronic systems. Optional courses and thesis projects enable the students to specialize in a particular sub-branch of electronics.

(2) Physics
These courses present those topics on physics needed for an understanding of modern electronic devices.

(3) Computer Science
In this course, the student reviews an introduction to computer processes and the familiarity with computer operating procedures required for the computer-oriented electronic engineering courses.

(4) Operations Analysis
In this course the student learns how to apply operations analysis principles and probability and statistics to system engineering with emphasis on military applications.

(5) Mathematics
These courses provide the requisite mathematical background for the courses in engineering electronics.

The following programs should be considered as typical ones rather than as rigid and standardized. The programs of study for the Engineer's degree will be developed in consultation with the Chairman, Department of Electrical Engineering and must have his approval.

BASIC CURRICULUM

First Quarter

MA 1100	Calculus Review	4- 0
EE 2101	Principles of Electrical Engineering	3- 2
MA 2045	Introduction to Linear Algebra	3- 0
CS 2110	Introduction to Computers and Programming	4- 0
		14- 2

Second Quarter

PH 1041	Review of Mechanics and Optics	4- 2
MA 2121	Differential Equations and Infinite Series	4- 0
EE 2102	Circuit Analysis	4- 2
EE 2211	Electronic Engineering Fundamentals I	4- 2
		16- 6

Third Quarter

MA 2172	Complex Variables	4- 0
EE 2212	Electronic Engineering Fundamentals II	4- 3
EE 2103	Linear System Analysis	4- 2
EE 2810	Digital Machines	3- 3
		15- 8

Fourth Quarter

MA 2161	Introduction to Mathematical Physics	4- 0
PH 2241	Waves and Particles	4- 2
EE 2216	Pulse and Digital Circuits	4- 3
EE 2114	Communications Theory I	4- 0
		16- 5

Fifth Quarter

PH 2641	Atomic Physics	4- 2
EE 2217	Communications Circuits	4- 3
EE 2621	Introduction to Fields and Waves	4- 1
EE 2411	Control Systems	3- 3
		15- 9

BACHELOR OF SCIENCE

Sixth Quarter

EE 2215	Special Electronic Devices	4- 2
EE 2622	Electromagnetic Engineering	3- 0
OA 3201	Fundamentals of Operations Research	4- 0
EE 3432	Radar Systems	3- 2
		14- 4

Seventh Quarter

EE 2311	Principle of Energy Conversion	3- 2
EE 3631	Antennas and Propagation	3- 2
MN 2970	Material Management	4- 0
EE 3481	Principles of Electronic Warfare	3- 2
		13- 6

MASTER of SCIENCE

Sixth Quarter

PS 3411	Probability Theory	4- 0
EE 3215	Microwave Devices	4- 2
EE 3622	Electromagnetic Theory	3- 0
EE 4121	Advanced Network Theory I	3- 2
		14- 4

Seventh Quarter

EE 4433	Advanced Radar Systems	3- 2
EE 4571	Statistical Communications Theory	3- 2
	One Elective	3- 2
EE 0810	Thesis Research	0- 0
EE 0951	Thesis Seminar	0- 1
		9- 7

Eighth Quarter

OA 3202	Methods of Operations/Systems Analysis	4- 0
	Two Electives	6- 4
EE 0810	Thesis Research	0- 0
EE 0951	Thesis Seminar	0- 1
		10- 5

Ninth Quarter

EE 4461	Advanced Systems Engineering	3- 1
	One Elective	3- 2
EE 0810	Thesis Research	0- 0
EE 0951	Thesis Seminar	0- 1
		6- 4

MASTER of SCIENCE
OPTION ELECTIVES

EE 3264	Advanced Theory of Semiconductor Devices	4- 0
EE 3311	Energy Conversion	3- 2
EE 3471	Guidance and Navigation	3- 0
EE 3812	Switching Theory and Logic Design	3- 2
EE 3822	Engineering Applications of Computers	3- 3
EE 3831	Computer Aided Network Analysis and Design	3- 2
EE 4414	Stochastic Control Theory	2- 2
EE 4481	Electronic Warfare Techniques and Systems	3- 2
EE 4541	Signal Processing	3- 1
EE 4581	Information Theory	3- 1
EE 4652	Microwave Circuits and Measurements	3- 2
PH 3741	Electronic Properties of Metals and Semiconductors	4- 2

Courses selected must meet objective of one of the following options:

Advanced Electronics
Information and Control
Information Processing
Electronic Warfare

ENGINEER

Sixth Quarter

PS 3411	Probability Theory I	4-0
EE 3215	Microwave Devices	4-2
EE 3622	Electromagnetic Theory	3-0
EE 4121	Advanced Network Theory I	3-2
		14-4

Seventh Quarter

EE 4433	Advanced Radar Systems	3-2
PH 3741	Electronic Properties of Metals and Semiconductors	4-2
EE 4571	Statistical Communications Theory	3-2
EE 3822	Engineering Applications of Computers	3-3
		16-9

Eighth Quarter

EE 4541	Signal Processing	3-1
EE 3311	Energy Conversion	3-2
	One Elective	3-2
EE 0810	Thesis Research	0-0
		9-5

Ninth Quarter

EE 4581	Information Theory	3-1
EE 4631	Antenna Engineering	3-2
	One Elective	3-2
EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
		9-6

Tenth Quarter

EE 0810	Thesis Research	0-0
	Industrial Experience Tour	0-0
		0-0

Eleventh Quarter

EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
EE 4481	Electronic Warfare Techniques and Systems	3-2
EE 4461	Advanced Systems Engineering	3-1
	One Elective	3-2
		9-6

Twelfth Quarter

OA 3202	Methods of Operations Analysis/ Systems Analysis	4-0
	One Elective	3-2
EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
		7-3

ENGINEER
OPTION ELECTIVES

EE 3264	Advanced Theory of Semiconductor Devices	4-0
EE 4412	Nonlinear Systems	3-3
EE 3831	Computer Aided Network Analysis and Design	3-2
EE 4122	Advanced Network Theory II	3-2
EE 4123	Advanced Network Theory III	3-2
EE 4414	Stochastic Control Theory	2-2
EE 4415	Algebraic Methods in Control Theory	3-0
EE 4416	Topics in Modern Control Theory	3-0
EE 4417	Optimal Control Theory	4-0
EE 4452	Underwater Acoustic Systems Engineering	4-2
EE 4473	Missile Guidance Systems	3-1
EE 4671	Theory of Propagation	3-0
EE 4823	Advanced Digital Computer Systems	3-1
PH 4790	Theory of Quantum Devices	3-0

Courses selected must meet objectives of one of the following options:

Advanced Electronics
Information and Control
Informations Processing
Electronic Warfare

COMMUNICATIONS ENGINEERING (600)

OBJECTIVE – To provide instruction to officers who will perform in a position in one of the following general categories:

a. Communications Officer on type/fleet commander staffs, certain afloat commands, and shore communication stations.

b. System Engineer for various Defense Communication Agency Regions.

c. Technical Advisor or Program Director in Naval Communications Command Headquarters or CNO Staff (OP 07/94)

DESCRIPTION – As a result of this curriculum, the officer graduate will have a sound understanding of communcations engineering and its application. To achieve this goal, the following arrangement is made:

(1) Electrical Engineering
These courses include the study of electronic devices and circuits, information and signal processing and transmission, and computation and control techniques. These fundamentals are then applied to the engineering study and analysis of modern communications and related systems.

(2) Physics
In these courses the student learns the physics of wave propagation, interference, polarization, etc. of electro-magnetic waves; photo electronic devices and semiconductors.

(3) Computer Science
In this course the student learns how to program computers to assist him in his course projects in computer oriented electronic engineering courses.

(4) Operations Analysis
In this course the student learns how to apply operations analysis principles and probability and statistics to system engineering with emphasis on military applications.

(5) Mathematics
All mathematics courses are designed to enable the student to undertake the engineering electronics course.

BACHELOR of SCIENCE

Sixth Quarter

EE 2215	Special Electronic Devices	4-2
EE 3622	Electromagnetic Theory	3-0
OA 3201	Fundamentals of Operations Research	4-0
EE 3116	Communications Theory II	3-2
		14-4

Seventh Quarter

EE 2311	Principles of Energy Conversion	3-2
EE 3631	Antennas and Propagation	3-2
MN 2970	Material Management	4-0
EE 3422	Modern Communications	3-2
		13-6

MASTER of SCIENCE

Sixth Quarter

PS 3411	Probability Theory I	4-0
EE 3215	Microwave Devices	4-2
EE 3622	Electromagnetic Theory	3-0
EE 4121	Advanced Network Theory I	3-2
		14-4

Seventh Quarter

EE 4571	Statistical Communications Theory	3-2
EE 4433	Advanced Radar Systems	3-2
EE 3631	Antennas and Propagation	3-2
EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
		9-7

Eighth Quarter

OA 3202	Methods of Operations Analysis/ Systems Analysis	4-0
	One Elective*	3-2
EE 3422	Modern Communications	3-2
EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
		10-5

Ninth Quarter

EE 4461	Advanced Systems Engineering	3-1
	One Elective*	3-2
EE 0810	Thesis Research	0-0
EE 0951	Thesis Seminar	0-1
		6-4

*see Electronics Masters Group Electives
(Quarters 1 through 5 same as Group EM Curriculum 590)

ENGINEER

Same as for Electronics (590).

COMMUNICATIONS MANAGEMENT CURRICULUM (620)

OBJECTIVE – To provide instruction to officers who will perform as Communications Managers of new communications system applications or as Communications Officers in large commands and staffs, afloat and ashore, including the Organization of the Joint Chiefs of Staff and the Defense Communications Agency.

DESCRIPTION – As a result of this curriculum, the officer graduate will have a basic understanding of computers, management and communications systems. The following arrangement is established:

(1) Computer Science
In these courses the student learns programming both as an educational device and a tool for management. The student also learns computer terminology, organization and operation as a user rather than as an engineer. These courses are considered vital to the manager of any automated system.

(2) Management
In these courses the student learns personal and group behavior, management of human resources, resource management, economics, contract administration and data processing. To support management courses the student must have some probability and statistics and related mathematics courses. As a further tool to management the student is also introduced to operations analysis as applied to management.

(3) Communications
The communication courses are designed to acquaint the student with the organization and planning required for fleet, staff and national communications. Long range plans for communications are also introduced. These courses are offered at the end of the curriculum to ensure that the new manager has current applicable information.

(4) Electronics
These courses are designed to give a non-engineering approach to electronics as applied to communications. They are designed to give the prospective manager sufficient knowledge to be able to discuss and understand transmitters, receivers, antennas, transmission of energy and propagation. As in management, certain mathematical tools are required to the understanding of electronics.

QUALIFICATIONS FOR ADMISSION TO COMMUNICATIONS MANAGEMENT – Admission to this curricula requires a Baccalaureate degree with average grades. Completion of mathematics through college algebra and trigonometry is required. The student must be ready to start calculus courses on enrollment.

The degree of Master of Science in Management will be awarded for successful completion of the prescribed program.

Curriculum Convening Dates: March and September

Course Length: Basic course length is six (6) quarters.

Thesis Requirement: A thesis will not be required.

First Quarter

CS 2100	Introduction to Computers and Programming	4-0

MA 1105	Calculus and Analytic Geometry I	5-0
MN 3106	Individual Behavior	4-0
MN 3150	Financial Accounting	4-0
		17-0

Second Quarter

MN 3030	Introduction to Economics	4-0
MA 1106	Calculus and Analytic Geometry II	5-0
MN 3105	Management Fundamentals	4-0
EE 2222	Electronic Fundamentals I	3-2
		16-2

Third Quarter

MA 2121	Differential Equations and Infinite Series	4-0
MN 3130	Macroeconomic Theory	4-0
PS 3000	Management Statistics	5-0
EE 2223	Electronic Fundamentals II	3-2
		16-3

Fourth Quarter

CS 3200	Logical Design of Digital Computers	4-0
EE 2224	Communication and Digital Electronics	4-3
MN 3171	Resource Management for Defense	4-0
OA 3211	Operations Analysis for Management	4-0
		16-3

Fifth Quarter

MN 4171	Procurement and Contract Administration	4-0
EE 2613	Energy Transmission for Communications	3-2
MN 4182	Data Processing Management	4-0
CO 2111	Communications Organization and Planning	4-0
		15-2

Sixth Quarter

CO 2112	Communications Systems	3-2
MN 4183	Business Data Processing	4-0
MN 4181	Management Informations Systems	4-0
	Elective	4-0
		15-2

Electives

CS 3111	Programming Languages	4-0
MN 3140	Microeconomic Theory	4-0
MN 3161	Managerial Accounting	4-0
MN 4105	Management Policy	4-0

Library Periodical Room

ENGINEERING SCIENCE PROGRAMS CURRICULUM NUMBER 460

PETER BERNARD BOYNE, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1957; B.S. (EE) Naval Postgraduate School, 1964.

ELMO JOSEPH STEWART, Academic Associate; B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Institute, 1953.

OBJECTIVE –

a. To refresh officer students in undergraduate mathematics and physical sciences for twenty-four weeks in preparation for admission into an advanced technical program.

b. To provide an extensive thirty-six week education to supplement and fortify prior undergraduate work.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree and successful completion of at least one college mathematics course in algebra or trigonometry.

DESCRIPTION – There are two annual inputs to the Engineering Science Programs, one in March, the other in September. After successfully completing six months in Engineering Science, almost all officers transfer into an advanced technical curriculum. Acceptance by another curriculum depends upon the number of available quotas in that curriculum and the student's academic performance. The academic performance demonstrated in Engineering Science greatly influences the decision with respect to the student's academic ability, regardless of previous scholastic achievement.

To adapt the Engineering Science curriculum to the varied academic backgrounds presented by the officer students, four basic programs are available to each input:

(1) SA – For those officers with a good physical science and mathematics academic background.

(2) SB – For those officers with a fair physical science and mathematics academic background.

(3) SC – For those officers with a weak physical science and mathematics academic background.

(4) SD – For those officers with little or no physical science and minimal (one course in algebra or trigonometry) mathematics academic background.

Additional factors that affect the placement of an officer in one of these programs are: undergraduate courses and grades achieved, undergraduate institution, length of time away from formal academic study and, when feasible, the officer's personal desires.

During his first quarter, each Engineering Science officer student attends a series of lectures given by the curricular officers of other programs in which the details of their respective curricula are presented. In this way, the new officer student is exposed to every technical program which is available to him at the Naval Postgraduate School.

No degree or subspecialty qualification results from successful completion of an Engineering Science program.

The Engineering Science curriculum provides a beneficial six-month academic warmup to every officer student who desires advanced technical training. This same officer enjoys the advantage of selecting an advanced technical program after attending the Engineering Science lecture series and being exposed to all the Naval Postgraduate School programs available to him. The terminal officer student receives a thirty-six week education during which his undergraduate education in mathematics and physical sciences has been broadened and updated. By virtue of this improved educational foundation, the terminal student has improved his ability to understand and cope with the scientific environment of which he is a part. This can only enhance his value and future professional performance as an officer.

The courses listed in each program are those recommended to enhance an officer's opportunity for a technical curriculum. Substitutions may be made for the third and fourth courses in each respective quarter to fulfill prerequisites for a specific technical curriculum or to complement undergraduate work. Course substitutions will depend on the officer's academic background and the availability of the course desired. Allied officers are requested to take American Life and Institutions, GV 1368, (3- 0), in place of a scheduled course during the first quarter.

GROUP SA

First Quarter

MA1105	Calculus and Analytic Geometry I	5- 0
PH 1011	Basic Physics I	4- 0
MA2025	Logic, Sets and Finite Mathematics	4- 0
CS 2100	Introduction to Computers and Programming	4- 0
		17- 0

Second Quarter

MA 1106	Calculus and Analytic Geometry II	5- 0
PH 1012	Basic Physics II	4- 0
CH 2001	General Principles of Chemistry	3- 2
PS 2501	Introduction to Probability and Statistics I	4- 0
		16- 2

Third Quarter

MA 1107	Calculus and Analytic Geometry III	3- 0
PH 2017	Basic Physics III	4- 2
OA 2201	Elements of Operations Research/ Systems Analysis	4- 0
MA 2161	Introduction to Mathematical Physics	3- 0
		14- 2

GROUP SB

First Quarter

MA1105	Calculus and Analytic Geometry I	5- 0
PH 1011	Basic Physics I	4- 0
EE 2221	General Electronics	4- 2
OC 2110	Introduction to Oceanography	3- 0
		16- 2

Second Quarter

MA 1106	Calculus and Analytic Geometry II	5- 0
PH 1012	Basic Physics II	4- 0
MA 2025	Logic, Sets and Finite Mathematics	4- 0
CH 2001	General Principles of Chemistry	3- 2
		16- 2

Third Quarter

MA 1107	Calculus and Analytic Geometry III	3-0
PH 2017	Basic Physics III	4-2
OA 2201	Elements of Operations Research/ Systems Analysis	4-0
CS 2100	Introduction to Computers and Programming	4-0
		15-2

GROUP SC

First Quarter

MA 1021	College Algebra and Trigonometry	4-0
PH 1005	Elementary Physics I	4-2
OC 2110	Introduction to Oceanography	3-0
CH 1001	Introductory General Chemistry I	4-2
		15-4

Second Quarter

MA 1115	Calculus I	5-0
PH 1006	Elementary Physics II	3-2
EE 2221	General Electronics	4-2
CS 2100	Introduction to Computers and Programming	4-0
		16-4

Third Quarter

MA 1116	Calculus II	5-0
PH 1007	Elementary Physics III	4-2
PS 2000	Elementary Probability and Statistics	4-0
MA 1030	Elementary Sets with Applications	3-0
		16-2

GROUP SD

First Quarter

MA 1021	College Algebra and Trigonometry	4-0
PH 1005	Elementary Physics I	4-2
OC 2110	Introduction to Oceanography	3-0
CH 1001	Introductory General Chemistry I	4-2
		15-4

Second Quarter

MA 1105	Calculus and Analytic Geometry I	5-0
PH 1006	Elementary Physics II	3-2
EE 2221	General Electronics	4-2
CH 1002	Introductory General Chemistry II	3-2
		15-6

Third Quarter

MA 1106	Calculus and Analytic Geometry II	5-0
PH 1007	Elementary Physics III	4-2
PS 2000	Elementary Probability and Statistics	4-0
CS 2100	Introduction to Computers and Programming	4-0
		17-2

Analog Computer Laboratory

ENVIRONMENTAL SCIENCES PROGRAMS
CURRICULA NUMBERS 371, 372, AND 440

JAMES JOSEPH DAGDIGIAN, Commander, U.S. Navy; Curricular Officer, B.S., Massachusetts Maritime Academy, 1953; B.S., Meteorology, Naval Postgraduate School, 1962.

GLENN HAROLD JUNG, Academic Associate; B.S. Massachusetts Institute of Technology, 1949; M.S., 1952; PhD., Texas Agricultural and Mechanical College, 1955.

CHARLES H. BASSETT, JR., Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., West Virginia University, 1956; M.S., Naval Postgraduate School, 1965.

OBJECTIVE – To provide advanced education in meteorology and oceanography to meet the Navy's operational and technical requirements in the environmental sciences.

QUALIFICATIONS FOR ADMISSION – Admission to curricula in the environmental sciences requires a baccalaureate degree with above average grades in mathematics and the physical sciences. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation. The Oceanography Curriculum additionally requires one year of college chemistry.

The baccalaureate degree and mathematics requirement are waived for admission to the General Meteorology Curriculum provided mathematics prerequisite to calculus has been completed.

DESCRIPTION – Curriculum number 372 consists of two meteorology curricula; the General Meteorology Curriculum of seven quarters duration and the Advanced Meteorology Curriculum of eight quarters duration. Matriculation is scheduled for quarters beginning in September and March.

A Bachelor of Science in Meteorology degree is awarded upon successful completion of the General Meteorology Curriculum if the general requirements for the Bachelor of Science degree are fulfilled; the degree of Master of Science in Meteorology is attainable through the Advanced Meteorology Curriculum.

The Meteorology Curriculum, number 372, consists basically of core sequences of courses in dynamic, synoptic, and physical meteorology. Sufficient practical laboratory work and oceanographic courses are included to prepare officers to become qualified operational meteorologists with a working knowledge of oceanography. Numerical methods are emphasized, and the Advanced Meteorology Curriculum prepares officers to conduct independent scientific research. Upon completion of the curriculum, unrestricted line officers are assigned a subspecialty qualification code of 8701P or 8701Q.

The General and Advanced Meteorology Curricula cover the same material but differ in the mathematical requirements and the depth of which the dynamic and physical aspects of meteorology are pursued.

Enrollment in the Meteorology Curriculum number 371 is restricted to graduating students of the Officer Candidate School. This curriculum is of four quarters duration with matriculation in January and July. Upon completion the officers are assigned an 1815 designator.

Based on their academic performance, officers completing the Meteorology Curriculum 371 will be given an opportunity to be reassigned to the Postgraduate School after one tour in a meteorological billet. During this reassignment, the degree of Master of Science in Meteorology is attainable in four quarters.

The Oceanography Curriculum, number 440, is of eight quarters duration, and classes convene in September and March. The Oceanography Curriculum provides a broad basic education in oceanography, including courses in biological, geological, and chemical oceanography. The core of the curriculum is, however, the sequence of courses in physical oceanography. Emphasis is placed upon the application of oceanography to naval operations, and practical experience in the use of oceanographic instruments and the collection of scientific observations at sea is included. As in meteorology, computer technology is emphasized, and officers are prepared to conduct independent research.

A Master of Science degree is awarded upon completion of the curriculum provided the general requirements for the master of science degree are met. There is no provision for the awarding of a baccalaureate degree in oceanography. Unrestricted line officers completing the Oceanography Curriculum, number 440, will be assigned a subspecialty qualification code 8703P.

Individuals with suitable qualifications may request approval for modified programs to build competence in particular aspects of physical oceanography or in fields such as ocean acoustics or ocean engineering.

Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program in either Meteorology or Oceanography and obtain a Master's degree upon completion of four quarters course work, including an acceptable thesis.

METEOROLOGY CURRICULUM
CURRICULUM NUMBER 371
(Group MG)

First Quarter

MA 2121	Differential Equations and Infinite Series	4-0
MA 3181	Vector Analysis	3-0
MR 1105	Weather Codes-Observations-Plotting	0-3
MR 2200	Introduction to Meteorology	3-0
MR 3411	Meteorological Thermodynamics	4-0
		14-3

Second Quarter

MR 2220	Weather Map Analysis	4-0
MR 2225	Weather Map Analysis Laboratory	0-6
MR 4321	Dynamic Meteorology I	4-0
MR 4412	Heat Transfer Processes	4-0
		12-6

Third Quarter

MR 3230	Tropospheric and Stratospheric Meteorology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-9
MR 4322	Dynamic Meteorology II	4-0
CS 2100	Introduction to Digital Computers	4-0
		12-9

Fourth Quarter

MR 3250	Tropical and Southern Hemisphere Meteorology	3-0
MR 3255	Tropical and Southern Hemisphere Meteorology Laboratory	0-6
MR 3260	Prognostic Charts and Extended Forecasting	3-0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0-6
MR 3303	Computer Meteorology	4-2
		10-14

ADVANCED METEOROLOGY CURRICULUM

CURRICULUM NUMBER 372

(Group MM)

First Quarter

MR 1105	Weather Codes–Observations–Plotting	0-3
MA 1100	Calculus Review	4-0
OC 3221	Descriptive Oceanography	4-0
MR 2200	Introduction to Meteorology	3-0
MR 2410	Meteorological Instruments	3-2
		14-5

Second Quarter

MA 2047	Linear Algebra and Vector Analysis	4-0
MA 2121	Differential Equations and Infinite Series	4-0
MR 3510	Statistical Climatology	4-2
MR 3411	Meteorological Thermodynamics	4-0
		16-2

Third Quarter

MA 3132	Partial Differential Equations and Integral Transforms	4-0
MR 2220	Weather Map Analysis	4-0
MR 2225	Weather Map Analysis Laboratory	0-6
MR 4412	Heat Transfer Processes	4-0
MR 4321	Dynamic Meteorology I	4-0
		16-6

Fourth Quarter

MA 2232	Numerical Methods	4-0
MR 3230	Tropospheric and Stratospheric Meteorology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-9
MR 4322	Dynamic Meteorology II	4-0
		12-9

Fifth Quarter

MA 3243	Numerical Methods for Partial Differential Equations	4-1
MR 3250	Tropical and Southern Hemisphere Meteorology	3-0
MR 3255	Tropical and Southern Hemisphere Meteorology Laboratory	0-6
MR 4323	Numerical Weather Prediction	4-2
		11-9

Sixth Quarter

OC 3260	Sound in the Ocean	3-0
MR 3260	Prognostic Charts and Extended Forecasting	3-0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0-6
MR 4413	Air-Sea Interaction	3-0
	Thesis	0-0
		9-6

Seventh Quarter

OC 3611	Ocean Wave and Surf Forecasting	2-0
OC 3615	Ocean Wave and Surf Forecasting Laboratory	0-6
MR 2279	Operational Meteorology	1-6
	Thesis	0-0
		3-12

Eighth Quarter

OC 3616	Oceanographic Forecasting	3-0
OC 3621	Oceanographic Forecasting Laboratory	0-4
MR 4900	Seminar in Meteorology	2-0
	Elective	3-0
	Thesis	0-0
		8-4

Electives

MR 4240	Advanced Atmosphere Analysis	3-0
MR 4800	Special Topics in Meteorology or	3-0

oceanography, hydrodynamics, or mathematics courses.

GENERAL METEOROLOGY CURRICULUM

CURRICULUM NUMBER 372

(Group MA)

First Quarter

MA 1115	Calculus I	5-0
OC 3221	Descriptive Oceanography	4-0
MR 2200	Introduction to Meteorology	3-0
MR 2410	Meteorological Instruments	3-2
		15-2

Second Quarter

MR 1105	Weather Codes–Observations–Plotting	0-3
MA 1116	Calculus II	5-0
MA 2047	Linear Algebra and Vector Analysis	4-0
MR 2510	Climatology	4-2
MR 2411	Introduction to Thermodynamics of Meteorology	4-0
		17-5

Third Quarter

CS 2100	Introduction to Computers and Programming	4-0
MR 2220	Weather Map Analysis	4-0
MR 2225	Weather Map Analysis Laboratory	0-6
MR 3301	Fundamentals of Dynamic Meteorology I	4-0
		12-6

Fourth Quarter

OC 3260	Sound in the Ocean	3-0
MR 3230	Tropospheric and Stratospheric Meteorology	4-0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0-9
MR 3302	Fundamentals of Dynamic Meteorology II	4-0
		11-9

Fifth Quarter

MR 3403	Introduction to Energy-Transfer Processes	4-0
MR 3250	Tropical and Southern Hemisphere Meteorology	3-0
MR 3255	Tropical and Southern Hemisphere Meteorology Laboratory	0-6
MR 3303	Computer Meteorology	4-2
		11-8

Sixth Quarter

MR 3260	Prognostic Charts and Extended Forecasting	3-0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0-6
OC 3616	Oceanographic Forecasting	3-0
OC 3621	Oceanographic Forecasting Laboratory	0-4
	Research Problem	0-0
		6-10

Seventh Quarter

MR 2279	Operational Meteorology	1-6
OC 3611	Ocean Wave and Surf Forecasting	2-0
OC 3615	Ocean Wave and Surf Forecasting Laboratory	0-6
MR 3900	Seminar in Meteorology	2-0
	Research Problem	0-0
		5-12

OCEANOGRAPHY CURRICULUM

CURRICULUM NUMBER 440

(Group OP)

First Quarter

MA 1100	Calculus Review	4-0
MR 2200	Introduction to Meteorology	3-0
MR 2205	Meteorology for Oceanographers	0-4
OC 3221	Descriptive Oceanography	4-0
OC 3420	Biological Oceanography	3-3
		14-7

Second Quarter

MA 2047	Linear Algebra and Vector Analysis	4-0
MA 2121	Differential Equations and Infinite Series	4-0
OC 3520	Chemical Oceanography	3-2
*MS 2228	Introduction to Engineering Materials	3-2
		14-4

Third Quarter

MA 2232	Numerical Methods	4-0
MA 3132	Partial Differential Equations and Integral Transforms	4-0
OC 4251	Dynamical Oceanography I	4-0
OC 3320	Geological Oceanography	3-3
		15-3

Fourth Quarter

OC 3150	Geophysical Random Processes	4-2
OC 4252	Dynamical Oceanography II	4-0
OC 3700	Oceanographic Instrumentation and Observations	3-0
OC 3710	Field Experience in Oceanography	0-4
		11-6

Fifth Quarter

PH 3431	Physics of Sound in the Ocean	4-2
MA 3243	Numerical Methods for Partial Differential Equations	4-1
OC 4253	Dynamical Oceanography III	3-0
OC 4211	Waves and Tides	4-0
		15-3

Sixth Quarter

	Elective	3-0
OC 4260	Sound in the Ocean	3-0
OC 4213	Coastal Oceanography	4-1
OC 4612	Polar Oceanography	3-0
	Thesis	0-0
		13-1

Seventh Quarter

OC 3601	Ocean Wave Forecasting	3-0
OC 3605	Ocean Wave Forecasting Laboratory	0-6
MR 4413	Air-Sea Interaction	3-0
	Thesis	0-0
		6-6

Eighth Quarter

OC 3616	Oceanographic Forecasting	3-0
OC 3621	Oceanographic Forecasting Laboratory	0-4
OC 4900	Seminar in Oceanography	3-0
	Thesis	0-0
		6-4

Electives

OC 4422	Marine Fouling	1-4
OC 4421	Marine Ecology	1-4
OC 3801	Ocean Operations I	3-1
OC 4802	Ocean Operations II	3-1
OC 4803	Physical Properties of Marine Sediments	2-3
OC 4340	Marine Geophysics	3-0

*Or elective.

MANAGEMENT AND COMPUTER SCIENCE PROGRAMS
Curricula Numbers 367, 368 and 817

EDWARD I. McQUISTON, Jr., Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1949; M.S. in Management, Naval Postgraduate School, 1963.

MARTIN E. LEWIS, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.E.C.E., University of Southern California, 1953; B.S.M.E., Naval Postgraduate School, 1961.

GERALD L. BARKSDALE, Jr., Academic Associate for Computer Science and Computer Systems Management; B.A., 1965, Rice University; B.S., 1965; M.S.E.E., 1966.

RICHARD L. ELSTER, Academic Associate for Management; B.A., 1963, University of Minnesota; M.A., 1965; Ph.D., 1967.

COMPUTER SYSTEMS MANAGEMENT CURRICULUM
Curriculum Number 367
(Group PM)

OBJECTIVE – To provide officers with a sound understanding of computer technology, enabling them to distinguish the capabilities and limitation of digital computers in various applications and developing the ability to effectively manage computer-based activities or data processing centers.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with above average grades in mathematics is required. Completion of two semesters of college mathematics at, or above, the level of college algebra is considered to be minimal preparation for Supply Corps Officers. For Navy Line Officers the completion of differential and integral calculus is also necessary.

DESCRIPTION – The curriculum consists of five academic quarters (15 months). Classes convene semiannually in March and September. To satisfy the requirements of sponsoring activities, students may select five elective courses as indicated in order to pursue their special areas of interest. For line officers, courses are provided which emphasize the technical areas of programming, the use of computers, and quantitative decision making techniques. For supply officers, courses are provided in the areas of procurement, logistics, and financial management.

Students in this curriculum are afforded the opportunity to qualify for the Master of Science Degree in Computer Systems Management. All USN graduates are assigned educational achievement codes indicating qualification for subspecialist P-Coded billets in the 8600 series Computer Systems Management.

First Quarter

MA	2300	Mathematics for Management	5-0
CS	2100	Introduction to Computers & Programming	4-0
MN	3106	Behavioral Science	4-0
MN	3060	Management Accounting	4-0
CS	0110	FORTRAN Programming	3-0
			20-0

Second Quarter

CS	3111	Programming Languages	4-0
CS	3200	Logical Design of Digital Computers	4-0
PS	3011	Probability & Statistics for Management I	4-0
MN	3105	Theory and Practice of Management	4-0
			16-0

Third Quarter

CS	3112	Operating Systems	4-0
PS	3012	Probability & Statistics for Management II	4-0
MN	3030	Introduction to Economics	4-0
		Elective (3000/4000 level CS, MN, or OA Course)	4-0
			16-0

Fourth Quarter

OA	3211	Operations Analysis for Management	4-0
MN	3171	Resources Management for Defense	4-0
		Elective (3000/4000 level CS, MN, or OA Course)	4-0
		Elective (3000/4000 level CS, or OA Course)	4-0
			16-0

Fifth Quarter

MN	4181	Management Information Syatems	4-0
MN	4182	Data Processing Management	4-0
		Elective (4000 level CS, MN, or OA Course)	4-0
		Elective (4000 level CS, MN, or OA Course)	4-0
			16-0

COMPUTER SCIENCE CURRICULUM
Curriculum Number 368
(Group CS)

OBJECTIVE – To provide selected officers with an advanced education in computer science in order that they will have a sound technical appreciation of computer theory and technology with the ability to specify, design and manage computer-based systems.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with a pattern of above average grades in mathematics is required. Completion of mathematics through differential and integral calculus is considered minimal preparation. Courses affording a background in physical science or engineering fields are highly desirable.

DESCRIPTION – A relatively new academic discipline, computer science is concerned with the representation, storage and manipulation of information by techniques and devices applicable to a wide variety of problems. This program is designed to help fulfill the Navy's rapidly expanding needs in the field of automatic data processing, both of an operational and supporting nature.

Classes convene semi-annually, in March and September. All students take a common curriculum for the first nine months (three quarters). Those officers selected for the Master's program continue for an additional year of study (for a total of seven quarters, overall) and are afforded the opportunity to qualify for the degree Master of Science in Computer Science. This selection is based on the student's academic performance, his preference, and availability. Officers not selected for the Master's program complete one final quarter in the Bachelor's program (four quarters overall) and upon successful completion, are awarded the degree Bachelor of Science with major in Computer Science. Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a Master's degree upon completion of four quarters course work, including an acceptable thesis.

This program involves course work in computer science supported by instruction in mathematics, probability and statistics, operations analysis, and management. In computer science, the emphasis is on programming systems and systems design, particularly those aspects of the theory of relevance to military applications. The Master's program permits further specialization by way of elective courses. The student will acquire significant practical experience on the excellent equipment of the Postgraduate School's Computer Facility. Most of the later courses, and, it is expected, the thesis, will involve heavy use of computers.

All Naval officers successfully completing either the seven-quarter Master's program or four-quarter Bachelor's program are considered qualified to fill any P-coded billet in the 8600 series, Computer Systems Management.

First Quarter

CS	2110	Introduction to Computer Processes	3-2
MA	1100	Calculus Review	4-0
MA	2025	Logic, Sets and Finite Mathematics	4-0
MA	2045	Introduction to Linear Algebra	3-0
			14-2

In addition, those students with no prior computer programming experience will enroll in CS 0110.

Second Quarter

CS	3111	Programming Languages	4-0
CS	3200	Logical Design of Digital Computers	4-0
MA	2121	Differential Equations and Infinite Series	4-0
PS	3401	Intermediate Probability and Statistics I	4-0
			16-0

Third Quarter

CS	3112	Operating Systems	4-0
PS	3402	Intermediate Probability and Statistics II	4-0
MA	3232	Numerical Analysis	4-0
MA	3026	Topics in Discrete Mathematics	4-0
			16-0

Fourth Quarter

CS	3201	Computer Systems Design	4-0
CS	3300	Information Structures	3-0
CS	3601	Automata and Formal Languages (Master)	3-0
MN	4182	Data Processing Management (Bachelor)	4-0
OA	3205	Operations Research for Computer Scientists	4-0
			15-0

Fifth Quarter

CS	4113	Compiler Design and Implementation	3-2
CS	4202	Interactive Computation Systems	3-2
CS	3204	Data Communication (Spring Input)	4-0
CS	4310	Non-numerical Information Processing (Fall Input)	4-0
OA	3653	Systems Simulation	4-0
			14-4

Sixth Quarter

MN	4182	Data Processing Management	4-0
CS	4900	Advanced Topics in Computer Science	4-0
OS	0810	Thesis	0-0
			8-0

Seventh Quarter

CS	3204	Data Communications (Fall Input)	4-0
CS	4310	Non-numerical Information Processing (Spring Input)	4-0
Elective (CS, EE, MA, or OA)			3/4-0 or 0-8
Thesis			0-0
			4-8 or 8-8

MANAGEMENT CURRICULUM
Curriculum Number 817
(Group MN)

OBJECTIVE – To provide officers with increased education in management which will improve their capabilities for organizing, planning, directing, coordinating and controlling activities in which the resources of men, money, and materials are combined to accomplish Navy objectives.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with overall academic performance of at least C+ is required. Completion of two semesters of college mathematics at, or above, the level of college algebra, and a C average in all quantitative courses is considered to be minimal preparation. Courses in differential and integral calculus are very desirable.

DESCRIPTION – The curriculum is of twelve months duration, convening semiannually in January and July. All officers, regardless of designator, are required to participate in the "core" courses. These courses provide the foundation and tools of management and lead into the electives which permit specialization in fields of interest to sponsoring bureaus and agencies.

Classroom instruction is supplemented by a quest lecturer series which affords the officer an opportunity to hear discussions of management topics by senior military officers, business executives, and prominent educators.

Successful completion of this program may lead to the award of a Master of Science in Management degree. Educational achievement codes are assigned to graduates by the Chief of Naval Personnel, indicating qualification for appropriate sub-specialist P-Coded billets.

First Quarter

MA	2300	Mathematics for Management	5-0
MN	3106	Behavioral Science	4-0
MN	3060	Management Accounting	4-0

MN	3105	Theory and Practice of Management	4-0
CS	0110	FORTRAN Programming	3-0
			20-0

Second Quarter

PS	3000	Management Statistics	5-0
MN	3030	Introduction to Economics	4-0
		Elective (in area of specialization)	4-0
		Elective (3000/4000 level course in MN, OA, or CS)	4-0
			17-0

Third Quarter

OA	3211	Operations Analysis for Management	4-0
MN	4183	Business Data Processing	4-0
MN	3171	Resources Management for Defense	4-0
		Elective (3000/4000 level course in MN, OA, or CS)	4-0
			16-0

Fourth Quarter

Elective (in area of specialization) 4000 level	4-0
Elective (in area of specialization) 400 level	4-0
Elective (3000/4000 level, MN, OA, or CS)	4-0
Elective (3000/4000 level, MN, OA, or CS)	4-0
	16-0

Note: A thesis in the area of specialization may be undertaken in the Third and Fourth Quarters in lieu of one elective in each of the Quarters.

Examples of possible elective course sequences in two sample areas of specialization are as follows, keeping in mind core courses, the degree requirements, and course prerequisites:

A. Sample of Personnel Management Course Sequence:

Second Quarter

			Prerequisites	Hrs.
MN	3110	Individual Behavior	none	4-0
MN	3125	Organizational Behavior	MN 3106	4-0

Third Quarter

			Prerequisites	Hrs.
MN	3147	Labor Economics	MN 3140	4-0

Fourth Quarter

			Prerequisites	Hrs.
MN	4147	Industrial Relations	MN 3147	4-0
MN	4112	Personnel Selection & Classification	(PS 3000) (MN 3110)	4-0
MN	4171	Procurement & Contract Administration	MN 3171	4-0
MN	4145	Systems Analysis	(MN 3030) (OA 3211) (MN 3060)	4-0

B. Sample of Financial Management Course Sequence:

Second Quarter

			Prerequisites	Hrs.
MN	3161	Managerial Acounting	MN 3060	4-0
MN	3110	Individual Behavior	none	4-0

Third Quarter

			Prerequisites	Hrs.
MN	3121	Group & Organizational Behavior	MN 3110	4-0

Fourth Quarter

			Prerequisites	Hrs.
MN	4181	Managemant Information Systems	(MN3060) (MN 4183)	4-0
MN	4161	Controllership	(MN 3121) (MN 3161) (MN 4183) (OA 3211)	4-0
MN	4152	Financial Policy	(MN 3161) (PS 3000)	4-0
MN	4145	Systems Analysis	(MN 3030) (OA 3211) (MN 3060)	4-0

NAVAL ENGINEERING PROGRAMS
CURRICULUM NUMBER 570

JOHN RENISON WALES, Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1951; B.S. in Marine Engineering, Webb Institute of Naval Architecture, 1957, M.S. in Naval Architecture, 1957.

ROY WALTERS PROWELL, Academic Associate; B.S. in Industrial Engineering, Lehigh Univ., 1936; M.S. in Mechanical Engineering Univ. of Pittsburgh, 1943.

OBJECTIVE – To provide selected officers with advanced education in MECHANICAL or ELECTRICAL engineering to meet the requirements of the Navy for Officers with technical competence in the areas of engineering mechanics, naval hydrodynamics, thermosciences, nuclear reactor systems and power sources, ocean mechanical engineering, naval electric machinery, electronics, circuits and feedback control, and electric power systems.

QUALIFICATIONS FOR ADMISSION – To qualify for admission to the Naval Engineering Programs, a Baccalaureate degree with a grade average of B or above in mathematics, physical sciences, and engineering is required. Completion of mathematics through integral calculus, engineering physics, and chemistry is considered to be minimal preparation for these programs. Courses in statics, dynamics, fluid mechanics, thermodynamics, electric fields, electric circuits, and electronics are desirable.

DESCRIPTION – Qualified students initially enter a common Naval Engineering (General) Curriculum. Entrance to this curriculum is semi-annually in March and September. At the end of the second quarter, students are selected to pursue studies in a specialty of either MECHANICAL or ELECTRICAL engineering. Upon completion of the first year of study, qualified students in each specialty are selected to follow a Master's degree curriculum. After completion of seven quarters, students from the M.S. group are further selected to follow an Engineer degree curriculum in various groups of specialty in either mechanical or electrical engineering.

The criteria for selection are academic performance, individual preference, and tour availability.

The length of each curriculum is dependent upon the qualifications and prior education of each student. While well qualified students can complete the respective curricula in a shorter time than indicated by receiving credit for prior academic programs, *the length of each individual program given below is based on a minimal preparation prior to admission:*

Mechanical Engineering (B.S. Degree)	7 quarters
Mechanical Engineering (M.S. Degree)	9 quarters
Mechanical Engineering (Engineer's Degree)	12 quarters
Electrical Engineering (B.S. Degree)	7 quarters
Electrical Engineering (M.S. Degree)	9 quarters
Electrical Engineering (Engineer's Degree)	12 quarters

The completion of a satisfactory thesis is required for the M.S. and Engineer degree in each specialty. An acceptable thesis for the Engineer's Degree is acceptable for meeting the thesis requirements of the Master's Degree. Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a Master's degree upon completion of four quarters course work, including an acceptable thesis.

A limited number of officers who demonstrate superior academic performance and are otherwise eligible may apply for doctoral level studies in Mechanical or Electrical Engineering. Successful completion of these studies lead to the award of the degree of Doctor of Philosophy.

Those officers successfully completing these programs will be identified as subspecialists in accordance with the current Bureau of Naval Personnel Instructions.

By the very nature of the Mechanical and Electrical Engineering disciplines, considerable flexibility in the development of individual student programs is possible. *Accordingly the following programs should be considered as typical ones rather than as rigid and standardized:*

NAVAL ENGINEERING (GENERAL PROGRAM)
(Group NG)

Common to all Naval Engineering students

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
EE 2101	Principles of Electrical Engineering	3-2
ME 2501	Mechanics I	4-0
		14-2

Second Quarter

MA 2121	Differential Equations & Infinite Series	4-0
EE 2102	Circuit Analysis	4-2
ME 2101	Engineering Thermodynamics	4-1
ME 2502	Mechanics II	3-0
		15-3

MECHANICAL ENGINEERING (B.S.M.E.)
(Group NH)

Third Quarter

MA 2232	Numerical Methods	4-0
ME 2201	Fluid Mechanics	4-2
ME 2601	Mechanics of Solids I	3-2
MS 2201	Engineering Materials I	3-2
		14-6

Fourth Quarter

MA 3132	Partial Differential Equations	4-0
ME 3521	Mechanical Vibrations	3-2
ME 3611	Mechanics of Solids II	4-0
ME 2410	Mechanical Engineering Lab I	1-3
		12-5

Fifth Quarter

ME 2711	Machine Design I.	3-2
ME 3170	Heat Transfer and Gas Dynamics	4-2
EE 2201	Electronics Survey	4-2
PH 2810	Survey of Nuclear Physics	4-0
		15-6

Sixth Quarter

ME 3811	Automatic Control Systems	3-2
ME 3301	Nuclear Power Systems	4-0
ME 3440	Engineering Systems Analysis	4-0
MN 3171	Resource Management for Defense	4-0
		15-2

Seventh Quarter

ME 3430	Mechanical Lab II	2-4
ME 3801	Fluid Power Control	3-2
OA 3201	Fundamentals of Operations Analysis	4-0
ME 3450	Marine Gas Power Systems	3-2
		12-8

MECHANICAL ENGINEERING (MSME)

ENGINEERING MECHANICS

(Group NC)

Quarters 3 and 4 same as for Group NH above

Fifth Quarter

ME 2711	Machine Design I	3-2
ME 3202	Gas Dynamics	3-0
ME 3150	Heat Transfer	4-2
PH 2810	Survey of Nuclear Physics	4-0
		14-4

Sixth Quarter

ME 3811	Automatic Control Systems	3-2
ME 3301	Nuclear Power Systems	4-0
ME 3712	Machine Design II	3-4
ME 3440	Engineering Systems Analysis	4-0
		14-6

Seventh Quarter

EE 2201	Electronics Survey	4-2
ME 3430	Mechanical Engineering Lab II	2-4
ME 3801	Fluid Power Control	3-2
ME 4512	Advanced Dynamics	4-0
		13-8

Eighth Quarter

ME 4522	Advanced Vibrations	3-1
MS 3202	Properties of Structural Materials	3-2
ME 0810	Thesis	0-0
		6-3

Ninth Quarter

ME 4612	Mechanics of Solids III	4-0
OA 3201	Fundamentals of Operations Analysis	4-0
MN 3171	Resource Management for Defense	4-0
ME 0810	Thesis	0-0
		12-0

MECHANICAL ENGINEERING (MSME)

FLUID DYNAMICS

(Group NF)

Quarters 3 and 4 same as for Group NH above

Fifth Quarter

ME 2711	Machine Design I	3-2
ME 3202	Gas Dynamics	3-0
ME 3161	Conduction and Radiation Heat Transfer	3-0
PH 2810	Survey of Nuclear Physics	4-0
		13-2

Sixth Quarter

ME 3811	Automatic Control Systems	3-2
ME 3301	Nuclear Power Systems	4-0
ME 4211	Hydrodynamics	4-0
ME 3440	Engineering Systems Analysis	4-0
		15-2

Seventh Quarter

EE 2201	Electronics Survey	4-2
ME 3430	Mechanical Engineering Lab II	2-4
ME 3801	Fluid Power Control	3-2
ME 4220	Boundary Layer Theory	4-0
		13-8

Eighth Quarter

ME 4162	Convection Heat Transfer	4-0
ME 4230	Advanced Topics in Fluid Dynamics and Heat Transfer	4-0
	Thesis	0-0
		8-0

Ninth Quarter

ME 4140	Direct Energy Conversion	3-0
OA 3201	Fundamentals of Operations Analysis	4-0
MN 3171	Resource Management for Defense	4-0
ME 0810	Thesis	0-0
		11-0

MECHANICAL ENGINEERING (MSME)

NUCLEAR ENGINEERING

(Group NN)

Quarters 3 and 4 same as for Group NH above

Fifth Quarter

ME 2711	Machine Design I	3-2
ME 3202	Gas Dynamics	3-0
ME 3161	Conduction and Radiation Heat Transfer	3-0
PH 2810	Survey of Nuclear Physics	4-0
		13-2

Sixth Quarter

ME 3315	Nuclear Measurements Lab	1-4
ME 3440	Engineering Systems Analysis	4-0
ME 3811	Automatic Control Systems	3-2
ME 4311	Nuclear Reactor Theory	5-0
		13-6

Seventh Quarter

EE 2201	Electronics Survey	4-2
ME 3430	Mechanical Engineering Lab II	2-4
ME 3801	Fluid Power Control	3-2
ME 4220	Boundary Layer Theory	4-0
		13-8

Eighth Quarter

ME 4162	Convection Heat Transfer	4-0
ME 4321	Reactor Engineering Principles and Design	4-2
ME 0810	Thesis	0-0
		8-2

Ninth Quarter

ME 4140	Direct Energy Conversion	3-0
OA 3201	Fundamentals of Operations Analysis	4-0
MN 3171	Resource Management for Defense	4-0
ME 0810	Thesis	0-0
		11-0

MECHANICAL ENGINEERING (MSME)
OCEAN MECHANICAL
(Group NO)

Quarters 3 and 4 same as for Group NH above

Fifth Quarter

ME 2711	Machine Design I.	3- 2
ME 3170	Heat Transfer and Gas Dynamics	5- 0
PH 2810	Survey of Nuclear Physics	4- 0
OC 3221	Descriptive Oceanography	4- 0
		16- 2

Sixth Quarter

ME 3301	Nuclear Power Systems	4- 0
ME 3440	Engineering Systems Analysis	4- 0
ME 4211	Hydrodynamics	4- 0
OC 3700	Ocean Instrumentation and Observation	3- 0
		15- 0

Seventh Quarter

ME 3430	Mechanical Engineering Lab II	2- 4
ME 3801	Fluid Power Control.	3- 2
ME 4220	Boundary Layer Theory.	4- 0
OC 3250	Dynamical Oceanography	4- 0
		13- 6

Eighth Quarter

OC 3801	Ocean Operations I	3- 1
MN 3171	Resource Management for Defense	4- 0
ME 0810	Thesis	0- 0
		7- 1

Ninth Quarter

ME 4902	Special Topics in ME	3- 0
OC 4802	Ocean Operations II	3- 1
OA 3201	Fundamentals of Operations Analysis	4- 0
ME 0810	Thesis	0- 0
		10- 1

ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
MA 4611 Calculus of Variations

Specialization Courses, Fluid Dynamics and Heat Transer (NR)

ME 4240 Advanced Hydrodynamics
ME 4321 Reactor Engineering Principles & Design
ME 4512 Advanced Dynamics
ME 4620 Theory of Continuous Media
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
MA 2172 Complex Variables

Specialization Courses, Nuclear Engineering (NQ)

ME 3341 Radiation Shielding
ME 4211 Hydrodynamics
ME 4230 Advanced Topics in Fluid Dynamics and Heat Transfer
ME 4312 Advanced Nuclear Reactor Theory
ME 4620 Theory of Continuous Media
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
MA 2172 Complex Variables

Specialization Courses, Ocean Mechanical Engineering (NS)

ME 4140 Direct Energy Conversion
ME 4240 Advanced Hydrodynamics
ME 4612 Mechanics of Solids III
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
OC 3601 Ocean Wave Forecasting
OC 4211 Waves & Tides
OC 4251 Dynamical Oceanography, I

MECHANICAL ENGINEERING– ENGINEER PROGRAMS
(Groups NP, NR, NQ, NS)

To achieve the degree *Mechanical Engineer*, the student must complete an additional three quarters of study beyond the requirements for the Master of Science degree. Additional courses are taken to give a more comprehensive understanding of the previously selected area of specialization. Thesis research for the Engineer degree is equivalent to approximately seven courses. In addition, an industrial tour of six weeks duration gives opportunity for the student to work directly with engineers on a problem in his area of specialization.

Specialization Courses, Engineering Mechanics (NP)

ME 4140 Direct Energy Conversion
ME 4211 Hydrodynamics
ME 4220 Boundary Layer Theory
ME 4613 Advanced Methods of Analysis in Elasticity
ME 4620 Theory of Continuous Media

ELECTRICAL ENGINEERING (BSEE)
(Group NL)

Quarters One and Two same as Group NG

Quarter Three

EE 2103	Linear Systems Analysis	4-2
MA 2172	Complex Variable	4-0
MA 2232	Numerical Methods	4-0
PS 3411	Probability Theory I	4-0
		16-2

Quarter Four

EE 2211	Electronic Engineering Fundamentals I	4-2
EE 2114	Communication Theory I	4-0
EE 2411	Control Systems	3-3
MA 2161	Introduction to Mathematical Physics	4-0
		15-5

Quarter Five

EE 2311	Principles of Energy Conversion	3-2
EE 2212	Electronic Engineering Fundamentals II	4-3

EE 2621	Introduction to Fields & Waves	4-1
PH 2810	Survey of Nuclear Physics	4-0
		15-6

Quarter Six

EE 2216	Pulse & Digital Circuits	4-3
EE 2810	Digital Machines	3-3
EE 3263	Transistor and Integrated Circuit Applications	3-3
OA 3202	Methods of Operations Analysis/Systems Analysis	4-0
		14-9

Quarter Seven

EE 2217	Electronic Communications Circuits	4-3
EE 2312	Electromagnetic Machines	3-4
EE 2622	Electromagnetic Engineering	3-1
MN 3171	Resource Management for Defense	4-0
		14-8

ELECTRICAL ENGINEERING (MSEE)
(Control Systems, Group NE)

Quarters One through Four same as for Group NL above

Quarter Five

EE 2212	Electronic Engineering Fundamentals II	4-3
EE 2311	Principles of Energy Conversion	3-2
EE 4412	Nonlinear Systems	3-3
EE 2621	Introduction to Fields & Waves	4-1
		14-9

Quarter Six

EE 2216	Pulse & Digital Circuits	4-3
EE 3622	Electromagnetic Theory	3-0
EE 2810	Digital Machines	3-3
OA 3202	Methods of Operations Analysis/Systems Analysis	4-0
		14-6

Quarter Seven

EE 2312	Electromagnetic Machines	3-4
EE 4414	Stochastic Control Theory	2-2
EE 4417	Optimal Control	4-0
EE 4121	Advanced Network Theory I	3-2
		12-8

Quarter Eight

EE 3313	Marine Electrical Analysis & Design	2-4
EE 3822	Engineering Applications of Computers	3-3
EE 4571	Statistical Communication Theory	3-2
EE 0810	Thesis	0-0
		8-9

Quarter Nine

EE 3263	Transistor and Integrated Circuit Applications	3-3
MN 3171	Resource Management for Defense	4-0
EE 0180	Thesis	0-0
		7-3

ELECTRICAL ENGINEERING ENGINEER PROGRAMS
(Groups NU, NV, NW)

Programs leading to the degree of *Electrical Engineer* are individually arranged in consultation with an advisor appointed by the department of Electrical Engineering. Opportunity is provided to specialize in control systems, communications, and information theory, or computer technology. In addition to completing the courses listed for the Master of Science degree, the student will take the courses indicated for his area of specialization, plus a minimum of nine electives. Thesis research for the Engineer degree is equivalent to approximately seven courses. An industrial tour of six weeks duration gives opportunity for the student to work directly with engineers on a problem in his area of specialization.

Specialization Courses, Control Systems (NU)

This area provides a comprehensive understanding of the principles and design of control systems and their application to marine electrical engineering.

EE 4414 Stochastic Control Theory
EE 4415 Algebraic Methods in Control Theory
EE 4417 Optimal Control

Specialization Courses, Communications and Information Theory (NV)

Emphasis is placed on a comprehensive understanding of the principles of communication and information theory.

EE 4541 Signal Processing
EE 4571 Statistical Communication Theory
EE 4581 Information Theory

Specialization Course, Computer Technology (NW)

The objective is to provide a comprehensive understanding of electrical engineering with in-depth coverage of computer technology.

EE 3812 Switching Theory and Logical Design
EE 3822 Engineering Applications of Computers
EE 4823 Advanced Digital Computer Systems

MATHEMATICS – M.S. PROGRAM
CURRICULUM NUMBER 430
(Group NMX)

OBJECTIVE – To provide advanced studies in mathematics for selected college graduates in order to help meet the Navy's need for officers with advanced education in this field.

DESCRIPTION – The curriculum is of four quarters' duration; classes commence in July and terminate the following June. Students ordered to this curriculum report direct from their college upon graduation. Candidates for this program must have satisfied the requirements for a major in mathematics, including courses in advanced calculus, matrices, and complex variables. Additionally, candidates must have attained a B average or better for all math courses taken. Successful completion of the curriculum leads to the award of the degree of Master of Science with a major in Mathematics.

First Quarter

MA 3565	Modern Algebra I	3-0
MA 3730	Numerical Analysis & Computation	3-0
MA 4635	Functions of Real Variables I	3-0
PS 4001	Advanced Probability Theory	3-0
		12-0

Second Quarter

MA 3566	Modern Algebra II	3-0
MA 4636	Functions of Real Variables II	3-0
MA 4945	Problem Seminar.	3-0
PS 4002	Advanced Statistics and Decision Theory	3-0
		12-0

Third Quarter

MA 3660	Boundary Value Problems	3-0
MA 4637	Introduction to Functional Analysis	3-0
MA 4872	Topics in Calculus of Variations	3-0
MA 0810	Thesis	0-0
		9-0

Fourth Quarter

MA 4622	Principles & Techniques of Applied Mathematics	3-0
	Elective	3-0
	Elective	3-0
MA 0810	Thesis	0-0
		9-0

Professor Student Work Sessions

OPERATIONS RESEARCH/SYSTEMS ANALYSIS PROGRAMS CURRICULUM NUMBER 360

JOHN DONALD HARTLEY, Commander, U.S. NAVY; Curricular Officer; B.S., Naval Academy, 1952; Naval Postgraduate School, 1964.

ERNEST WILLIAM BARKER, Lieutenant Commander, U.S. NAVY; Assistant Curricular Officer; B.S., Naval Postgraduate School, 1963; B.S. in Operations Research, 1966.

WILLIAM PEYTON CUNNINGHAM, Academic Associate; B.S., Yale Univ., 1928; Ph.D., 1932.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM CURRICULUM NUMBER 360 (Group RO)

OBJECTIVE – To provide selected officers with a sound education in quantitative methods and to develop their analytical ability in order that they may (1) formulate new concepts and apply the results of operations research/systems analysis with greater effectiveness, and (2) define and solve military problems more effectively.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with above average grade in mathematics is required. Completion of mathematics through differential and integral calculus is considered minimal preparation. A one year course in college physics is highly desired (Supply Officers excluded). Students lacking these quantitative prerequisites will be accepted, in certain special cases, where their undergraduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative areas and outstanding motivation for the program.

DESCRIPTION – The Operations Research/Systems Analysis program is interdisciplinary in nature, consisting of course work in operations analysis, probability and statistics, mathematics, physics, economics, and computer science. Classes convene seminannually, in March and September. All students take a common core curriculum during the first year (four quarters) although there are slight variations designed to meet particular career needs of Navy Line, Supply Corps, Marine Corps, Army and Air Force Officers. Those officers selected for the Master's program continue for a second year of study (for a total of eight quarters, overall) and are afforded the opportunity to qualify for the degree Master of Science in Operations Research.

Selected Naval Academy, NROTC, and OCS graduates may enter directly into a graduate program and obtain a master's degree upon completion of four quarters course work, including an acceptable thesis.

Additionally, students in the Master's program must complete an elective sequence approved by the Department of Operations Analysis, and submit an acceptable thesis on a subject previously approved by the Department.

An integral part of the Master's program is a six-week intersessional experience tour taken during the second half of the fifth quarter in which the student officers are assigned as working members of appropriate military or industrial groups engaged in operations research/systems analysis of military problems. This field trip is designed to permit the student, on an individual basis, to participate in some phase of active operations research in the "real world", and, secondarily, to assist him in finding a problem of interest for subsequent thesis study.

Selection for the Master's program is based on the student's academic performance and potential. Those officers not selected for the Master's program are graduated at the end of five quarters, and upon successful completion, are awarded the degree of Bachelor of Science in Operations Research.

At present, all Naval officers successfully completing either the eight-quarter Master's program or the five-quarter Bachelor's program are considered qualified to fill Operations Analysis Sub-specialist P-Coded billets (P-8500 and P-8501). The degree awarded, in either case, is considered immaterial in attaining the qualification to fill OA Subspecialist P-Coded billets.

An important adjunct to the formal classroom work is a seminar series in which guest lectures present first-hand information as to practical principles and techniques in the field of Operations Research/Systems Analysis.

A limited number of officers who demonstrate superior academic performance are encouraged to apply for doctoral study in operations research.

First Quarter

MA 1101	Calculus Review	5- 0
MA 2042	Linear Algebra	4- 0
PS 2301	Probability	4- 0
OA 2600	Historical Introduction to Operation Analysis	2- 0
OA 2601	Introduction to Decision Analysis	2- 0
OA 0001	Seminar	0- 2
		17- 2

Second Quarter

MA 2110	Selected Topics from Advanced Calculus	4- 0
PS 3302	Probability and Statistics	4- 1
PH 2121	Physical Models I	4- 0
OA 3657	Human Factors	4- 0
OA 0001	Seminar	0- 2
		16- 3

Third Quarter

MN 3141	Microeconomics	4- 0
OA 3604	Linear Programming	4- 0
PS 3303	Statistics	4- 1
OA 3653	System Simulation	4- 0
or		
MN 3060	Management Accounting (Supply)	4- 0
OA 0001	Seminar	0- 2
		16- 3

Fourth Quarter

OA 3610	Utility Theory & Resource Allocation	4- 0
OA 3654	War Gaming	3- 2
OA 3704	Stochastic Models I	4- 0
PH 2122	Physical Models II	4- 2
or		
OA 3620	Inventory I (Supply).	3- 0
OA 0001	Seminar	0- 2
		15- 4

Fifth Quarter (Master's Program)

During the first six weeks of the Quarter, students will take two courses at an accelerated pace:

OA 3611	Systems Analysis I	4- 0
OA 3660	Analysis of Operational Data	3- 1
OA 0001	Seminar	0- 2
		7- 3

The student experience tour is taken during the last six weeks of the Quarter.

Fifth Quarter (Bachelor's Program)

OA 3605	Methods of OR/SA	4- 0
OA 3611	Systems Analysis I	4- 0
OA 3900	Workshop in OR/SA	4- 0
OA 3910	Selected Topics in OR/SA	4- 0
OA 0001	Seminar	0- 2
		16- 2

Sixth Quarter (Master's Program)

OA 4631	Non-Linear & Dynamic Programming	4- 0
OA 4705	Stochastic Models II	4- 0
* OA 4651	Search & Detection	4- 0
* OA 3655	Methods for Combat Development	4- 0
* OA 4662	Reliability & Weapon Systems Effectiveness Measurement	4- 0
* OA 3611	Inventory II (Supply)	4- 0
OA 0001	Seminar	0- 2
	Elective	3- 0 to 4- 0
		15- 2 to 16- 2

* Select one only

Seventh Quarter (Master's Program)

OA 3671	Cybernetics and Analysis of Information Systems	4- 0
OA 4633	Network Flows and Graphs	3- 0
OA 0001	Seminar	0- 2
	Elective	3- 0 to 4- 0
OA 0810	Thesis	0- 0
		10- 2 to 10- 2

Eighth Quarter (Master's Program)

OA 3612	Systems Analysis II	4- 0
OA 4622	Seminar in Supply Systems (Supply)	4- 0
	Elective	3- 0 to
	Elective	3- 0 to 4- 0
OA 0001	Seminar	0- 2
OA 0810	Thesis	0- 0
		10- 2 to 16- 2

ELECTIVES

All students in the Master's program must complete an elective sequence of at least three courses approved by the Department of Operations Analysis. Electives may be chosen from the following list of courses (although it should be noted that only certain courses will be offered in any particular quarter):

OA 3620 Inventory I
OA 3621 Inventory II
OA 3656 O/R Problems in Special Warfare
OA 3658 Human Factors II
OA 3660 Analysis of Operational Data
OA 3664 Theory of Pattern Recognition
OA 4613 Theory of Systems Analysis
OA 4615 Econometrics
OA 4632 Mathematical Programming
OA 4633 Networks Flows & Graphs
OA 4634 Games of Strategy
OA 4635 Non Linear Programming
OA 4636 Dynamic Programming
OA 4642 Advanced War Gaming
OA 4652 O/R Problems in Naval Warfare
OA 4662 Reliability and Weapons System Effectiveness
OA 4680 Human Performance Evaluation
OA 4706 Stochastic Models III
OA 4910 Selected Topics in OR/SA
PS 4306 Applied Statistics
PS 4321 Design of Experiments
PS 4323 Decision Theory
PS 4431 Advanced Probability
PS 4432 Stochastic Processes I
PS 4433 Stochastic Processes II
PS 4440 Time Series Analysis
MN 3130 Macroeconomic Theory
CS 3111 Programming Languages
CS 3112 Operating Systems
PH 3421 Underwater Acoustics
PH 3921 Conceptual Models of Modern Physics

ORDNANCE ENGINEERING PROGRAMS CURRICULAR NUMBERS 521, 530 and 535

George Clarence Sup, Commander U.S. Navy; Curricular Officer; B.S., Physics, Naval Postgraduate School, 1960.

John Norvell Dyer, Academic Associate; B. A., University of California at Berkeley, 1956; Ph.D., 1960.

NUCLEAR SCIENCE (EFFECTS) CURRICULUM NUMBER 521

OBJECTIVE – To educate officers in those aspects of both classical and modern physics and related disciplines that pertain to the phenomena associated with the effects of nuclear weapons. Fundamental studies include the broad areas of (a) classical mechanics of particles and continua, (b) thermodynamics and statistical physics, (c) propagation of electromagnetic waves in various media and classical radiation theory, and (d) modern physics including quantum mechanics and atomic, nuclear, and solid state physics. This coverage provides a basis for specialized study of nuclear processes, radiation and thermal effects in matter including electronic devices and living organisms, the generation and propagation of shock waves, radiation-chemistry, and the properties of the upper atmosphere. Thesis research is conducted in an area of specialized study.

QUALIFICATIONS FOR ADMISSION – A Baccalaureate degree with above average grades.in mathematics, physical sciences, and engineering physics and one year of chemistry is considered to be minimal preparation. Courses in mechanics, thermodynamics, and electrical engineering are very desirable.

DESCRIPTION – This curriculum is sponsored by the Defense Atomic Support Agency as a joint service course for selected officers of the Army, Navy, Air Force, Marine Corps and Coast Guard. Classes convene annually in July. Successful completion of the curriculum leads to the award of the degree Master of Science in Physics. Students who fail to demonstrate their ability at the graduate level will be continued in the program through its completion provided that sustained satisfactory academic performance is maintained at or above the baccalaureate level; if otherwise eligible, such students will be awarded the degree Bachelor of Science in Physics.

The duration of the curriculum is two years for officers with minimal preparation or who have been out of school for several years. In addition, for officers who can report early, the curriculum is preceded by a six-week refresher period which consists of non-credit courses in basic mathematics, physics, chemistry, and FORTRAN programming. The refresher period and the first four quarters of the two-year curriculum are designed to provide a smooth transition from previous studies and to provide the undergraduate background necessary for the subsequent advanced courses and thesis research. Portions or all of this undergraduate preparation may be omitted by the better academically prepared officers to shorten their time on board or to study a wider variety of graduate electives. Upon arrival at the School each officer will be counseled and a personalized program will be constructed to meet his academic needs.

This curriculum is available under the Immediate Graduate Education Program for qualified USNA, NROTC, and OCS graduates who have majored in physics and are motivated toward immediate continued education at the graduate level. (BuPers Inst 1520.103 pertains.) This is a one-year course-of study and consists of the last four quarters of the two-year curriculum modified, if necessary, to take into account the student's undergraduate preparation. Successful completion of this program also leads to the award of the degree Master of Scicnce in Physics.

A program in physics leading to the degree Doctor of Philosophy may be offered to a limited number of exceptionally well- qualified students. A student may apply for this additional education at any time in the curriculum. Participation in the doctoral program will require the approval of both the Defense Atomic Support Agency and the parent services.

Upon completion of the program, officer-students will take a field trip to Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, for a specially tailored Weapons Oricntation Advanccd Course given by the Nuclear Weapons Training Directorate. This field trip will be taken as tcmporary duty under instruction en route to their new duty stations under pcrmanenet changc of station orders issued by their parcnt scrvices.

Unrestricted line officcrs of the Navy graduating from this program will be recommended for the subspecialty qualification code of 8407P. Subject to agreement between the Defense Atomic Support Agency and their respective services all officers completing the program are eligible for duty assignment within the DASA complex.

REPRESENTATIVE CURRICULUM (Group RZ)

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
PH 1051	Review of Vector Mechanics and Optics	4-2
EE 2231	Electronics I (Nuclear)	3-3
		14-5

Second Quarter

MA 2121	Differential Equations and Infinite Series	4-0
MA 2161	Introduction to Mathematical Physics	4-0
PH 2151	Mechanics I	4-0
EE 2232	Electronics II (Nuclear)	3-3
		15-3

Third Quarter

PH 2251	Waves and Particles	4-2
PH 2351	Electromagnetism I	4-0
PH 2152	Mechanics II	4-0
PS 2315	Data Reduction and Error Analysis	4-0
		16-2

Fourth Quarter

PH 3651	Atomic Physics	4-2
PH 2352	Electromagnetism II	3-0
PH 3951	Introduction to Quantum Mechanics	4-0
PH 2551	Thermodynamics	3-0
PH 0999	Physics Colloquium	0-1
		14-3

Fifth Quarter

PH 3652	Elements of Molecular, Solid State, and Nuclear Physics	4-2
PH 4353	Electromagnetism III	3-0
PH 3461	Explosive Shock Waves	4-0
PH 3561	Introductory Statistical Physics	4-0
PH 0999	Physics Colloquium	0-1
		15-3

Sixth Quarter

PH 4851	Nuclear Physics	4-2
CH 3401	Chemical Theory	4-0
PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
	Graduate Option Elective	4-0
		12-3

Seventh Quarter

CH 4508	Radio and Radiation Chemistry	4-2
PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
	Graduate Option Elective	5-0
		9-3

Eighth Quarter

PH 4750	Radiation Effects in Solids	5-0
PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
	Graduate Option Elective	5-0
		10-1

Graduate Options
Option A — Air/Space Phenomena

PH 4630	Space Physics I–Physics of the Upper Atmosphere	4-0
BI 3850	Biological Effects of Radiation	5-0
	and one of	
PH 3157	Physics of Continua	4-0
PH 4661	Plasma Physics I	4-0
PH 4881	Advanced Nuclear Physics I	3-0
MA 3185	Tensor Analysis	3-0

or any other graduate course in physics or related disciplines which supports the objectives of the curriculum and is consistent with the student's interests and capabilities.

Option B — Radiation Biology

BI 3800	Cellular and Molecular Biology	4-0
BI 3801	Animal Physiology	5-0
BI 4802	Radiation Biology	5-0

ORDNANCE SYSTEMS ENGINEERING CURRICULUM NUMBER 530

OBJECTIVE — To provide officers an advanced technical education based on a broad foundation which emphasizes the scientific and engineering principles underlying the field of ordnance, and an introduction to technical management. Although the principal aim of the curriculum is to qualify officers for technical duty assignment in the shore establishment, particularly the Naval Ordnance Systems Command, the at-sea professional capability of graduating officers will be greatly enhanced. Ashore or afloat technical competence in modern ordnance and related systems is a key to success.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree with above average grades in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics and one year of chemistry is considered to be minimal preparation.

DESCRIPTION — Classes convene in September and March. Subject to service needs officers may select curricula majoring in chemistry, electrical engineering, or physics, Depending on his academic background and the length of his availability at the School each officer may enter a curriculum leading to a degree Bachelor of Science (BS), Master of Science (MS), Electrical Engineer (EE), or Doctor of Philosophy (Ph.D). For most officers the first four or five quarters in all curricula are designed to bridge the gap from previous studies and to provide the additional undergraduate background necessary for the subsequent advanced courses. In addition, for those officers who can report early, the curriculm is preceded by a six-week refresher period which consists of non-credit courses in basic mathematics, physics, chemistry, and FORTRAN programming. All or portions of this undergraduate study may be omitted by the better academically prepared officers to shorten their time on board or to permit them to study a wide variety of graduate electives. Officers less academically prepared may be enrolled in the Engineering Science Curriculum for one or more quarters in order to improve their probability for success in Ordnance Engineering. On arrival at the School each officer will be counseled and have a personalized curriculum constructed to fit his academic needs.

Near the end of the first quarter each officer will select his major. In subsequent quarters curricula may vary, by courses, depending upon the specialty areas of interest to the student and scheduling limitations.

Early in the second year officers who have demonstrated capability for graduate study will be evaluated for an advanced program. The total length of each curriculum, including adequate time for thesis research, depends essentially on the academic requirements for the degree and the officer's availability. Normally BS programs are seven quarters duration, MS programs nine quarters, EE programs twelve quarters, and Ph.D. programs four years. Consistent with the needs of the service and professional career requirements academically qualified officers are encouraged to select the longer programs.

These curricula are also available under the Immediate Graduate Education Program for qualified USNA, OCS and NROTC graduates who have majored in chemistry, electrical engineering, or physics and who are motivated toward immediate continued education at the graduate level. (BuPers Inst. 1520.103 pertains.) In each major area, this program is a one year course-of-study and consists of the last four quarters of the normal nine-quarter MS curriculum modified, if necessary, to take into account the student's undergraduate preparation.

The following are representative curricula of the various programs offered in Ordnance Engineering. Curricula for individual officers are designed to be academically sound, meet the basic qualification requirements of the Naval Ordnance Systems Command, and permit selection of electives of interest.

Upon successful completion of the curriculum, unrestricted line officers will be recommended for subspecialty qualification codes as follows:

Physics Majors	8302P
Chemistry Majors	8303P
Electrical Engineering Majors	8304P

ORDNANCE SYSTEMS ENGINEERING (CHEMISTRY) CURRICULUM

leading to the degree Master of Science in Chemistry

OBJECTIVE – To enhance overall professional capability by providing broad coverage of general subject matter and study in depth in one particular aspect of applied or theoretical chemistry of interest to the Navy and to the individual officer. The applied chemistry portions cover practical aspects that range from application through development and manufacture of current and future chemical systems such as explosives, plastics, and fuels. The theoretical portions provide the concepts of molecular engineering and an understanding of basic chemical processes such as those of explosion, corrosion, electrochemical fuel cells, and biological effects. Classroom instruction is complemented by independent thesis research; digital computer computations may be an integral part of each.

REPRESENTATIVE CURRICULUM (Group WC)

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
PH 1051	Review of Vector Mechanics and Optics	4-2
EE 2101	Principles of Electrical Engineering	3-2
		14-4

Second Quarter

MA 2121	Differential Equations and Infinite Series	4-0
CH 2001	General Principles of Chemistry	3-2
CH 2401	General Thermodynamics	3-0
EE 2102	Circuit Analysis	4-2
		14-4

Third Quarter

MA 2161	Introduction to Mathematical Physics	4-0
CH 2101	Inorganic Analysis	3-3
CH 2402	Introduction to Physical Chemistry	3-3
PH 2151	Mechanics I	4-0
		14-6

Fourth Quarter

CH 2301	Organic Chemistry I	4-2
CH 2102	Inorganic Chemistry	3-3
CH 2405	Physical Chemistry Topics	4-3
PH 2251	Waves and Particles	4-2
		15-10

Fifth Quarter

CH 2302	Organic Chemistry II	3-3
CH 3201	Chemical Instruments	3-3
PS 3411	Probability Theory I	4-0
EE 2201	Electronics Survey	4-2
CH 0800	Chemistry Seminar	0-1
		14-9

Sixth Quarter

CH 3301	Physical Organic I	3-0
CH 3101	Advanced Inorganic Chemistry	3-3
CH 3405	Molecular Dynamics	5-0
CS 2100	Introduction to Computers and Programming	4-0
CH 0800	Chemistry Seminar	0-1
		15-4

Seventh Quarter

CH 3403	Chemical Thermodynamics	3-0
CH 0800	Chemistry Seminar	0-1
CH 0810	Thesis Research	0-0
	Graduate Option Elective	3-0
		6-1

Eighth Quarter

CH 3701	Control Analysis for Chemical Systems	3-3
CH 3705	Reaction Motors	3-0
CH 0800	Chemistry Seminar	0-1
CH 0810	Thesis Research	0-0
		6-4

Ninth Quarter

CH 4701	Process Control	3-2
OA 3202	Methods of Operations;Systems Analysis	4-0
CH 0800	Chemistry Seminar	0-1
CH 0810	Thesis Research	0-0
		7-3

Graduate Options

Each student in an advanced program will pursue a graduate option that is consistent with his interests and with the objectives of the curriculum. The option will be in a specialty area in chemistry and consist of the student's thesis research and one related graduate course in chemistry. The specialty areas are:

Chemical Engineering. The chemical engineering specialty includes study of chemical systems such as fuels, plastics, propellants, and explosives that are of practical military concern. Associated work in process control theory deals with problems in operation and control, not only of chemical processes, but, also those associated with other systems such as missile guidance, aircraft, and ship control. Applied advanced mathematics and both digital and analogue computer techniques form an essential part of this work.

Inorganic Chemistry. This specialty treats the physical and chemical properties of metallic and non-metallic species and the correlation with molecular structure. In particular, chemical reactions are studied as to nature, extent, energetics and velocity, with applications useful for the synthesis of new materials.

Chemistry of Carbon. This specialty leads to an understanding of the processes of importance in carbon-based systems (organic chemistry) such as explosives, fuels and plastics. It develops the significant parameters in the molecular design and utilization of these and other organic materials. Techniques of modern instrumentation such as infrared, ultraviolet and mass spectrometry and nuclear magnetic resonance measurements are an essential part of these studies.

Chemical Physics. The chemical physics specialty is interdisciplinary, integrating physical measurements with theoretical developments in the areas of both chemistry and physics. The study involves quantum chemistry, statistical mechanics, and molecular spectroscopy. Thesis research is an independent study of the microscopic and macroscopic structure and behavior of matter. This may involve measurements in any part of the electromagnetic spectrum from radio frequency and microwaves to far ultraviolet and x-rays.

ORDNANCE SYSTEMS ENGINEERING (ELECTRICAL ENGINEERING) CURRICULUM

leading to the degree Master of Science in Electrical Engineering

OBJECTIVE – To educate officers in the fundamentals of electrical engineering technology and its application to modern ordnance. Basic principles of electronics, electromagnetic theory, and control theory provide a starting point for advanced study and thesis research in modern feedback control theory, information transfer theory, and electronic systems including radar, sonar, missile guidance, and computers. Graduates of this program will have the technical competence required in the research, design, development, production, maintenance, and operation of advanced electronic and electromechanical systems.

REPRESENTATIVE CURRICULUM (Group WX)

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
PH 1051	Review of Vector Mechanics and Optics	4-2
EE 2101	Principles of Electrical Engineering	3-2
		14-4

Second Quarter

MA 2121	Differential Equations and Infinite Series	4-0
CS 2110	Introduction to Computer Processes	3-2
EE 2211	Electronic Engineering Fundamentals I	4-2
EE 2102	Circuit Analysis	4-2
		15-6

Third Quarter

MA 2172	Complex Variables	4-0
MA 2161	Introduction to Mathematical Physics	4-0
EE 2212	Electronic Engineering Fundamentals II	4-3
EE 2103	Linear Systems Analysis	4-2
		16-5

Fourth Quarter

PH 2241	Waves and Particles	4-0
EE 2810	Digital Machines	3-3
EE 2216	Pulse and Digital Circuits	4-3
EE 2114	Communication Theory I	4-0
		15-6

Fifth Quarter

PH 2641	Atomic Physics	4-2
EE 2621	Introduction to Fields and Waves	4-1
EE 2217	Communication Circuits	4-3
EE 2411	Control Systems	3-3
EE 0951	Thesis Seminar	0-1
		15-10

Sixth Quarter

EE 4121	Advanced Network Theory I	3-2
EE 3622	Electromagnetic Theory	3-0
EE 3215	Microwave Devices	4-2
PS 3411	Probability Theory I	4-0
EE 0951	Thesis Seminar	0-1
		14-5

Seventh Quarter

EE 4433	Advanced Radar Systems	3-2
EE 4571	Statistical Communication Theory	3-2
OA 3202	Methods of Operations/Systems Analysis	4-0
EE 0951	Thesis Seminar	0-1
	Graduate Option Elective	3-2
		13-7

Eighth Quarter

EE 4473	Missile Guidance Systems	3-1
EE 0951	Thesis Seminar	0-1
EE 0810	Thesis Research	0-0
	Graduate Option Elective	3-2
		6-4

Ninth Quarter

EE 4481	Electronic Warfare Techniques and Systems	3-2
EE 0951	Thesis Seminar	0-1
EE 0810	Thesis Research	0-0
	Graduate Option Elective	3-2
		6-5

Graduate Options

Each student in an advanced program will pursue one or more graduate options each consisting of at least two graduate courses in a specialty area in Electrical Engineering and related disciplines that is consistent with the student's interests and the objectives of the curriculum. Typical MS and EE programs include three and twelve option elective courses respectively. The specialty areas are:

Control Theory. The control theory specialty is designed to provide the student with an understanding of modern methods used in weapon control systems. The concepts and techniques studied are applied to guided missile technology, pursuit-evasion strategies, optimal control policies, and estimation and identification as employed in automatic target tracking and navigational systems.

Electronic Systems. The electronic systems specialty affords students the opportunity for advanced study in the physical principles and processes underlying the operation of modern electronic devices, signal and data processing techniques, electronic circuit design, and systems engineering. These studies are then applied to the understanding of modern electronic systems such as radar, sonar and electronic countermeasure equipments.

Communication and Information Theory. This specialty includes advanced studies in information transfer, signal and data processing, antennas and propagation, and circuit design. These studies are then applied to the understanding of how information is handled in modern systems such as radar, sonar, digital computers, and electronic countermeasure equipments.

ORDNANCE SYSTEMS ENGINEERING (AIR/SPACE PHYSICS) CURRICULUM

Leading to the degree
Master of Science in Physics

OBJECTIVE – To develop the officers' ability to deal effectively with a broad spectrum of applied technical problems through a study of the fundamental physical processes common to these applications. This is accomplished by a broad coverage of the basic physical principles combined with advanced courses and independent research in one area of specialization. The basic physics courses cover three broad areas (a) mechanics and thermodynamics including the particle, continuum and statistical aspects; (b) classical electricity and magnetism through electromagnetic radiation theory and (c) modern physics including atomic and nuclear, quantum mechanics and space physics.

REPRESENTATIVE CURRICULUM (Group WP)

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
PH 1051	Review of Vector Mechanics and Optics	4-2
EE 2101	Principles of Electrical Engineering	3-2
		14-4

Second Quarter

MA 2121	Differential Equations and Infinite Series	4-0
CS 2100	Introduction to Computers and Programming	4-0
PH 2151	Mechanics I	4-0
EE 2102	Circuit Analysis	4-2
		16-2

Third Quarter

MA 2161	Introduction to Mathematical Physics	4-0
MA 2172	Complex Variables	4-0
PH 2152	Mechanics II	4-0
EE 2201	Electronics Survey	4-2
		16-2

Fourth Quarter

PH 2351	Electromagnetism I	4-0
PH 2551	Thermodynamics	3-0
PS 3411	Probability Theory I	4-0
PH 2251	Waves and Particles	4-2
		15-2

Fifth Quarter

PH 2352	Electromagnetism II	3-0
AE 3043	Fundamental Concepts of Gas Dynamics	3-2
PH 3951	Introduction to Quantum Mechanics	4-0
PH 3651	Atomic Physics	4-2
PH 0999	Physics Colloquium	0-1
		14-5

Sixth Quarter

PH 4353	Electromagnetism III	3-0
PH 3561	Introductory Statistical Physics	4-0
OA 3202	Methods of Operations/Systems Analysis	4-0
PH 3652	Elements of Molecular, Solid State and Nuclear Physics	4-2
PH 0999	Physics Colloquium	0-1
		15-3

Seventh Quarter

PH 4661	Plasma Physics I	4-0
PH 4630	Space Physics I (Upper Atmosphere)	4-0
PH 3157	Physics of Continua	4-0
PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
		12-1

Eighth Quarter

AE 3951	Dynamics of Real Gas Flow	4-0
PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
	Graduate Option Elective	4-0
		8-1

Ninth Quarter

PH 0999	Physics Colloquium	0-1
PH 0810	Thesis Research	0-0
	Graduate Option Elective	4-0
	Graduate Option Elective	4-0
		8-1

Graduate Options

Each student in an advanced program will pursue one or more graduate options each consisting of at least two graduate courses in a specialty area in physics and related disciplines that is consistent with the student's interests and the objectives of the curriculum. The specialty areas are:

Space Physics. This specialization concentrates on those fundamental physical processes in the Earth's upper atmosphere and interplanetary space whose understanding is essential to the solution of many applied problems, such as re-entry physics, communication blackouts due to the naturally or artificially disturbed ionosphere, and energy propagation and dissipation at high altitudes.

Plasma Physics. This specialization concentrates on the collective phenomena of ionized media, in which the continuum properties of the assembly of particles are dominant; such phenomena include interaction of plasma with a magnetic field and the occurrence, propagation and dispersion of waves in inhomogeneous plasma. These topics are basic to an understanding of the formation of the ionosphere, ionospheric communication, whistler propagation, re-entry communication, plasma propulsion, MHD power generation and fusion power.

Nuclear Physics. This specialization provides the students with a deeper understanding of basic nuclear processes and phenomena. It acquaints him with the equipment used in nuclear research, especially as needed by an officer to understand the applications of nuclear physics to various branches of current technology.

Radiation Effects (Solids). This specialization concentrates on the effects of radiation on the physical properties of solids and on the operations of solid-state devices. Applications are to micro-electronic devices and to other devises in current use.

Solid State. In solid state physics a wealth of topics is studies such as lasers, quantum electronics, the structure of crystals, together with their thermal, optical, and acoustic properties, superconductivity, magnetic phenomena, the physics of semiconductors along with their application in various devices, and the electronic properties of metals and insulators. Active research programs are being carried out in several of these areas.

UNDERWATER PHYSICS SYSTEMS CURRICULUM NUMBER 535

OBJECTIVE — To provide officers with a thorough understanding of those aspects of fundamental science and electrical engineering associated with antisubmarine warfare. Program coverage includes such areas as: propagation of sound in the sea, transducer theory, signal processing, electronics, and noise and vibration control.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree with better than average grades in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics and one year of chemistry is considered to be minimal preparation.

DESCRIPTION — Classes convene annually in September. The curriculum is interdisciplinary with courses drawn principally from the fields of physics and electrical engineering. Depending on his academic ability and the length of his availability at the School each officer may enter a curriculum leading to the degree of Bachelor of Science (BS) in Electrical Engineering, Master of Science (MS) in Engineering Acoustics, Electrical Engineer (EE), or Doctor of Philosophy (Ph.D). In the advanced programs thesis research may be done in the fields of acoustics, hydrodynamics, signal processing, or systems engineering.

Normally the BS program is seven quarters long, the MS program nine quarters, the EE program twelve quarters, and the Ph.D. program four years. Students selected for the EE program will complete the courses in the MS program and approximately ten additional electives principally in Electrical Engineering. In addition, for those officers who can report early, the curriculum is preceded by a six-week refresher period which consists of non-credit courses in basic mathematics, physics, chemistry, and FORTRAN programming The refresher period and the first four quarters of the curriculum are designed to bridge the gap from previous studies and to provide the undergraduate background necessary for the subsequent advanced courses and thesis research. Portions of all of this undergraduate study may be omitted by the better academically prepared officers to shorten their time on board or permit study of a variety of graduate level electives. On arrival at the School each officer will be counseled and a personalized curriculum will be constructed to fit his individual needs.

This curriculum is available under the Immediate Graduate Education Program for qualified USNA, OCS and NROTC graduates who have majored in Electrical Engineering and are motivated toward immediate continued education at the graduate level. (BuPers Inst 1520.103 pertains)

Classes convene in July for this one-year program which consists of thesis research and eleven graduate courses that provide a coverage approximately equivalent to Quarters Four through Seven in the normal nine-quarter MS curriculum. Successful completion of this program leads to the award of the degree MS in Engineering Acoustics.

U.S. Navy unrestricted line officer (aviation) will be assigned the subspecialty qualification code 8103P upon completion of the program. Other U.S. Navy unrestricted line officers may choose either the 8205P or 8305P code upon completion.

REPRESENTATIVE CURRICULUM (Group UX)

First Quarter

MA 1100	Calculus Review	4-0
MA 2045	Introduction to Linear Algebra	3-0
EE 2101	Principles of Electrical Engineering	3-2
PH 1051	Review of Vector Mechanics and Optics	4-2
		14-4

Second Quarter

MA 2121	Differential Equations and Infinite Series	4-0
MA 2161	Introduction to Mathematical Physics	4-0
EE 2102	Circuit Analysis	4-2
EE 2211	Electronic Engineering Fundamentals I	4-2
		16-4

Third Quarter

PH 2151	Mechanics I	4- 0
MA 2172	Complex Variables	4- 0
EE 2103	Linear Systems Analysis	4- 2
EE 2212	Electronic Engineering Fundamentals II	4- 3
		16- 5

Fourth Quarter

PH 3451	Fundamental Acoustics	4- 1
EE 2621	Introduction to Fields and Waves	4- 1
EE 2114	Communication Theory I	4- 0
MA 2232	Numerical Methods	4- 0
		16- 2

Fifth Quarter

PH 3452	Underwater Acoustics	4- 2
EE 3622	Electromagnetic Theory	3- 0
PS 3411	Probability Theory I	4- 0
PH 3157	Physics of Continua	4- 0
PH 0499	Acoustics Colloquium	0- 1
		15- 3

Sixth Quarter

PH 4453	Propagation of Waves in Fluids	4- 0
PH 4455	Advanced Acoustics Laboratory	0- 3
EE 4571	Statistical Communication Theory	3- 2
PH 4454	Transducer Theory and Design	3- 2
EE 0951	Thesis Seminar	0- 1
		10 -8

Seventh Quarter

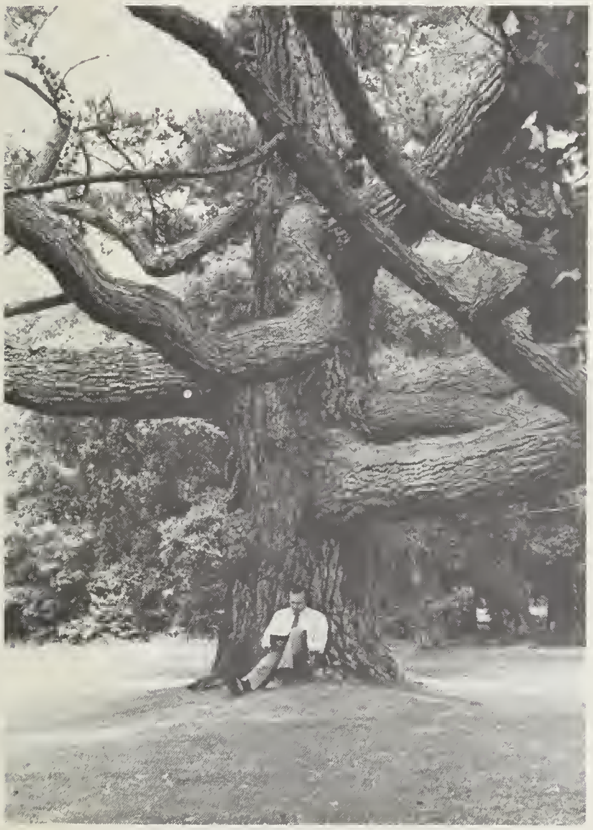
OC 3221	Descriptive Oceanography	4- 0
EE 4451	Sonar Systems Engineering	4- 2
EE 4541	Signal Processing	3- 1
EE 0951	Thesis Seminar	0- 1
PH 0810 or EE 0810	Thesis Research	0- 0
		11- 4

Eighth Quarter

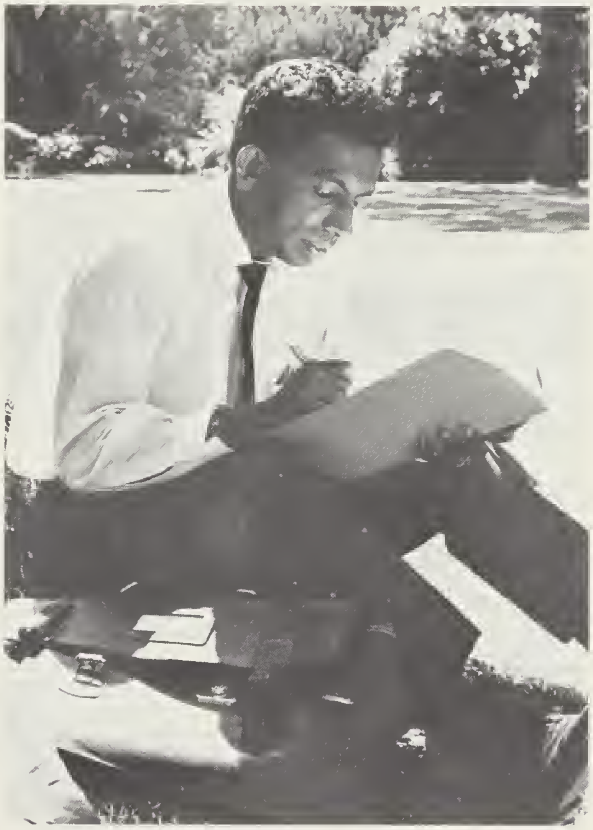
OC 4260	Sound in the Ocean	3- 0
ME 3500	Mechanical Vibrations and Noise Control	4- 0
EE 0951	Thesis Seminar	0- 1
PH 0810 or EE 0810	Thesis Research	0- 0
		7- 1

Ninth Quarter

PH 4456	Seminar in Applications of Underwater Sound	3- 0
OA 3202	Survey of Operations/Systems Analysis	4- 0
PH 0499	Acoustics Colloquium	0- 1
PH 0810 or EE 0810	Thesis Research	0- 0
		7- 0



Campus Scene



Lt. E. Perera, Royal Ceylon Navy, Oceanography Student

CURRICULA CONDUCTED AT CIVILIAN UNIVERSITIES

Curriculum	*Number*	*Length*	*Institution*	*Curricular-Supervisory Control Authority*
Business Administration	810	2 yrs.	Harvard	NAVSUPSYSCOMD
			Stanford	NAVSUPSYSCOMD
Civil Engineering (Advanced)	470	1-2 yrs.	Georgia Tech	NAVFACENGCOMD
Typical Options:			M.I.T.	NAVFACENGCOMD
			Princeton	NAVFACENGCOMD
Structures			Purdue	NAVFACENGCOMD
Soil Mechanics			R.P.I.	NAVFACENGCOMD
Sanitary Engineering			Stanford	NAVFACENGCOMD
Waterfront Facilities			Texas A & M	NAVFACENGCOMD
Facilities Planning			Tulane	NAVFACENGCOMD
Construction Engineering			U. of Cal. (Berkeley)	NAVFACENGCOMD
Civil Engineering Administration			U. of Colo.	NAVFACENGCOMD
Deep Ocean Construction Engineering			U. of Ill.	NAVFACENGCOMD
			U. of Mich.	NAVFACENGCOMD
			U. of Minn.	NAVFACENGCOMD
			U. of Wash.	NAVFACENGCOMD
Electrical/Electronics Engineering (CEC)	471	12-18 mos.	U. of Mich.	NAVFACENGCOMD
			R.P.I.	NAVFACENGCOMD
Financial Management	812	1 yr.	Geo. Wash. U.*	NAVCOMP
Hydrographic Engineering (Geodesy)	475	2 yrs.	Ohio St. U.	OPNAV (OP-09B5)
International Law	672	1 yr.	Geo. Wash. U.*	JAG
International Relations	671	1 yr.	American U.*	BUPERS
			Harvard	BUPERS
Law (Army Judge Advocate Officers Advanced Course)	881	9 mos.	U. of Virginia	JAG
Management and Industrial Engineering	540	1 yr.	R.P.I.	AVORD/AIRSYSCOMD
Mechanical Engineering (CEC)	473	1 yr.	R.P.I.	NAVFACENGCOMD
Naval Construction and Engineering	510	2/3 yrs.	M.I.T.	NAVSHIPSYSCOMD
Nuclear Power Engineering (CEC)	572	18 mos.	Penn. State U.	NAVFACENGCOMD
Nuclear Power Engineering (ED)	520	18 mos.	Penn. State U.	NAVFACGENCOMD/NAVSHIPS
			U. of Mich.	NAVSHIPSYSCOMD
Oceanography	440	2 yrs.	U. of Miami (Florida)*	NPGS
			U. of Washington	NPGS
			Texas A & M	NPGS
			U. of Cal. (San Diego)*	NPGS
			M.I.T.	NPGS
Ocean Law	883	12 mos.	U. of Miami (Florida)*	JAG
Petroleum Administration and Management	880	1 yr.	S.M.U.*	JAG
Petroleum Engineering (CEC)	630	1 yr.	U. of Texas	NAVFACENGCOMD
		6-12 mos.	Industry	
Petroleum Management	811	17 mos.	U. of Kansas	NAVSUPSYSCOMD
Political Science	680	2 yrs.	Fletcher School of Law and Diplomacy, Tufts	OPNAV (OP-61)
			U. of Washington	OPNAV (OP-61)
Procurement Management	815	15 mos.	U. of Mich.	NAVSUPSYSCOMD
		12 mos.	Geo. Wash. U.	NAVSUPSYSCOMD
Public Relations	920	18 mos.	U. of Wisc.	CHINFO
			Boston Univ.	CHINFO
Religion	970	9 mos.	Various	Chief of Chaplains
Retailing	830	1 yr.	Michigan State*	NAVSUPSYSCOMD
Subsistence Technology	860	1 yr.	Michigan State*	NAVSUPSYSCOMD
Systems Inventory Management	819	2 yrs.	Harvard	NAVSUPSYSCOMD
Taxation	882	1 yr.	Geo. Wash. Univ.*	JAG
Transportation Management	813	1 yr.	Mich. State*	NAVSUPSYSCOMD

*No NROTC unit at Institution.

CURRICULA AT OTHER UNIVERSITIES

The curricula listed in this section are conducted entirely at civilian educational institutions. Quotas for enrollment must be approved by the Chief of Naval Personnel. The table indicates the duration of each curriculum, the location, and the curricular supervisory control authority. Administration of officer students in connection with educational matters is exercised by the Superintendent, Naval Postgraduate School, through the commanding Officer , NROTC Unit, or through the Senior Officer Student at those institutions where no NROTC Unit is established

The information on courses is taken from college catalogues, but is subject to change from year to year. Changes depend on scheduling problems at the educational institutions and on the academic backgrounds of students. Further detailed information can be obtained from the catalogue of the institution concerned, or by writing to the institution.

BUSINESS ADMINISTRATION CURRICULUM NUMBER 810

At Harvard University

OBJECTIVE–To give emphasis to the following areas of study: (1) recognition of problems, (2) realistic administrative follow-through on decisions. (3) an understanding and realistic handling of human relations, (4) administrative powers in general, (5) the relationship of business to the government and to the public welfare, (6) the integration of business functions, and (7) the point of view of the Chief Executive and the directors responsible for over-all operations so as to give the student an effective start in the development of his managerial skills and an appreciation of the responsibilities of a business administrator.

Course length: Two years
Degree attainable: Master of Business Administration
Typical Curriculum:

First Year (All courses required)

Elements of Administration:
Finance
Human Behavior in Organizations I and II
Organizational Problems
Managerial Economics, Reporting and Control I and II
Managerial Economics, Reporting and Control III and IV
Marketing
Planning and the Business Environment
Production
Written Analysis of Cases

Second Year (10 half-year courses required)

Business Policy (Required)
Courses in General Business Management
Courses in Industrial and Financial Accounting
Courses in Production/Manufacturing
Courses in Finance/Investment
Courses in Advanced/International Economics
Courses in Personnel Administration/Human Relations
Courses in Marketing/Sales/Merchandising
Courses in Transportation
Courses in Military Management
Courses in Taxation
Courses in Foreign Operations
Courses in Probability and Statistics for Business Decision
Courses in Industrial Procurement

At Stanford University

OBJECTIVE–To give the student a foundation in the following areas: (1) the external environment of the commercial firm, (2) the internal and organizational environment of the firm, (3) quantitative methods and tools of control, and (4) the management of major functions; to give the student an opportunity to apply the knowledge, skills and attitudes acquired to the solution of action-oriented problems involving the entire commercial enterprise

Course length: Two years
Degree attainable: Master of Business Administration
Typical curriculum:

Required –First Year

Organization Behavior
Marketing Management I & II
Quantitative Methods I, II & III
Business Economics I & II
Management Accounting I & II
Business Finance I & II
Manufacturing I & II
Employment Relationships

Second Year

Courses in Industrial and Financial Accounting, Audit Comptrollership
Courses in Production/Manufacturing
Courses in Finance/Investment/Banking
Counrses in Personnel Administration/Industrial Relations
Courses in Marketing/Sales
Courses in Transportation
Courses in Insurance/Risk Management
Courses in Advanced Economics/International Trade
Courses in Research/Small Business Management
Courses in Business Information Systems Data Processing
Courses in Purchasing

CIVIL ENGINEERING (ADVANCED) CURRICULUM NUMBER 470

At:Georgia Institute of Technology
Massachusetts of Technology
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Stanford University
Texas A&M
Tulane University
University of California (Berkeley)
University of Colorado
University of Illinois
University of Michigan
University of Minnesota
University of Washington

OBJECTIVE–To educate officers for civil engineering duties. Options are available in all major fields of civil engineering. Typical options are: construction engineering, structures, soil mechanics, sanitary engineering, waterfront facilities, facilities planning and civil engineering administration. Officers without previous civil engineering education would undertake a two-year curriculum; officers holding a Bachelor of Civil Engineering degree would undertake a one-year curriculum. This program is to qualify line officers (1100) for civil engineering duties and to provide advanced education for Civil Engineering Corps officers (5100).

Course length: One to two years
Degree attainable: Master of Science in Civil Engineering
Typical Curriculum: (For two-year Structures Option)

First Year

Contracts and Specifications
Mathematics
Engineering & Construction Economy
Structures Theory I, II
Elementary Mechanics
Geology for Engineers
Digital Computers
Properties of Soils
Properties of Concrete
Behavior and Design of Metal Structures
Sanitary Engineering Processes

Second Year

Reinforced Concrete Design
Advanced Mathematics
Soil Mechanics
Hydraulics-Surface drainage
Advance Structure Analysis
Behavior of Concrete Members
Applied Soil Mechanics
Special Problems
Structural Design in Metals
Applied Structural Mechanics
Foundation Engineering

ELECTRICAL/ELECTRONICS ENGINEERING (CEC) CURRICULUM NUMBER 471

At: Georgia Institute of Technology
Massachusetts Institute of Technology
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Stanford University
Texas A&M
Tulane University
University of California (Berkeley)
University of Colorado
University of Illinois
University of Michigan
University of Minnesota
University of Washington

Objective: To provide advanced education for selected CEC officers in electrical engineering with emphasis on power plants and electrical utility distribution, and in the field of electronics with options in communications engineering, computer engineering, engineering systems and design, electromagnetic field theory, and microwave engineering.

Course length: 12 to 18 months
Degree attainable: Master of Science in Electrical Engineering/Electronics Engineering

FINANCIAL MANAGEMENT CURRICULUM NUMBER 812

At George Washington University

OBJECTIVE–To develop in officers of mature judgment and a broad background of professional experience the ability to interpret and analyze operational statistics for the purpose of developing standards of performance to provide a periodic review of operations in order to denote areas of management which are not meeting standards; to review budget estimates; and to plan programs for the improvement of management economy and efficiency through better organization, administration and procedures and better utilization of manpower, materials, facilities, funds, and time. The course is designed to give graduates a working knowledge of managerial controls adequate for assignment to financial management duties as a normal preparation for command and executive billets in the shore establishment.

Course length: One year
Degree attainable: Master of Science in Business Administration.
Typical Curriculum:

Undergraduate:

Survey of Accounting
Industrial and Governmental Economics
Statistical Decision Making
Management Communication

Graduates:

Cost Accounting
Managerial Accounting
Internal Control and Auditing
Survey of Data Processing
Financial Management
Seminar in Marketing
Business Organization and Management
Management Engineering
Readings and Conferences in Financial Management
Research Seminar
Research Seminar in Comptrollership
Human Relations in Administration
Governmental Budgeting

HYDROGRAPHIC ENGINEERING (GEODESY) CURRICULUM NUMBER 475

At Ohio State University

OBJECTIVE – To prepare officers for assignment to duties at the Oceanographic Office, on geodetic survey expeditions, and fleet staffs. The curriculum presents a fundamental theoretical knowledge of geodesy, cartography, and photogrammetry, particularly as applied to hydrographic surveying and the compilation and production of charts and maps.

Course length: Two years

Degree attainable: Master of Science in Geology

INTERNATIONAL LAW
CURRICULUM NUMBER 672

At George Washington University

OBJECTIVE–To prepare Judge Advocate General Corps Officers (2500) for duties involving problems of international law. The course encompasses international law and agreements including the law of air, sea, and space legal aspects of U. S. foreign relations, negotiations, and legal regulation of international coercion. A thesis on a topic of significant international law interest is required. In addition, certain studies of a geographic area selected by the student will be conducted.

Course length: One year

Degree attainable: Master of Laws

INTERNATIONAL RELATIONS
CURRICULUM NUMBER 671

At: American University

Harvard University

OBJECTIVE–To provide a broad understanding of the forces and factors in international relations to equip officers to meet responsibilities involving knowledge of the international situation, including awareness of the role of sea power in world affairs.

Course length: One year

Degree attainable: Master of Arts

LAW
CURRICULUM NUMBER 881

(Army Judge Advocate Officers Advanced Course)

At: University of Virginia

OBJECTIVE–To prepare more experienced Judge Advocate General Corps Officers (2500) for advanced staff responsibilities in the various legal fields. The course encompasses all branches of military law with emphasis on the administration of the Uniform Code of Military Justice, military affairs, civil affairs arising out of the operation of or litigation of military law including the laws of war, procurement and contract law, and legal assistance to military personnel.

Course length: Nine months

MANAGEMENT AND INDUSTRIAL ENGINEERING
CURRICULUM NUMBER 540

At Rensselaer Polytechnic Institute

OBJECTIVE – To prepare selected officers for managerial and industrial engineering billets in the Navy's industrial organization. The curriculum majors in industrial engineering and its application to managerial problems.

Course length: One year

Degree attainable: Master of Science in Management Engineering

Typical Curriculum:

Summer

Review of Quantitative Methods
Statistical Methods
Law in Management and Engineering
Data Processing

Fall:

Cost Finding and Control
New Product Problems or
Organization and Management of Marketing
Organization Planning and Development
Industrial Relations
Production Management I

Spring:

Administrative Practice and Behavior
Financial Planning and Control
Seminar in Management
Production Management II
Analytical Methods in Management

MECHANICAL ENGINEERING (CEC)
CURRICULUM NUMBER 473

At Rensselaer Polytechnic Institute

OBJECTIVE – To provide advanced education for selected CEC officers in mechanical engineering with emphasis on power plants, heating and ventilation.

Course length: One year

Degree attainable: Master of Science in Mechanical Engineering

NAVAL CONSTRUCTION AND ENGINEERING
CURRICULUM NUMBER 510

At Massachusetts Institute of Technology

OBJECTIVE – To qualify selected officers for duty assignments in the fields of naval construction and marine engineering. The curricula are arranged to provide a broad capability in naval architecture and an exceptional capability in one option or specialty. Options are available in the following areas: hull design and construction, marine electrical engineering, electronics engineering, ocean engineering, and ship propulsion engineering. Selection of options is made after completion of the first summer term. Exceptional students are encouraged to pursue advanced work at the doctoral level. Successful completion of this curriculum leads to "Engineering Duty" designation (1400) for those officers who request it.

Course length: Two or three years

Degree attainable: Master of Science in Naval Architecture and Marine Engineering, and for students who successfully complete the three-year program, the Degree of Naval Engineer

Typical Curriculum:

(Hull Design and Construction Option)

First Summer:

Strength of Materials and Dynamics
Applied Hydrostatics
Review of Mathematics

First Year:

Structural Mechanics
Fluid Mechanics
Thermodynamics
History of Naval Ships
Advanced Calculus for Engineers
Naval Structural Engineering
Heat Transfer
Introduction to Nuclear Physics
Principles of Naval Architecture
Naval Ship General Arrangements I
Introduction to Probability and Random Variables

Second Summer:

Digital Computer Program Systems
Advanced Calculus for Engineers

Second Year:

Advanced Hydromechanics I and II
Properties of Metals
Naval Structural Theory I and II
Naval Ship Propulsion I
Mechanical Vibration
Naval Ship General Arrangements II
Naval Structural Analysis
Advanced Mechanics
Properties of Metals
Electives: Experimental Hydrodynamics
Naval Structural Design I
Naval Electrical Engineering

Third Summer:

Industrial Tour

Third Year:

Advanced Structural Mechanics
Experimental Stress Analysis
Principles of Ship Design
Principles of Naval Ship Design
Hydroacoustics
Naval Ship Propulsion II
Electives: Naval Structural Design II
Buckling of Structures
Plasticity
Thesis

NUCLEAR POWER ENGINEERING (CEC) CURRICULUM NUMBER 572

At: The Pennsylvania State University
University of Michigan

OBJECTIVE: – To provide education for selected CEC officers in nuclear power engineering. Graduates of this curriculum will normally be assigned duties in the shore nuclear power program under the technical direction of the NAVFACENGCOMD.

Course length: 18 months
Degree attainable: Master of Science

OCEANOGRAPHY CURRICULUM NUMBER 440

At: University of Washington
Texas A&M College
University of Miami (Florida)
University of California (San Diego)
Massachusetts Institute of Technology

OBJECTIVE – To prepare officers for assignment to billets requiring comprehensive theoretical and practical foundation in the various aspects of oceanography. Students may specialize in physical, biological, chemical, or geological oceanography. Entering students are expected to have a baccalaureate degree in physics, mathematics, meteorology, geophysics, or engineering, including the following undergraduate work: mathematics through differential equations (about 20 semester hours), physics (about 25 semester hours), chemistry through quantitative analysis, and introductory courses in biology, oceanography, geology, and meteorology.

Course length: Two years
Degree attainable: Master of Science in Oceanography

PETROLEUM ADMINISTRATION AND MANAGEMENT (Gas, Oil and Water Rights) CURRICULUM NUMBER 880

At Southern Methodist University

OBJECTIVE – To provide Judge Advocate General Corps Officers (2500) with a study of government regulations in oil and gas law taxation problems, and special research and study of the evolution of law concerning water rights, current law affecting these rights, and technical problems attendant thereto so as to prepare them for assignment to billets concerned with the administration and management of the Naval Petroleum and Oil Shale Reserves and with the special problems in the field of water rights.

Course length: One year
Degree attainable: Master of Laws in Oil and Gas

PETROLEUM ENGINEERING (CEC) CURRICULUM NUMBER 630

At University of Texas
and in the petroleum industry

OBJECTIVE – To prepare selected CEC officers for assignments to duty involving the administration and operations of Naval Petroleum and Oil Shale Reserves. The curriculum provides the student with a knowledge of petroleum development and production procedures, geology, petroleum economics and reservoir engineering.

Course length: One year of academic work followed by up to one year in the field with a major oil company
Degree attainable: Master of Science in Petroleum Engineering

PETROLEUM MANAGEMENT CURRICULUM NUMBER 811

At University of Kansas

OBJECTIVE – To provide officers of the Supply Corps graduate level education in the functional proficiency field of petroleum management and administration.

Course length: Seventeen months
Degree attainable: Master of Science
Typical Curriculum:

Fall:

Quantitative Analysis I
Material and Energy
Development of Oil and Gas Lands
Theoretical Principles of Petroleum Production

Spring:

Quantitative Analysis II
Field Practice in Natural Gas
Appraisal of Oil and Gas Properties
Research

Summer:

Personnel Management
Legal Aspects of Business Research

Fall:

Petroleum Management Research

POLITICAL SCIENCE CURRICULUM NUMBER 680

At: The Fletcher School of Law and Diplomacy, Tufts Graduate School of Public Affairs, University of Washington

OBJECTIVE – To equip a limited number of intellectually mature officers with a broad professional background in international relations in order that they may provide professional advice and assistance in the formulation and execution of national policy. Studies should be specifically directed toward obtaining sound knowledge and understanding in:

(1) The theory of international politics, economics, law, and U.S. diplomatic history.

(2) The politics, geography, and history of one of the following regions of the world: Europe, Asia, Africa, Western Hemisphere.

(3) The history, role and importance of world-wide and regional international organizations.

(4) Development and execution of U.S. political, military and economic policy as it pertains to U.S. foreign relations.

Course length: Two years
Degree attainable: Master of Arts

PROCUREMENT MANAGEMENT CURRICULUM NUMBER 815

At University of Michigan

OBJECTIVE – To provide officers of the Supply Corps graduate level education in the field of military and commercial procurement:

Course length: One year
Degree attainable: Master of Business Administration

PUBLIC RELATIONS CURRICULUM NUMBER 920

At University of Wisconsin
Boston University

OBJECTIVE – To provide advanced qualifications of officers in the field of public relations. Officers selected for program must have previous education or experience in public information and public relations. The curriculum will be made up from regular course offerings of the university and will be based on an officer student's background and particular interest within the curricular area.

Course length: One year to 18 months
Degree attainable: Master of Arts in Public Relations

RELIGION CURRICULUM NUMBER 970

At: Harvard University
Yale University
Catholic University
University of Chicago
University of Notre Dame
Fordham University
Union Theological Seminary

OBJECTIVE – To broaden the education of officer students in such fields as psychology, theology, homiletics, and counseling, hospital ministry and education.

Course length: 9 months

RETAILING CURRICULUM NUMBER 830

At Michigan State University

OBJECTIVE – To provide officers of the Supply Corps with graduate level education in the functional proficiency field of retailing. Emphasis is placed on consumer markets, sales promotion, merchandise and merchandising, and the management functions associated therewith.

Course length: One year
Degree attainable: Master of Business Administration

SUBSISTENCE TECHNOLOGY CURRICULUM NUMBER 860

At Michigan State University

OBJECTIVE – To provide officers of the Supply Corps with graduate level education in the field of food management.

Course length: One year
Degree attainable: Master of Business Administration

SYSTEMS INVENTORY MANAGEMENT CURRICULUM NUMBER 819

At Harvard University

OBJECTIVE – To provide officers of the Supply Corps with a well-grounded education at the graduate level in the scientific methods of inventory management.

Course length: Two years
Degree attainable: Master of Business Administration
Typical curriculum:

First Year (Required)
Elements of Administration:

Finance
Human Behavior in Organizations I and II
Organizational Problems
Managerial Economics, Report, and Control I and IV
Managerial Economics, Reporting and Control II and III
Marketing
Planning and the Business Environment
Production
Written Analysis of Cases

Second Year: (Required)

Management Information Systems
Business Logistics
Financial Accounting I and II
Seminar in Military Marketing and Project Management

Second Year: (Electives) (Four to be selected)

Cost Administration
Industrial Procurement
Managing Technological Change
Planning and Controlling Production
*Analysis of Quantitative Data I and II
*Probability and Statistics for Business Decision I and II
*Topics in Operations Analysis I and II
*Management Economics

*Prerequisite –Mathematics through Differential Calculus

TRANSPORTATION MANAGEMENT CURRICULUM NUMBER 813

At Michigan State University

OBJECTIVE – To provide officers of the Supply Corps with graduate level education in the functional proficiency field of transportation management.

Course length: One year
Degree attainable: Master of Business Administration

Typical Curriculum:

Basic Accounting II
Financial Management
Basic Marketing
Basic Statistics I
Accounting for Financial and Profit Management II
Problems in Business Economics
Basic Statistics II
Transportation Policy
Accounting for Financial and Profit Management III
Human Problems in Administration
Social Problems in Administration
Marketing Management
Transportation Seminar

ACADEMIC DEPARTMENTS
and
COURSE DESCRIPTIONS

☆

DEPARTMENT OF AERONAUTICS

Richard William Bell, Professor of Aeronautics; Chairman (1951),* A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

Wendell Marois Coates, Professor Emeritus and Distinguished Professor (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

George Judson Higgins, Professor Emeritus (1942); B.S. in Eng. (AeE), Univ. of Michigan, 1923; AeE., 1934.

Henry Lebrecht Kohler, Professor Emeritus (1943); B.S. in M.E., Univ. of Illinois, 1929; M.S. in M.E., Yale Univ., 1930; M.E., 1931.

Robert Edwin Ball, Associate Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

James Allan Jamieson Bennett, Visiting Professor of Aeronautics (1969); B.S., Univ. of Glasgow, 1923; M.A., 1926; Ph.D., 1927; D.I.C., London, 1927; D. Sc., Univ. of Glasgow, 1939.

Oscar Biblarz, Assistant Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S., 1963; Ph.D., Stanford Univ., 1968.

Daniel Joseph Collins, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

Theodore Henry Gawain, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

Ulrich Haupt, Associate Professor of Aeronautics (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

Charles Horace Kahr, Jr., Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

Donald Merrill Layton, Associate Professor of Aeronautics (1965); B.S., Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954.

Gerald Herbert Lindsey, Associate Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ. 1960; M.S., 1962; Ph.D., California Institute of Technology, 1966.

James Avery Miller, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., 1957; Ph.D., Illinois Institute of Technology, 1963.

David Willis Netzer, Assistant Professor of Aeronautics, (1968); Net B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ., 1962; Ph.D., 1968.

Louis Vincent Schmidt, Associate Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

Michael Hans Vavra, Distinguished Professor of Aeronautics (1947); Dipl. Ing., Swiss Federal Institute of Technology, 1934; Ph.D., Univ. of Vienna, 1958.

Robert Diefendorf Zucker, Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

*The Year of joining the Postgraduate School Faculty is indicated in parentheses.

AERONAUTICAL LABORATORIES

Seven major laboratory divisions facilitate instructional and research programs in subsonic aerodynamics, structural test, rocket propulsion, cascades and turbomachinery, flight mechanics, gasdynamics, and jet engines.

The subsonic aerodynamics laboratory consists of two low-speed continuous flow wind tunnels and a large continuous flow smoke tunnel. Standard techniques are used in the 32x45 inch and 42x60 inch wind tunnels to measure quantities such as steady and unsteady velocity pressure, loads, and hinge moments to study basic fluid flows about bodies, stability and control of aerodynamic vehicles, and unsteady flows about bluff bodies and lifting surfaces. The three-dimensional smoke tunnel has a basic test section of 5x5x12 feet expandable to 15x15x12 feet. The smoke filaments are pulsed and may be studied stroboscopically and photographed to define the flow field in a variety of applications.

The structural test laboratory contains testing machines with varying capacities up to 600,000 pounds for demonstration and analysis of relatively small structures. Large aircraft components such as a P2V wing, an F8U-2 wing, and an A3D tail are accommodated on the special loading floor of the laboratory where static and vibration tests are carried out. An adjacent strain-gage and instrumentation laboratory is employed for instruction in structural testing techniques. A well equipped dynamics laboratory contains shaker tables, analog computers, and associated electronic instrumentation. Class work and research are conducted in various areas of applied mechanics such as non-linear structural dynamics, elastic wave propagation, and dynamic transfer function evaluation.

The rocket laboratory consists of an instrumented control room, a propellant chemistry laboratory, a high pressure air facility which provides dry, filtered air to 3500 psia, and three test cells for operation of solid, liquid, gaseous, and hybrid rocker motors. Tests may be conducted on a large centrifuge to pressures of 1500 psia, and to accelerations of 2000g. A photographically equipped centrifuge, a bi-phase rocket motor and a gas chromatograph are also in operation.

The advanced facilities of the cascade and turbomachinery laboratories are distributed in three buildings, one of which provides low speed tests with rectilinear cascades of large dimensions. The source of air is a 700 HP fan, either to draw or to blow air through the test items, which delivers about 100,000 cfm of air at a pressure difference of about 40 inches of water. This source can be used also to perform model tests with flow channels, inlet and discharge casings, scrolls and diffusors. The special rectilinear cascade test rig is equipped with semi-automatic instrumentation; data are obtained with an electronic logging system for data reduction on digital computers.A second building houses a centrifugal compressor test rig, instrumented for conventional performance measurements and for special investigations of three-dimensional flows about both the stationary and the rotating vanes. The third building is used for high speed tests, in three test cells, monitored from a central control room. A 1250 HP variable–speed axial-flow compressor, which is instrumented also for interstage measurements, produces high pressure air either for turbine testing, or to drive test compressors, pumps, and other test items. This building contains many different types of turbomachinery including a 3-stage axial flow compressor, a transonic axial test rig with vacuum exhauster system, a radial turbine test rig, turbomachinery including a 3-stage axial flow compressor, a transonic axial turbine test rig with vacuum exhauster system, a radial turbine test rig, a transonic compressor test rig, a critical shaft speed test bench, a 3-stage centrifugal compressor and a radial compressor test rig. An adjacent control room contains a complete data acquisition system. Adjacent to the third building is a hotspin test unit, where disks and propellers can be rotated at speeds up to 50,000 rpm. Heating and cooling elements make it possible to impose radial temperature gradients. Instrumentation is provided to conduct stress work, with strain gauges, up to 27,000 rpm and at maxumum temperatures of 1800°F. Also available are a probe calibration tunnel with annular cross section for the calibration of pressure and hot-wire probes and a two phase flow test rig for direct measurement of wall shear stress.

The flight mechanics laboratory utilizes an instrumented Navy US–2A aircraft, based at NALF Monterey, for classroom and research projects. In addition, a jet instrument trainer has been modified into a cockpit simulator suitable for use in problems of variable stability. This simulator is used in conjunction with the Electrical Engineering Department's hybrid computer. An additional simulator has been constructed and is being utilized with the Aeronautics Department's analog computer to study pilot reaction to rigid and movable control sticks.

The gas dynamics laboratory includes a blow-down supersonic wind tunnel having a 4x4 inch test section and an operating Mach number range from 1.4 to 4. Instruments associated with this facility include 6" and 9" Mach Zehnder interferometers and 5" and 9" Schlieren systems for flow observations. A cold-driven, three inch, double-diaphragm shock tube has been constructed for measurement of the thermal conductivity of noble gases and for the study of vibration relaxation, gas dissociation, and ionization. He-Ne, Argon, and CO_2 lasers are utilized in various experiments including a Gaertner-Jeong holography system. An electrohydrodynamic research facility in which electric power generation and turbulence are being studied, and a coaxial plasma accelerator, have recently been completed. Another facility is an open circuit oscillating flow wind tunnel, two feet square and 18 feet long, in which nearly sinusoidal perturbations may be superimposed on the free stream flow by means of a series of four synchronously driven rotating shutters; frequencies of 0.1 to 250 cps may be obtained. Principal instrumentation available for this tunnel is a ten channel constant-temperature linearized hot-wire anemometer.

The jet engine laboratory provides full scale operation of current and future Naval aircraft jet engines. Two complete test cells are available, one for testing turboprop engines and the other for testing turbojet engines, operated from an adjacent control room. A separate engine maintenance shop is located adjacent to the test cells.

In addition, a computation laboratory has been set up to facilitate analytical solutions of classroom and research problems. A remote console for the Naval Postgraduate School IBM 360-67 computer is available, together with Wang calculator consoles and other desk calculators.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of these degrees as by the Aeronautics Department. In addition the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement to these programs is a baccalaureate degree in engineering or science, with minimum coverage in basic prerequisite sciences in semester hours as follows: mathematics (20), basic engineering (30), electrical engineering (14), physics (8), and chemistry (8). Students entering with approved standing, but following a significant lapse in continuity with previous academic work, normally will take refresher courses in engineering fundamentals and mathematics at the upper division level before entering into the degree program.

Final approval of programs leading to degrees in Aeronautical Engineering is to be obtained from the Chairman, Department of Aeronautics.

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

Students who do not enter candidacy for an advanced degree may earn the Bachelor of Science in Aeronautical Engineering degree in an approved curriculum including a minimum of 60 credits in courses 3000-3999, to be drawn from the four required fields: mathematics, flight structures, flow dynamics, and flight systems technology. These courses normally begin following two quarters of refresher work in fundamentals. Coverage in mathematics will include one course in addition to vector analysis, preferably in probability and statistics. The degree of emphasis among other fields may be varied but must include modern developments in performance and control of aerospace vehicles, in gas dynamics, and in systems design. In addition to mathematics a minimum of 8 credits in courses 2000-3999 usually will be taken outside the major department.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

1. Students who have a major in aeronautics, and who have earned the baccalaureate degree in the previous year, may apply for admission directly to graduate status. Other students normally will be selected to graduate standing at the end of three quarters in residence.

2. The Master of Science in Aeronautical Engineering degree requires a minimum of 36 graduate course credits to be completed following selection to graduate standing, at least 20 of them in courses 4000-4999, plus an acceptable thesis (this requirement may be waived by the Chairman, Department of Aeronautics; accordingly, the minimum number of required graduate course credits will be increased to 44). An acceptable thesis for the Engineer's Degree may also be accepted as meeting the thesis requirements of the Master's Degree. At least one advanced mathematics course in

addition to vector calculus is required. Core courses normally will be included in engineering dynamics, continuum mechanics and boundary layer flows.

3. The courses of study may be arranged in consultation with the thesis advisor to meet the needs of the research program. Excessive specialization is not encouraged, but it is expected that beyond the core subjects the candidate will concentrate on two related sequences in Aeronautics plus prerequisite extra-departmental courses.

AERONAUTICAL ENGINEER

1. Students entering with a time lapse since earning a baccalaureate degree in engineering or science can earn the Aeronautical Engineer degree in three years. Admission to candidacy for this degree occurs during the second year of residence, following completion of the Aeronautics graduate examination.

2. This degree requires a minimum of 76 graduate course credits to be completed following selection to graduate standing, normally to include graduate core coverage as listed under the Master's degree, plus an acceptable thesis. An acceptable thesis for the Engineer's Degree may also be accepted as meeting the thesis requirements of the Master's Degree. Not less than 36 of these graduate credits must be in courses 4000-4999; aeronautics credits to be counted in this total must also be in courses 4000-4999. The program of study will be developed for each student in consultation with his thesis advisor. A variety of subjects to provide a broad foundation in aero-space science, and in engineering applications suitable to the major specialty, generally will be required.

DOCTOR OF PHILOSOPHY

Entrance into the doctorate program may be requested by officers currently enrolled who have completed the Aeronautics graduate examination with a sufficiently high standing. An oral screening examination will be scheduled by the Department Chairman, to be conducted by members of the Department whom he selects. Eligibility in the program must be established by the petitioner's performance in this screening examination, before the additional time required of his assignment to the School can be determined. Thereafter the requirements to be met are as outlined under the section on general information at the front of the Catalogue. Programs are currently offered in gasdynamics, flight structures, propulsion, and aerospace physics.

The Department also accepts officer students selected in the Navywide Doctoral Study Program, and civilian students selected in the School's Cooperative Doctoral Program with the Navy and other Defense Laboratories. These students will have had prior Master's degrees in science or engineering. They must also further demonstrate their eligibility in the Aeronautics doctorate program subsequent to enrollment, in both the written graduate examination and the oral screening examination.

AERONAUTICS

Unless otherwise stated the common core of courses listed on page 67 for the first three quarters, or equivalent preparation to be approved by the Chairman, Department of Aeronautics, is prerequisite to all other aeronautics courses. It is also advisable that the review courses AE 0110 and MA 0110 precede the common core of courses.

AE 0010 AERONAUTICAL ENGINEERING SEMINAR (0-2) Oral presentations of material not covered in formal courses. Topics cover a wide spectrum of subjects ranging from reports of current research to survey treatments of fields of scientific and engineering interest.

AE 0110 REVIEW OF STATICS AND ELEMENTARY STRENGTH OF MATERIALS (4-4) A special six-week course to review the principles of statics of rigid bodies and pin-connected trusses; stress, strain and Hooke's law; simple tension, compression, and shear. Properties of areas and volumes, and of materials. TEXT: Beer and Johnson, *Mechanics for Engineers, Statics.*

AE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

AE 2021 AERO-STRUCTURES I (3-2) Multi-dimensional concepts of stress and strain, mechanical behavior of materials, structural idealization, bending and torsional stress analysis of typical aero-structural components. TEXT: Rivello, *Theory and Analysis of Flight Structures.*

AE 2022 AERO-STRUCTURES II (3-2) Introduction to energy methods, deflection analysis of aero-structures, statically indeterminate structures, and stability of bean-columns. TEXT: Rivello, *Theory and Analysis of Flight Structures.* PREREQUISITE: AE 2021.

AE 2031 VEHICLE AERODYNAMICS I (3-2) Kinematic principles, dynamics of particles, conservation laws; aircraft vehicle performance including range, endurance, climb rate, take-off and landing. TEXTS: Greenwood, *Principles of Dynamics* and Houghton and Brock, *Aerodynamics for Engineering Students.*

AE 2032 VEHICLE AERODYNAMICS II (3-2) Elements of two-dimensional flow, this airfoil theory, finite wing theory, static aeroelastic effects on wing loads. TEXT: Houghton and Brock, *Aerodynamics for Engineering Students.* PREREQUISITE: AE 2031, AE 2041.

AE 2041 BASIC FLUID MECHANICS (3-2) Elementary fluid mechanics. Properties of fluids, fluid statics, dimensional analysis and dynamic similarity; principles of continuity, energy, and momentum; losses in internal flow systems, laminar and turbulent flow regimes; flow measurement; introduction to boundary layers, pressure and friction drag. TEXT: Pao, *Fluid Mechanics.*

AE 2042 ENGINEERING THERMODYNAMICS (3-2) Fundamental concepts of thermodynamics. Equations of state, properties of pure substances, property relations; first and second laws of thermodynamics, entrophy, irreversibility, availability; non-reactive mixtures; power cycle analysis. TEXT: Saad, *Thermodynamics for Engineers.*

AE 2801 INTRODUCTION TO AERO-LABORATORIES (0-3) An introduction to modern experimental techniques and instrumentation. Lectures, demonstrations and simple experiments in the use of sensing devices, intermediate components, readout and recording devices. Evaluation of errors, data reduction and analysis, report writing. Familiarization with aeronautical engineering facilities. TEXTS: Holman, *Experimental Methods for Engineers* and Schenck, *Theories of Engineering Experimentation.*

Upper Division or Graduate Courses

AE 3015 ENGINEERING DYNAMICS (3-2) Lagrange's equations for particle systems; rigid body dynamics and the inertia tensor; Euler equations. Introduction to vibration theory and the eigenvalue problem. TEXT: Greenwood, *Principles of Dynamics* PREREQUISITE: AE 2031.

AE 3033 VEHICLE AERODYNAMICS III (3-2) Principles of longitudinal, lateral, and directional static stability and control of aircraft; single degree of freedom analysis; dynamic stability concepts of aircraft, analog computer techniques. TEXTS: Houghton and Brock, *Aerodynamics for Engineering Students* and Seckel, *Stability and Control of Airplanes and Helicopters.* PREREQUISITE: AE 2032.

AE 3043 FUNDAMENTAL CONCEPTS OF GASDYNAMICS (3-2) The dynamics and thermodynamics of compressible fluid flow. One-dimensional isentropic flow, normal and oblique shocks, Prandtl-Meyer flow; Fanno and Rayleigh flows. Applications to aeronautics. TEXT: Rotty, *Introduction to Gas Dynamics* or John, *Gas Dynamics.* PREREQUISITE: AE 2042.

AE 3331 FLIGHT EVALUATION TECHNIQUES I (2-0) Quantitative and qualitative techniques for evaluation of aircraft performance in flight. Data acquisition systems. Course work supported by AE 3831, a flying laboratory in Naval Aircraft. TEXTS: NATC Performance Test Manual and NATC Engine Performance Manual.

AE 3332 FLIGHT EVALUATION TECHNIQUES II (2-0) Techniques for evaluation of aircraft static and dynamic stability and control characteristics. Course work supported by AE 3832, a flying laboratory in Naval Aircraft. TEXTS: NATC Stability and Control Manual and Mil Spec Mil-F-8785A. PREREQUISITE: AE 3331.

AE 3811 SOLID MECHANICS LABORATORY (0-3) Selected experiments in the areas of aero-structures and dynamics. TEXT: Dally and Riley,*Experimental Stress Analysis*. PREREQUISITES: AE 2022, AE 3015 concurrently.

AE 3831 FLIGHT EVALUATION TECHNIQUES LAB I (0-4) In-flight investigations of the technical aerodynamics of aircraft pertinent to performance evaluation. PREREQUISITE: AE 3331 concurrently.

AE 3832 FLIGHT EVALUATION TECHNIQUES LAB II (0-4) In-flight investigations of the technical aerodynamics of aircraft pertinent to static and dynamic stability and control. PREREQUISITE: AE 3332 concurrently.

AE 3851 GASDYNAMICS LABORATORY (0-3) Selected experiments in the areas of subsonic and supersonic compressible fluid flow. TEXTS: Pope, *Wind Tunnel Testing* and Keenan and Kay, *Gas Tables*. PREREQUISITES: AE 2032, AE 3043.

AE 3911 AEROSTRUCTURAL PERFORMANCE (3-2) Strength of structural elements and composite structures. Engineering problems in instability. Introduction to matrix methods of aerostructures and analysis. TEXT: Rivell, *Theory and Analysis of Flight Structures.*

AE 3931 FLIGHT DYNAMICS (3-2) Static and dynamic stability of aircraft, stick-fixed and stick-free; control force and displacement; general and transient motions; cross-coupling; effects of changes in variables; aeroelastic effects. TEXTS: Houghton and Brock, *Aerodynamics for Engineering Students* and Etkin, *Dynamics of Flight, Stability and Control.*

AE 3932 FUNDAMENTALS OF AUTOMATIC CONTROLS (3-2) Requirements for automatic controls of aircraft; basic techniques for achieving and evluating satisfactory aircraft control systems. TEXTS: Clark, *Introduction to Automatic Control Systems* and Etkin, *Dynamics of Flight, Stability and Control.*

AE 3941 HEAT TRANSFER (3-2) Elements of heat transfer including steady and nonsteady conduction, free and forced convection, heat transfer with change in phase, thermal radiation dimensional analysis, numerical and analog methods. TEXT: Holman, *Heat Transfer.*

AE 3942 FLIGHT PROPULSION (3-2) Basic mechanics of thrust by propellers, rotors, jets and rockets. Momentum and blade element theory of propellers. Thermodynamic analysis of reciprocating engines, turbo-jets, turbo-props, turbo-fans, ramjets and chemical rockets. TEXT: Hesse and Mumford, *Jet Propulsion for Aerospace Applications.*

AE 3951 DYNAMICS OF REAL GAS FLOW (4-0) The fundamentals of high-speed, high-temperature flow of a gas. Analysis will involve the consideration of an ideal dissociated gas as well as of ionization effects, and in general the effects of non-ideal gas flow on classical gas dynamic problems. Discussion and analysis of flows with equilibrium and nonequilibrium thermodynamics. Detailed analysis of shock structure and the plasma sheath.

AE 3971 FLIGHT VEHICLE DESIGN I (3-3) Development of a basic understanding for design problems through the integration of various disciplines into an overall system; evaluating requirements for airworthiness and minimum weight; determining structural strength of component parts. General trends for future developments.

AE 3972 FLIGHT VEHICLE DESIGN II (3-3) Continuation of AE 3971.

Graduate Courses

AE 4101 FLIGHT VEHICLE STRUCTURAL ANALYSIS I (3-2) Matrix methods of structural analysis of aircraft and space-vehicle structures. Structural idealization; stiffness and flexibility properties of structural elements; matrix displacement and matrix force methods; structural partitioning and analysis of substructures.

AE 4102 FLIGHT VEHICLE STRUCTURAL ANALYSIS II (3-2) Theory of plates and shell structures as applied to aircraft and space-vehicles. Classical theory; analytical methods of analysis; numerical methods of analysis; stability; design considerations.

AE 4131 SOLID MECHANICS FOR AERONAUTICAL ENGINEERS I (4-0) An overview of elastic analysis of continua beginning with the formulation of the three dimensional field equations of elasticity and continuing with methods of stress analysis, including classical analytical methods, experimental methods and numerical methods. Theories of failure are also presented by which the stress analysis can be used to assess ultimate structural integrity. TEXT: Wang, *Applied Elasticity.*

AE 4132 SOLID MECHANICS FOR AERONAUTICAL ENGINEERS II (4-0) An in-depth treatment of current methods of analysis applicable to aerospace structures, which include two-dimensional solutions by means of complex variables, photoelasticity and finite elements. TEXT: Wang, *Applied Elasticity.* PREREQUISITE: AE 4131.

AE 4139 SPECIAL TOPICS IN SOLID MECHANICS I (4-0) Selected advanced coverage from topics including: plasticity, viscoelasticity, general stability, thermoelasticity, nonlinear elasticity, wave propagation, fracture mechanics. May be repeated for credit with a different topic. PREREQUISITE: Consent of Department Chairman.

AE 4271 DESIGN PROBLEMS IN AERONAUTICS I (3-3) A complex engineering problem in the field of flight vehicles is presented for solution by systems-oriented methods, with the primary purpose of developing basic understanding for the design process. Integration of various disciplines, evaluation of airworthiness requirements, real-life complexities, and team work with clearly assigned responsibilities are emphasized. PREREQUISITE: Consent of Department Chairman.

AE 4272 DESIGN PROBLEMS IN AERONAUTICS II (3-3) Continuation of AE 4271.

AE 4301 FLIGHT VEHICLE RESPONSE (3-2) Topics in advanced stability and control of flight vehicles including the effects of cross-soupling, aeroelasticity, and reentry dynamics. TEXT: Etkin, *Dynamics of Flight, Stability and Control.*

AE 4302 LOW SPEED VEHICLE AERODYNAMICS (3-2) Topics in the stability, control and performance characteristics of low-speed aircraft; ground effect phenomena; VTOL, STOL and rotary wing aircraft, air cushion and compound vehicles. TEXT: Gessow and Meyers, *Aerodynamics of the Helicopter.*

AE 4316 STRUCTURAL DYNAMICS (3-2) Response of discrete and continuous systems of deterministic excitations, estimation methods for solving the eigenvalue problem; wave propagation in solids and fluids; response to stochastic processes. TEXT: Meirovitch, *Analytical Methods in Vibrations.*

AE 4317 AEROELASTICITY (4-0) Static aeroelasticity problems in aircraft; non-stationary airfoil theory; strip and lifting surface concepts. Application to the flutter problem. Transient loads, gusts, buffet, and stall flutter. TEXTS: Fung, *Theory of Aeroelasticity* and Bisplinghoff, Ashley, and Hoffman, *Aeroelasticity.* PREREQUISITE: AE 4316.

AE 4341 GUIDANCE AND CONTROL FOR AEROSPACE SYSTEMS I (3-2) Power controls and stability augmentation; component and pilot transfer functions; applications of frequence response techniques; systems analysis of aircraft controls; cross-coupling; performance specifications and response shaping. TEXTS: Clark, *Introduction to Automatic Control Systems* and Etkin, *Dynamics of Flight, Stability and Control.*

AE 4342 GUIDANCE AND CONTROL FOR AEROSPACE SYSTEMS II (3-2) Vehicle dynamics and interaction with augmentation devices and automatic controls; automatic power compensation; time-modulated aerodynamic controls; missile control; terrain following. Random processes and auto-correlation functions; adaptive control systems; power spectral densities. Optimum design. TEXTS: Clark, *Introduction to Automatic Control Systems* and Etkin, *Dynamics of Flight, Stability and Control.* PREREQUISITE: AE 4341.

AE 4401 ADVANCED THERMODYNAMICS (3-2) Reactive mixtures, kinetic theory, transport phenomena, quantum statistics, partition functions, thermodynamic properties. TEXTS: Lee, Sears, Turcotte, *Statistical Thermodynamics* and Saad *Thermodynamics for Engineers.*

AE 4402 COMBUSTION (3-2) Formation of molecules and chemical bonds; classical chemical kinetics, rate laws; premixed systems, detonations and deflagrations; diffusion flames; ignition theory. TEXT: Penner, *Chemistry Problems in Jet Propulsion.* PREREQUISITE: AE 4401.

AE 4409 ADVANCED TOPICS IN COMBUSTION (3-2) Chemical reactions in flow systems, solid propellant combustion, liquid droplet combustion, supercritical combustion. PREREQUISITE: AE 4402.

AE 4431 AEROTHERMODYNAMICS OF TURBOMACHINES (4-0). Application of fundamental laws of fluid dynamics and thermodynamics to the analysis of flows in tubomachines. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.*

AE 4432 ADVANCED THEORY OF TURBOMACHINES (4-0). Advanced theory and methods for design and performance prediction of turbomachines. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITES: AE 4431.

AE 4439 TURBOPROPULSION SYSTEMS (4-0). Application of fluid dynamics, thermodynamics and stress analysis to the design of turbomachinery for power plants for aircraft and vehicle propulsion. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITE: AE 4432.

AE 4501 ADVANCED GASDYNAMICS (4-0). Similarity and perturbation methods applied to two-dimensional subsonic, supersonic and transonic flow. Shock wave interactions and reflections with reference to the hodograph plane. Method of characteristics: unsteady, and supersonic. Influence of viscosity and heat conduction on gas dynamics. TEXT: Owczarek, *Fundamentals of Gas Dynamics.*

AE 4502 HYPERSONIC FLOW AND REAL GAS EFFECTS (3-2). Hypersonic flow with emphasis on small perturbation analysis, similarity solutions and Newtonian flow. Real gas effects will be studied (dissociation, ionization) with reference to problems such as Couette flow, the wavy wall, Prandtl-Meyer flow, and the plasma sheath. PREREQUISITE: AE 4501.

AE 4503 AERODYNAMICS OF WINGS AND BODIES (3-2). Study of three-dimensional wings and bodies in subsonic and supersonic flow. Slender body theory and flow reversal theorems. Singular perturbation problems and unsteady flow. TEXT: Ashley and Landahl, *Aerodynamics of Wings and Bodies.*

AE 4504 MAGNETO/ELECTROFLUIDDYNAMICS (3-2) Advanced energy conversion and propulsion systems which employ magneto/electrofluiddynamic principles. Definition and review of the pertinent physical concepts. Current and future applications. TEXTS: Sutton and Sherman, *Engineering Magnetohydrodynamics* and Brown, *Introduction to Electrical Discharges in Gases.*

AE 4509 SPECIAL TOPICS IN GASDYNAMICS (4-0) Topics selected to illustrate typical research developments such as advances in the theory of fluid turbulence, computer simulation of fluid flow, advanced magnetohydrodynamics and/or electrohydrodynamics, high temperature effects in gas dynamics, the dynamics of rarified gases, hydrodynamic stability and transition, boundary layers in oscillating flows. May be repeated for credit when topic changes. PREREQUISITE: Consent of Department Chairman.

AE 4511 BOUNDARY LAYER THEORY (4-0) Some exact solutions of the Navier-Stokes equations. Boundary layer concept and equations, momentum and energy integrals, stability and transition. Fundamentals of turbulent flow; laminar and turbulent boundary layers with arbitrary pressure gradients. Techniques of solution. TEXT: Schlichting, *Boundary Layer Theory.*

AE 4512 CONVECTIVE HEAT AND MASS TRANSFER (4-0) Convective heat and mass transfer in ducts and from exposed surfaces; laminar and turbulent flows. Analytic techniques, integral and numerical methods, experimental correlations. Effects of variations in thermophysical properties. Combined heat and mass transfer. TEXTS: Kays, *Convective Heat Transfer* and Spaulding, *Convective Mass Transfer.* PREREQUISITE: AE 4511.

AE 4519 SPECIAL TOPICS IN HEAT AND MASS TRANSFER (4-0) Selected topics in steady and non-steady heat transfer by radiation and conduction, multi-dimensional conduction, gas body radiation and hypersonic reentry heat and mass transfer. Offered to suit the needs of individual classes. May be repeated for credit when topic changes. PREREQUISITE: Consent of Department Chairman.

AE 4632 COMPUTER METHODS IN AERONAUTICS (3-2) Solution of eignevalue problems. Solution of ordinary and partial differential equations for aero-structures, gas dynamics, flight mechanics, dynamics and heat transfer. Introduction to computer graphics, design optimization, hybrid computers, and aerospace vehicle simulation. TEXTS: McCracken and Dorn, *Numerical Methods and FORTRAN Programming* and Crandall, *Engineering Analysis.* PREREQUISITE: MA 3232.

AE 4831 TURBOMACHINERY LABORATORY I (0-3) Measurements of overall performance of turbomachines. PREREQUISITE: AE 4431 concurrently.

AE 4832 TURBOMACHINERY LABORATORY II (0-3) Detailed investigations of stationary and rotating components of turbomachines. PREREQUISITE: AE 4432 concurrently.

LCDR R.C. Stoddard receives diploma from Dean Rinehart

AVIATION SAFETY PROGRAMS

JAMES CHRISTIAN NIELSEN, Associate Professor of Aeronautical Engr. and Safety; Director (1966)*; B.S.A.E., Univ. of Washington, 1950; M.S.A.E., 1957.

RUSSELL BRANSON BOMBERGER, Associate Professor of Law and Psychology (1958); B.S., Temple Univ., 1955; Ll.B., LaSalle Univ., 1968; J.D., 1969; M.A., Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

CRAIG MERRILL BRADBURY, Lieutenant Commander, U.S. Navy, Instructor in Aircraft Accident Prevention and Crash Investigation (1969); B.S., Naval Postgraduate School, 1963.

JAMES LEE FLETCHER, Commander, U.S. Navy, Instructor in Aeronautical Engr. and Safety (1968); B.S.A.E., Univ. of Oklahoma, 1959.

STANLEY GARTH PARKER, Associate Professor of Aviation Medicine (1969); M.D., Louisiana State University, 1943.

LESTER CHARLES WIBLE, Assistant Professor of Aviation Accident Prevention and Crash Investigation (1965); B.S., Naval Academy, 1945.

*The year of joining the Postgraduate School Faculty is indicated in parentheses.

The Aviation Safety Officers' Course is offered on a temporary additional duty basis to those Officers so ordered by the Chief of Naval Personnel. The following courses constitute the program and are taken simultaneously: AO 2310, AO 2320, AO 2360, AO 2352, and AO 2381.

Officers regularly enrolled in other curricula at the Postgraduate School may qualify as Aviation Safety Officers by completion of the program requirements.

AVIATION

Upper Division Courses

AO 2301 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Mathematics through college algebra and geometry; physics through mechanics and heat. (This course is for students in the BA program.)

AO 2302 AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (3-2). This course consists of (a) a study of existing Navy Department instructions covering all aspects of accident investigation and reporting procedures, (b) methods and techniques of accident investigation; (c) implementation and use of a prevention program, and (d) physiological factors of flight. PREREQUISITE: AO 2301 or AO 2303 (may be taken concurrently).

AO 2303 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Mathematics through calculus, courses in thermodynamics, statics and dynamics. (This course is for students of the BS program.)

AO 2310 AERO ENGINEERING SAFETY (6-0). A survey of aeronautical engineering for the Aviation Safety Officer. Mathematics review, basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations.

AO 2320 AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (4-0). This course consists of (a) a study of existing Navy Department instructions covering all aspects of accident investigation and reporting procedures, (b) methods and techniques of accident investigation, and (c) implementation and use of a prevention program.

AO 2360 AVIATION PHYSIOLOGY (2-0). A review of basic fundamentals of physiology with emphasis on the circulatory and respiratory systems with the objective of understanding the principles associated with the physiological stresses encountered in aviation. The role of the squadron flight surgeon in the squadron training program and his duties in aviation accident prevention, investigation and reporting.

PSYCHOLOGY

Upper Division Courses

PY 2050 GENERAL PSYCHOLOGY (3-0). A study of prin- of rational and emotional processes in human thought and action.

AO 2352 PSYCHOLOGY IN ACCIDENT PREVENTION AND INVESTIGATION (4-0). A study of logical and psychological principles and practices useful in developing mental efficiency and emotional strength, designed especially for the Aviation Safety Officer.

LAW

Upper Division Courses

AO 2381 AVIATION LAW (1-0). A study of the privileged status of the Aircraft Accident Investigation designed especially for the Aviation Safety Officer Program.

DEPARTMENT OF BUSINESS ADMINISTRATION AND ECONOMICS

JOHN WALLIS CREIGHTON, Professor of Management and Chairman (1967)*; B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

PAUL MARSHMAN CARRICK, Associate Professor of Management (1969); B.A., Northwestern University, 1949; Ph.D., University of California at Berkeley, 1956.

WILLIAM HOWARD CHURCH, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

JAMES BARRIE COWIE, Associate Professor of Management Science (1963); B.Sc. (honors), Glasgow Univ., 1958; C.I.A., 1959.

LESLIE DARBYSHIRE, Professor of Management (1962); B.A., Univ. of Bristol. 1950; D.B.A., Univ. of Washington, 1957.

PAUL EISENHARDT, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Management (1969); B.S., Brown Univ., 1967; M.B.A., Harvard Univ., 1969.

RICHARD SANFORD ELSTER, Assistant Professor of Management (1969); B.A., Univ. of Minnesota, 1963; M.A., Univ. of Minnesota, 1965; Ph.D., Univ. of Minnesota, 1967.

JAMES MORGAN FREMGEN, Professor of Accounting (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

JAMES GARRISON GANZ, Lieutenant Commander, U.S. Navy, Instructor in Management (1968); B.A., Univ. of Washington, 1960; M.S., Naval Postgraduate School, 1968.

THOMAS L. GRAINGER, Ensign, U.S. Naval Reserve, Instructor in Management (1970); B.S., Yale Univ., 1966; M.B.A., Wharton School of Finance and Commerce, 1968.

H. ARTHUR HOVERLAND, Associate Professor of Management (1963); B.S., Miami Univ., 1951; M.S., Univ. of Illinois, 1954; Ph.D., Univ. of Michigan, 1963.

JAMES PATRICK HYNES, Assistant Professor of Management (1969); B.A., Univ. of Notre Dame, 1966; M.B.A., Michigan State Univ., 1967; Ph.D., Michigan State Univ., 1970.

JAMES ALVIN JOLLY, Associate Professor of Management (1969); B.A., Univ. of the Pacific, 1950; M.B.A., Univ. of Santa Clara, 1963; Ph.D., 1970.

ROBERT STEPHEN LANDE, Assistant Professor of Management (1967); B.A., Swarthmore College, 1961.

HENRY LOUIS LANE, Lieutenant Commander, U.S. Navy, Instructor in Management (1968); B.S., Univ. of Colorado, 1951.

MARK HUNTER LEE, Lieutenant (junior grade), U.S. Naval Reserve, Instructor in Management (1969); B.A., UCLA, 1967; M.B.A., Stanford University, 1967.

JOE HOWARD McDONALD, Ensign, U.S. Naval Reserve, Instructor in Management (1969); B.A., Duke Univ., 1967; M.B.A., Duke Univ., 1969.

GERALD LEE MUSGRAVE, Assistant Professor of Management (1968); B.A., San Fernando Valley State College, 1964; M.S., Michigan State Univ., 1966; Ph.D., 1970.

M. SIDDIEG NOORZOY, Assistant Professor of Management (1969); B.A., Univ. of California at Berkeley, 1957; M.A., 1960; Ph.D., Univ. of Washington, 1965.

JOHN DAVID SENGER, Associate Professor of Management (1967); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

MELVIN JOHN STECKLER, Associate Professor of Management (1966); B.S.M.E., Univ. of Washington, 1949; M.B.A., 1957; D.B.A., Harvard Univ., 1967.

JAMES W. VIGEN, Associate Professor of Management (1970); B.S., Colorado State Univ., 1960; 1963; Ph.D., Ohio State Univ., 1965.

RICHARD THEODORE WAIBEL, Assistant Professor of Management (1969); B.S., Penn. State Univ., 1965.

WILLIAM HALE WEGENER, Ensign, U.S. Naval Reserve, Instructor in Management (1969); B.A., Dartmouth College, 1966; M.B.A., Stanford Univ., 1968.

NORMAN KEITH WOMER, Lieutenant (junior grade), U.S. Naval Reserve, Assistant Professor of Management (1969); B.A., Miami Univ., 1966; Ph.D., Penn State Univ., 1970.

DEPARTMENTAL REQUIREMENTS FOR DEGREES

BACHELOR OF SCIENCE WITH MAJOR IN BUSINESS ADMINISTRATION

1. A candidate for the Bachelor of Science degree with a major in business administration must meet the general requirements for the baccalaureate degree. Additionally, he must meet the following specific requirements for the major:

a. A minimum of 34 quarter hours of course work at or above the 2000 level.

b. Successful completion or validation by advanced credit of approved courses in each of the following areas of study:

Behavioral Sciences
Computers and Programming
Economics
Financial Management and Accounting
Material Management
Statistics

MASTER OF SCIENCE IN MANAGEMENT

1. A candidate for the degree of Master of Science in Management must complete satisfactorily either (A) a minimum of 56 hours of graduate level work with 16 hours at the 4000 level or (B) a minimum of 48 hours of graduate level work, with 8 hours at the 4000 level, and a thesis. This is a minimum requirement for all major areas in Management.

2. Degree requirements for all of the majors in management must include completion of at least one graduate level course in each of the following areas of study:

Economics
Probability and Statistics
Financial Management
Behavioral Sciences
Management Theory
Operations Research

3. In addition to the subject area requirements listed in paragraph 2, each candidate must fulfill the requirements of one of the following sequences:

PERSONNEL MANAGEMENT
Sixteen or more quarter hours at the graduate level in approved Personnel Management courses.

FINANCIAL MANAGEMENT
Sixteen or more quarter hours at the graduate level in approved Financial Management courses.

MATERIAL MANAGEMENT
Sixteen or more quarter hours at the graduate level in approved courses in the area of Material Management.

MANAGEMENT SCIENCE
Sixteen or more quarter hours at the graduate level in approved courses in Quantitative Management or Operations Analysis.

ECONOMICS
Sixteen or more quarter hours at the graduate level in approved Economics courses.

COMMUNICATIONS MANAGEMENT
Sixteen or more quarter hours at the graduate level in approved courses in Computer Science, Data Processing, and Material Management, plus an approved sequence of courses in electrical engineering and communications.

4. All curricula are subject to the approval of the Business Administration and Economics Department.

MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

1. A candidate for the degree of Master of Science in Computer Systems Management must complete satisfactorily either (A) a minimum of 56 quarter hours of graduate level course work or (B) a minimum of 48 quarter hours of graduate level course work and an acceptable thesis.

2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Computer Science
Data Processing
Economics
Financial Management and Accounting
Material Management
Operations Research
Statistics

MANAGEMENT

MN 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MN 1500 PERSONAL AFFAIRS (2-0). Personal estate planning including: government benefits, insurance, budgeting, real estate, securities, wills, and trusts.

Upper Division Courses

MN 2510 HUMAN BEHAVIOR (4-0). A survey of some of the important aspects of human behavior that affect performance and satisfaction within an organization. Theories and empirical findings from the bahavioral sciences, including motivation, learning, social conditioning, personality, and the measurement of individual behavior patterns.

MN 2521 GROUP BEHAVIOR AND ORGANIZATION THEORY (4-0). A survey of theories and empirical findings concerning group effectiveness, leadership, group pressure, and role behavior. Theories and practices of organizational activities such as planning, direction, and control. Examination of organizational processes of particular importance to military and governmental organizations. PREREQUISITE: MN 2510.

MN 2550 PRINCIPLES OF ACCOUNTING (4-0). Study of the basic principles of accounting in business and government. Topics covered include the basic postulates and principles of financial accounting, the accounting cycle, accounting for assets and equities, financial statement content and analysis, manufacturing cost accounting, and the fundamentals of governmental accounting..

MN 2900 MANAGEMENT OF HUMAN RESOURCES (4-0). A course emphasizing those aspects of individual and group behavior having particularly important influences upon organizational effectiveness. The impact these aspects of behavior have upon personnal management are also stressed.

MN 2970 MATERIAL MANAGEMENT (4-0). Military logistics processes and the organization of the Navy for logistics administration including: the planning-programming-budgeting cycle, budget development and execution, procurement, and hardware development.

UPPER DIVISION OR GRADUATE COURSES

MN 3030 INTRODUCTION TO ECONOMICS (4-0). Survey of the methodology of economics and its application to such problems as economic development, employment, inflation, industrial organization, consumer behavior and defense economics.

MN 3043 ECONOMIC DEVELOPMENT I (4-0). Goals and problems of economic development. Theoretical and policy issues, approaches to economic development, market system vs. public planning. PREREQUISITES: MN 3030 or equivalent.

MN 3046 COMPARATIVE ECONOMIC SYSTEMS (4-0). The characteristics and functions of an economic system. Criteria for evaluating the performance of contemporary economies. The analysis of alternative patterns of control, planning and market structures under capitalism, socialism, and mixed economies. PREREQUISITES: MN 3140,

MN 3060 MANAGEMENT ACCOUNTING (4-0). Introduction to the basic concepts and principles of accounting in business and government. Emphasis is placed on uses of accounting data by management in planning, control, and decision making. Applications of automatic data processing to accounting systems are discussed.

MN 3105 THE THEORY AND PRACTICE OF MANAGEMENT (4-0). An intorduction to the field of management as a body of knowledge related to a concrete practice. Discusses the various theories of management, their origins, their substance, and their applications to real world situations.

MN 3106 BEHAVIORAL SCIENCE (4-0). Aspects of individual and group behavior and their influence on organizational effectiveness.

MN 3110 INDIVIDUAL BEHAVIOR (4-0). Study of the basic characteristics and determinants of individual behavior. Specific topics covered include personality, motivation, learning, behavior conditioning, and introduction to tests and measurements. Implications for effective administrative practice.

MN 3121 GROUP AND ORGANIZATIONAL BEHAVIOR (4-0) Studies of small group behavior and the relationship between the individual and the group. Survey of organization theory, including organizational structure, controls, and systems. Analysis of decision making processes in organizations, of leadership and of factors affecting organizational growth and development. PREREQUISITES: MN 3110 or MW 3106.

MN 3125 ORGANIZATIONAL BEHAVIOR AND ADMINISTRATION (4-0). Analysis of human situations within organizations and their administrative implications. The course focuses on the responses made by individuals and groups to the influences bearing upon their behavior in organizational settings.

MN 3130 MACROECONOMIC THEORY (4-0). Development of macroeconomic models to analyze the relationships between aggregate demand, debt and financial assets, rate of technical advance, and national income. The monetary system and international monetary relationships. PREREQUISITES: MN 3030 and calculus.

MN 3140 MICROECONOMIC THEORY (4-0). Determinants of the allocation of resources and the composition of output. Consumer choice theory. Partial equilibrium analysis of the significance of market structure. Introduction to welfare economics using quantitative techniques. PREREQUISITE: MN 3030 or equivalent; calculus.

MN 3141 MICROECONOMICS (4-0). Determinants of the allocation of resources and the composition of output. Consumer behavior and utility theory; theories of the firm; significance of market structure. PREREQUISITE: MN 3030.

MN 3143 MANAGERIAL ECONOMICS (4-0). Microeconomic theory and its applications to private and public decision making. Investment decisions and capital budgeting; significance of market structure upon performance; investment decisions and capital budgeting. Case and Industry studies. PREREQUISITE: MN 3030.

MN 3147 LABOR ECONOMICS (4-0). Development of the labor movement, its organizational structure, ideologies, policies and practices. Alternative theories of wage determination. Effects of unions on wages and the rate of technical change. PREREQUISITE: MN 3141 or MN 3140.

MN 3150 FINANCIAL ACCOUNTING (4-0). Study of the basic postulates and principles of accounting. Specific topics include the accounting cycle, asset valuation, equities and capital structure, financial statement analysis, and elementary cost accounting.

MN 3161 MANAGERIAL ACCOUNTING (4-0). Survey of cost accounting systems, including overhead costing, job order and process cost systems, variable and absorption costing, and standard costs. Emphasis is on applications of accounting data to planning, control, and decision making. Topics covered include flexible budgets, variance analysis, cost-volume-profit analysis, and incremental profit analysis. Capital budgeting is examined extensively. PREREQUISITE: MN 3150 or consent of instructor.

MN 3171 RESOURCE MANAGEMENT FOR DEFENSE (4-0). Introduction to the management of resources within the Department of Defense, with particular emphasis on the economic, social, and political environment in which the military manager operates. Study of the problems of allocating resources for defense, providing support for military programs, and collecting and processing quantitative management information that relates to these resources. Specific topics include weapons systems acquisition, the planning-programming-budgeting cycle, research and development, material aupport, systems for management of resources for operating activities, systems for management of inventory and similar assets, and systems for management of acquisition, use, and disposition of capital assets.

MN 3191 ANALYTICAL TECHNIQUES FOR MANAGEMENT (4-0). Decision-making procedures. Descriptive and inferential statistics emphasizing hypothesis testing and parameter estimation. Additional topics covered include investment decision procedures, selected elements of game theory, and risk taking. PREREQUISITE: MA 2300.

MN 3445 LINEAR ECONOMICS I (4-0). Development and application of linear models to the specification and control of economic relationships. Input-output models of the American economy; linear programming models of the firm; linear production functions and dynamic input-output models. PREREQUISITE: MN 3140; linear algebra recommended.

MN 3645 INVESTIGATIVE METHODS OF ECONOMICS I (4-0). Development and applications of selected statistical techniques. General linear hypothesis and regression theory. The Gauss-Markoff theorem; analysis of varience and hypothesis testing. Stochastic processes and their application. PREREQUISITES: MN 3140; PS 3000.

MN 3770 INDUSTRIAL ORGANIZATION (4-0). Analysis of the structure, conduct and performance of American industry. Public policy issues, implementation of anti-trust and other business legislation. PREREQUISITES: MN 3140 or MN 3141; PS 3000.

MN 3780 ECONOMICS OF REGULATION (4-0). Analysis of regulatory alternatives and market performance in selected economic settings. Federal Government regulatory practice; communication; air, rail, and highway transportation; petroleum; product standardization; Armed Service Procurement Regulation. Applications of the public utility concept. State and local government practices. PREREQUISITE: MN 3140 or MN 3141.

MN 3941 ENGINEERING ECONOMICS (4-0). An introduction to the basic concepts of microeconomics necessary for decision making; alternative market models; theories of production, with particular attention to technological considerations, production and cost functions; and supply curves. The analysis of investment decision problems. PREREQUISITES: MN 3030; a course in probability and statistics is recommended.

MN 3999 SELECTED TOPICS IN MANAGEMENT (4-0). Presentation of a wide selection of topics from the current literature. This course may be repeated if course content changes. PREREQUISITE: A background of advanced work in the relevant area and permission of the instructor.

Graduate Courses

MN 4043 ECONOMIC DEVELOPMENT II (4-0). Theories of economic development, and development policy issues, country and regional studies. PREREQUISITES: MN 3043, MN 3130, and MN 3141.

MN 4101 PERSONNEL MANAGEMENT AND LABOR RELATIONS (4-0). Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development and current status of labor-management relations in industry and government. Analysis of the economics of the labor market and the implications of government regulations for wages and labor-management bargaining practices. PREREQUISITES: MN 3110 and MN 3141.

MN 4105 MANAGEMENT POLICY (4-0). Study and appraisal of a variety of policies requiring the analysis of problems and the formulation of decisions in both business and governmental enterprises. Use of case materials, management games, and other devices as exercises in decision making and the executive action under conditions of uncertainty and change. PREREQUISITES: MN 3121, MN 3130, MN 3161, MN 3171, CS 0110, and OA 3211.

MN 4109 DIRECTED STUDY (2-0 to 8-0). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the instructor, and a B average.

MN 4111 SEMINAR IN BEHAVORIAL SCIENCE (4-0). A combination of directed readings and individual student's research projects presented for discussion in class. Emphasis is placed on empirical analysis of behavioral patterns and relationships. PREREQUISITES: MN 3121 and CS 0110.

MN 4112 PERSONNEL SELECTION AND CLASSIFICATION (4-0). Analysis of human performance within organizations. This course considers the methods available for measuring and predicting the performances of the members of organizations. Methods of measuring differences between people via employment interviewing. testing, and life-history data are discussed. Techniques for studying and recording job behavior are also considered. In addition, the various strategies for personnel decisions are discussed in terms of validation, and selection and placement models. PREREQUISITES: MN 3110, and PS 3000.

MN 4113 PERSONNEL TRAINING AND DEVELOPMENT (4-0). Determination of the skills, knowledges and attitudes in which people should be trained. Analysis of who should be trained and the methods currently available for training are discussed. Techniques available for evaluating the efficacy of training are also considered. PREREQUISITE: MN 3110.

MN 4114 PERSONNEL PERFORMANCE EVALUATION (4-0). Current methods of appraising the work performance of individuals in different types of work are reviewed. Problems associated with each method are analyzed. Performance evaluation is examined as a system interfacing with selection, classification, training, advancement, and retention.

MN 4115 PERSONNEL MOTIVATION (4-0). A brief summary of the traditional theories of motivation is given. Several motivation to work theories are discussed along with the research concerning these theories. Current research on the roles of compensation in personnel motivation is considered.

MN 4121 SEMINAR IN ORGANIZATION THEORY AND MANAGEMENT PRACTICE (4-0). A research and discussion approach to the problem areas of organization theory, management practice, and the contributions of various theoretical disciplines to the evolving sciences of management. Particular attention is given to the implications of changes in the environment of organizations, in their internal technology, and in the state of knowledge about human behavior. PREREQUISITE: MN 3121.

MN 4130 MACROECONOMIC POLICY (4-0). Development and application of aggregate economic models to selected policy issues. Emphasis will be placed upon the use and interpretation of econometric models. PREREQUISITES: MN 3130, MN 3140 or MN 3141.

MN 4135 MONETARY ECONOMICS (4-0). The interralations between monetary and non-monetary variables in the economy. PREREQUISITES: MN 3130 and MN 3140.

MN 4141 ECONOMIC THEORY AND MICROECONOMIC POLICY (4-0). Further developments of the concepts of imperfect competition and economic efficiency. Pricing and price-making policy issues. Introduction to economics of risk aversion. Analyses of major U.S. industries and government policies. PREREQUISITES: MN 3130, and MN 3140 or MN 3141.

MN 4142 INTERNATIONAL ECONOMIC POLICY (4-0). Leading issues of international trade policy. Emphasis on the relation of theory to specific international problems. Analysis of commercial policies of the U.S., European economic unions and developing countries.

MN 4145 SYSTEMS ANALYSIS (4-0). This course will concentrate on the analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Systems analysis case studies will be emphasized. PREREQUISITES: MN 3030, OA 3211 and MN 3060.

MN 4147 INDUSTRIAL RELATIONS (4-0). Development of the institutions and techniques for resolving conflict over wages and conditions of work. Theories of bargaining and arbitration. PREREQUISITE: MN 3147.

MN 4152 DECISION MAKING FOR FINANCIAL MANAGEMENT (4-0). The management of the finance function in government and industry. Specific topics include cash and working capital management, long-term financing, determination of optimal capital structure, and valuation of a going concern. PREREQUISITES: MN 3161, and PS 3000.

MN 4153 SEMINAR IN ACCOUNTING AND CONTROL I (4-0). Research and discussion of current developments and controversies in accounting and financial controls for government and industry. Students will be expected to do individual or small-group studies and to make reports thereon. PREREQUISITES: MN 3161, CS 0110, and PS 3000 or equivalents.

MN 4154 SEMINAR IN ACCOUNTING AND CONTROL II (4-0). See description under MN 4153. PREREQUISITES: MN 3161, CS 0110, and PS 3000 or equivalents.

MN 4161 CONTROLLERSHIP (4-0). This course employs the case method of study and seeks to integrate the various disciplines that support the management function, with particular emphasis on financial analysis for decision making. PREREQUISITES: MN 3121, MN 3161, CS 0110, and OA 3211.

MN 4171 PROCUREMENT AND CONTRACT ADMINISTRATION (4-0). Study of the elements of the procurement cycle, including the determination of the requirements, contract law, technical and production problems, fiscal controls, facilities, inspections, and terminations. Military procurement regulations are analyzed to determine their impact on efficient military logistic systems. PREREQUISITE: MN 3171.

MN 4181 MANAGEMENT INFORMATION SYSTEMS (4-0). Study of the "total systems" concept. Development and discussion of an integrated information system, employing a computer and data processing equipment, used by management for planning and control purposes. Analysis of actual information systems used in industry and the government. PREREQUISITES: MN 3150 and CS 0110, or consent of instructor.

MN 4182 DATA PROCESSING MANAGEMENT (4-0). Study of computer systems analysis and design. Management of ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: feasibility studies, selection, and acquisition of equipment; evaluation of computer hardware and software; installation and effective utilization of ADP equipment; and various types of computer applications. PREREQUISITE: Course in computer programming.

MN 4183 BUSINESS DATA PROCESSING (4-0). Study of manual, semi-automatic, and automatic systems for the routine processing of data. Specific topics covered include accounting and auditing applications, sequential and random processing with digital computers, and control techniques. Students in small teams will study actual industrial and/or military management situations and recommend appropriate data processing systems. PREREQUISITES: Courses in computer programming and probability and statistics.

MN 4191 QUANTITATIVE DECISION TECHNIQUES (4-0). A study of the applications of scientific techniques, particularly mathematical and statistical, to management decision making. Consideration of applications of quantitative methods of analysis to complex problems with the aid of computers. PREREQUISITES: Courses in computer programming and OA 3211.

MN 4225 LABOR LAW (4-0). Labor law as it affects management labor and the public with special emphasis on legal problems confronting military personnel in managerial situations.

MN 4445 LINEAR ECONOMICS II (4-0). Linear models of multi-stage decision making. Dynamic programming; alternative approaches to multi-dimensional optimization problems. PREREQUISITE: MN 3445.

MN 4645 INVESTIGATIVE METHODS OF ECONOMICS II (4-0). Specification of economic systems. Simultaneous equations and identification issues in econometric model construction. Application of econometric methods in analyses of industrial organization and economic planning. PREREQUISITE: MN 3645.

MN 4931 SEMINAR IN MACROECONOMIC POLICY (4-0). PREREQUISITE: Consent of instructor.

MN 4941 SEMINAR IN MICROECONOMICS (4-0). PREREQUISITE: Consent of instructor.

COMPUTER SCIENCE

Computer Science is an interdepartmental effort at the Naval Postgraduate School. As such, the teaching faculty is drawn from the Departments of Electrical Engineering, Mathematics and Operations Analysis.

DEGREE REQUIREMENTS

BACHELOR OR SCIENCE WITH MAJOR IN COMPUTER SCIENCE

The requirements for a Bachelor of Science degree with major in Computer Science will include at least 10 hours in upper division mathematics, 6 hours in probability and statistics, 18 hours in computer science, and 4 hours in management.

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. To obtain the Master of Science degree in Computer Science, the students must have satisfied the requirements for the Bachelor of Science degree in Computer Science.

2. In addition, the student must successfully complete a minimum of 40 quarter hours of graduate credit distributed as follows:

	Minimum Hours
Computer Science	20
Mathematics	8
Operations Analysis	10

3. In addition, the student must successfully complete an acceptable thesis.

A listing of Computer Science courses appears under the course listings of the Mathematics Department and the Electrical Engineering Department.

Curricular officer Academic Associate Student Conference

DEPARTMENT OF ELECTRICAL ENGINEERING

SYDNEY RICHARDPARKER, Professor of Electrical Engineering; Chairman (1966); B.E.E.,* City College of New York, 1944, M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

ROY STANLEY GLASGOW, Dean Emeritus (1949); B.S., Washington Univ. 1918; M.S., Harvard, 1922; E.E., Washington Univ., 1925; D.Sc., (Hon.), 1961.

GEORGE ROBERT GIET, Professor Emeritus and Distinguished Professor (1925); A.B., Columbia Univ., 1921; E.E., 1923.

ORVAL HAROLD POLK, Professor Emeritus (1945); B.S. Univ. of Colorado, 1927; M.S., Univ. of Arizona, 1933; E.E., Univ. of Colorado, 1940.

RICHARD CARVEL HENSEN WHEELER, Professor Emeritus (1929); B.E., Johns Hopkins Univ., 1923; D. Eng., Rensselaer Polytechnic Institute, 1926.

RICHARD WILLIAM ADLER, Assistant Professor of Electrical Engineering (1969); B.S., Penn State, 1956; M.S., 1958.

RODNEY REID BADGER, Lieutenant, U.S. Navy; Instructor in Communications (1968); B.S., U.S. Naval Academy, 1964.

WILLIAM MALCOLM BAUER, Professor of Electronics (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S., Harvard Univ., 1929; D.Sc., 1940.

ORESTES METHODIUS BAYCURA, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute, 1957; M.S., Univ. of Pittsburgh, 1959; D.Sc., 1963.

FRANCIS WILLIAM BORST, JR., Lieutenant Commander, U.S. Navy; Instructor in Communications (1969); BA Middlebury College, 1948.

JOHN MILLER BOULDRY, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

STEPHEN BREIDA, Associate Professor of Electronics (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E., Purdue Univ., 1954.

JAMES DOUGAL CAMPBELL, Lieutenant Junior Grade, U.S. Naval Reserve; Assistant Professor of Electrical Engineering (1969); B.S., Univ. of Missouri, 1965; M.S., 1966; Ph.D., 1969.

SHU-GAR CHAN, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1954; M.S., Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

JESSE GERALD CHANEY, Professor of Electronics (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

PAUL EUGENE COOPER, Professor of Electronics (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

MITCHELL LAVETTE COTTON, Associate Professor of Electronics (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California at Berkeley, 1954.

RONALD DAN De LAURA, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor in Computer Science (1969); B.S. Univ. of California at Los Angeles, 1966; M.S. 1968.

JAMES STEVE DEMETRY, Associate Professor of Electrical Engineering (1960); B.S. Worcester Polytechnic Institute, 1958; M.S., 1960; Ph.D., Naval Postgraduate School, 1964.

GERALD DEAN EWING, Associate Professor of Electrical Engineering (1963); A.A., College of Marin, 1955, B.S.E.E., Univ. of California at Berkeley, 1957; M.S.E.E., 1959; E.E., Oregon State Univ., 1962; Ph.D., 1964.

EDWARD MARKHAM GARDNER, Professor of Electrical Engineering (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

ALEX GERBA, JR., Associate Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

DAVID BOYSEN HOISINGTON, Professor of Electronics (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

RAYMOND KENNETH HOUSTON, Professor of Electrical Engineering (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

DONALD EVAN KIRK, Associate Professor of Electrical Engineering (1965); B.S., Worcester Polytechnic Institute, 1959; M.S., Naval Postgraduate School, 1961; Ph.D., University of Illinois, 1964.

CLARENCE FREDERICK KLAMM, JR., Professor of Electronics, (1951); B.S., Washington Univ., 1943; M.S., 1948.

GEORGE HEINEMANN MARMONT, Professor of Electronics (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

CARL ERNEST MENNEKEN, Professor of Electronics (1942); B.S., Univ. of Florida, 1932; M.S., Univ. of Michigan, 1936.

ROBERT LEE MILLER, Professor of Electronics (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

RAYMOND PATRICK MURRAY, Associate Professor of Electronics (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

GLEN ALLEN MYERS, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E., Stanford Univ., 1956; Ph.D., 1965.

HERBERT LEROY MYERS, Assistant Professor of Electrical Engineering (1951); B.S., Univ. of Southern California, 1951.

CHARLES BENJAMIN OLER, Professor of Electrical Engineering (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., Johns Hopkins Univ., 1950.

RUDOLF PANHOLZER, Associate Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule Graz, Austria, 1953; M.S.E.E., Stanford Univ., 1956; D.Sc., Technische Hochschule Graz, Austria, 1961.

GEORGE ANTHONY RAHE, Associate Professor of Electrical Engineering (1965); B.S., Univ. of California at Los Angeles, 1957; M.S. 1959; Ph.D., 1965.

CHARLES HARRY ROTHAUGE, Professor of Electrical Engineering (1949); B.E. Johns Hopkins Univ., 1940; D.Eng., 1949.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

ABRAHAM SHEINGOLD, Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

WILLIAM CONLEY SMITH, Professor of Electrical Engineering (1946); B.S., Ohio Univ., 1935; M.S., 1939.

DONALD ALAN STENTZ, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S., Naval Postgraduate School, 1958.

ROBERT DENNEY STRUM, Associate Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946; M.S., Univ. of Santa Clara, 1964.

FREDERICK WALCUTT TERMAN, Assistant Professor of Electrical Engineering (1964); B.S., Stanford Univ., 1949; M.S., 1950.

GEORGE JULIUS THALER, Professor of Electrical Engineering (1951); B.E., Johns Hopkins Univ., 1940, D.Eng., 1947.

HAROLD ARTHUR TITUS, Associate Professor of Electronics (1962); B.S., Kansas Univ., 1952; M.S., Stanford Univ., 1957; Ph.D., 1962.

JOHN BENJAMIN TURNER, JR., Associate Professor of Electronics (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California at Berkeley, 1948.

ALLEN EDGAR VIVELL, Professor of Electrical Engineering (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

JOHN ROBERT WARD, Professor of Electrical Engineering (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952, Ph.D., 1958.

MILTON LUDELL WILCOX, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938 M.S. Univ. of Notre Dame, 1956.

* The year of joining the Postgraduate School Faculty is indicated in parentheses.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific academic requirements for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

1. Candidates for this degree must generally satisfy the following requirements while in residence at the Naval Postgraduate School, except in the case of candidates entering the school with advanced standing, when due allowance will be made for advanced transfer credits.

Discipline:	Subject:	Approximate Quarter Hours:
Electrical Engineering	Fields and Circuits	13
	Electronic Devices and Circuits	15
	Communication Theory	4
	Electromagnetic Theory	3
	Energy Conversion	4
	Electronic Computers	4*
	Control Theory	4
		47
Mathematics	Calculus, vectors, matrices, series, differential equations and complex variables	12

* Courses in computer programming or theory with MA and CS prefixes may be substituted for electrical engineering courses in computers with approval of the Chairman of the Department.

2. An additional 11 quarter hours are to be taken in upper division courses in Electrical Engineering and 9 quarter hours in areas such as mechanics, dynamics, properties of matter, physical chemistry and thermodynamics. Minor departures from these requirements may be approved by the Department as long as the total number of hours in upper division courses is not reduced.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

A minimum of 40 quarter hours of graduate work beyond the requirements for the Bachelor of Science in Electrical Engineering degree shall be required for the degree of Master of Science in Electrical Engineering. The academic records of those students who do not complete the requirements for the Bachelor of Science in Electrical Engineering degree at the Naval Postgraduate School will be evaluated by the Department of Electrical Engineering to determine what additional undergraduate courses need be taken to quality for entry into the graduate program. Of the 40 quarter hours, a minimum of four courses of at least 12 hours, must be in the course sequence 4000-4999. At least 30 hours shall be required in Electrical Engineering subject. An acceptable thesis must be presented. An acceptable thesis for the Engineer's Degree may also be accepted as meeting the thesis requirements of the Master's Degree.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer. Normally, this program is of three years' duration. Candidates for the Engineers's degree are selected during their second year in residence.

2. A minimum of 80 graduate course credits are required for the award of the Engineer's degree. Of these at least 30 hours are to be in the courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman, Department of Electrical Engineering.

DOCTOR OF PHILOSOPHY

The Department of Electrical Engineering has an active program leading to the degree of Doctor of Philosophy. Areas of special strength in the department are signal processing systems, electronic processes and devices, and control theory. Joint programs with the Department of Physics are possible. The degree requirements are as outlined under the general school requirements for the Doctor's degree.

ELECTRICAL ENGINEERING LABORATORIES

The Electrical Engineering Laboratories have ample facilities for comprehensive instructional and research programs in all phases of present-day electrical engineering, including electrical circuits, machinery and measurements, electronic devices, circuits and systems, feedback control mechanisms and systems, and computer technology.

The extensive conventional facilities in the Electrical Circuits and Machinery Laboratories are supplemented by special bridges and other measuring equipment, data-recording devices and generalized machine sets and a direct energy conversion laboratory. Analog computers are available for simulation and analysis of circuits, machines, devices and systems.

In the Electronics Laboratories, facilities are provided for investigating the characteristics of modern electronic devices, circuits and equipments at frequencies ranging from d-c to the optical region. Available systems include representative communications, radar, laser, telemetry, sonar and countermeasures systems and navigational aids. Special facilities are available for intensive study of transmission and radiation properties of electromagnetic energy, including a microwave anechoic chamber and an antenna model range.

The Computer Laboratory of the Department of Electrical Engineering is a School-wide direct access computer complex wherein each student programs and operates the computer system for the solution of his own problems. The facility includes a medium sized digital computer, two high performance input-output display units and a general purpose hybrid/analog computer, all integrated into a single computer system. These facilities support research and instruction in digital and hybrid computation simulation, control engineering, information processing, and business and war gaming.

The Servomechanisms Laboratory is equipped with analyzers, recorders and the basic units required to synthesize and test a wide variety of systems. Analog computers serve an important role in the synthesis and analysis of control systems.

When precision measurements are required, calibrated instruments and highly stabilized frequency standard sources are available.

BIOLOGY

Upper Division or Graduate Courses

BI 3800 CELLULAR AND MOLECULAR BIOLOGY (4-0). The fundamental principles of the living cell covered from a biochemical and biophysical standpoint. The structure and role of macro-molecules in the cell is studied; in particular DNA, RNA and their relations to cell function, to the synthesis of proteins, and to genetics. PREREQUISITES: PH 3652, CH 3401, PH 2551, and a course in probability and statistics.

BI 3801 ANIMAL PHYSIOLOGY (5-0). A comprehensive course in mammalian physiology, emphasizing human functional aspects. PREREQUISITE: BI 3800.

BI 3850 BIOLOGICAL EFFECTS OF RADIATION (5-0). This course treats the effects of radiation on individual living cells and on the whole mammalian organism, including man. Sufficient biological background material is presented, as required for an understanding of the radiation effects. Aspects of radiological safety are also treated. PREREQUISITES: PH 3652, CH 3401, PH 2551, a course in probability and statistics.

Graduate Courses

BI 4802 RADIATION BIOLOGY (5-0). Fundamental processes of energy transfer from radiation to living matter. Biochemical, physiological and genetic effects of radiation. Methods of experimental radiation biology. PREREQUISITES: BI 3801 and appropriate courses in nuclear physics.

BI 4822 SPECIAL TOPICS IN RADIATION BIOLOGY (2-0). Study of important current topics in radiation biology. PREREQUISITE: Appropriate biological background.

BI 4823 SPECIAL TOPICS IN RADIATION BIOLOGY (2-01). A continuation of BI 4822. A study of important current topics in radiation and biology.

COMMUNICATIONS

Upper Division Courses

CO 2111 COMMUNICATIONS ORGANIZATION AND PLANNING (4-0). Organization and functions of Department of Defense Communications Systems, including command and control functions. A study of the National Communications System, Defense Communications Systems, and the complete Naval communications organization, including the Naval Security Group. Integration of the various organizational systems is emphasized. The role of communications in the Naval Planning process is studied as well as an introduction to communications planning.

CO 2112 COMMUNICATION SYSTEMS (3-2). Brief review of the development of the broadcast, ship shore and tactical communication systems and sub-systems within the Navy, and their relationship to the Defense Communication System. Systems schemes and outlines of AUTODIN, AUTOVON, Multi-Channel, Tactical Satellite and ON-Line Cryptographic systems are studied with emphasis on problems and solutions associated with compatability, installation and operating procedures. PREREQUISITE: CO 2111.

COMPUTER SCIENCE

*CS 0001 SEMINAR (0-1).

*CS 0110 FORTRAN PROGRAMMING (3-0).

*CS 0810 THESIS RESEARCH (0-0)

Upper Division Courses

*CS 2100 INTRODUCTION TO COMPUTERS AND PROGRAMMING (4-0).

*CS 2110 INTRODUCTION TO COMPUTER PROCESSES (3-2).

Upper Division or Graduate Courses

*CS 3111 PROGRAMMING LANGUAGES (4-0).

*CS 3112 OPERATING SYSTEMS (4-0).

CS 3200 LOGICAL DESIGN OF DIGITAL COMPUTERS (4-0). Introduction to the techniques of logical design of computer elements and systems. Boolean algebra, propositional logic, truth tables, simplification of expressions. Applications to switching, circuit elements, design of combinatorial and sequential circuits. Reduction of descriptions of processes to Boolean form. Logic of arithmetic and control units, storage elements. Principles of digital systems design. Existing forms of machine organization. PREREQUISITE: CS 2100 or equivalent.

CS 3201 COMPUTER SYSTEMS DESIGN (4-0). Formulation and design of somputer systems. Allocation of system resources. System availability measures. Case studies: real-time and batch systems. Procedures and criteria for system evaluation and selection. PREREQUISITES: CS 3112

CS 3204 DATA COMMUNICATIONS (4-0). Quantitative study of communication processes. Concepts fundamental to the engineering of accurate, efficient communication links and systems. Elements of information theory. Communication channels and their capacity; encoding and decoding of data over noisy channels. Error detection and correction. Coding schemes; binary systems. Design of effective transmission links in computer-based systems. Survey of devices available for data communications in a military environment. Real-time control systems. PREREQUISITES: CS 3111. CS 3200, MA 2232.

*CS 3300 INFORMATION STRUCTURES (3-0).

*CA 3601 AUTOMATA AND FORMAL LANGUAGES (3-0).

CS 3800 DIRECTED STUDY IN COMPUTER SCIENCES (0-2 to 0-8). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the instructor.

Graduate Courses

*CS 4113 COMPILER DESIGN AND IMPLEMENTATION (3-2).

*CS 4202 INTERACTIVE COMPUTATION SYSTEMS (3-2).

*CS 4310 NON-NUMERICAL INFORMATION PROCESSING (4-0)

CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0). Discussion of selected topics in the fields of current research in computer science. PREREQUISITE: Consent of instructor.

*See listing under Mathematics Department.

ELECTRICAL ENGINEERING

EE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

EE 0951 THESIS SEMINAR (0-1). Lectures on subjects of current interest will be presented by invited guests from other universities and from industry, as well as by faculty members of the Naval Postgraduate School.

Upper Division Courses

EE 2101 PRINCIPLES OF ELECTRICAL ENGINEERING (3-2). Basic concepts of electric and magnetic fields with emphasis on electrical engineering applications; the circuit concept; v-i relations; Kirchloff's voltage and current laws; power and energy. PREREQUISITE: Integral Calculus and MA 2045 (may be concurrent.)

EE 2102 CIRCUIT ANALYSIS (4-2). Solution of network equations using basic Laplace transform methods; transfer functions; poles and zeros; sinusoidal steady-state analysis including phasor methods, frequency response including resonance, network theorems, tow-part parameters, balanced polyphase circuits, and coupled circuits. PREREQUISITE: EE 2101 or equivalent.

EE 2103 LINEAR SYSTEMS ANALYSIS (4-2). Applications of Fourier series and Fourier transform methods; convolution; state-variable formulation and solution; signal flow graphs; simulation of linear systems on analog and digital computers. PREREQUISITES: EE 2102; Differential Equations; Complex Variable Theory and Fortran may be concurrent.

EE 2114 COMMUNICATION THEORY I (4-0). In this introductory course the following concepts and their mathematical formulations are presented; power spectral density; matched filters; sampling; pulse encoding methods; frequency and time multiplexing; amplitude, frequency and phase modulation. In addition, a comparison of modulation methods is presented. PREREQUISITES: EE2103 and EE 2212.

EE 2201 ELECTRONICS SURVEY (4-2). A one-term survey course for non-electrical engineering curricula, with emphsis on the general operational characteristics of representative electronic devices. Topics included are: physical process in common devices; current-voltage relations of diodes and active devices; basic electronic circuits. PREREQUISITE: EE 2102.

EE 2211 ELECTRONIC ENGINEERING FUNDAMENTALS I (4-2). A general introduction to electronic devices, circuits and systems is followed by the consideration of the electronic properties of matter, conduction and emission processes, diodes and diode circuits, multi-terminal control devices, amplifier characteristics, and equivalent-circuit representations and analysis of linear amplifiers. PREREQUISITE: EE 2102 (may be concurrent).

EE 2212 ELECTRONIC ENGINEERING FUNDAMENTALS II (4-3). Topics include small-signal amplifiers, feed-back amplifiers, amplifier arrangements for integrated circuits, power amplifiers, electronic power supplies. PREREQUISITE: EE 2211.

EE 2215 SPECIAL ELECTRONIC DEVICES (4-2). The topics studied include charged-particle dynamics, microwave tubes, parametric amplifiers, non-reciprocal microwave devices, quantum-electronic and other current device developments. PREREQUISITES: EE 2212, EE 2621 and PH 2641.

EE 2216 PULSE AND DIGITAL CIRCUITS (4-3). The topics studied include basic waveform characteristics and shaping techniques, wide-band linear amplifiers, characteristics of electronic switching devices, clipping, clamping and switching circuits, multivibrator and trigger circuits, time-base generators, logic circuits, counting and timing circuits. PREREQUISITE: EE 2212.

EE 2217 COMMUNICATION CIRCUITS (4-3). Electronic circuits used for the transmission and reception of analog and digital signals. Topics include oscillators, modulators and demodulators, frequency converters, and special-purpose amplifiers. PREREQUISITES: EE 2216. EE 2114.

EE 2221 GENERAL ELECTRONICS (4-2). A one-quarter survey course for nonengineering curricula. Consideration of the basic concepts of electrical circuit analysis is followed by a study of the underlying physical processes and operational characteristics of common electronic devices and some representative device applications in electronic circuits and systems. PREREQUISITE: College Algebra.

EE 2222 ELECTRONIC FUNDAMENTALS I (3-2). The first of a sequence for nonengineering curricula. An introduction to electronic devices, circuits and systems is followed by a consideration of basic concepts of electrical circuit analysis, electronic conduction and emission processes in electronic devices and operational properties of diodes and control devices. PREREQUISITE: A course in Calculus.

EE 2223 ELECTRONIC FUNDAMENTALS II (3-3). A continuation of EE 2222. Included topics are linear amplifier analysis, feedback techniques, tuned amplifiers, power amplifiers, and electronic power supplies. PREREQUISITE: EE 2222.

EE 2224 COMMUNICATION AND DIGITAL ELECTRONICS (4-3). Frequency spectra for information transmission, oscillators, modulation and demodulation techniques, frequency conversion, pulse circuits and digital techniques, communication transmitters and receivers. PREREQUISITE: EE 2223.

EE 2231 ELECTRONICS I (Nuclear) (3-3). This is the first of two courses designed to give the Nuclear Engineering student an appreciation of electronic equipment used in this science. Topics are: Steady-state circuit analysis, transient concepts, and basic theory of vacuum and semi-conductor diodes, control-type tubes, and transistors. PREREQUISITES: Mathematics through calculus.

EE 2232 ELECTRONICS II (Nuclear) (3-3). This course considers vacuum-tube and transistor circuits, such as power supplies, voltage amplifiers, feedback circuits, pulse amplifiers, and pulse-shaping circuits. Basic concepts are then applied to a variety of special circuits, including: integral and differential discriminators; coincidence and anti-coincidence circuits, count-rate meters, and scalers. PREREQUISITE: EE 2231.

EE 2311 PRINCIPLES OF ENERGY CONVERSION (3-2). An introduction to the principles of energy conversion. Topics presented are thermoelectric, thermionic, photovoltaic, electrochemical and electromagnetic methods of energy conversion. PREREQUISITES: EE 2621, ME 2101, CH 2402, PH 2641, the equivalent or by permission of Instructor.

EE 2312 ELECTROMAGNETIC MACHINES (3-4). The model oriented approach to the analysis of rotating machines and amplifiers is utilized to obtain their dynamic and steady state characteristics. DC motors, generators and control machines are analysed. PREREQUISITES: EE 2311 or EE 3311, EE 2103.

EE 2411 CONTROL SYSTEMS (3-3). Introduction to the analysis and design of linear feedback control systems by means of s-plane and frequency response methods. Analysis using state variables; design using frequency and time domain performance indices is discussed. Laboratory work includes simulation using analog and digital computers; testing and evaluation of physical systems. PREREQUISITES: EE 2103 and MA 2232 or their equivalent.

EE 2613 ENERGY TRANSMISSION FOR COMMUNICATIONS (4-3). A one quarter survey course of basic electromagnetic principles, transmission-line theory, propagation of electromagnetic waves and antennas. PREREQUISITES: EE 2224, MA 2121.

EE 2621 INTRODUCTION TO FIELDS AND WAVES (4-1). Static field theory is developed and applied to boundary value problems. Field theory is continued and extended to time-varying fields. Transmission-line theory is developed and applications are presented in the laboratory. PREREQUISITES: MA 2161, EE 2103.

EE 2622 ELECTROMAGNETIC ENGINEERING (3-0). Principles of guided waves are presented such as rectangular and cylindrical wave guides and cavity resonators. Additional topics presented are skin effect, plane wave propagation and reflection of waves. PREREQUISITE: EE 2621.

EE 2711 ELECTRICAL MEASUREMENTS (3-3). A study of methods and techniques for the measurement of electrical quantities such as voltage, current, power, frequency, phase angle, circuit parameters, fields, etc., and including statistical analysis of experimental data with emphasis on precision and accuracy. PREREQUISITES: EE 2102 and EE 2212.

EE 2810 DIGITAL MACHINES (3-3). Basic principles of digital system design with emphasis upon the organization and programming of simple computors. Elements of Boolean algebra and logic design. Storage organization and control. Input-output data flow. Relation of machine logic to program design. Laboratory sessions are devoted to study of computer logical elements, processing, storage, and I/O units. PREREQUISITE: CS 2110.

Upper Division or Graduate Courses

EE 3116 COMMUNICATION THEORY II (3-2). A continuation of EE 2114. The concept of information measure (entropy) is introduced and its significance for communication systems is discussed. Noise sources and their measurement are treated. Statistical methods for handling noise and random signals are presented, followed by a study of detection problems in radar and pulse transmission systems. Correlation functions and their applications to communication systems are introduced. PREREQUISITES: EE 2114. A course in probability and statistics.

EE 3215 MICROWAVE DEVICES (4-2). The topics studied include particle dynamics, electron beam-forming focusing techniques, microwave tubes, negative resistance and variable-reactance devices, non-reciprocal microwave devices, quantum-electronic devices, microelectronic and other current device developments. PREREQUISITES: EE 2212, EE 2621 and PH 2641.

EE 3263 TRANSISTOR AND INTEGRATED CIRCUIT APPLICATIONS (3-3). Analysis and design considerations of selected circuits using bipolar and field-effect transistors, and linear integrated circuits. PREREQUISITE: EE 2212.

EE 3264 ADVANCED THEORY OF SEMICONDUCTOR DEVICES (4-0). The application of solid state physics to the analysis and characteristics of semiconductor diodes, transistors, and integrated circuits will be studied. Attention will be given to the relationship between the internal physical processes in these devices and their responses to large, high-frequency and transient signals. PREREQUISITES: EE 2212 and PH 3741 or equivalent.

EE 3311 ENERGY CONVERSION (3-2). A consideration and application of principles used in the conversion of energy to the electric form. Devices utilizing these principles are analyzed and include thermoelectric, thermionic, electrochemical and others. A term paper based on library research in the energy conversion field is required. PREREQUISITES: EE 2621, CH 2402, ME 2101, PH 2641, the equivalent or by permission of the Instructor.

EE 3313 MARINE ELECTRICAL ANALYSIS AND DESIGN (2-4). Design principles of elctric machines are studied. Symmetrical components are presented and applications are made in the short circuit analysis of a portion of a ship's power distribution system. A computer study of a static excitation system is made. PREREQUISITES: EE 2312 and EE 2411.

EE 3422 MODERN COMMUNICATIONS (3-2). A study of modern communications trends, with emphasis on theoretical study of current and proposed systems. The topics covered include multiplex systems, coding, and pseudo-random noise modulation systems. PREREQUISITE: EE 3116 or EE 4571.

EE 3432 RADAR SYSTEMS (3-2). The principles of pulse radar systems are developed in classroom and laboratory exercises. Additional topics developed include the radar equation, doppler systems, automatic target-tracking systems, pulse compression, and multiple-unit steerable-array radars. PREREQUISITES: EE 2114, EE 2215, and EE 2622.

EE 3471 GUIDANCE AND NAVIGATION (3-2). A study of the principles involved in the guidance and navigation of platforms operated in a water, air or space environment. Topics include: beam forming directional sensing techniques, interrogation methods; time and phase difference systems; high resolution methods including inertial, celestial, and optical techniques; and closed loop telemetry systems used for automatic guidance. PREREQUISITES: EE 2411, EE 3631.

EE 3481 PRINCIPLES OF ELECTRONIC WARFARE (3-2). Electronic countermeasure and counter countermeasure (ECM and ECCM) techniques are developed with applications to radar, infra-red, communications, and sonar systems. Topics include signal intercept and analysis, denial jammers, deceptive jammers, confusion reflectors, decoys, target masking and modification, and anti-jamming techniques. PREREQUISITES: EE 3432 and SECRET Clearance.

EE 3622 ELECTROMAGNETIC THEORY (3-0). The time-varying Maxwell equations and general boundary conditions are presented. Solutions to the wave equation in unbounded regions are studied. Maxwell's equations are applied to systems of guided waves and cavity resonators. PREREQUISITE : EE 2621.

EE 3631 ANTENNAS AND PROPAGATION (3-2). An engineering course covering the major classes of antennas for communications and radar followed by a study of the properties of the atmosphere and its effect on the propagation of surface, space, and sky waves. While essentially stressing engineering, the course applies to practical systems the field theory presented in earlier courses. PREREQUISITES: EE 2622 or EE 3622.

EE 3731 INSTRUMENTS AND EQUIPMENT FOR OCEAN OPERATION (4-3). A study of measuring techniques, sensors, transducers and special electrical and sonic equipment for data-gathering, processing and communications in a deep-water environment. Specific topics covered include navigational instruments, precise positioning, high-pressure electrical circuitry, communications, acoustic transducers and systems, motors and underwater power supplies. PREREQUISITES: PH 3421 and an undergraduate course in electronics.

EE 3812 SWITCHING THEORY AND LOGIC DESIGN (3-2). Models for logic elements and networks. Equivalence and machine minimization. Threshold logic. Synthesis of combinational and sequential networks. State assignment. Applications to digital machine design. Laboratory work is oriented around a project in logic network design. PREREQUISITE: EE 2810.

EE 3822 ENGINEERING APPLICATIONS OF COMPUTERS (3-3). Use of digital, analog, and hybrid computing machines in various application areas, e. g., systems design, parameter optimization, adaptive control, data acquisition and filtering, signal processing, biomedical instrumentation. Special techniques for real-time processing and simulation. Laboratory work is conducted in small groups and involves applications studies using the various types of computers. PREREQUISITE: EE 2810.

EE 3831 COMPUTER-AIDED NETWORK ANALYSIS AND DESIGN (3-2). Introduction to the application of computers in the analysis and design of passive and active networks. Topics included are: linear and non-linear networks; DC, AC, and transient analysis; sensitivity and optimization problems; off-line and on-line designs; theory and application of various general and special-purpose computer programs such as ECAP, CORNAP, CALAHAN, NASAP. Students will use these programs for their design problems. PREREQUISITES: EE 2211, EE 2103, and MA 2232 or equivalent.

Graduate Courses

EE 4121 ADVANCED NETWORK THEORY I (3-2). Topology. Circuit formulations, nonlinear modeling, and computer solution. Circuit sensitivity models. Concepts and tests for passivity, activity, causality, and stability. Driving point synthesis. Introduction to transfer function properties and synthesis. PREREQUISITES: EE 2103 and EE 2211.

EE 4122 ADVANCED NETWORK THEORY II (3-2). Transfer function synthesis. N-port properties. N-port synthesis. The scattering matrix. The approximation problem. PREREQUISITE: EE 4121.

EE 4123 ADVANCED NETWORK THEORY III (3-2). Topics selected from the following: Active network synthesis. Topological synthesis. Time-domain synthesis. Advanced computer methods in network design. PREREQUISITE: EE 4122.

EE 4412 NONLINEAR SYSTEMS (3-3). Techniques for the analysis of nonlinear feedback systems. Phase plane and describing function analysis. Relay servomechanisms. Lyapunov method. Popov stability. Laboratory work includes analog and digital simulation. PREREQUISITE: EE 2411.

EE 4414 STOCHASTIC CONTROL THEORY (2-2). Statistical and probabilistic concepts are applied to the development of optimal methods for estimation, prediction, and identification. These methods are applied to the stochastic control problem. PREREQUISITES: EE 2411 and PS 3411.

EE 4415 ALGEBRAIC METHODS IN CONTROL THEORY (3-0). This course treats advanced concepts in root-locus theory including graphical and analytic (algebraic) design of compensation. Extension is made to two-parameter analysis and design. The Mitrovic-Siljak relationships are developed, leading to the coefficient plane and parameter-plane methods. Stability analysis, adjustment, design and synthesis using parameter-plane methods are treated in detail. Extensions to multiparameter problems are discussed. PREREQUISITE: EE 2411.

EE 4416 TOPICS IN MODERN CONTROL THEORY (3-0). A course intended to acquaint the student with recent developments in control as found in the research publications of the profession. Topics are selected at the direction of the instructor and may include such subjects as Adaptive Systems, Digital and Hybrid Simulation, Finite State Automata, Learning Systems, Lyapunov Methods, Popov Stability, Sensitivity, etc. PREREQUISITE: Consent of the Instructor.

EE 4417 OPTIMAL CONTROL (4-0). The optimal control problem is treated using the calculus of variations. Pontryagin's maximum principle, and dynamic programming. Optimal pursuit–evasion strategies are considered. PREREQUISITE: EE 2411.

EE 4421 ELECTRO-OPTIC SYSTEMS ENGINEERING (3-1). Analysis and design of electro-optic systems such as laser communication, optical information processing, laser radar, infra-red systems, low-light-level television. Emphasis is on system characteristics as determined by electro-optic devices. PREREQUISITES: EE 2114, EE 3622, consent of Instructor.

EE 4433 ADVANCED RADAR SYSTEMS (3-2). The radar range equation is developed in a form including signal integration, the effects of target cross-section, fluctuations, and propagation losses. Modern techniques discussed include pulse compression, frequency-modulated radar, MTI, pulse doppler systems, monopulse tracking systems, multiple-unit steerable array radars, and synthetic aperture systems. Laboratory sessions deal with basic pulse radar systems from which the advanced techniques have developed, with pulse compression, and with the measurement of radar cross section of targets. PREREQUISITES: EE 3622, EE 3215, EE 4571 (may be concurrent) and SECRET Clearance.

EE 4451 SONAR SYSTEMS ENGINEERING (3-2). A study of the theory and engineering practices pertaining to passive and active sonar systems. This study emphasizes the research and development of underwater acoustic surveillance systems. The objective of the course is to determine how the engineering design is conditioned by the characteriestics of the transmission medium as well as the operational requirements. PREREQUISITES: PH 4454, EE 4571, EE 2212, SECRET Clearance.

EE 4452 UNDERWATER ACOUSTIC SYSTEMS ENGINEERING (4-2). A study of the thoery and engineering principles of underwater acoustics, communications, surveillance, and navigational systems. Emphasis is placed on the principles and problems common to all underwater acoustic systems, and the design trade-off's that are available to the engineer. The laboratory periods are used for making engineering tests on existing systems and designing, building, and testing a system or subsystem of the student's own design. PREREQUISITES: EE 4571, EE 2212.

EE 4461 ADVANCED SYSTEMS ENGINEERING (3-1). An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. The class will be expected to participate in a group project involving a feasibility study of a proposed new system. PREREQUISITES: EE 4571 and EE 2411.

EE 4473 MISSILE GUIDANCE SYSTEMS (3-1). Principles of inertial sensors and autonavigator systems. Radar and Infra-red trackers. Trajectory analysis. Steering logic. Proportional navigation. Pursuit-evasion strategy. Control of ballistic and aerodynamic vehicles. Navigation and guidance in space. Laboratory work is concerned with testing of components and evaluation by computer simulation of complete guidance system performance. PREREQUISITES: EE 4412, EE 4433 or equivalent.

EE 4481 ELECTRONIC WARFARE TECHNIQUES AND SYSTEMS (3-2). Active and passive countermeasure techniques are considered, including signal representation, signal analysis, and signal interception. Important parameters of radar and communications systems are defined. Denial and deceptive jamming techniques are considered along with counter and countermeasure techniques. Signal intercept systems are treated. Acoustic, radio-frequency, infra-red, and optical countermeasures are discussed. PREREQUISITES: EE 4433 and SCRRET Clearance.

EE 4491 NUCLEAR REACTOR CONTROL SYSTEMS (3-0). The nonlinear reactor kinetic equations are analyzed under controlled and accidental input conditions. The small-signal input method is used and the zero-power and power-to-reactivity feedback transfer functions are obtained. The requirements for stable and accurate operation of automatic flux control are established using linear feedback control theory. Digital computer methods of simulating the nonlinear system are used to check on the validity of the linear theory. Modern control theory application to nuclear reactor systems is introduced. PREREQUISITE: EE 4412.

EE 4541 SIGNAL PROCESSING (3-1). Application of statistical decision theory to the detection of signals in noise. Ambiguity diagrams for signal detection and parameter estimation; signal design. Applications to antenna and transducer arrays. Signal processing in detection and tracking systems. PREREQUISITE: EE 4571.

EE 4571 STATISTICAL COMMUNICATION THEORY (3-2). This course is a more advanced sequel to EE 3114 than EE 2116. Basic concepts of information theory are introduced and their significance for communication systems is discussed. A study of noise source and a mathematical treatment of noise and random signals. based on statistical methods are presented. Transmission of such signals through linear and non-linear networks is analyzed. Statistical decision theory applications to signal detection and interpretation are illustrated by selected problems. PREREQUISITES: EE 2114 and PS 3411.

EE 4581 INFORMATION THEORY (3-1). Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to channel capacity and coding; coding methods. Effects of noise on information transmission. Selected applications of the theory to systems. PREREQUISITE EE 4571.

EE 4623 SELECTED TOPICS IN ADVANCED ELECTROMAGNETIC ENGINEERING (3-0). An advanced course beginning with theorems and concepts such as the equivalence principle, reciprocity, Green's functions, integral equations, and the reaction concept. Specific topics covering recent developments in periodic and travelling wave structures, radiation, scattering, and diffraction will be selected to meet the needs of the students. PREREQUISITE: EE 3622.

EE 4631 ANTENNA ENGINEERING (3-2). This course is intended to make the student familiar with the more common types of antennas and feed systems. The attack is essentially an engineering approach, applying to practical systems the mathematics and field theory presented in earlier courses. The laboratory is directed to the measurement of field intensities, antenna patterns, input impedence and feed systems. PREREQUISITE: EE 3622.

EE 4652 MICROWAVE CIRCUITS AND MEASUREMENTS (3-2). A study of microwave components as circuit elements. Topics to be studied will include: waveguides as transmission lines, waveguides, impedance concepts, matrix formulation for obstacles in waveguides, and resonant cavities as microwave circuit elements. PREREQUISITE: EE 3622.

EE 4671 THEORY OF PROPAGATION (3-0). Properties of the atmosphere and its effect on the propagation of surface, space, and sky waves. Additional topics include: coverage prediction, frequency selection, noise, and tropospheric and ionospheric scatter. PREREQUISITE: EE 2622 or EE 3622.

EE 4823 ADVANCED DIGITAL COMPUTER SYSTEMS (3-1). A course intended to acquaint the student with recent developments in digital systems as found in the research publications of the profession. Topics are selected the discretion of the instructor and may include such subjects as: machine organization, computer graphics, man-machine interfaces, design automation, parallel processing, etc. An individually planned laboratory program is directed toward an experimental project involving state-of-the-art utilization of computer hardware or software. PREREQUISITE: EE 3812.

EE 4831 COMPUTATIONAL METHODS FOR SYSTEM OPTIMIZATION (3-2). Computational algorithms are applied to the design of optimum systems. Topics include parameter and trajectory optimization of control systems, and optimum network design procedures. PREREQUISITES: EE 4417, EE 4121.

EE 4900 SPECIAL TOPICS IN ELECTRICAL ENGINEERING (2-0). Supervised study of the periodicals in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. PREREQUISITE: Consent of the department chairman.

ENGINEERING ACOUSTICS

The Engineering Acoustics program is carried out as an inter-disciplinary effort with courses drawn principally from the fields of electrical engineering and physics. The emphasis is on those aspects of acoustics concerning propagation of sound in water, in applications of underwater sound, and on the electrical engineering of instrumentation for underwater sound detection.

DEGREE REQUIREMENTS MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

1. A student pursuing a program leading to a Master of Science in Engineering Acoustics must have completed work which would qualify him for a Bachelor of Science degree in engineering or physical science. Credit requirement for the Master of Science degree must be met by courses in addition to those used to satisfy this requirement.

2. The Master of Science in Engineering Acoustics requires a minimum of 36 graduate credit quarter hours of course work; at least 20 graduate quarter hours must be taken in acoustics and its applications. One 4000 level course from each of three of the following areas must be included: wave propagation, vibration and noise control, transducer theory, sonar systems, and signal processing.

3. An acceptable thesis must be completed.

Approach to King Hall

ENGINEERING SCIENCE

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

1. The following are the minimum requirements for the degree Bachelor of Science in Engineering Science.

2. The degree in Engineering Science requires a minimum of 100 quarter hours in Engineering and Science of which at least 50 hours the upper division level.

3. The following specific requirements must be met. Areas marked with an asterisk must include laboratory work:

	Approximate Quarter Hrs.
a. Mathematics through calculus	17
b. Chemistry and Material Science*	15
c. Classical and modern Physics	16
d. Electrical Engineering including Electronics*	14
e. Mechanical Engineering including Mechanics and Thermodynamics	11
f. Probability and Statistics	3
g. Computers and Data Processing	4
h. Elective in Engineering and Science	20
	100

Electives will be chosen from courses in Mathematics, Chemistry or Physics, Electrical Engineering, Mechanical Engineering, Probability and Statistics, Computer Science, Oceanography, Meteorology, Operations Analysis.

The graphical drum plotter works on the same principle as a child's Etch-a-Sketch, making those who use it look like technical artists.

DEPARTMENT OF GOVERNMENT AND HUMANITIES

EMMETT FRANCIS O'NEIL, Professor of Government and Humanities; Chairman (1958)*; A.B., Harvard Univ., 1931; M.A., Univ. of Michigan, 1932; Ph.D., 1941.

WILLIAM PAUL ALEXANDER, JR., Assistant Professor of Political Science (1968); A.B., Davidson College, 1954; M.A., Vanderbilt University, 1961: Ph.D., University of Rochester (pending).

LOFTUR L. BJARNASON, Professor of Literature (1958); A.B., Univ. of Utah, 1934; A.M., Harvard Univ., 1939; Ph.D., Stanford Univ., 1951.

WILLIAM CLAYTON BOGGESS, Associate Professor of Speech (1956); B.S., Univ. of Southern California, 1953; M.S., 1954.

BARBARA LOUISE GABEL, Associate Professor of English (1967); A.B., Dickinson College, 1945; A.M., Peabody College, 1946; Ph.D., Univ. of North Carolina, 1954.

STEPHEN GOTTSCHALK, Assistant Professor of History (1968); M.A., Occidental College, 1962; M.A., Univ of California, 1963; Ph.D., 1969.

BOYD FRANCIS HUFF, Professor of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California, 1955.

JAMES MICHAEL McADAMS, Ensign, U.S. Naval Reserve (1969); Instructor in Political Science; B.A., Univ. New Mexico, 1967; M.A., 1968.

LAWRENCE WARD PEARSON, Ensign, U.S. Naval Reserve, (1969); Instructor in Political Science; B.A., Univ. of Maryland, 1967; M.A., Indiana Univ., 1968.

BURTON MacLYNN SMITH, Associate Professor of Speech (1955); B.A., Univ. of Wisconsin, 1936; M.A., 1937.

RUSSEL HENRY STOLFI, Associate Professor of History (1970); B.S., Stanford Univ., 1954; M.A., 1964; Ph.D., 1966.

FRANK M. TETI, Associate Professor of Political Science (1970); B.A., Los Angeles State College, 1960; M.A., 1962; Diploma, Institute of World Affairs, 1961; Ph.D., Maxwell School of Public Affairs, Syracuse University, 1966.

*The year of joining the Postgraduate School Faculty is in parentheses.

LABORATORY FACILITY

The SPEECH LABORATORY is equipped with a closed circuit television and video-tape machine and has three cameras that provide a total of seven camera angles for speakers to be video-taped during classroom exercises. It is also equipped with a solid state sound system that is built into a lightweight adjustable lectern. A visual aids room adjoining the laboratory enables the speaker to use many types of audiovisual aids to support his speech.

Work is now being done with classes in conference dynamics which allows both instant replay and the compiling of data for future study and illustration in this area.

DEPARTMENT REQUIREMENTS FOR THE DEGREE BACHELOR OF ARTS WITH MAJOR IN GOVERNMENT (INTERNATIONAL RELATIONS)

A minimum of 40 quarter hours of upper division (2000 level) courses in Government, including the following:

	Quarter Hrs.
a. B.A. Required Courses: GV 2160, GV 2161, GV 2163, GV 2164 and GV 2272	18
b. Major Electives: Two courses each from the fields of International Relations and Comparative Government, and one elective from either field.	20
c. One elective from the field of American Government	3-4

ENGLISH

EN 0110 READING IMPROVEMENT (0-5). A course to improve the student's reading speed and comprehension. Associated areas involved in reading are stressed, especially vocabulary-building, study habits and composition.

Lower Division Courses

EN 0111 REVIEW OF THE FUNDAMENTALS OF GRAMMAR AND MECHANICS (1-1). A special course designed to extend the student's command of the principles of standard English usage.

EN 1010 FUNDAMENTALS OF WRITING (3-0). The fundamentals of grammar and rhetoric with practice in writing.

Upper Division Courses

EN 2010 ADVANCED WRITING (3-0). Intensive writing experience with the grammatical and rhetorical principles underlying sound expository and argumentative prose. PREREQUISITE: Freshman English or permission of Chairman of Department.

EN 2239 DIRECTED STUDIES IN WRITING (2-0). Independent study in areas of writing in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

GOVERNMENT

Lower Division Courses

GV 1060 U.S.GOVERNMENT (4-0). American political institutions and processes, the Constitution, parties, interest groups, elections, and voting behavior, with special emphasis on current issues and problems.

GV 1368 AMERICAN LIFE AND INSTITUTIONS (3-0). American political institutions and the political, social, economic, and cultural aspects of American life. Open only to Allied Officers.

Upper Division Courses

GV 2061 NATIONAL SECURITY (3-0). Analysis of the national defense structure, the formulation and execution of strategic concepts; relationships of weapons systems; economic factors and political potentials and requirements to the achievement of national goals. PREREQUISITE: GV 1060.

GV 2160 COMPARATIVE GOVERNMENT (4-0). An analytical and comparative study of the form and functioning of the major types of contemporary government with emphasis on the policy-making process. PREREQUISITE: GV 1060.

GV 2161 INTRODUCTION TO INTERNATIONAL RELATIONS (3-0). The relations of nations, including a consideration of the factors of national power and study of international interests, and organizations.

GV 2163 POLITICAL THOUGHT (4-0). The principal political philosophers; Plato to the French Revolution.

GV 2164 COMPARATIVE IDEOLOGIES (3-0). The major ideological forces in contemporary World Affairs and the developmental patterns of Democracy, Socialism, Communism, and Fascism. PREREQUISITE: GV 2163.

GV 2165 THEORIES OF POLITICAL STRATEGY (4-0). An examination of some recent descriptive theories of political behavior with emphasis on the thoery of games, positive political theory, and other mathematical approaches; the substantive political content rather than the mathematics will be stressed.

GV 2262 THEORY AND PRACTICE OF INTERNATIONAL POLITICS (4-0). A theoretical approach to the study of international relations and an analysis of the factors, organization strategies, and techniques of international politics. PREREQUISITES: HI 2130; GV 2161.

GV 2263 GOVERNMENT AND POLITICS OF THE MIDDLE EAST (4-0). A study of political economic, social, cultural and strategic aspects of the contemporary Middle East and its role in international relations.

GV 2264 GOVERNMENT AND POLITICS OF THE SOVIET UNION (4-0). The structure and function of the Soviet government and Communist Party in decision-making and planning in the Soviet Union. PREREQUISITE: HI 2130.

GV 2265 GOVERNMENT AND POLITICS OF SOUTHEAST ASIA (4-0). The international, internal, and military problems of the southeast Asian states.

GV 2266 GOVERNMENT AND POLITICS OF EAST ASIA (4-0). The international, internal, and military problems of China, Japan, and Korea.

GV 2268 RECENT EUROPEAN DIPLOMACY (1945—Present) (4-0). Foreign affairs of the major European states from 1945 to the present. PREREQUISITE: HI 2030.

GV 2270 AMERICAN POLITICAL THOUGHT (3-0). A study of American political thought from the colonial period to the present. PREREQUISITES: GV 1060, 2163; HI 2032, HI 2131.

GV 2271 AMERICAN CONSTITUTIONAL ISSUES (3-0). The United States Constitution and its development, with emphasis on leading constitutional issues such as federalism, civil-military relations, public-private interest and civel rights. PREREQUISITES: GV 1060; HI 2032, 2131.

GV 2272 AMERICAN TRADITIONS AND IDEALS (4-0). The traditions, ideals and values of our civilization and the role of the military in implementing the image of America in the world. PREREQUISITES: HI 2032, HI 2131, GV 2163.

GV 2273 RECENT AMERICAN DIPLOMACY (4-0). An analysis of the major problems of United States foreign relations in Europe, Latin America and the Far East from 1898 to the present. PREREQUISITES: HI 2030, HI 2032.

GV 2274 AMERICAN PARTY POLITICS (3-0). The nature and function of political parties; origin, development, structure, internal management and control; relation of parties and pressure groups to legislation and administration; analysis of voting behavior and participation in politics. PREREQUISITE: GV 1060.

GV 2279 or GV 3279 DIRECTED STUDIES IN GOVERNMENT (Credit open). Independent study in government in subjects in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

HISTORY

Upper Division Courses

HI 2030 EUROPEAN HISTORY (1914-1945) (3-0). Foreign and domestic affairs of the major European states from the First World War through the immediate aftermath of the Second World War.

HI 2032 U.S. HISTORY (1865-present) (3-0). A survey of the political, economic and social history of the United States from Reconstruction to the present.

HI 2130 EUROPEAN HISTORY (1815-1914) (3-0). Foreign and domestic affairs of the major European states from the Congress of Vienna to the outbreak of the First World War.

HI 2131 U.S. HISTORY (1763-1865) (3-0). A survey of the political, economic and soical history of the United States from the Colonial Period to the end of the Civil War.

HI 2232 RECENT U.S. HISTORY (1933-present) (3-0). A political, social, economic and intellectual history of the United States from the New Deal to the present. Emphasis is given to the impact on urbanization and industrialization on the development of American thought and society.

HI 2239 or HI 3239 DIRECTED STUDIES IN HISTORY (Credit open). Independent study in history in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

HISTORY

Upper Division or Graduate Courses

HI 3032 HISTORY OF RECENT INSURGENCY WARFARE (4-0). Study of the more important insurgencies in recent history from the Russian Revolution of 1917 to the more recent uprisings on five major continents. The study covers the selected insurgencies in detail emphasizing the general historical forces operating, e.g., Nationalism, Socialism, Imperialism, etc., as well as the particular forms of development. Emphasis will be on accurate description of events in order to derive patterns of insurgency warfare.

LITERATURE

Lower Division Courses

LT 1040 APPRECIATION OF LITERATURE (3-0). A study of selected works of literature. The selection is intended to enhance the student's understanding and appreciation of literature as the most commonly used vehicle in expressing the aspirations, the hopes, and the enduring problems of mankind.

Upper Division Courses

LT 2241 MASTERPIECES OF AMERICAN LITERATURE (3-0). A study of selected works of American literature as they reflect the cultural, political, and sociological aspirations of the American people. PREREQUISITE: LT 1040 or permission of the Chairman of Department.

LT 2242 MASTERPIECES OF BRITISH LITERATURE (3-0). A study of British literature with its cultural and historical implications. A modified survey approach is used, but selected works and authors are studied in some depth. PREREQUISITE: Same as for LT 2241.

LT 2243 MASTERPIECES OF EUROPEAN LITERATURE (3-0). A study of selected masterpieces of European literature. An effort is made to impress the student with the continuity of the Western European intellectual heritage. PREREQUISITE: LT 1040 or permission of Chairman of the Department.

LT 2244 MASTERPIECES OF WORLD LITERATURE (3-0). A study of selected masterpieces of world literature. The selection will vary, depending upon the needs and interests of the students. PREREQUISITES: LT 1040, plus at least one of the following: LT 2241, 2242, 2243.

PSYCHOLOGY

Upper Division Courses

PY 2050 GENERAL PSYCHOLOGY (3-0). A study of principles of rational and emotional processes in human thought and action.

PY 2251 APPLIED SOCIAL PSYCHOLOGY (3-1). An application of psychological principles to problems of personality growth, motivation, and interpersonal relations. PREREQUISITE: PY 2050 or permission of Chairman of Department.

SPEECH

Lower Division Courses

SP 1020 PUBLIC SPEAKING (3-0). Practice in preparing and delivering extemporaneous speeches, emphasizing principles and techniques of oral style.

SP 1021 CONFERENCE PROCEDURES (3-0). Theory and practice of group dynamics applied to conferences, with emphasis on group problem-solving in completed staff work.

Upper Division Courses

SP 2020 STAFF BRIEFING (3-1). Preparation for command briefing through practice in precis and abstract writing, source survey, planning visual materials, platform behavior and video-tape critiques. The student is required to produce oral briefings supported by written memorandum-for-record or staff study. PREREQUISITE: SP 1020 or equivalent.

SP 2221 ADVANCED SPEECH (2-1). Practical application of techniques learned in SP 1020 with stress on composition, platform technique, audience situations and audience response. Opportunity to address off-campus audiences is provided. PREREQUISITE: SP 1020 or equivalent. Enrollment limited.

INTERDISCIPLINARY GROUP PROJECTS

OBJECTIVE – The group project has the objective of presenting the student with a complex problem which has to be solved by systems-oriented methods. It offers an alternative to the conventional research project which presents the student with a well-defined problem to be solved by science-oriented methods.

The group project represents a complex system which cannot be solved by an individual effort. Its solution requires team work of specialists from the early phases of problem definition and conceptual design until an optimum solution is presented in the final report. It involves application of fundamental principles and analytical methods to the solution of complex problems. It includes many aspects of a problem, including social, economic and political factors.

Such a group project provides the student with an opportunity to participate in a creative effort, to broaden his understanding of real-life problems, and to become aware of the need for communicating with other disciplines.

DESCRIPTION – Participation in an Interdisciplinary Group project will be used in lieu of the thesis requirement for the Master of Science degree. Approval, on an individual basis, must be obtained in advance from the chairman of the student's major department. Enrollment in the project should occur in two consecutive quarters during the last three quarters of the student's program. The courses will be offered only if sufficient enrollment, a minimum of twelve, is obtained with representation from at least three disciplines.

It shall be the responsibility of the students to define the problem, develop a project management plan, solve the problem, and write the final report. The management plan shall account for:

a. group organization
b. determination of problem solution goals and assignment of these goals to project members.
c. schedule of completion dates for the goals
d. development of a format for weekly progress reports

GROUP PROJECTS

GP 0910 Advanced Project (4-0).

This is the first of a two-course sequence in which students and faculty from three or more disciplines work together as a team to solve as completely as is feasible a specific problem. The purpose of the course is to offer students the opportunity to formulate and solve a complex problem of current interest using systems-oriented methods. The scope and details of the problem are defined by the faculty and students. PREREQUISITE: Permission of Department Chairman.

GP 0911 Advanced Project (8-0). Continuation of GP 0910.

DEPARTMENT OF MATERIAL SCIENCE AND CHEMISTRY

JOHN HENRY DUFFIN, Professor of Chemical Engineering; Chairman (1962)*; B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

NEWTON WEBER BUERGER, Professor Emeritus (1942); B.S., Massachusetts Institute of Technology, 1933; M.S. 1934; Ph.D. 1939.

WILLIAM WISNER HAWES, Professor Emeritus (1952); B.S., Ch.E., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

JOHN ROBERT CLARK, Professor of Metallurgy (1947); B.S., Union College, 1935; Sc.D., Massachusetts Institute of Technology, 1942.

ROBERT WESLEY HELLIWELL, Assistant Professor of Materials Science (1968); B.A., Read College, 1958; M.S., Stanford University, 1965.

CARL ADOLF HERING, Professor of Chemical Engineering (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

GILBERT FORD KINNEY, Distinguished Professor and Professor of Chemical Engineering (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

GEORGE DANIEL MARSHALL, JR., Professor of Metallurgy (1946); B.S., Yale Univ., 1930; M.S., 1932.

GEORGE HAROLD McFARLIN, Professor of Chemistry (1948); B.A., Indiana Univ., 1925; M.A., 1926.

RICHARD ALAN REINHARDT, Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 1943; Ph.D., 1947.

MELVIN FERGUSON REYNOLDS, Professor of Chemistry (1946); B.S., Franklin and Marshall College, 1932; M.S., New York Univ., 1935; Ph.D., 1937.

CHARLES FREDERICK ROWELL, Assistant Professor of Chemistry (1962); B.S., Syracuse Univ., 1956; M.S., Iowa State Univ., 1959; Ph.D., Oregon State Univ., 1964.

JOHN WILFRED SCHULTZ, Associate Professor of Chemistry (1958); B.S., Oregon State College, 1953; Ph.D., Brown Univ., 1957.

JAMES EDWARD SINCLAIR, Professor of Chemistry (1946); B.S., Ch. Eng., Johns Hopkins Univ., 1945; M.S., Naval Postgraduate School, 1956.

WILLIAM MARSHALL TOLLES, Associate Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 1962.

JAMES WOODROW WILSON, Professor of Chemical Engineering (1949); B.A., Stephen F. Austin State, 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S., in Ch.E., Texas A.&M. College, 1941.

** The year of joining the Postgraduate School Faculty is indicated in parentheses.*

LABORATORIES

The chemical laboratories provide facilities for undergraduate and graduate study and research in chemistry. Included for these purposes are: a radiochemistry ("hot") laboratory with Geiger and scintillation counters and special apparatus for handling and testing radioactive materials; a molecular spectroscopy laboratory, including infrared, ultraviolet, and magnetic resonance (ESR and NMR) spectrometers; a chemical instruments laboratory with infrared and ultraviolet spectrophotometers, vapor fractometers, refractometers, vapor pressure osmometers, polarographs, and other instruments commonly used for chemical determinations. A plastics laboratory is available for molding plastics and testing their mechanical properties. The department has an explosives laboratory with impact tester, ballistics mortar, chronograph and other apparatus for evaluating explosives. In the rocket propellent laboratory, small batches of solid propellents can be produced and many of the ballistic parameters and mechanical properties measured. Facilities are available for burning rate studies.

The materials laboratories are well equipped for both materials science and materials engineering studies and research. For these purposes standard universal testing machines, hardness testers, etc., are available for mechanical property determinations, plus a programable Instron testing instrument. For metallurgical studies the laboratory is equipped with heat-treating furnaces, metallographs, and microscopes. A plastics laboratory is available for evaluation of the mechanical, physical and chemical properties of plastics. Facilities for basic materials science studies include: several x-ray diffraction units; precision heating and powder cameras; Weissenberg x-ray unit; precision goniometers; recording photodensitometer, etc. Metal fabricating equipment includes welding facilities, a swaging machine, rolling mill, induction and vacuum melting furnaces and a die-casting machine, and provides facilities for materials processing studies. A laboratory for high and low temperature studies of materials, including creep testing machines, afford additional modern equipment for materials research.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN CHEMISTRY OR MATERIAL SCIENCE

A specific curriculum should be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Department of Material Science and Chemistry at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

BACHELOR OF SCIENCE IN CHEMISTRY

1. A major in chemistry should include a minimum of 44 quarter hours of chemistry (of which 9 quarter hours are elective), 17 quarter hours of physics (through general and modern physics), 18 quarter hours of mathematics (through differential equations) and 12 quarter hours of elective upper

division courses in engineering, mathematics, or science (including chemistry). At least 96 of the quarter hours must be upper division level.

2. The following specific requirements must be met. Courses in chemistry and general physics must include laboratory work.

Discipline	*Subject*	*Approximate Quarter Hrs.*
Chemistry	General	4
	Inorganic	3
	Analytical	4
	Organic	9
	Physical	14
		34
Physics	General	13
	Modern (Atomic)	4
		17
Mathematics	College Algebra and Trigonometry	4
	Analytical Geometry and Calculus	11
	Differential Equations	3
		18

3. The 9 elective quarter hours in chemistry must be fulfilled by taking at least upper division courses in chemistry or chemical engineering.

MASTER OF SCIENCE IN CHEMISTRY

1. To obtain a degree, Master of Science in Chemistry, the student must have completed work equivalent to the Bachelor of Science requirements of this department.

2. In addition the student must successfully complete the following with a grade point average of 2.0 in all chemistry courses:

a. One graduate course in each of the following areas: Chemical Thermodynamics, Inorganic Chemistry, Physical-Organic Chemistry and Quantum Chemistry. Minimum total quarter hours–13.

b. Two or more courses at the 4000 level in chemistry. These courses must have a total of not less than six quarter hours of lecture and must be approved by the Department of Material Science and Chemistry. Minimum total quarters hours–6.

c. A thesis demonstrating ability to perform independent and original work and requiring a research effort equivalent to at least half-time for three quarters.

d. Sufficient supporting courses in science, mathematics and engineering to meet school requirements.

MASTER OF SCIENCE IN MATERIAL SCIENCE

1. The following is a statement of departmental minimum requirements for the degree of Master of Science in Material Science. A candidate shall previously have satisfied the requirements for a Bachelor's degree with a major in science or engineering. Credit requirements in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

2. A minimum credit of 16 quarter hours in 4000 level courses in Material Science is required. These shall include at least one course each in the areas of metals, ceramics, and plastics. A minimum of 10 quarter hours of graduate credit must be earned outside the major department. A total of at least 20 quarter hours of 4000 level courses must be included in the program.

3. Completion of a thesis and its acceptance by the department are required. A maximum of 7 quarter hours of graduate credit may be allowed toward satisfaction of the School requirement for 40 quarter hours, but the thesis credit may not be used to satisfy the requirements of paragraph 2.

CHEMISTRY AND CHEMICAL ENGINEERING

CH 0110 REFRESHER CHEMISTRY (4-0). Review of basic concepts of Chemistry. Topics include chemical bonding, stoichiometry, solutions, kinetics, equilibria, pH, and electrochemistry. TEXT: Sienko and Plane, *Chemistry,* 3rd ed. PREREQUISITE: None.

CH 0800 CHEMISTRY SEMINAR (0-1). A departmental program in which invited speakers and resident faculty speak on current topics in chemistry, material science and related areas. Students majoring in either chemistry or material science will report on their research and may also be requested to report on assigned topics from the literature. PREREQUISITE: None.

CH 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

CH 1001 INTRODUCTORY GENERAL CHEMISTRY I (4-2). The first quarter course of a two quarter sequence for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter. TEXT: Sienko and Plane, *Chemistry,* 3rd ed.

CH 1002 INTRODUCTORY GENERAL CHEMISTRY II (3-2). The second quarter of a two-quarter sequence for students who have not had chemistry before coming to the Postgraduate School. TEXT: Same as CH 1001. PREREQUISITE: CH 1001.

Upper Division Courses

CH 2001 GENERAL PRINCIPLES OF CHEMISTRY (3-2). A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter and chemical equilibria. Special attention is given to the compounds of carbon. Elementary physical chemistry experiments are performed in the laboratory. TEXT: Mahan, *University Chemistry.* PREREQUISITE: College Chemistry.

CH 2101 INORGANIC ANALYSIS (3-3). A continuation of CH 2001. Computations involving acid-base, solubility, and complex ion equilibria. Principles of quantitative analysis. Descriptive inorganic chemistry. Laboratory work will consist of gravimetric and volumetric analysis. TEXT: Skoog and West, *Fundamentals of Analytical Chemistry;* Mahan, *University Chemistry.* PREREQUISITE: CH 2001 or CH 1002.

CH 2102 INORGANIC CHEMISTRY (3-3). Redox reactions and the electrode potential. Introduction to reaction mechanism. Bonding in inorganic species. Acids and bases. Laboratory will make use of qualitative, semi-quantitative, and instrumental methods to study the principles further, especially as applied to the solution chemistry of the metals. TEXT: Douglas and McDaniel, *Concepts and Models of Inorganic Chemistry.* PREREQUISITES: CH 2101 and CH 2402.

CH 2301 ORGANIC CHEMISTRY I (4-2). The first quarter of a two quarter study of the chemistry of organic compounds. TEXT: Roberts and Caserio, *Basic Principles of Organic Chemistry.* PREREQUISITE: CH 2402. (May be taken concurrently).

CH 2302 ORGANIC CHEMISTRY II (3-3). A continuation of CH 2301. The study of Organic Chemistry is pursued further with emphasis in the laboratory on synthetic techniques. TEXT: Roberts and Caserio, *Basic Principles of Organic Chemistry.* PREREQUISITE: CH 2301.

CH 2401 GENERAL THERMODYNAMICS (3-0). (See listing of PH 2551.)

CH 2402 INTRODUCTION TO PHYSICAL CHEMISTRY (3-3). The course will include such topics as properties of matter, thermochemistry, chemical thermodynamics, chemical equilibria, kinetics, and electrochemistry. TEXT: Moore, *Physical Chemistry,* 3rd ed. PREREQUISITES: CH 2401, CH 2001.

CH 2405 PHYSICAL CHEMISTRY TOPICS (4-3). Completion of study of topics of undergraduate physical chemistry begun in CH 2402. TEXTS: Moore, *Physical Chemistry*; 3rd ed. j; Salzberg et al, *Laboratory Course in Physical Chemistry* PREREQUISITE CH 2402.

CH 2705 PLASTICS AND HIGH POLYMERS (2-2). A study of the general nature of plastics and high polymers. This includes the correlation between properties and chemical structure. In the laboratory plastics are made, molded, tested and identified. TEXTS: Golding, *Polymers and Resins;* Kinney, *Engineering Properties and Application of Plastics.* PREREQUISITE: CH 2001.

Upper Division or Graduate Courses

CH 3101 ADVANCED INORGANIC CHEMISTRY (3-3). Coordination compounds and crystal field theory. Chemistry of the halogens and of nitrogen. The laboratory introduces the student to general methods for investigating chemical reactions. TEXT: Cotton and Wilkinson, *Advanced Inorganic Chemistry,* 2nd ed. PREREQUISITES: CH 2102, CH 2405, PH 3651 completed or CH 3405 concurrently.

CH 3201 CHEMICAL INSTRUMENTS (3-3). A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. TEXTS: Ewing, *Instrumental Methods of Chemical Analysis,* 4th ed.; Silverstein and Bassler, *Spectrometric Identification of Organic Compounds,* 2nd ed. PREREQUISITES: CH 2101 and CH 2405.

CH 3301 PHYSICAL ORGANIC I (3-0). First quarter of a two-quarter sequence. In this term the tools available for the study of organic mechanisms are discussed and appropriate examples used. TEXTS: Hine, *Physical Organic Chemistry,* 2nd ed.; Gould, *Structure and Mechanism in Organic Chemistry.* PREREQUISITES: CH 2302, CH 3201.

CH 3401 CHEMICAL THEORY (4-0). An advanced one-term course concerned with topics in chemistry of special interest to physics majors. Topics include chemical bonding and quantum chemistry, symmetry of chemical systems and group theory, molecular spectroscopy, chemical equilibrium, rates of chemical reactions, and electrochemistry. TEXTS: Philips, *Basic Quantum Chemistry;* Moore, *Physical Chemistry,* 3rd ed. PREREQUISITES: College Chemistry, PH 3651, Matrix Mechanics and CH 2401.

CH 3403 CHEMICAL THERMODYNAMICS (3-0). Application of thermodynamics to real gases, non-electrolytes, electrolytic solutions, multicomponent solutions. Calculations of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and other molecular data. TEXTS: Klotz, *Chemical Thermodynamics;* Lewis and Randall, *Thermodynamics,* 2nd ed. PREREQUISITE: CH 2402.

CH 3405 MOLECULAR DYNAMICS (5-0). Direct application of the Shroedinger wave equation to the hydrogen atom, angular momentum, matrix formulation of quantum mechanics, electron spin, the Pauli principle, interaction with electromagnetic radiation, development of group theory and application in quantum mechanics, and application of preceeding framework to molecular hybridization, molecular orbital theory, ligand field theory, and vibrational spectra. TEXTS: Pilar, *Elementary Quantum Chemistry;* Cotton, *Chemical Applications of Group Theory.* PREREQUISITES: CH 2405, Matrix Algebra.

CH 3701 CONTROL ANALYSIS FOR CHEMICAL SYSTEMS (3-3). Introduction to the analysis and design of linear feedback control systems using illustrations based on chemical processes. Frequency response and LaPlace transform methods are used and the state variable approach is presented. Derivation and analysis of process models is emphasized and systems set up and solved using digital and hybrid computers. PREREQUISITE: MA 2232.

CH 3705 REACTION MOTORS (3-0). A study of the fundamentals of rocket motors including a discussion of flight dynamics, mechanics, compressible flow, heat transfer, properties of solid and liquid propellants, design and performance parameters of solid, liquid and hybrid motors, and future developments. TEXTS: Sarner, *Propellant Chemistry* Sutton, *Rocket Propulsion Elements.* PREREQUISITE: CH 2401.

CH 3709 EXPLOSIVES CHEMISTRY (3-2). Chemical and physical properties of explosives are related to modes of behavior and physical principles of use. Basic principles of testing and evaluation of explosives. Trends in new developments are surveyed. Independent exploratory work in the laboratory in such areas as manner of initiation, sensitivity, brisance, power, heats of explosion and combustion. TEXTS:

Cook, *The Science of High Explosives;* Davis, *Chemistry of Powder and Explosives;* Rinehart and Pearson, *Explosive Working of Metals.* PREREQUISITE: CH 2001.

CH 3713 BLAST AND SHOCK EFFECTS (3-0). Generation of blast and shock waves by explosions, propagation of shock waves in air, scaling laws for explosions, shock and blast loads on structures, damage and damage mechanisms, thermal and ionizing radiation effects, principles of protection against damage. TEXT: Kinney, *Shocks in Air.* PREREQUISITES: CH 2401, CH 3401, or CH 2402.

CH 3717 UNIT OPERATIONS (3-2). An introduction to the study of the unit operations of chemical engineering. Selection of and primary emphasis on particular unit operations will be made on the basis of current student specialties. TEXTS: Foust et al., *Principles of Unit Operations*; Bird et al., *Transport Phenomena*; Smith and McCabe, *Unit Operations of Chemical Engineering.* PREREQUISITES: MA 1100, CH 2402, CH 2401.

Graduate Courses

CH 4302 PHYSICAL ORGANIC II (3-0). The techniques discussed in CH 3301 are used in the study of organic reaction mechanisms as currently understood. TEXT: See CH 3301. PREREQUISITE: CH 3301.

CH 4406 QUANTUM CHEMISTRY (3-0). A study of molecular spectra and molecular electronic structure, emphasizing theory, interpretation, and prediction of spectra utilizing the quantum mechanical formulation. PREREQUISITE: CH 3405.

CH 4410 CHEMICAL KINETICS (3-0). Experimental methods and interpretation of data. Collision theory and activated-complex theory. Mechanisms of reactions. TEXT: Frost and Pearson, *Kinetics and Mechanisms.* PREREQUISITE: CH 2405 and consent of instructor.

CH 4415 STATISTICAL MECHANICS (4-0). A general treatment of the principles of quantum and classical statistical mechanics with applications to chemical systems. Included are distribution laws and the relationships of Fermi-Dirac, Bose-Einstein, and corrected Boltzmann statistics; statistical entropy and thermodynamic functions for corrected Boltzmann statistics; applications to chemical equilibria, diatomic and polyatomic molecules including ortho and para hydrogen; canonical and grand canonical ensembles; real gases. TEXT: Davidson, *Statistical Mechanics.* PREREQUISITE: CH 2405.

CH 4505 RADIATION CHEMISTRY (3-0). A study of the theory behind the chemical processes occurring when ionizing and electromagnetic radiation interact with matter. Includes electronic states of molecules, introduction to photochemistry, properties of gaseous ions and free radicals, chain reactions. TEXT: Spinks and Woods, *An Introduction to Radiation Chemistry.* PREREQUISITE: CH 3401 or CH 2405.

CH 4508 RADIO AND RADIATION CHEMISTRY (4-2). This course covers the subject outline for CH 4405 for three lectures of each week. The remaining lecture and laboratory covers the salient points of separation and handling of radioactive chemical systems. TEXT: Spinks and Woods, *An Introduction to Radiation Chemistry.* PREREQUISITES: CH 3401 or equivalent and Nuclear Physics (may be taken concurrently).

CH 4701 PROCESS CONTROL (3-2). A continuation of CH 3701 wherein complex control systems are studied. These include valves and transmission lines, heat exchangers, level control, flow control, control of distillation columns and chemical reactors and finally blending and pH control. Sampled data systems and optimization techniques are considered. TEXTS: Harriott, *Process Control*; Coughanowr and Koppel, *Process Control.* PREREQUISITE: Common Control Course (CH 3701).

CH 4709 APPLIED MATHEMATICS OF CHEMICAL ENGINEERING (3-2). The differential equations describing various chemical engineering processes are derived and solved using analytic and numeric techniques. Electronic computers will be used to obtain solutions to problems. TEXTS: Mickley et al., *Applied Mathematics in Chemical Engineering;* Wylie, *Advanced Engineering Mathematics.* PREREQUISITES: MA 1100, CH 2401, CH 2402.

CH 4800 SPECIAL TOPICS (2-0 to 4-0). Pursuit of deeper understanding of some topic chosen by the student and the instructor; may involve directed reading and conference or a lecture pattern. May be repeated for credit with a different topic. Typical topics are listed as follows:

(1) Chemical Engineering Kinetics
Chemical engineering applications with emphasis on large scale equipment design.

(2) Heat Transfer
Chemical engineering applications with emphasis on large scale and unusual equipment design.

(3) Natural Products
Study of degradation and synthesis of steroids, alkaloids and terpenes.

(4) Advanced Organic Chemistry
Study of new synthetic approaches in depth.

(5) Photochemistry
Chemical processes resulting from the interaction of electromagnetic radiation with matter.

(6) Inorganic Reaction Mechanisms
Theory and experiment concerning mechanisms of substitution and redox reaction for inorganic systems.

PREREQUISITE: Consent of the instructor.

MATERIALS

MS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MS 1021 ELEMENTS OF MATERIALS SCIENCE I (3-2). An introduction to the nature and properties of materials for engineering applications. An essentially qualitative treatment of factors which govern the selection of materials. Classification of materials by type based on their chemical, physical and mechanical properties. Methods, processes and problems in the production of commercial materials. Introduction to crystal structure, phase equilibria, plastic deformation, recrystallization, grain growth, and precipitation hardening. TEXT: Van Vlack, *Elements of Materials Science, 2nd ed.* PREREQUISITE: CH 1001 or equivalent.

MS 1022 ELEMENTS OF MATERIALS SCIENCE II (2-2). Continuation of subject matter introduced in MS 1021 with stress on specific materials systems such as steel, plastics, and composites. Discussion of environmental factors and suggestions for avoiding or interpreting service failures. TEXT: Van Vlack, *Elements of Materials Science, 2nd ed.* PREREQUISITE: MS 1021.

Upper Division Courses

MS 2201 ENGINEERING MATERIALS (3-2). An introduction to the concepts of material science primarily for students in Mechanical Engineering. The concepts of atomic, crystal, micro- and macrostructure, their control and effects on chemical and physical properties will be emphasized. The role of defects is discussed. TEXT: Barrett, Tetelman and Nix, *Introduction to Materials Science, Part I.* PREREQUISITES: Elementary courses in Physics and Chemistry.

MS 2218 ELEMENTS OF ENGINEERING MATERIALS (3-2). The fundamental principles of Materials Science are presented, including a discussion of crystal structures, defects in crystal structures, phase equilibria, reaction rates and hardening mechanisms. Practical examples are discussed and included in laboratory exercises. TEXT: Barrett, Tetelman and Nix, *Introduction to Materials Science, Part I.* PREREQUISITES: Elementary courses in Physics and Chemistry.

MS 2228 INTRODUCTION TO ENGINEERING MATERIALS (3-2). A survey of engineering materials with emphasis upon applications in a marine environment. Microstructure, physical properties, environmental deterioration and materials selection are discussed. TEXT: Van Vlack, *Elements of Materials Science.* PREREQUISITES: Elementary courses in Physics and Chemistry.

Upper Division Graduate Courses

MS 3202 PROPERTIES OF STRUCTURAL MATERIALS (3-2). The properties of structural materials are related to microstructure and defects. Topics of interest to the Naval engineer are selected, including iron, aluminum, and titanium alloys, high strength steels, welding and other joining techniques, and environmental deterioration. TEXT: Clark and Varney, *Physical Metallurgy for Engineers.* PREREQUISITE: MS 2201.

MS 3218 MECHANICAL PROPERTIES OF AEROSPACE MATERIALS I (2-2). The mechanical properties of aerospace materials are related to atomic and microscopic internal structural defects. The behavior of metals during mechanical failure, as in fatigue, creep, and brittle and ductile rupture, is explained in terms of interrelations among strain hardening, ductility, and deformation. Practical alloy systems, polymers, fiber composites, glasses, and special topics are discussed. TEXTS: Barrett, Nix and Tetelman, *Introduction to Materials Science, Part II;* Parker, *Materials for Missiles and Spacecraft.* PREREQUISITE: MS 2218.

MS 3219 MECHANICAL PROPERTIES OF AEROSPACE MATERIALS II (4-0). The mechanical properties of specific aerospace materials will be discussed. Materials applications discussed will include conditions of tensile and compressive loading, rate of loading, viscoelastic damping, pre-stressing, and effect of temperature change. Composites will be treated in iso-stress and iso-strain loading conditions. PREREQUISITE: MS 3218.

MS 3303 NUCLEAR REACTOR MATERIALS (3-0). A discussion of materials used in reactor construction including fuels, moderators, absorbers, shielding materials, structural materials and coolants. While the nuclear requirements dictating the use of specific materials are pointed out and radiation effects are discussed, emphasis is on the technology of the materials. TEXTS: *Reactor Handbook, 2nd ed.;* Kaufmann, *Nuclear Reactor Fuel Elements.* PREREQUISITE: MS 2202.

MS 3304 CORROSION (3-2). Presents the basic chemical, electrochemical, mechanical and metallurgical factors which influence the corrosion, oxidation and deterioration of materials. Discusses standard methods of corrosion control such as cathodic protection, coatings, cladding, alloy selection and inhibitors; special problems encountered in unfamiliar environments. TEXT: Uhlig, *Corrosion and Corrosion Control.* PREREQUISITE: MS 1022 or MS 2202.

Graduate Courses

MS 4206 THE STRUCTURE AND MECHANICAL PROPERTIES OF CRYSTALS (3-0). A discussion of dislocations in crystals and the mechanical properties to be expected in real crystals. The topics discussed include the forces between dislocations, stacking faults and partial dislocations, the generation of dislocations during crystal growth and during plastic deformation, the locking of dislocations. The experimental investigation of dislocations by optical methods, decorating techniques, electron transmission microscopy, and diffraction methods are discussed. TEXTS: Fridel, *Dislocations;* Weertman and Weertman, *Elementary Dislocation Theory;* Amelinck, *The Direct Observation of Dislocation.* PREREQUISITES: MS 2202, PH 3651.

MS 4215 PHASE TRANSFORMATIONS (3-4). The thermodynamics and kinetics of transformations in solids. The free energy of alloys, solidification, precipitation, recrystallization, diffusion and diffusionless transformations. Extensive individual initiative is allowed and expected in the laboratory. TEXTS: Reed-Hill, *Physical Metallurgy Principles;* Fine, *Introduction to Phase Transformations in Condensed Systems;* Wayman, *Introduction to the Crystallography of Martensite Transformation.* PREREQUISITE: MS 2202.

MS 4302 SPECIAL TOPICS IN MATERIAL SCIENCE (hours by arrangement). Independent study of advanced subjects not regularly offered. PREREQUISITE: Consent of the instructor.

MS 4304 ENVIRONMENTAL DETERIORATION OF MATERIALS (3-3). The role of corrosive atmosphere, metallurgical structure, surface physics and stress state in leading to catastrophic embrittlement of high strength materials. Particular reference to stress corrosion, hydrogen embrittlement, liquid-metal embrittlement and corrosion fatigue. TEXTS: Fontana and Greene, *Corrosion Engineering;* Staehle, *Proceedings of the International Conference on Fundamental As-*

pects of Stress Corrosion Cracking. PREREQUISITE: MS 3304.

MS 4305 MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS (3-0). The properties and preparation of materials used in electrical and electronic applications. Among the materials discussed are ferromagnetic materials, both hard and soft, ferrimagnetic materials, semiconductors, both elemental and compound, insulators and dielectrics, piezoelectric and ferroelectric crystals. The electronic, crystallographic and thermodynamic principles controlling these materials are discussed and the heat treatments, compositions and methods of fabrication of commercial materials are emphasized. TEXT: Nusbaum, *Electronic and Magnetic Behavior of Materials.* PREREQUISITE: MS 2202.

MS 4312 MATERIALS SYSTEMS (3-0). Attempts to establish criteria of standard environment and standard behavior of engineering materials. Examines properties of materials at extremes of temperature, rate and duration and frequency of loading, corrosive environment, and the conditions of outer space. Examines factors amenable to control at the molecular and structural levels and illustrates with real materials. Development of materials to meet requirements of extreme environmental conditions is illustrated by alloy steels, refractory metals and alloys, composites, cermets and special materials. TEXT: Dorn, *Mechanical Behavior of Materials at Elevated Temperatures.* PREREQUISITE: MS 2202.

MS 4320 PROPERTIES OF CERAMIC MATERIALS (4-0). Occurrences, syntheses and properties of ceramic raw materials. Kinetic and phase equilibrium principles underlying the production of ceramics and glasses. Structure of typical ceramics and glasses. TEXT: Kingery, *Introduction to Ceramics.* PREREQUISITE: CH 2402.

MS 4401 PHYSICS OF SOLIDS (3-0). A course intended for students particularly interested in material science and which will cover topics being developed in the literature but with emphasis on crystallographic and mechanical subjects such as order-disorder, symmetry and anti-symmetry, twinning, brittle fracture, transition temperatures, etc. TEXTS: Instructors Notes, Current Literature. PREREQUISITES: MS 4215 or PH 3651 or PH 4751.

MS 4811 MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS (3-0). The response of single crystals and polycrystalline aggregates to mechanical stress. The plastic deformation and fracture of real materials including metals and alloys, ceramics and cermets, composites, and polymers. Fracture resulting from fatigue and environmental conditions will be discussed. Creep and Mechanical properties at elevated temperature will be described and current theories discussed. TEXT: Dieter, *Mechanical Metallurgy.* PREREQUISITES: MS 2202, Engineering Mechanics.

DEPARTMENT OF MATHEMATICS

ROBERT EUGENE GASKELL, Professor of Mathematics; Chairman (1966)*; A.B., Albion College, 1933; M.S. Univ. of Michigan, 1934; Ph.D., 1940.

HORACE CROOKHAM AYRES, Professor Emeritus (1958); B.S., Univ. of Washington, 1931; M.S., 1931; Ph.D., Univ. of California at Berkeley, 1936.

ALADUKE BOYD MEWBORN, Professor Emeritus and Distinguished Professor (1946); B.S., Univ. of Arizona, 1927; M.S., 1931; Ph.D., California Institute of Technology, 1940

CHARLES HENRY RAWLINS, JR., Professor Emeritus (1922); Ph.B., Dickinson College, 1910; M.A., 1913; Ph.D., Johns Hopkins Univ., 1916.

GERALD LEONARD BARKSDALE, JR., Assistant Professor of Mathematics (1967); B.S., Rice Univ., 1965; M.S., 1966.

ALAN PAUL BENDER, Ensign; U.S. Naval Reserve; Instructor of Mathematics (1969); B.A., Univ. of Minnesota, 1967; M.S., 1968.

WILLARD EVAN BLEICK, Professor of Mathematics (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

ROBERT COY BOLLES, Ensign, U.S. Naval Reserve; Instructor of Mathematics (1969); B.S., Yale Univ., 1967; M.S., Univ. of Pennsylvania 1968.

WALTER SCOTT BRAINERD, Assistant Professor of Mathematics (1967); B.A., Univ. of Colorado, 1958; M.A. Univ. of Maryland, 1961; Ph.D., Purdue Univ., 1967.

PHILIP G. CALABRESE, Assistant Professor of Mathematics (1968); B.S., Illinois Institute of Technology, 1963; Ph.D., 1968.

DANIEL LEE DAVIS, Lieutenant (junior grade), U.S. Naval Reserve; Assistant Professor of Mathematics (1969); B.S., Georgia Institute of Technology, 1965; Ph.D., California Institute of Technology, 1969.

DANNY RAY DIXON, Ensign U.S. Naval Reserve; Instructor of Mathematics (1969); B.S., Southern Methodist Univ., 1966; M.S., 1967.

RICHARD JEROME ESTELL, Ensign, U.S. Naval Reserve; Instructor of Mathematics (1969); B.A., Univ. of Iowa, 1967; M.S., 1968.

FRANK DAVID FAULKNER, Professor of Mathematics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942; Ph.D., Univ. of Michigan, 1969.

JOSEPH GIARRATANA, Professor of Mathematics (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

ROBERT WELDON HUNT, Associate Professor of Mathematics (1968); B.S., West Texas State Univ., 1956; M.S., Univ. of Utah, 1958; Ph.D., 1961.

TOKE JAYACHANDRAN, Associate Professor of Mathematics (1967); B.S., V.R. College, Nellore India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

WALTER JENNINGS, Professor of Mathematics (1947); B.A., Ohio State Univ., 1932; B.S., 1932; M.A., 1934.

GARY ARLEN KILDALL, Lieutenant (junior grade), U.S. Naval Reserve; Instructor of Mathematics (1969); B.S., Univ. of Washington, 1967; M.S., 1968.

UNO ROBERT KODRES, Associate Professor of Mathematics (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

LADIS DANIEL KOVACH, Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., 1948; M.S., Western Reserve Univ., 1940; Ph.D., Purdue Univ., 1951.

BYRON LEWIS KOLITZ, Lieutenant, U.S. Naval Reserve; Instructor of Mathematics (1969); B.A., Vanderbilt Univ., M.S., Univ. of Florida, 1966.

LEE GEORGE LITZLER, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Mathematics (1969); B.A., Univ. of Texas 1967; M.S., 1969.

KENNETH ROBERT LUCAS, Associate Professor of Mathematics (1958); B.S., Washburn, Univ., 1949; Ph.D., Kansas Univ., 1957.

HERMAN BERNHARD MARKS, Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

GEORGE WILLIAM MORRIS, Professor of Mathematics (1968); B.A., Southwestern Institute of Technology 1942; M.A., Univ. of Oklahoma, 1947; Ph.D., UCLA, 1957.

JOHN PHILIP PIERCE, Professor of Mathematics (1948); B.S. in E.E., Worcester Polytechnic Institute, 1931; Master of E.E., Polytechnic Institute of Brooklyn, 1937.

RUDOLPH WILLIAM PREISENDORFER, Professor of Mathematics, (1970); B.S., Massachusetts Institute of Technology, 1952; Ph.D., 1956.

FRANCES McCONNELL PULLIAM, Professor of Mathematics (1949); B.A., Univ. of Illinois, 1937; M.A., 1938; Ph.D., 1947.

ALAN BRUCE ROBERTS, Ensign, U.S. Naval Reserve; Instructor of Mathematics (1969); B.A., Univ. of Texas, 1967; M.A., 1969.

DONALD WILFORD ROBINSON, Visiting Professor of Mathematics (1969); B.S., Univ. of Utah 1948; M.A., 1952; Ph.D., Case Institute of Technology, 1956.

ALBERT BEAUREGARD SCHWARZKOPF, III, Lieutenant, U.S. Naval Reserve; Assistant Professor of Mathematics (1968); B.A., Vanderbilt Univ., 1964; Ph.D., Univ. of Virginia, 1968.

ALAN McKEAN SHORB, Assistant Professor of Mathematics (1968); B.A. Swarthmore College, 1960; M.A., Cornell Univ. 1965.

EDWARD ANTHONY SINGER, Lieutenant Commander, U.S. Navy; Instructor of Mathematics (1969); B.A., Miami Univ., 1961; M.S., Naval Postgraduate School, 1968.

THOMAS HOLLISTER SOUTHARD, Visiting Professor of Mathematics (1969); B.A., Ohio State Univ., 1932; M.A., 1933; Ph.D., 1936.

JAMES HERBERT SPALDING, III, Lieutenant, U.S. Naval Reserve; Instructor of Mathematics (1968); B.S., Old Dominion College, 1966; M.S., College of William and Mary, 1968.

ELMO JOSEPH STEWART, Professor of Mathematics (1955) B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Institute, 1953.

DONALD HERBERT TRAHAN, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

MAURICE DEAN WEIR, Assistant Professor of Mathematics (1969); B.A., Whitman College, 1961, M.S., Carnegie-Mellon Univ., 1963.

CARROLL ORVILLE WILDE, Associate Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

*The year of joining the Postgraduate School faculty is indicated in Parentheses.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MATHEMATICS

The Department of Mathematics offers a Bachelor of Science or a Master of Science degree to qualified students. An interested student should consult the Chairman of the Mathematics Department for an evaluation of his previous academic record to determine his potential for successfully completing a degree program.

If the student's previous record is found to be adequate, a mathematics program is designed which satisfies the Departmental requirements and fits the interest, preparation and aptitude of the student. This program, and subsequent changes in the program, must be approved by the Departmental Chairman.

BACHELOR OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. Of the total quarter hours specified in the general requirements for the degree of Bachelor of Science, a student majoring in mathematics must complete at least 30 quarter hours of approved course work in mathematics beyond calculus, and must have an average QPR of 1.25 or greater in these 30 quarter hours.

2. The following topics are specifically included in any major program. Courses listed in parentheses or their equivalents may be used to satisfy the requirements.

a. 6 hours of Analysis	(MA 3605-3606)
b. 6 hours of Algebra	(MA 3046-3047)
c. 4 hours of Differential Equations	(MA 2121)
d. 3 hours of Complex Analysis	(MA 2172)
e. 4 hours of Probability and Statistics	(PS 2501)

MASTER OF SCIENCE DEGREE WITH MAJOR IN MATHEMATICS

1. In order to pursue a program leading to Master of Science degree with major in mathematics, a student must have a background which would qualify him for a Bachelor of Science degree with major in mathematics, as stated above. A student whose background does not satisfay this requirement may take course work to eliminate this deficiency. However, such courses cannot be counted toward satisfying the Departmental requirements for the degree of Master of Science.

2. A curriculum which satisfies the Master of Science degree requirements consists of a minimum of 45 quarter hours of approved courses in mathematics and related subjects. An acceptable thesis may be counted as equivalent to nine quarter hours. A student must have a QPR of 2.0 or greater in the courses in his program.

3. At the discretion of the Chairman of the Department of Mathematics, a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics. If a student writes an acceptable thesis, then he will be given the equivalent of nine quarter hours of course work for the thesis.

4. The following topics are specifically included in any major program:
   a. 6 hours of Algebra
   b. 6 hours of Analysis

5. The main areas for thesis topics are
   a. Computer Science
   b. Differential Equations
   c. Fourier Analysis
   d. Functional Analysis
   e. Numerical Methods
   f. Optimal Control
   g. Probability and Statistics
   h. Tensor Analysis and Applications

COMPUTER SCIENCE

CS 0001 SEMINAR (0-1). Special lectures; guest lectures; discussion of student thesis research, faculty research projects. PREREQUISITE: None.

CS 0110 FORTRAN PROGRAMMING (3-0). The basic elements of FORTRAN are covered. Practical application of the principles is afforded by means of a series of problems of increasing difficulty.

CS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

UPPER DIVISION COURSES

CS 2100 INTRODUCTION TO COMPUTERS AND PROGRAMMING (4-0). Characteristics of general purpose digital computers. Fundamentals of programming. Problem analysis; programming aids; compilers and assemblers. Problems selected from numerical and non-numerical areas. PREREQUISITE: CS 0110 or equivalent.

CS 2110 INTRODUCTION TO COMPUTER PROCESSES (3-2). Logical organization of information. Machine language and instruction repertoires. Input/Output considerations. Subroutines, macros, Assembler Language and higher level languages. Lab Sessions will introduce computing laboratory procedures, use of unit-record equipment and debugging procedures and program dumps. PREREQUISITE: CS 0110 or equivalent.

UPPER DIVISION OR GRADUATE COURSES

CS 3111 PROGRAMMING LANGUAGES (4-0). An introduction to the significant features and applications of several programming languages. Formal definition of a language through syntactic and semantic specification. Some representative languages of the following types will be studied: a procedure-oriented language, a business-oriented language, a string-processing language, a list-processing language and a conversational language. PREREQUISITE: CS 0110 or equivalent.

CS 3112 OPERATING SYSTEMS (4-0). Classical serial processing techniques, processor and Input-Output overlap. Multiprogramming, multiprocessing, stack-oriented processing. Addressing, indexing operations, storage allocation techniques. Time sharing, paging and task scheduling. Comparison of currently available large scale digital computer systems. PREREQUISITE: CS 2110 or CS 3111.

*CS 3200 LOGICAL DESIGN OF DIGITAL COMPUTERS. (4-0).

*CS 3201 COMPUTER SYSTEMS DESIGN (4-0).

*CS 3204 DATA COMMUNICATIONS (4-0).

CS 3300 INFORMATION STRUCTURES (3-0). Basic concepts of data. Linear lists, strings, arrays, and orthogonal lists. Representation of trees and graphs. Storage systems and structures, and storage allocation and collection. Symbol tables and searching techniques. Sorting (ordering) techniques. Formal specification of data structures, data structures in programming languages, and generalized data management. PREREQUISITE: CS 3111.

CS 3601 AUTOMATA AND FORMAL LANGUAGES (3-0). Logical networks, neural networks, finite automata, minimalization of automata, regular expressions, context-free languages and push-down automata, context-sensitive languages and linear-bounded automata. Ambiguity in formal languages. PREREQUISITE: MA 2025 or equivalent.

CS 3800 DIRECTED STUDY IN COMPUTER SCIENCES (0-2 to 0-8). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the instructor.

* See listing under Electrical Engineering Department.

GRADUATE COURSES

CS 4113 COMPILER DESIGN AND IMPLEMENTATION (3-2). Review of programming language structures, translation, loading, execution and storage allocation. Compilation of simple expressions and statements. Organization of a compiler: compile-time and run-time symbol tables; lexical and syntax scanning; object code generation; diagnostic procedures; object code optimization; and general design techniques. Use of translator writing systems. Laboratory will emphasize practical application of compiler implementation techniques. PREREQUISITES: CS 2110 and CS 3111.

CS 4202 INTERACTIVE COMPUTATION SYSTEMS (3-2). A study of the man-computer interface and methods for computer-assisted problem solving. System facilities for man-computer interaction. Consoles, communication lines, computers, data sets, operating systems. Computer graphics, data structures, transformations and graphics software. Memory requirements, storage, file and data management. Languages for man-computer interaction. Command, procedure, problem and special-purpose languages. Laboratory work includes individual projects using CRT consoles. PREREQUISITES: Consent of instructor.

CS 4310 NON-NUMERICAL INFORMATION PROCESSING (4-0). Definition of heuristic versus algorithmic methods, rationale of heuristic approach, description of cognitive processes and approaches to mathematical invention. Objective of work in artificial intelligence, simulation of cognitive behavior and self-organizing systems. Heuristic programming techniques including the use of list-processing languages. Survey of examples from representative application areas. The mind-brain problem and the nature of intelligence. Class and individual projects to illustrate basic concepts. PREREQUISITE: CS 2110 or CS 3111.

CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0). Discussion of selected topics in the fields of current research in computer science. PREREQUISITE: Consent of instructor.

MATHEMATICS

MA 0110 REFRESHER MATHEMATICS (3-7). Review of algebra, trigonometry, analytic geometry, and calculus. Students will be given review work to suit their individual needs.

MA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MA 1010 INTERMEDIATE ALGEBRA (4-0). The set of real numbers and postulates for the development of the algebra of real numbers. Proofs of some elementary theorems for the algebra of the real numbers. Applications of the postulates and theorems to addition, subtraction, multiplication, division and factoring of algebraic expressions. Application to word problems, first degree equations and equations of higher degree. Functions, graphs and inequalities. Exponents and logarithms. Sequences, series and the binomial theorem. Complex numbers. PREREQUISITE: None.

MA 1021 COLLEGE ALGEBRA AND TRIGONOMETRY (4-0). Brief review of algebraic fundamentals. Slide rule and logarithmic methods of computation. Algebra of complex numbers, quadratic equations. Systems of equations, determinants, Cramer's rule. Binomial theorem. Mathematical induction. Trigonometric functions of the general angle. Identities. Solution of right and oblique triangles. Elements of the theory of equations. PREREQUISITE: MA 1010 or equivalent.

MA 1030 ELEMENTARY SETS WITH APPLICATIONS (3-0). Study of the vital role played by set theory throughout contemporary mathematics. A brief introduction to naive set theory is followed by an elementary treatment of logic and the nature of mathematical proof. Techniques of informal proof are implemented in proving standard theorems about sets. Following a study of relation and function as an application of set theory, a Boolean algebra is defined and used to summarize the algebra of both sets and logic. A final application is given through a systematic treatment of finite probability theory from a set theory point of view. PREREQUISITE: None.

MA 1100 CALCULUS REVIEW (4-0). Functions of one variable, limits, derivatives, continuity, indefinite and definte integrals, transcendental functions, Taylor's theorem; vectors in two and three dimensions, functions of several variables, partial derivatives, multiple integration. PREREQUISITE: A previous course in calculus.

MA 1101 REVIEW OF CALCULUS FUNDAMENTALS (5-0). Development of the real numbers as an ordered field. Study of limits. Review of elementary calculus, including basic differentiation and integration formulas, Taylor's theorem. Calculus of functions of several variables, partial derivatives, chain rule differentiation, Jacobians, multiple integrals and transformation of integrals. PREREQUISITE: A previous course in calculus.

MA 1105 CALCULUS AND ANALYTIC GEOMETRY I (5-0). Introduction to plane analytic geometry, functions of one variable, limits, derivative of rational functions, indefinite integrals, definite integration with applications, elementary transcendental functions. PREREQUISITE: MA 1021.

MA 1106 CALCULUS AND ANALYTIC GEOMETRY II (5-0). Methods of integration, improper integrals, conic sections, hyperbolic functions, polar coordinates, introduction to vector algebra in two and three dimensional space, functions of several variables, tangent plane and normal line, partial differentiation. PREREQUISITE: MA 1105.

MA 1107 CALCULUS AND ANALYTIC GEOMETRY III (3-0). Higher order partial derivatives, maxima and minima for functions of two variables, multiple integrals with applications, infinite series. L'Hospital's rule, introduction to differential equations. PREREQUISITE: MA 1106.

MA 1115 CALCULUS I (5-0). Introduction to plane analytic geometry, functions of one variable, limits, continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, elementary vector algebra, vector differentiations. PREREQUISITE: Some previous work in calculus.

MA 1116 CALCULUS II (5-0). Polar coordinates, vector algebra and vector calculus in three dimensional space, functions of several variables, double and triple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1115.

Upper Division Courses

MA 2025 LOGIC, SETS AND FINITE MATHEMATICS (4-0). Propositional logic and elements of set theory. Relations, functions and partitions. Elements of finite probability theory. PREREQUISITE: None.

MA 2042 LINEAR ALGEBRA (4-0). Elementary matrix algebra. Vector spaces, linear dependence, basis, dimension, rank. Systems of linear equations. Determinants. Linear transformations, change of basis, characteristic equation, roots and vectors of a matrix. Special matrices: symmetric, orthogonal, inverse. Orthogonal reduction of symmetric matrix. Inverse by partitioning. Introduction to quadratic forms. Cayley Hamilton theorem. Algebra of vectors through triple products. Calculus of vectors including introduction to gradient, divergence, curl. PREREQUISITE: MA 1101 (may be taken concurrently).

MA 2045 INTRODUCTION TO LINEAR ALGEBRA (3-0). Complex numbers. Systems of linear algebraic equations. Matrix algebra. Vector spaces. Rank. Inverse by Gauss' method. Determinants. Adjoint and inverse. Characteristic equation, roots and vectors – proper axes for quadric surface, solution of system of differential equations. Orthogonal reduction to diagonal form. PREREQUISITE: MA 1100 or equivalent.

MA 2047 LINEAR ALGEBRA AND VECTOR ANALYSIS (4-0). Systems of linear equations. Matrix algebra. Inverse by Gauss' method. Determinants. Adjoint and inverse. Vector spaces. Rank. Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems. PREREQUISITE: MA 1100 or equivalent.

MA 2110 SELECTED TOPICS FROM ADVANCED CALCULUS (4-0). A selection of topics from Advanced Calculus, such as infinite series, differential equations, improper integrals, introduction to functions of a complex variable. PREREQUISITE: MA 1101 or equivalent.

MA 2121 DIFFERENTIAL EQUATIONS AND INFINITE SERIES (4-0). Ordinary differential equations: infinite series of constants and functions; Taylor series in one and two varibles with remainder; series solutions of ordinary differential equations including Bessel's equation; Fourier series. PREREQUISITE: MA 1100 or equivalent.

MA 2161 INTRODUCTION TO MATHEMATICAL PHYSICS (4-0). An introduction to the techniques used in solving problems in the classical field theories. Vector and scalar fields are studied. Solutions to the source-free equations most often encountered in physics are discussed. PREREQUISITES: MA 1110 and MA 2121 (the latter may be taken concurrently).

MA 2172 COMPLEX VARIABLES (4-0). Analytic functions, integration and series representations. Residue theory and application to Laplace transform. Conformal mapping and applications. PREREQUISITE: MA 2121 or equivalent.

MA 2232 NUMERICAL METHODS (4-0). Error propagation. Evaluation of functions. Nonlinear equations. Linear algebra for computers. Interpolation. Least squares approximation. Numerical integration. Ordinary differential equations. PREREQUISITE: MA 2121 and CS 0110 or equivalent.

MA 2300 MATHEMATICS FOR MANAGEMENT (5-0). This course is designed to provide the mathematical basis for modern managerial tools and techniques. It includes a review of algebra, systems of linear equations and linear inequalities, introductory material from linear programming, vectors and matrices, a brief survey of differential and integral calculus. PREREQUISITE: None.

Upper Division or Graduate Courses

MA 3026 TOPICS IN DISCRETE MATHEMATICS (4-0). Review of mathematical induction. Elements of number theory: divisibility, congruences and prime numbers. Generating functions and combinatorial problems. Elements of graph theory. PREREQUISITE: MA 2025.

MA 3042 LINEAR ALGEBRA (5-0). Systems of linear algebraic equations. Matrix algebra. Vector spaces. Rank. Inverse by Gauss' method. Determinants. Adjoint and inverse. Characteristic equation, roots, vectors – proper axes for a quadric surface, applications to systems of differential equations. Similarity to a diagonal matrix. Special types of matrices.

Orthogonal reduction to diagonal form. Quadratic forms and reductions. Lambda matrices and related topics. Cayley-Hamilton theorem and reduced characteristic function. Canonical forms of a matrix and applications – systems of differential equations, stability criteria, matrix equations. PREREQUISITE: MA 2121 or equivalent.

MA 3046 LINEAR ALGEBRA (3-0). Special types of matrices. Orthogonal reduction of a real symmetric matrix to diagonal form. Quadratic forms and reductions to expressions involving only squares of the variables. Applications to maxima and minima. Lambda matrices and related topics. Cayley-Hamilton theorem. PREREQUISITE: MA 2045.

MA 3047 LINEAR ALGEBRA (3-0). Reduced characteristic function. Canonical forms. Idempotent and nilpotent matrices. Solutions to matrix polynomial equations. Functions of a square matrix. Applications such as to differential equations, stability criteria. PREREQUISITE: MA 3046.

MA 3053 GRAPH THEORY AND COMBINATORIAL ANALYSIS (3-0). Permutations and combinations. Generating functions. The principle of inclusion and exclusion. Partitions, compositions. Trees and networks. Paths, circuits, chains and cycles of a graph. The fundamental numbers in graph theory. Associated matrix and incidence matrix. Transportation networks. PREREQUISITE: MA 1030 or equivalent.

MA 3130 DIFFERENTIAL EQUATIONS (4-0). Taylor and Fourier expansions. Linear differential equations, including series solutions. Bessel functions and Legendre polynomials; applications in the solution of partial differential equations. Sturm-Liouville systems and orthogonal-function expansions in solving boundary value problems. PREREQUISITE: MA 1100 or equivalent.

MA 3132 PARTIAL DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (4-0). Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions, Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3173 LAPLACE TRANSFORM AND COMPLEX VARIABLES (4-0). Definition and some elementary properties of the Laplace and Fourier transform. Application of these properties to the solution of differential equations. Analytic functions. Residue theory and application to Laplace transform. Conformal mapping and applications. PREREQUISITE: MA 3130 or equivalent.

MA 3181 VECTOR ANALYSIS (3-0). Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1100 or equivalent.

MA 3185 TENSOR ANALYSIS (3-0). Definition of a tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The co-variant derivative and its application to geodesics. The Riemann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3232 NUMERICAL ANALYSIS (4-0). Solution of equations. Zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations. Numerical solutions of ordinary differential equations. PREREQUISITE: MA 2121 and FORTRAN programming or equivalent.

MA 3243 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS (4-0). Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. The implicit alternating direction method. Approximations at irregular boundaries. Elliptic equations. The Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. A term project involving the solution of a suitably difficult boundary value problem is required. PREREQUISITES: MA 2232 and MA 3132 or equivalent.

MA 3362 ORBITAL MECHANICS (3-0). Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. The determination of orbits. The three body problem. Perturbations. PREREQUISITE: A course in dynamics.

MA 3393 TOPICS IN APPLIED MATHEMATICS (Credit Variable). The subject matter of this seminar will vary according to the interests of the participants. Topics will be chosen from the fields of modern optimization theory, applied mathematics, relativity theory, or from the other fields. PREREQUISITE: Consent of Instructor.

MA 3565 MODERN ALGEBRA I (3-0). Elements of set theory, equivalence relations and sets. Mappings and composition of mappings. Some elementary properties of integers, e.g., Euclidean algorithm, g.c.d., l.c.m., congruence relation. Group theory, subgroups. Normal subgroups and quotient groups. Homomorphisms, isomorphisms and automorphisms. Counting principles. PREREQUISITE: Consent of Instructor.

MA 3566 MODERN ALGEBRA II (3-0). Rings, ideals and quotient rings, Euclidean rings and polynomial rings. Linear vector spaces. Fields, extension fields, Galois groups and solvability. PREREQUISITE: MA 3565.

MA 3605 FUNDAMENTALS OF ANALYSIS I (3-0). Elements of set theory, the real number system, and the usual topology in E_N. Properties of continuous functions. Differentials of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorems, extremum problems). PREREQUISITE: Consent of Instructor.

MA 3606 FUNDAMENTALS OF ANNALYSIS II (3-0). Functions of bounded variation and theory of Riemann-Stieltjes integration. Multiple and iterated integrals. Convergence theorems for sequences and series of functions. PREREQUISITE: MA 3605.

MA 3610 INTRODUCTION TO GENERAL TOPOLOGY (3-0). Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures, Tychonoff product theorem, Alexandroff and Stone-Cech compactification. PREREQUISITE: MA 3605.

MA 3660 BOUNDARY VALUE PROBLEMS (3-0). The partial differential equations of physics and their solutions by separation of variables. Orthogonal sets of functions; Fourier series, their convergence and other properties. Applications to boundary value problems, verification and uniqueness of solutions. Continuation to include Bessel functions and Legendre polynomials. PREREQUISITE: MA 2121 or equivalent.

MA 3675 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I (3-0). Selected topics from the theory of functions of a real variable. Complex functions and analytic functions. Integration in the complex plane. Series of complex functions. Power series. Laurent series. PREREQUISITE: Consent of Instructor.

MA 3676 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE II (3-0). Singularities of complex functions. Residues and contour integration. Zeros of analytic functions, factors of and infinite product representations for analytic functions. Maximum modulus theorems for analytic and harmonic functions. Conformal mapping. PREREQUISITE: MA 3675.

MA 3691 SEMINAR IN ANALYSIS (3-0). Topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

MA 3730 NUMERICAL ANALYSIS AND COMPUTATION (3-0). Algorithms, flow charts, and FORTRAN statements. Difference equations. Iterative procedures to solve equations and systems of equations. Linear difference equations. Quotient-difference algorithms. FORTRAN subroutines. The interpolating polynomial and its construction. Numerical differentiation and integration. Numerical solution of differential eguations. PREREQUISITE: Graduate standing in engineering or sciences.

Graduate Courses

MA 4237 ADVANCED TOPICS IN NUMERICAL ANALYSIS (4-0). The subject matter will vary according to the abilities and interests of those enrolled. PREREQUISITE: MA 3243.

MA 4375 MATHEMATICS OF CONTINUA I (3-0). Strain analysis. Stress analysis. Constitutive relations. Fundamental equations of elastodynamics. Fundamental equations of hydrodynamics. Wave propagation and diffusion in layered media. Unidimensional applications in vibration, heat conduction, and electromagnetic diffusion. The inverse unidimensional problem and seismic applications. PREREQUISITE: MA 3173 or consent of the instructor.

MA 4376 MATHEMATICS OF CONTINUA II (3-0). Essential concepts from complex analysis. The Kolossoff-Muskhelishvili formulation of the two-dimensional thermoelastic problem in terms of conformal mapping. Essential concepts from harmonic analysis. The Papkovich-Neuber formulation of the three-dimensional thermoelastic problem. Wave propagation. Shock propagation. The work of Lax, Von Neumann and Richtmyer. PREREQUISITE: MA 4375.

MA 4501 TOPICS IN FOUNDATIONS OF MATHEMATICS (3-0). A selection of topics in foundations of mathematics. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4593 TOPICS IN ALGEBRA (3-0). A selection of topics in algebra. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4611 CALCULUS OF VARIATIONS (3-0). Bliss differential methods, Euler equations, Weierstrass-maximum principle, Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and applications to engineering and control problems. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4620 THEORY OF ORDINARY DIFFERENTIAL EQUATIONS (3-0). Existence and uniquesness of solutions of ordinary differential equations, linear systems of differential equations, self-adjoint eigenvalue problems. PREREQUISITE: Advanced calculus and consent of instructor.

MA 4622 PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS (3-0). Generalized functions and direct operational methods for solving linear problems; Green's functions and solution of ordinary and partial differential equations; eigenvalue problems of ordinary differential equations. PREREQUISITES: MA 3047 and MA 4637 (the latter may be taken concurrently).

MA 4635 FUNCTIONS OF REAL VARIABLES I (3-0). Axiomatic set theory, development of the real numbers, semicontinuous functions, absolutely continuous functions, functions of bounded variation. Classical Lebesgue measure and integration theory in E_1, convergence theorems and L_p spaces. PREREQUISITE: MA 3606.

MA 4636 FUNCTIONS OF REAL VARIABLES II (3-0). Abstract measure and integration theory, signed measures, Radon-Nikodym theorem. Lebesgue decomposition and product measures. Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 4635.

MA 4637 INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). An introduction to Banach and Hilbert spaces, including open mapping-closed graph theorem, weak and weak* topologies, spectral theorems for compact Hermitian operators. Hermitian bounded and normal bounded operators. PREREQUISITE: MA 4636.

MA 4662 INTEGRAL EQUATIONS (3-0). Integral equations of the first and second kinds. The Fredholm alternative. Volterea equations. Neumann series. Integral equations with symmetric kernels. Hilbert-Schmidt theory. Singular equations. Applications. PREREQUISITE: Consent of Instructor.

MA 4672 INTEGRAL TRANSFORMS (3-0). The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 2171.

MA 4693 TOPICS IN ANALYSIS (3-0). A selection of topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than once. PREREQUISITE: Consent of Instructor.

MA 4872 TOPICS IN CALCULUS OF VARIATIONS (3-0). Recent developments in the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applied to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: special variations, variation of extremals, dynamic programming. Applications in ship routing and missile control.

PREREQUISITES: MA 2121, MA 3046 and computer programming or Consent of Instructor.

MA 4945 PROBLEM SEMINAR (3-0). Under the guidance of several faculty members, the student is exposed to a variety of problems from diverse fields with the purpose of enhancing problem-solving ability and breadth of conceptualization. The problems fall into five or six classes, each representing a central theme of a mathematical topic or problem-solving technique. Approximately half the time is devoted to lectures by the participating faculty, during which time problems are posed and relevant techniques for their solution discussed. The other half is devoted to the presentation and discussion of solutions by the students. PREREQUISITES: B.S. in Mathematics, or equivalent.

PROBABILITY AND STATISTICS

Upper Division Courses

PS 2000 ELEMENTARY PROBABILITY AND STATISTICS (4-0). A pre-calculus treatment of selected topics in probability and statistics. Includes elementary probability, binomial distribution, normal distribution, random sampling, testing hypotheses, confidence limits, regression and correlation. PREREQUISITE: College algebra.

* PS 2301 PROBABILITY (4-0).

PS 2315 DATA REDUCTION AND ERROR ANALYSIS (4-0). An introduction to the practical techniques and procedures of experiment design, data acquisition and reduction, and error analysis in the physical sciences and engineering. Topics will include systematic and random errors, distributions, estimates of distribution parameters, least-squares fitting, multiple regression, tests of goodness-of-fit, and computer techniques for the treatment of data. PREREQUISITES: CS 0110 or equivalent, MA 1100 and MA 2045.

PS 2501 INTRODUCTION TO PROBABILITY AND STATISTICS I (4-0). A treatment of selected topics from probability and statistics using elementary concepts from calculus. Includes the definition of probability, useful probability distribution, sampling theory. PREREQUISITE: Integral and differential calculus, MA 1105, MA 1115 or equivalent.

PS 2502 INTRODUCTION TO PROBABILITY AND STATISTICS II (4-0). A continuation of PS 2501. Includes topics from statistical inference, curve fitting, regression and correlation, and some non-parametric tests. PREREQUISITE: PS 2501 or consent of instructor.

Upper Division or Graduate Courses

PS 3000 MANAGEMENT STATISTICS (5-0). A one-quarter pre-calculus course in probability and statistics designed for application in management. Includes definition and interpretation of probability, random variables, expectation, important probability distributions, sampling estimation, testing hypotheses, regression.

PS 3011 PROBABILITY AND STATISTICS FOR MANAGEMENT I (4-0). A treatment of selected topics in probability and statistics for management applications using elementary concepts from calculus. Includes probability models, discrete and continuous random variables, some important distributions, sampling theory and an introduction to statistical inference.

PS 3012 PROBABILITY AND STATISTICS FOR MANAGEMENT II (4-0). A continuation of PS 3011. Includes inference for normal populations, estimation procedures, non-parametric procedures and linear models. PREREQUISITE: PS 3011 or consent of instructor.

* PS 3302 PROBABILITY AND STATISTICS (4-1).

* PS 3303 STATISTICS (4-1).

PS 3401 INTERMEDIATE PROBABILITY AND STATISTICS I (4-0). A course in probability using the tools of calculus and leading toward applications in mathematical statistics. Includes topics from set theory, definition and calculation of probability, random variables and distribution functions, some standard distributions, joint distributions. PREREQUISITE: Mathematical maturity beyond differential and integral calculus.

PS 3402 INTERMEDIATE PROBABILITY AND STATISTICS II (4-0). A continuation of PS 3501 covering topics from mathematical statistics. Includes topics from sampling and statistics, estimation and testing hypotheses, Bayesian methods, and least squares regression theory. PREREQUISITE: PS 3401 or consent of instructor.

PS 3411 PROBABILITY THEORY I (4-0). Axiomatic probability, repeated trials, random variables and their distributions, functions of random variables and multidimensional random variables and some limit theorems. PREREQUISITE: Mathematical maturity beyond differential and integral calculus.

PS 3412 PROBABILITY THEORY II (4-0). Stochastic processes, time series, linear mean-square estimation. Brownian motion and Markov processes and Poisson processes. PREREQUISITE: PS 3411 or consent of instructor.

PS 3421 NONPARAMETRIC STATISTICS (4-0). One-sample tests, two-sample tests, tests for independence, nonparametric analysis of variance and correlation statistics. PREREQUISITE: Consent of instructor.

PS 3441 ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS (4-0). Linear models, noise-reducing designs, fixed random and mixed models and incomplete designs. PREREQUISITE: Consent of instructor.

PS 3451 STATISTICS FOR BUSINESS AND MANAGEMENT (4-0). Decision problems under uncertainty, Bayesian approach to decision problems, binomial sampling, normal distribution and Bayesian inference. PREREQUISITE: PS 2501 or equivalent.

*PS 3510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0).

Graduate Courses

PS 4001 ADVANCED PROBABILITY THEORY (3-0). Axiomatic probability, random variables and their probability distributions, parameters of probability distributions, characteristic functions and limit theorems. PREREQUISITE: Advanced calculus or consent of instructor.

PS 4002 ADVANCED STATISTICS AND DECISION THE-

ORY (3-0). Sample moments and their functions, order statistics, theory of runs, significance tests and theory of estimation. PREREQUISITE: PS 4001 or consent of instructor.

* PS 4306 APPLIED STATISTICS (4-0).

*PS 4321 DESIGN OF EXPERIMENTS (3-1).

* PS 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (3-1).

* PS 4323 DECISION THEORY (3-0).

PS 4325 ADVANCED DESIGN OF EXPERIMENTS (4-0). Incomplete block designs. Yondeu squares, fractional designs, response surfaces and robustness properties of analysis of variance tests. PREREQUISITE: PS 4321.

PS 4327 RANDOM FUNCTIONS (4-0). Introduction to mathematical problems of random natural phenomena, such as the random movements of ocean surfaces, the reflection of light and sound from these surfaces, and motions of floating objects on them. Emphasis on mathematical concepts needed to solve these and related problems: Wiener processes, harmonic analysis of random functions, probability density functions of linear systems driven by random forces; Rice's statistics of random functions, such as zerocrossing, maxima, and envelope statistics, and other geometric statistics. Current problems of statistical geometry. PREREQUISITE: Consent of instructor.

* PS 4431 ADVANCED PROBABILITY (3-0).

*PS 4432 STOCHASTIC PROCESSES I (4-0).

*PS 4433 STOCHASTIC PROCESSES II (4-0).

* PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0).

*PS 4440 TIME SERIES ANALYSIS (4-0).

* See listing under Operations Analysis Department.

Mechanical Engineering Laboratory

DEPARTMENT OF MECHANICAL ENGINEERING

TURGUT SARPKAYA, Professor of Mechanical Engineering; Chairman (1967)*; M.S. in M.E., Tech. Univ. of Istanbul, 1951; Ph.D., Univ. of Iowa, 1954; Research Professor, Univ. of Manchestor, 1966.

ERNEST KENNETH GATCOMBE, Professor Emeritus (1946); B.S., Univ. of Maine, 1931; M.S., Purdue Univ., 1939; Ph.D., Cornell Univ., 1944.

DENNIS KAVANAUGH, Professor Emeritus (1926); B.S., Lehigh Univ., 1914.

HAROLD MARSHALL WRIGHT, Professor Emeritus (1945); B.Sc. in M.E., North Carolina State College, 1930; M.M.E., Rensselaer Polytechnic Institute, 1931.

JOHN EDISON BROCK, Professor of Mechanical Engineering (1954); B.S.M.E., Purdue Univ., 1938; M.S.E., 1941; Ph.D., Univ. of Minnesota, 1950.

JOSEPH GILLES CANTIN, Associate Professor of Mechanical Engineering (1960); B.A.Sc., Ecole Polytechnique (Montreal), 1950; M.Sc., Stanford Univ., 1960; Ph.D., Univ. of California at Berkeley, 1968.

CLARENCE JIMMY GARRISON, Assistant Professor of Mechanical Engineering (1970); B.S. in M.E., Univ. of Nebraska, 1960; M.S. in M.E., Univ. of Nebraska 1962; Ph.D., Univ. of Washington 1968.

THOMAS MICHAEL HOULIHAN, Assistant Professor of Mechanical Engineering (1969); B.M.E., Manhattan College, 1961; Ph.D., Syracuse Univ., 1968.

MATTHEW DENNIS KELLEHER, Assistant Professor of Mechanical Engineering (1967); B.S. in Eng. Sci., Notre Dame Univ., 1961; M.S.M.E., 1963; Ph.D., 1966.

PAUL JAMES MARTO, Associate Professor of Mechanical Engineering (1965); B.S., Univ. of Notre Dame, 1960; M.S. in Nuc. Sci., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

ROBERT EUGENE NEWTON, Professor of Mechanical Engineering (1951); B.S. in M.E., Washington Univ.. 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951; Research Professor, Univ. of Wales, Swansea, 1968.

DONG HUU NUGYEN, Assistant Professor of Mechanical Engineering (1969); B.S.M.E., Purdue Univ., 1960; M.S. in Nuc. Eng., 1961; Ph.D., Univ. of California at Berkeley, 1965.

ROBERT HARRY NUNN, Assistant Professor of Mechanical Engineering (1968); B.S., Univ. of California at Los Angeles, 1955; M.S.M.E., 1964; Ph.D., Univ. of California at Davis, 1967.

ROY WALTERS PROWELL, Professor of Mechanical Engineering (1946); B.S. in I.E., Lehigh Univ., 1936; M.S. in M.E., Univ. of Pittsburgh, 1943.

PAUL FRANCIS PUCCI, Professor of Mechanical Engineering (1956); B.S. in M.E., Purdue Univ., 1949; M.S. in M.E., 1950; Ph.D., Stanford Univ., 1955.

DAVID SALINAS, Assistant Professor of Mechanical Engineering (1970); B.S. in M.E., 1959; M.S. 1962; Ph.D., 1968, Univ. of California at Los Angeles.

RICHARD CAMERON WINFREY, Assistant Professor of Mechanical Engineering (1969); B.S. in M.E., Univ. of California at Berkeley, 1963; M.S.E., Univ. of California at Los Angeles, 1965; Ph.D., 1969.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum should be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

1. Entrance Requirements. Prior to entering an approved curriculum, a student must have successfully completed college courses as follows: Mathematics through integral calculus, one year of chemistry, and one year of phsyics.

2. Mechanical Engineering Courses. A minimum of 58 quarter hours in mechanical engineering courses is required, at least 30 of them being in courses 3000-4999.

3. Other Specific Coverage. The following minimum requirements must be met in each of the indicated disciplines.

MATHEMATICS -- One course in each of the following subjects: linear algebra, differential equations and series, numerical methods and digital computers, and partial differential equations.

ELECTRICAL ENGINEERING – 10 quarter hours.

MATERIAL SCIENCE – 4 quarter hours.

Some of these requirements may, with the consent of the departmental chairman, be met by transfer credit.

4. UPPER DIVISION CREDIT. Minimum credit of 94 quarter hours in upper division or higher level courses is required.

5. Sample Program. A sample program satisfying the above requirements is given under Naval Engineering Programs, Curriculum No. 570.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

1. Areas of Specialization. The Department of Mechanical Engineering offers Master of Science degrees with specialization in the following four areas: Engineering Mechanics, Fluid Dynamics and Thermo-Sciences, Nuclear Engineering, and Ocean Mechanical Engineering.

2. Undergraduate Preparation. A candidate shall have satisfied the requirements for the degree of Bachelor of Science in Engineering. Credit requirement in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

3. Mechanical Engineering Courses. The Master of Science degree in Mechanical Engineering requires a minimum of 36 quarter hours of graduate level credits, at least 10 of them in courses 4000-4999, plus an acceptable thesis.

4. Courses in Other Departments. A minimum of 8 quarter hours of graduate credit must be earned outside of the Mechanical Engineering Department.

5. Sample programs in various areas of specialization leading to the Master of Science degree in Mechanical Engineering are given under Naval Engineering Programs, Curriculum No. 570.

THE PROGRAM LEADING TO THE DEGREE OF MECHANICAL ENGINEER

Graduate students may, upon satisfactory completion of seven quarters of academic work, enter the program leading to the degree of Mechanical Engineer. Normally, this program is of three years duration.

The Engineer's degree requires a minimum of 76 graduate course credits, at least 30 of them in courses 4000-4999, plus an acceptable thesis pertinent to the area of specialization among the following four areas: Engineering Mechanics, Fluid Dynamics and Thermo-Sciences, Nuclear Engineering, and Ocean Mechanical Engineering. An acceptable thesis for the Engineer Degree may also be accepted as meeting the thesis requirements for the Masters Degree.

An advisor will be appointed by the departmental chairman for consultation in the development of a program of study and research. Approval of all programs must be obtained from the Chairman, Department of Mechanical Engineering.

THE PROGRAM LEADING TO THE DEGREE OF DOCTOR OF PHILOSOPHY

Graduate students may, upon satisfactory completion of eleven quarters of academic work, apply for the program leading to the degree of Doctor of Philosophy. Normally, this program requires the equivalent of at least three academic years of study beyond the baccalaureate level, with at least one academic year being spent at the Naval Postgraduate School. A Doctoral Committee is appointed for the student which has the full responsibility for providing a program of study suitable to the needs of the student and the requirements for award of the degree.

The Department of Mechanical Engineering is authorized to offer doctorate degrees in the areas of mechanics of deformable bodies and fluid mechancis and heat transfer.

A dissertation advisor is appointed by the Department Chairman who, together with the Doctoral Committee, is responsible for the development of a program of study and research. Approval of the programs must be obtained from the Academic Council.

MECHANICAL ENGINEERING LABORATORIES

The Mechanical Engineering Laboratories provide the facilities for instruction and research in mechanics of deformable bodies, fluid dynamics, thermo-sciences, nuclear engineering, and ocean mechanical engineering. Facilities in the mechanics laboratory include equipment for static, fatigue, and impact testing. Stress analysis equipment includes instrumentation for multi-channel recording of static and dynamic strains, a photoelasticity laboratory, and facilities for brittle lacquer studies. Dynamics equipment includes electrostatic exciters, force and motion transducers and associated instrumentation. An analog computer laboratory provides for electronic formulation of linear and non-linear engineering systems.

Facilities in the fluid dynamics laboratory include, in addition to facilities for standard experiments, a water tunnel, a fluid power control system, a swirling flow apparatus, a fluid amplifier text system, a six-channel hot-wire anemomcter system, numerous electronic amplifier and recorder units, and pressure transducers.

Equipment in the heat power laboratories includes a 175 HP gas turbine installation, a two-dimensional supersonic air nozzle with Schlieren equipment for analysis of shockwise flows. a two-stage axial flow test compressor, an experimental single-cylinder Diesel engine, a multi-stage centrifugal blower, an air flow metering bench, hydraulic test equipment including a two-stage centrifugal pump, an impulse turbine and a torque converter, a single-blow transient testing facility for compact heat exchanger surfaces, a small cryogenic facility for evaluating cryopumping surfaces, and several apparatus for research on pipes and nuclear boiling.

The nuclear engineering facility consists of an AGN reactor (licensed to a maximum power to 1,000 watts), a multichannel analyzer (512 channels and teletype), oscilloscopes and XY plotters. In addition, the department has several neutron sources, a visiflux irradiation tank, and several counting devices.

MECHANICAL ENGINEERING

ME 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

ME 2101 ENGINEERING THERMODYNAMICS (4-1). The fundamental laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis including reversed cycles. Gas-vapor mixtures. Combustion and dissociation. Application of thermodynamic principles to marine power plant equipment. TEXT: Reynolds, *Thermodynamics*. PREREQUISITE: MA 1100.

ME 2120 ELEMENTS OF ENGINEERING THERMODYNAMICS (3-2). The fundamental concepts of thermodynamics, thermodynamic properties and equations of state; the first law of thermodynamics, entropy and the second law of thermodynamics; cycle analysis with some applications. TEXT: Durham, *Thermodynamics*, 2nd ed. PREREQUISITE: PH 1015.

ME 2201 FLUID MECHANICS (4-2). Mechanical properties of fluids, hydrostatics, metacenter and stability analysis;

energy considerations in steady flow; principles of impulse-momentum and dynamic forces; dimensional analysis and theory of modelling; viscous effects, energy loss, laminar and turbulent flows; fluid flow measurements and problem work. TEXTS: Daugherty and Franzini, *Fluid Mechanics with Engineering Applications,* 6th ed.; Streeter, *Fluid Mechanics,* 4th ed. PREREQUISITES: ME 2502 and MA 2232 (May be concurrent).

ME 2410 MECHANICAL ENGINEERING LAB I (1-3). Fundamentals of mechanical measurements. Structured laboratory experiments using resistance strain gages, pressure transducers, temperature and flow measurement devices. Performance characteristics of operating system. TEXTS: Beckwith and Buck, *Mechanical Measurements;* Perry and Lissner, *The Strain Gage Primer.* PREREQUISITES: ME 2101, ME 2201, ME 2502, and ME 2601, any of which may be taken concurrently.

ME 2501 MECHANICS I (4-0). Laws of statics. Applications to structures and machines. Kinematics. Dynamics of a particle TEXT: Beer and Johnston, *Vector Mechanics.* PREREQUISITE: MA 1100 (May be concurrent).

ME 2502 MECHANICS II (3-0). Principles of dynamics. Work and energy. Impulse and momentum. Rigid body kinematics. Dynamics of rigid bodies. TEXT: Beer and Johnston, *Vector Mechanics.* PREREQUISITE: ME 2501.

ME 2561 STATICS (3-0). This course, designed specifically for the B.S. in Engineering Science Curriculum, deals with forces and force systems, moments and couples, resultants, equilibrants, free body diagrams, equilibrium of a free body, simple structures, friction, first and second moments, and centroids. TEXT: Meriam, *Mechanics.* PREREQUISITE: MA 1106.

ME 2562 DYNAMICS (4-0). This course, designed specifically for the B.S. in Engineering Science Curriculum, deals with basic concepts of kinematics, Newton's Laws, d'Alember's principle, work and energy, impulse and momentum, plane motion of a rigid body. TEXT: Meriam, *Mechanics.* PREREQUISITES: ME 2561.

ME 2601 MECHANICS OF SOLIDS I (3-2). Stress, strain, Hooke's law, tension and compression, shearing stresses, connections, thin vessels, torsion, statics of beams, stresses in beams, deflection of beams, combined loadings and combined stresses, columns. Strain energy, impact, simple indeterminate structures. Supporting laboratory work. TEXT: Timoshenko and Young, *Elements of Strength of Materials.* PREREQUISITES: ME 2501 and MA 1100.

ME 2641 STRUCTURAL MECHANICS (4-0). Review of statics of rigid bodies and applications to determined structures. Stress, strain, Hooke's law, tension and compression, shearing stresses. Connections, thin vessels, torsion. Statics of beams, flexural stresses and deformations, numerical methods. Simple indeterminate structures. Combined loadings and combined stresses. Columns. TEXT: Timoshenko and Young, *Elements of Strength of Materials.* PREREQUISITE: MA 1100 or equivalent and ME 2501 or equivalent.

ME 2711 MACHINE DESIGN I (3-2). Material selection, tolerances and allowances, variable loads and stress concentration, screw fastenings, springs, theories of failure, shafts, journal and plane surface bearings, ball and roller bearings; gears, flexible power-transmitting elements, brakes and clutches. TEXT: Faires, *Design of Machine Elements.* PREREQUISITE: ME 3611.

ME 2901 INDIVIDUAL STUDY IN MECHANICAL ENGINEERING (Hours to be arranged). Directed individual study by a student whose background or future plans require additional or exceptional treatment of material at the undergraduate level. PREREQUISITE: Permission of Department Chairman.

Upper Division or Graduate Courses

ME 3150 HEAT TRANSFER (4-2). Elementary treatment of the principles of heat transfer applicable to problems in Mechanical Engineering. Steady-state conduction, principles of forced and natural convection; thermal radiation; boiling; condensation; heat exchanger analysis. Use of the thermal circuit, analog, numerical and graphical techniques. Laboratory experiments. TEXT: Holman, *Heat Transfer.* PREREQUISITES: ME 2101, ME 2201, and MA 3132.

ME 3161 CONDUCTION AND RADIATION HEAT TRANSFER (3-0). Steady-state heat conduction in one and multi-dimensions with and without sources; transient conduction; numerical and analog methods for heat conduction; mechanical engineering application; black body radiation; radiation from real surfaces; radiation exchange between finite surfaces; radiation in absorbing and emitting media. TEXT: Chapman, *Heat Transfer,* 2nd ed. PREREQUISITES: ME 2101 and MA 3132.

ME 3170 HEAT TRANSFER AND GAS DYNAMICS (4-2). The fundamental heat transfer mechanisms; conduction, convection, and radiation; and the use of various techniques in the solution of heat transfer problems relating to mechanical engineering. Fundamentals of one-dimensional compressible flow including effects of area change, normal shock and friction. TEXTS: Holman, *Heat Transfer;* Shapiro, *The Dynamics and Thermodynamics of Compressible Flow.* PREREQUISITES: ME 2101, ME 2201, and MA 2121.

ME 3202 GAS DYNAMICS (3-0). Application of the continuity, momentum and energy theorems to the flow of compressible fluids, through devices encountered in mechanical engineering. One dimensional isentropic flow. Normal shock waves. Adiabatic flow in constant area ducts with friction. Flow in ducts with heating or cooling. Generalized one-dimensional continuous flow. Oblique shocks. TEXT: Shapiro, *The Dynamics and Thermodynamics of Compressible Flow.* PREREQUISITES: ME 2101 and ME 2201.

ME 3301 NUCLEAR POWER SYSTEMS (4-0). Fundamentals of nuclear reactor physics. Diffusion and slowing down of neutrons. Reactor kinetics and control. Radiation shielding. Engineering considerations in nuclear reactors including core thermal and hydraulic design. Principal reactor types. Radioisotopic power generation. TEXT: El Wakil, *Nuclear Power Engineering.* PREREQUISITES: ME 3170 or equivalent and PH 2810.

ME 3315 NUCLEAR MEASUREMENTS LAB (1-4). Laboratory experiments on the interaction of radiation with matter, radiation detection principles, neutron physics and nuclear reactor operation. The use of various health physics instruments and radiation detectors employed in nuclear reactor technology. Shielding length and Fermi age. Experiments involving reactor operation such as control rod calibration.

TEXT: Glower, *Experimental Reactor Analysis and Radiation Measurements.* PREREQUISITES: ME 2410 and ME 4311 (May be concurrent).

ME 3341 RADIATION SHIELDING (4-0). Radiation sources. Interaction of electromagnetic radiation, charged particles and neutrons with matter. The damage of radiation to materials and organisms. Shielding problems including radiation streaming in ducts and heating within the shield. The mechanical engineering design of radiation shields. TEXTS: Goldstein, *Fundamental Aspects of Reactor Shielding;* Rockwell, *Reactor Shielding Design Manual.* PREREQUISITES: ME 3301 or equivalent.

ME 3430 MECHANICAL ENGINEERING LAB II (2-4). A project-oriented continuation of mechanical measurement principles with emphasis on dynamic response characteristics and systems theory. Application of measurement techniques using projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations, and nuclear radiation detection. TEXT: Beckwith and Buck, *Mechanical Measurements.* PREREQUISITES: ME 2410, ME 3521, and ME 3611.

ME 3440 ENGINEERING SYSTEMS ANALYSIS (4-0). Classification of engineering problems. Study of equilibrium, eign value and propagation problems for both discrete and continuous systems. Rigorous construction of mathematical models. Classical methods of solution and numerical techniques. Digital computer applications. Problems in the theory of plates and shells, heat transfer, hydromechanics, and other areas of Mechanical Engineering are used as illustrations throughout the course. TEXT: Crandall, *Engineering Analysis;* Salvadori and Baron, *Numerical Methods in Engineering.* PREREQUISITES: ME 2101, ME 2201, ME 3521, and ME 3611.

ME 3450 MARINE GAS POWER SYSTEMS (3-2). Fundamentals of combustion and thermochemical analysis; spark and compressor ignition cycles using air standard and real mixture analyses; gas turbine cycle analyses, including the regenerated, inter-cooled, and reheat cycles; combined power plant analyses; total energy concepts; fundamentals of thermal jet and rocket propulsion analysis. TEXT: Lewis, *Gas Power Dynamics;* Instructor's notes. PREREQUISITES: ME 3202 and ME 3150.

ME 3500 MECHANICAL VIBRATIONS AND NOISE CONTROL (4-0). Fundamentals of vibrating systems of one and multiple degrees of freedom, free and forced vibrations, resonance, naval applications of noise control, vibration isolation, damping materials, vibration of some continuous systems, balancing, case studies in vibration and noise control. TEXTS: Vernon, *Linear Vibration Theory: Generalized Properties and Numerical Methods;* MacDuff and Curreri, *Vibration Control;* Skudrzyk, *Simple and Complex Vibratory Systems.* PREREQUISITES: MA 2172, MA 2232 or equivalent, PH 3157, and PH 3451.

ME 3521 MECHANICAL VIBRATIONS (3-2). Kinematics and kinetics of free and forced vibration of linear systems having one or two degrees of freedom. Energy methods. Applications to vibration isolation and suppression in mechanical systems. Vibration of bars, shafts and beams. Numerical solutions. Laboratory experiments with mechanical and simulated systems. TEXT: Thomson, *Vibration Theory and Applications.* PREREQUISITES: ME 2502, ME 2601, MA 2232, and MA 3132.

ME 3611 MECHANICS OF SOLIDS II (4-0). Further elastic analysis of statically indeterminate structures, beam columns, curved beams, unsymmetrical bending, shear center, beams on elastic foundations, plates and shells, thick walled cylinders, rotating discs, and elementary thermal stresses. TEXT: Timoshenko, *Strength of Materials,* Parts I and II. PREREQUISITES: ME 2502, ME 2601, MA 2121, and MA 2232.

ME 3642 STRUCTURAL THEORY (4-0). Stability and determinacy of simple structures. Energy methods. Matrix methods. Flexibility and stiffness methods. Dynamic response of systems having one, two, and many degrees of freedom. TEXTS: Gere and Weaver, *Analysis of Framed Structures;* Rogers, *Dynamics of Framed Structures.* PREREQUISITES: ME 2641 and MA 2121.

MA 3712 MACHINE DESIGN II (3-4). Machine design projects which require complete design studies. TEXT: Faires, *Design of Machine Elements.* PREREQUISITES: ME 2711 and ME 3521.

ME 3801 FLUID POWER CONTROL (3-2). Fluid power transmission; pressure-flow relationships; pneumatic systems and steady state operations; electromagnetic and electrohydraulic actuators; dynamic performance of physical systems; power steering, servomechanisms and servos for high-pressure hot gases. TEXTS: Merritt, *Hydraulic Control Systems;* Blackburn, *Fluid Power Control.* PREREQUISITES: ME 2201 and MA 3132.

ME 3811 AUTOMATIC CONTROL SYSTEMS (3-2). Ordinary linear automatic control systems; automatic regulation systems; special linear regulation systems; non-linear systems; methods of plotting the regulation-process curve; the stability of linear feedback systems; the design and compensation of feedback control systems and mechanical engineering applications. TEXTS: Goldberg, *Automatic Control: Principles of Systems Dynamics;* Garner, *Introduction to Control System Performance Measurements;* Anderson, *Analysis and Design of Pneumatic Systems.* PREREQUISITES: MA 3132 and ME 3440.

Graduate Courses

ME 4140 DIRECT ENERGY CONVERSION (3-0). Introduction to the principles of direct energy conversion employing thermoelectric, thermionic, photovoltaic, magnetohydrodynamic, and fuel cell power generators. TEXT: Angrist, *Direct Energy Conversion.* PREREQUISITES: ME 3150 (or equivalent), ME 3202, EE 2101, and MA 2121.

ME 4162 CONVECTION HEAT TRANSFER (4-0). Fundamental principles of forced and free convection; dimensionless correlations of convection; heat transfer during phase changes; combined conduction, convection and radiation heat transfer systems; heatexchanger with mechanical engineering applications. TEXTS: Chapman, *Heat Transfer,* 2nd Ed.; Kays, *Convective Heat and Mass Transfer.* PREREQUISITE: ME 3161 and ME 4220 (May be concurrent).

ME 4211 HYDRODYNAMICS (4-0). Potential and stream functions; vortex dynamics; body hydrodynamics; acquisition of potential solutions; conformal transformation and mapping; approximate solutions; discontinuous flows, and naval engineering applications. TEXTS: Robertson, *Hydrodynamics in Theory and Application;* Streeter, *Fluid Dynamics.* PREREQUISITES: MA 3132 and either ME 3170 or ME 3202.

ME 4220 BOUNDARY LAYER THEORY (4-0). Boundary layer equations; similar boundary-layers; study of the relationships between various boundary-layer functions with mechanical engineering applications; solutions of velocity and thermal-energy equations; axisymmetric, non-similar, and time-dependent boundary layers; stability of steady and unsteady boundary layers; transition and turbulence; equations of isotropic and homogeneous turbulence. TEXTS: Evans, *Laminar Boundary Layers;* Schlichting, *Boundary Layer Theory,* 6th Ed. PREREQUISITES: MA 3132 and either ME 3170 or ME 3202.

ME 4230 ADVANCED TOPICS IN FLUID DYNAMICS AND HEAT TRANSFER (4-0). Hydrodynamic stability; characteristics of turbulent flows; hot-wire anemometry, compressible boundary layer flows, unsteady heat conduction and convection; and in particular, topics selected in accordance with the current research interests of students and staff. TEXTS: Hinze, *Turbulence*; Kudryavstev, *Unsteady State Heat Transfer;* Schlichting, *Boundary Layer Theory,* 6th Ed., and instructor's notes. PREREQUISITES: ME 4162, ME 4211, ME 4220, and MA 2172 (May be taken concurrently).

ME 4240 ADVANCED HYDRODYNAMICS (4-0). Jets, wakes, and cavities; free-streamline theory; steady and unsteady separated flows; analysis of the motion of rotating masses of fluids; propagation of waves in complex systems; and in particular, topics selected in accordance with the current research interests of students and staff. TEXTS: Sedov, *Two-Dimensional Potential Flow Problems in Hydrodynamics;* Robertson, *Hydrodynamics in Theory and Application;* Lamb, *Hydrodynamics.* PREREQUISITES: ME 4211 and ME 3172 (May be taken concurrently).

ME 4311 NUCLEAR REACTOR THEORY (5-0). Nuclear reactions induced by neutrons. Neutron cross sections. The fission process. Diffusion and slowing down of neutrons in media with and without absorption. Fermi age theory. Reactor kinetics and control. Emphasis on reactor design parameters and their relation to reactor engineering problems. TEXT: Lamarsh, *Introduction to Nuclear Reactor Theory.* PREREQUISITES: PH 2810 and MA 3132.

ME 4312 ADVANCED NUCLEAR REACTOR THEORY (4-0). Multigroup diffusion methods. Reflected reactor systems. Design parameters in hetrogeneous reactors. Numerical techniques in reactor analysis. Introduction to transport theory. Perturbation theory. TEXT: Lamarsh, *Introduction to Nuclear Reactor Theory* with class notes. PREREQUISITES: ME 4311, MA 2172, and MA 3243.

ME 4321 REACTOR ENGINEERING PRINCIPLES AND DESIGN (4-2). Reactor heat generation and removal. Thermal stress analysis. Nuclear cycles and nuclear energy conversion. Principle types of reactor systems. The synthesis of reactor physics, heat transfer and hydraulics, properties of materials and safety requirements in reactor design. Design optimization procedures. Student group design project. TEXT: Glasstone and Sesouske, *Nuclear Reactor Engineering.* PREREQUISITES: ME 4311, ME 3161 and ME 4162.

ME 4512 ADVANCED DYNAMICS (4-0). Mechanics systems treated by advanced methods. Particle and rigid body kinematics in three dimensions. Systems of particles. The inertia tensor. Matrix formulations of rigid body kinematics. Hamiltonian and Lagrangian formulations and applications to electromechanical systems. TEXT: Synge and Griffith, *Principles of Mechanics* (or equivalent), plus classroom notes. PREREQUISITES: ME 2502 and ME 3521.

ME 4522 ADVANCED VIBRATIONS (3-1). Matrix analysis of mechanical systems with many degrees of freedom. Transient response. Shock isolation. Non-linear systems. Digital computer solutions. TEXT: Tong, *Theory of Mechanical Vibration.* PREREQUISITE: ME 3521.

ME 4612 MECHANICS OF SOLIDS III (4-0). Elements of theory of elasticity. Stress tensor and theories of failure. Torsion of noncircular sections. Plastic analysis. Matrix methods in structural analysis. Brittle fracture. TEXTS: Timoshenko and Goodier, *Theory of Elasticity;* Parker, *Brittle Behavior of Engineering Structures.* PREREQUISITES: MA 3132 and ME 3611.

ME 4613 ADVANCED METHODS OF ANALYSIS IN ELASTICITY (4-0). Modern methods of analysis for complex problems of elasticity. Plate and shell structures; finite element methods. Application to ship structures, submarine hulls, nuclear reactors. TEXT: Zienkiewicz, *The Finite Element Method.* PREREQUISITE: ME 4612.

ME 4620 THEORY OF CONTINUOUS MEDIA (4-0). Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Mechanical applications in the theory of elasticity and fluid dynamics. TEXT: Frederick and Chang, *Continuum Mechanics.* PREREQUISITES: ME 3611 and MA 3132.

ME 4902 ADVANCED STUDY IN MECHANICAL ENGINEERING (2-0 to 6-0). Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman.

DEPARTMENT OF METEOROLOGY

GEORGE JOSEPH HALTINER, Distinguished Professor and Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

RONNIE LEE ALBERTY, Assistant Professor of Meteorology (1967); B.S., Univ. of Missouri (Columbia Campus), 1963; M.S. 1965; Ph.D., 1967.

KENNETH LaVERN DAVIDSON, Assistant Professor of Meteorology (1970); B.S. Univ. of Minnesota, 1962; M.S. Univ. of Michigan, 1966; Ph.D., 1970.

WILLIAM DWIGHT DUTHIE, Distinguished Professor and Professor of Meteorology (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

RUSSELL LEONARD ELSBERRY, Assistant Professor of Meteorology (1968); B.S., Colorado State Univ., 1963; Ph.D., 1968.

HARRY DEAN HAMILTON, Commander, U.S. Navy; Assistant Professor Of Meteorology (1969); B.S., Univ. of Texas, 1955; M.S., Naval Postgraduate School, 1961; Fil. Lic., Univ. of Stockholm (Sweden), 1970.

JERRY DAVID MAHLMAN, Associate Professor of Meteorology (1967); A.B., Chadron State College, 1962; M.S., Colorado State Univ., 1964; Ph.D., 1967.

FRANK LIONEL MARTIN, Professor of Meteorology (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

WINSLOW BLODGETT OAKES, Lieutenant Commander, U.S. Navy; Instructor in Meteorology (1968); B.S., Renssalaer Polytechnic Institute, 1955; M.S. Naval Postgraduate School, 1962.

ROBERT JOSEPH RENARD, Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952; Ph.D., Florida State Univ., 1970.

CHARLES LUTHER TAYLOR, Associate Professor of Meteorology (1954); B.S. Pennsylvania State Univ., 1942; M.S., 1947.

WILLEM VAN DER BIJL, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ., Utrecht, 1952.

ROGER TERRY WILLIAMS, Associate Professor of Meteorology, (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph.D., 1963.

FRANCIS JOSEPH WINNINGHOFF, Assistant Professor of Meteorology (1970); B.A., UCLA., 1960; M.A., UCLA., 1961; Ph.D., UCLA., 1968.

* The year of joining the Postgraduate School Faculty is indicated in parentheses.

METEOROLOGY LABORATORIES

Meteorology facilities include all instruments in present-day use for measuring the physical and dynamic state of the atmosphere, as well as radio teletype and facsimile communications equipment for the rapid reception and dissemination of weather data in coded and analyzed form for the entire northern hemisphere.

The instruments for gathering weather data include rawinsonde equipment, which provides a continuous recording of temperature, pressure, humidity and wind direction and velocities at designated levels above the surface; radiosonde equipment whereby pressure, temperature and humidity information is transmitted to ground via radio signals from heights that may extend above 100,000 feet; a wiresonde that measures air temperature and humidity conditions in the lower strata of the atmosphere, and inversion meter designed for remote recordings of free air temperature at designated heights in the boundary layer.

The school has in daily operation an automatic picture transmission (APT) receiving apparatus for the reception of pictures from the NIMBUS, ESSA, and ATS weather satellites. Rectification grid templates are used in the laboratories for direct correlation of current satellite pictures with conventional synoptic analyses and nephanalyses.

Four meteorological laboratories are served by a closed circuit television network which has the transmitting studio in close proximity. Some of the equipment in the studio includes TV cameras, slide and movie projectors, sound facilities, and a video tape recorder.

The proximity of the Fleet Numerical Weather Facility on the school grounds provides introduction to the latest environmental computer products and the high speed data links utilized to provide transmission and automatic reproduction through a world-wide network.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN METEOROLOGY

Bachelor of Science in Meteorology

1. The degree of Bachelor of Science in Meteorology requires completion of:

   a. Mathematics courses including differential and integral calculus, vectors, digital computers, and numerical methods.

   b. Thirty-six quarter hours of meteorology courses including the basic sequences in dynamic, physical and synoptic meteorology.

   c. An acceptable research paper.

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

   a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.

b. Thirty-five quarter hours of graduate meteorology courses of which eighteen hours must be in the 4000 series.

c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, must be included in these 35 hours.

d. An acceptable thesis.

DOCTOR OF PHILOSOPHY

The Ph.D. is offered in the Department of Meteorology in the following areas of study: large scale atmospheric dynamics and numerical weather prediction.

The requirements for the degree are grouped into three categories: course work, research in conjunction with an approved dissertation, examination in both the major and a minor field and languages. The minor field is usually in oceanography, mathematics or physics.

The required examinations are described in this catalog in the section Requirements for the Doctor's Degree. The Department of Meteorology also requires a preliminary examination in order to show evidence of acceptability as a doctoral candidate.

Prospective students should consult with the Chairman of the Department of Meteorology for further information and guidance regarding doctoral programs.

METEOROLOGY

MR 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MR 1105 WEATHER CODES–OBSERVATIONS–PLOTTING (0-3). Acquaintance with weather codes and observation stressing utility and application; introduction to analysis of scalar fields stressing basic techniques and continuity. TEXTS: WBAN *Manuals for Synoptic, Radiosonde and Upper Wind Codes; International Cloud Atlas; Weather Station Index Manual; departmental notes.*

Upper Division Courses

MR 2200 INTRODUCTION TO METEOROLOGY (3-0). A general course which treats descriptively the composition and vertical structure of the atmosphere, physical processes, general circulation, air masses, fronts, cyclones and anti-cyclones, tropical disturbances, storms, and hurricanes. TEXTS: Petterson, *Introduction to Meteorology; AMS Glossary of Meteorology.* PREREQUISITE: None.

MR 2205 METEOROLOGY FOR OCEANOGRAPHERS (0-4). A laboratory course in weather observations, codes, and the technique of synoptic analysis. The emphasis is on the surface chart and the determination of meteorological parameters for application to problems in oceanography. TEXTS: WBAN *Manual for Synoptic Codes; Weather Station Index Manual; departmental notes; ASWEPS Series Manual, Vol. 3.* PREREQUISITES: MR 2200 Concurrently.

MR 2220 WEATHER MAP ANALYSIS (4-0). Graphical arithmetic; techniques of scalar and frontal analysis, evaluation of surface and upper-air data; structure and behavior of extratropical cyclones; stability analysis and air massis;/objective forecasting of weather elements; space/time cross sections. TEXTS: Barry, Bollay, Beers, *Handbook of Meteorology, departmental notes.* PREREQUISITES: MR 1105, MR 2200, MR 2411 or MR 3411; MR 3301 or MR 4321 concurrently.

MR 2225 WEATHER MAP ANALYSIS LABORATORY (0-6). Laboratory course taught in conjunction with MR 2220 Graphical arithmetic practice in upper-air and surface analysis analysis of upper-air soundings, and vertical space/time cross-sections; introduction of meteorological satellite observations, local forecasting techniques and mesoscale synoptic analysis. TEXTS: Berry, Bollay, Beers, *Handbook of Meteorology; departmental notes.* PREREQUISITES: MA 1105, MR 2220.

MR 2279 OPERATIONAL METEOROLOGY (1-6). Instruction and laboratory practice in operational functions and responsibilities of the Naval Weather Service. TEXTS: *Selected publications of the Air Systems Command, Air Weather Service, and Naval Weather Research Facility; departmental notes.* PREREQUISITE: MR 3255.

MR 2410 METEOROLOGICAL INSTRUMENTS (3-2). The application of the basic principles of mechanics, heat electricity, sound, and optics to meteorological instrumentation employed by the Navy with special emphasis on electronic and satellite developments. TEXTS: Middleton and Spilhaus, *Meteorological Instruments; selected papers and departmental notes.* PREREQUISITE: MA 1115 concurrently.

MR 2411 INTRODUCTION TO THERMODYNAMICS OF METEOROLOGY (4-0). A treatment of elementary thermodynamics and its application to meteorology with particular emphasis on thermodynamic charts and diagrams. Theories of condensation and precipitation processes. Geopotential determinations and instability criteria. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology.* PREREQUISITE: MA 1116 concurrently.

MR 2510 CLIMATOLOGY (4-2). Statistical evalution of meteorology elements in theory and in practice. (Frequency distributions. Correlation and regression.) Verification systems. Techniques of objective forecasting. Classification of climates. TEXTS: Conrad and Pollak, *Methods in Climatology, Schaum (Spiegel), Statistics; departmental notes.* PREREQUISITE: MA 1116 concurrently.

Upper Division or Graduate Courses

MR 3230 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY (4-0). Observation, computation, analysis, and synoptic interpretation of tropospheric and stratospheric data (to 10 mb) with emphasis on the middle and high altitude aspects of satellite meteorology, jet streams, tropopauses, vertical motion, hydrometeors, and related numerical products. TEXTS: Widger, *Meteorological Satellites; Riehl, Jet Streams of the Atmosphere; Craig, the Upper Atmosphere; various U.S. Navy, Environmental Science Services Administration and Air Weather Service publications; re-*

prints and departmental notes. PREREQUISITES: MR 2220; MR 4322 or MR 3302 concurrently.

MR 3235 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY LABORATORY (0-9). Practice in the meso-and synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships, and application to forecast problems. TEXTS: Widger, *Meteorological Satellites; Riehl, Jet Streams of the Atmosphere; Craig, The Upper Atmosphere; various U.S. Navy, Environmental Science Services Administration, and Air Weather Service publications; reprints and departmental notes.* PREREQUISITE: MR 2225; MR 3230 concurrently.

MR 3250 TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (3-0). The general circulation and air masses of the Southern Hemisphere; climatology and synoptic models in the tropics; analysis and forecasting tropical weather systems with emphasis on cyclones and meteorological satellite observations. TEXTS: Berry, Bollay, Beers, *Handbook of Meteorology; Riehl, Tropical Meteorology; Harding and Kotsch, Heavy weather Guide; departmental notes, reprints.* PREREQUISITES: MR 4322 or MR 3302, MR 3230.

MR 3255 TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY LABORATORY (0-6). Laboratory course associated with MR 3250. Contour (isobaric), streamline, and isotach analysis and forecasting with emphasis on climatology, tropical cyclones, and meteorological satellite observations. TEXT: Berry, Bollay, Beers, *Handbook of Meteorology; Riehl, Tropical Meteorology; Harding and Kotsch, Heavy Weather Guide; departmental notes, reprints.* PREREQUISITES: MR 3235 MR 3250 concurrently.

MR 3260 PROGNOSTIC CHARTS AND EXTENDED FORECASTING (3-0). Subjective and objective methods, both kinematical and dynamical, for constructing prognostic charts, upper-air and surface, with greater emphasis on the latter, graphical-numerical techniques; interpretation and alternation of computer-generated prognoses. Extended forecasting by weather type methods; interpretation of National Meteorological Center extended forecasts. TEXTS: George, *Weather Forecasting for Aeronantics; Petterssen, Weather Analysis and Forecasting Vol. I; Environmental Science Services Administration and Fleet Numerical Weather Facility Manuals, departmental notes.* PREREQUISITES: MR 4323 or MR 3303 concurrently.

MR 3265 PROGNOSTIC CHARTS AND EXTENDED FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with MR 3260. Extended analysis; practice in construction and interpretation of prognostic charts. Weather typing; interpretation of National Meteorological Center extended forecasts. TEXTS: George, *Weather Forecasting for Aeronantics; Environmental Science Services Administration and Fleet Numerical Weather Facility Manuals; departmental notes.* PREREQUISITES: MR 3235; MR 3260 concurrently.

MR 3301 FUNDAMENTALS OF DYNAMIC METEOROLOGY I (4-0). Equations of motion; wind types; trajectories and streamlines vertical variation of wind; friction, surface and spiral layers; continuity and tendency equations; mechanism of pressure changes, vorticity and divergence equations. TEXT: Haltiner and Martin *Dynamical and Physical Meteorology.* PREREQUISITES: MR 2411.

MR 3302 FUNDAMENTALS OF DYNAMIC METEOROLOGY II (4-0). Simple types of wave motion, filtering; objective analysis and numerical prediction; barotropic and baroclinic models, baroclinic instability; vertical velocity; finite differencing relaxation; numerical errors. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology; departmental notes:* PREREQUISITE: MR 3301.

MR 3303 COMPUTER METEOROLOGY (4-2). Objective analysis, barotropic and baroclinic models, computation schemes including instability effects, computer products of the Fleet Numerical Weather Central. Laboratory exercises in numerical weather prediction. TEXTS: Haltiner, *Numerical Weather Prediction; U.S. Naval Weather Service Manual for Computer Products.* PREREQUISITES: MR 3302, CS 2110.

MR 3403 INTRODUCTION TO ENERGY - TRANSFER PROCESSES (4-0). Properties of radiating matter in general; solar and terrestrial radiation and their effects on temperature distribution; the heat budget; structure of the wind in the friction layer and its significance in turbulent transfer; air-mass modification, forecasting the micrometeorological variables; interpretation of satellite radiation measurements from thermodynamic and heat budget considerations. TEXTS: Haltiner and Martin, *Dynamical and Physical Meteorology, departmental notes.* PREREQUISITE: MR 3302.

MR 3411 METEOROLOGICAL THERMODYNAMICS (4-0). The physical variables; equations of state; first law of thermodynamics; properties of gases, water, and moist air theories of condensation and precipitation processes; cloud physics, meteorological thermodynamic diagrams; air-mass identification indices; geopotential determinations, instability phenomena and criteria. TEXT: Haltiner and Martin. *Dynamical and Physical Meteorology.* PREREQUISITE: MA 2121 concurrently.

MR 3510 STATISTICAL CLIMATOLOGY (4-2). Statistical evaluation of meteorological elements in theory and in practice. (Frequency distribution, correlation and regression, analysis of variance, and time series analysis.) Verification systems. Techniques of objective forecasting. Classification of climates. TEXTS: Barger, *Climatology at Work; Panofsky and Brier. Some Applications of Statistics to Meteorology; departmental notes.* PREREQUISITE: MA 1100 concurrently.

MR 3900 SEMINAR IN METEOROLOGY (2-0). Students present original research or prepare summaries of recent findings in the field of meteorology and present synopses for group discussion. PREREQUISITE: None.

Graduate Courses

MR 4240 ADVANCED ATMOSPHERIC ANALYSIS (3-0). Advanced diagnostic techniques; vertical motion schemes including generalized omega equation and filtered vorticity and kinematic techniques; parcel dynamics along trajectories. Mesoscale analysis; application to severe storms and squall lines. Developments in atmospheric sensory systems; temperature profile determination and cloud motion from satellites, constant pressure balloons. PREREQUISITE: MR 4323.

MR 4242 ADVANCED TROPICAL METEOROLOGY (3-0). Scale analysis of tropical motions; large-scale wave spectra; observations and dynamics of near-equatorial stratospheric flows, to include boundary-layer considerations; dynamics and thermodynamics of tropical disturbances, particularly severe tropical cyclones. PREREQUISITES: MR 3250 or consent of instructor.

MR 4250 GENERAL CIRCULATION OF THE ATMOSPHERE (3-0). Stability of zonal flows and implications for wave regimes; heat and momentum balances; mean meridional circulations; energetics of the general circulation; experimental models of the general circulation; implications for other rotating geophysical systems; trace substance transport by large scale atmospheric processes; numerical models of the general circulation. PREREQUISITE: MR 4323.

MR 4321 DYNAMIC METEOROLOGY I (4-0). Equations of motion; coordinate systems and mapping; wind types, baroclinicity; vertical variation of wind, friction; diffusion of momentum; surface and spiral layers; continuity and tendency equations; structure of pressure systems; vorticity and divergence equations. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology; departmental notes.* PREREQUISITES: MA 3181, MR 3411.

MR 4322 DYNAMIC METEOROLOGY II (4-0). Scale analysis, perturbation method; solutions of equations of motion for simple sound, gravity, and synoptic waves; filtering; baroclinic and barotropic instability; energy equations, integral constraints. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology; departmental notes;* PREREQUISITE: MR 4321.

MR 4323 NUMERICAL WEATHER PREDICTION (4-2). Objective analysis, barotropic and baroclinic models; vertical velocity; finite-difference equations; computational instability; boundary conditions; relaxation techniques, inclusion of heat, friction, and moisture; energetic and general circulation models. TEXTS: Haltiner, *Numerical Weather Prediction; U.S. Naval Weather Service Manual for Computer Products.* PREREQUISITES: MR 4322, MA 3243 concurrently.

MR 4324 ADVANCED NUMERICAL WEATHER PREDICTION (3-0). Initialization, boundary conditions, finite difference schemes, stability and convergence; sensible, latent, and radiative heat transfer; simulation of sub-grid scale processes such as convection and friction; general circulation models, spectral methods. PREREQUISITE: MR 4323 or consent of instructor.

MR 4331 GEOPHYSICAL FLUID DYNAMICS I (3-0). Dynamics of a homogenious layer of fluid in a rotating system; scale analysis, dispersion and group velocity; barotropic and baroclinic instability – the discrete and the continuous spectrum of eigenvalues, boundary layer analysis with application in oceanography. PREREQUISITE: Consent of instructor.

MR 4332 GEOPHYSICAL FLUID DYNAMICS II (3-0). Thermal convection – infinitesimal and finite amplitude; mountain waves and energy propagation; energy cascade; fluid spin up through Ekman layers. PREREQUISITE: Consent of instructor.

MR 4412 HEAT TRANSFER PROCESSES (4-0). Black bodies and their properties; the fundamental laws of radiation flux transfer both in beam and diffused form, methods of terrestrial-flux computations by numerical methods with application of sounding data; interpretation of satellite radiation measurements both in terrestrial and solar regions. Surface-layer heat and water-vapor transports by turbulence and stability effects upon such transports including that of momentum; eddy-spectral analysis. The heat budget of the atmosphere. TEXTS: Elasser and Culbertson, *Atmospheric Radiation Tables; Lumley and Panofsky, The Structure of Atmospheric Turbulence.* PREREQUISITE: MR 4321 concurrently.

MR 4413 AIR SEA INTERACTION (3-0). A discussion of the processes occurring at the air-sea interface. Review of concepts in turbulence, transfer processes, momentum flux, heat flux, stability. Relation of micro-to macro-processes. Techniques of measuring turbulent quantities in the air and sea; problems in sensing, recording and analyzing data. Review of current literature. TEXTS: Priestley, *Turbulent Transfer in the Lower Atmosphere;* Lumley and Panofsky, *The Structure of Atmospheric Turbulence; Roll, Physics of the Marine Atmosphere; selected articles.* PREREQUISITES: MR 4322 or OC 4251.

MR 4422 UPPER ATMOSPHERE PHYSICS (3-0). Composition, temperature, and wind above 30 km. Physics and chemistry of ozonosphere and ionosphere. Atmospheric tides, earth's magnetic field, airglow, Van Allen belts. TEXTS: Craig, *The Upper Atmosphere;* Massey and Boyd, *The Upper Atmosphere, departmental notes.* PREREQUISITE: MR 4412.

MR 4800 SPECIAL TOPICS IN METEOROLOGY (3-0). Independent study of advanced topics in meteorology not regularly offered. PREREQUISITE: Consent of the instructor.

MR 4900 SEMINAR IN METEOROLOGY (2-0). Students present results of their thesis work for group discussion. PREREQUISITE: Preparation of Master's degree thesis concurrently.

DEPARTMENT OF OCEANOGRAPHY

DALE FREDERICK LEIPPER, Professor, Chairman (1968)*; B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography (La Jolla), 1950; Hon. D.Sc., Wittenberg Univ., 1968.

ROBERT SANBORN ANDREWS, Associate Professor (1968); B. of Geol. Engr., Univ. of Minnesota, 1958; M.S., Univ. of Washington, 1965.

NOEL EDWARD JAMES BOSTON, Associate Professor (1968), B.A.Sc., Univ. of British Columbia, 1959; M.S., Texas A&M Univ. 1963.

WARREN WILSON DENNER, Assistant Professor (1964), B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963; Ph.D., 1969.

JERRY ALAN GALT, Assistant Professor (1970), B.S., Univ. of Washington 1963 Physics; M.S., 1967, B.S. 1968, Math; Ph.D., 1969.

JACK ELLSWORTH GEARY, Commander, U.S. Navy; Assistant Professor (1968); B.S., Univ. of California, 1954; M.S., Naval Postgraduate School, 1961.

CLAUDE FINLEY GILES, Commander, U.S. Navy; Instructor (1967) B.S., Parks College of St. Louis Univ., 1948; B.S. in Meteorology, Naval Postgraduate School, 1955.

EUGENE CLINTON HADERLIE, Professor (1965) A.B., Univ. of California at Berkeley, 1943; M.A., 1948; Ph.S., 1950.

GLENN HAROLD JUNG, Professor (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas A&M Univ., 1955.

RAYMOND JAMES SMITH, Professor (1967), B.S., California Institute of Technology, 1945; M.S., 1948; M.A., Princeton Univ., 1950; Ph.D., 1951.

WARREN CHARLES THOMPSON, Professor (1953), B.A. Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas A&M Univ., 1953.

EDWARD BENNETT THORNTON, Assistant Professor (1969), B.A., Willamette Univ., 1962; B.S., Stanford Univ., 1964; M.E. in C.E., Univ. of Florida, 1966; Ph.D., 1970.

EUGENE DEWEES TRAGANZA, Associate Professor (1970); B.A. Indiana Univ., 1955; M.S. Texas A&M Univ. 1959; Ph.D., Univ. of Miami, 1966.

JOSEPH JOHN VON SCHWIND, Associate Professor (1967); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah at Salt Lake City, 1960; Ph.D., Texas A&M Univ., 1968.

JACOB BERTRAM WICKHAM, Associate Professor (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

* The year of joining the Postgraduate School Faculty is indicated in parentheses.

DEPARTMENTAL REQUIREMENTS FOR THE MASTER DEGREE OF SCIENCE IN OCEANOGRAPHY

Entrance to a program leading to the degree of Master of Science in Oceanography requires a baccalaureate degree in a field appropriate to the oceanography option chosen. Minimal requirements include mathematics through differential and integral calculus, one year of college physics, and one year of college chemistry.

The degree of Master of Science in Oceanography requires:

a. Completion of thirty-five quarter hours of graduate courses of which fifteen hours must be in the 4000 Oceanography series. The entire sequence of courses for the particular option selected must be approved by the Department of Oceanography.

b. An acceptable thesis on a topic approved by the Department of Oceanography.

Laboratory Facilities

Four jointly utilized meteorological/oceanographic laboratories are served by a closed circuit television network. Two beachfront laboratories are also maintained: a small biological oceanography laboratory with salt water aquaria and filtered salt water circulating system, and a 4,000 square foot laboratory with lecture room and student study areas. Equipment includes a wave tank, drying oven, and high pressure test chamber. Additionally, a small ocean engineering laboratory is maintained.

The School operates a 63-foot boat converted for use in oceanographic instruction and research. In the near future it is anticipated that a 150-foot AGOR-type vessel will also be available. For eight weeks each year use is made of AGOR vessels operated by the Naval Oceanographic Office for student indoctrination and research by students and faculty.

Oceanographic equipment installed in the beach area includes a wave guage and a tide gauge for recording nearshore wave action and local tide fluctuations.

OCEANOGRAPHY

OC 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OC 2110 INTRODUCTION TO OCEANOGRAPHY (3-0). An introductory course treating physical and chemical pro0 perties of sea water, submarine geology, and marine biology; the heat budget of the oceans; water masses and general circulation; currents, waves, and tides. TEXTS: Pickard, *Descriptive Physical Oceanography;* Coker, *This Great and Wide Sea;* Bascom, *Waves and Beaches.* PREREQUISITE: None.

Upper Division or Graduate Courses

OC 3150 GEOPHYSICAL RANDOM PROCESSES (4-2). Statistical evaluation of measurements in random media: ocean, atmosphere, and earth. Frequency distributions, correlation and regression, analysis of variance. Time series analysis; covariance, convolution, energy density spectrum, cross spectrum: TEXTS: Panofsky and Brier, *Some Applications of Statistics to Meteorology; departmental notes.* PREREQUISITES: MA 2232 and MA 3132.

OC 3221 DESCRIPTIVE OCEANOGRAPHY (4-0). Properties of sea water; geomorphology of the ocean basins; distribution of temperature, salinite, and oxygen; heat budget of the oceans; water masses and the three-dimensional circulation of the oceans; currents, waves, and tides. TEXTS: Pickard, *Descriptive Physical Oceanography;* Sverdrup, Johnson, and Fleming, *The Oceans;* Neumann and Pierson, *Principles of Physical Oceanography.* PREREQUISITE: None.

OC 3250 DYNAMICAL OCEANOGRAPHY (4-0). Properties of sea water, the equations of motion in rotating frame of reference; special cases of motion; geostrophic, inertial, frictional flow, etc., turbulence and mixing; convection; models of general circulation. Current measurements, direct and indirect. TEXTS: von Arx, *Introductory Physical Oceanography;* Proudman, *Dynamical Oceanography.* PREREQUISITES: MA 3132 concurrently; OC 3221.

OC 3260 SOUND IN THE OCEAN (3-0). Designed for students in the meteorology curricula. A brief introduction to physics of underwater acoustics followed by detailed discussion of oceanographic factors affecting sound transmission in the ocean including absorption, reflection from the surface and from the bottom, refraction, scattering, and ambient noise. TEXTS: *Selected references; departmental notes.* PREREQUISITE: OC 2110.

OC 3320 GEOLOGICAL OCEANOGRAPHY (3-3). General geological principles; physiography of the sea floor, especially continental shelves and slopes, submarine canyons, coral reefs, and the deep-sea floor; properties and distribution of sediments and rates of deposition; structure and origin of the ocean basins. TEXTS: Shepard, *Submarine Geology;* Gilluly Waters, and Woodford, *Principles of Geology;* Keen, *An Introduction to Marine Geology.* PREREQUISITE: None.

OC 3420 BIOLOGICAL OCEANOGRAPHY (3-3). General biological principles; the sea as an environment for life; major plant and animal groups in the sea; plankton and food cycles; primary productivity; boring and fouling organisms; bioacoustics, bioluminescence, and deep scattering layers; dangerous marine organisms; physiology of shallow water diving. Laboratory work and field trips dealing with marine organisms. TEXTS: Russell and Yonge, *The Seas;* Hedgpeth, *Seashore Life of the San Francisco Bay Region and the Coast of Northern California;* Dawson, *Seashore Plants of Northern California.* PREREQUISITE: None.

OC 3520 CHEMICAL OCEANOGRAPHY (3-2). Basic chemistry of solutions; chemical compositions of the oceans (disolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient, and other cycles in the sea; desalination; corrosion; geochemistry. TEXTS: Strickland and Parsons, *Methods in Chemical Oceanography.* PREREQUISITES: OC 3221, CH 1001 or CH 2001 or equivalent.

OC 3601 OCEAN WAVE FORECASTING (3-0). Statistical and spectral properties of ocean waves, the generation, propagation, and attentuation of surface wind waves in deep water; spectral and other forecasting techniques; wave observations and analysis. TEXTS: Kinsman, *Wind Waves;* H.O. Pub. 603. PREREQUISITE: OC 4211.

OC 3605 OCEAN WAVE FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with OC 3601. Exercises in wave observation, the analysis of wave records, wave forecasting from known wind fields derived from weather maps. TEXT: H.O. Pub. 603. PREREQUISITE: OC 3601 concurrently.

OC 3611 OCEAN WAVE AND SURF FORECASTING (2-0). Course designed for students in the meteorology curricula. Statistical and spectral properties of waves; wave observations and analysis of wave records; the generation propagation, and attenuation of sea and swell; techniques used in the forecasting of sea and swell; transformation of waves in shallow water. TEXT: H.O. Pub. 603 and H.O. Pub. 234. PREREQUISITE: OC 2110.

OC 3615 OCEAN WAVE AND SURF FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with OC 3611. Exercises in forecasting sea and swell generated under various synoptic weather conditions and in surf forecasting. TEXT: H.O. Pub. 603 and H.O. Pub. 234. PREREQUISITE: OC 3611 concurrently.

OC 3616 OCEANOGRAPHIC FORECASTING (3-0). Space and time variation of ocean density structure and associated parameters; behavior of vertical and horizontal temperature gradients; development of synoptic forecasting techniques applied to the upper ocean; air-sea interaction; advection and mixing effects on ocean density structure. Interpretation in terms of sound propagation paths and sonar range. TEXTS: James, *Antisubmarine Warfare Environmental Prediction System Manual No. 5;* selected publications. PREREQUISITES: OC 3260 or OC 4260; OC 4253 or MR 2411.

OC 3621 OCEANOGRAPHIC FORECASTING LABORATORY (0-4). Laboratory exercises illustrate principles developed in OC 3616 using actual air and ocean data, available forecasting techniques (ASWEPS, and others), and range manuals. Forecasting of sea surface temperature, mixed-layer depth, and sonar range. TEXTS: *ASWEPS Manual Series Vol. 7, Conversion Techniques* (CONFIDENTIAL); selected publications. PREREQUISITE: OC 3616 concurrently.

OC 3700 OCEANOGRAPHIC INSTRUMENTATION AND OBSERVATIONS (3-0). Theory of design and operation of oceanographic instruments; recording of oceanographic observations, measurements, and samples on log sheets. TEXTS: H.O. 607, selected references. PREREQUISITES: OC 2110 or OC 3220.

OC 3710 FIELD EXPERIENCE IN OCEANOGRAPHY (0-4). Laboratory course taught in conjunction with OC 3700. Use of standard oceanographic instruments in the conduct of a comprehensive oceanographic survey; processing and storage of data and samples; interpretation of results. TEXTS: H.O. 607; selected references. PREREQUISITES: OC 3321, OC 3420, OC 3520, and OC 3700 concurrently.

OC 3801 OCEAN OPERATIONS I (3-1). This course includes a comprehensive coverage of the present state-of-the-art associated with types of floating platforms; stationary platforms; submersible design, operation, and applications; manipulator design; diving operations; underwater construction and structures; energy sources; pressure vessels and testing programs; unmanned vehicles and platforms; deep drilling; dynamic positioning; buoys and deep water buoyancy; in general those operations associated with search, rescue, recovery, and salvage. Field trips made to laboratories deeply involved in oceanographic engineering work. TEXT: Class notes. PREREQUISITE: None.

Graduate Courses

OC 4211 WAVES AND TIDES (4-0). Linear theory of surface and internal waves; theory of finite amplitude waves; wind-wave spectra; theory of the astronomical tides; tide analysis and prediction; seiches and co-oscillations. TEXTS: Kinsman, *Wind Waves;* Defant, *Physical Oceanography, Vol. II.* PREREQUISITE: OC 4251 or OC 3250 concurrently.

OC 4213 COASTAL OCEANOGRAPHY (4-1). Shoal-water wave processes; breakers and surf; nearshore water circulations; beach characteristics; littoral drift; coastal hydraulics; storm tides. TEXTS: Weigel, *Oceanographical Engineering;* H.O. Pub. 234, *Breakers and Surf;* C.E.R.C. Tech. Memo. 4, *Shore Protection, Planning and Design;* Ippen, *Estuary and Coastline Hydrodynamics.* PREREQUISITE: OC 4211.

OC 4251 DYNAMICAL OCEANOGRAPHY I (4-0). Introduction to fluid mechanics: Newtonian fluids, stress tensor, strain tensor, vorticity; development of Navier-Stokes equation, application of steady and time-dependent equations to large scale ocean circulation, physical significance of coupling of steady and time dependent equations. Turbulence and diffusion: Reynolds stresses, turbulent transfer, oceanic turbulence. TEXTS: To be assigned. PREREQUISITES: OC 2110 and MA 3132 concurrently.

OC 4252 DYNAMICAL OCEANOGRAPHY II (4-0). The wind-driven ocean circulation: real fluid boundary conditions, steady-state linear theories, steady-state non-linear theories, vorticity arguments. Topographical influence on ocean currents, significance of inertial and frictional terms in an ocean with bottom topography. Time dependent motion: Rossby waves. TEXTS: Stommel, *The Gulf Stream;* Robinson, *Wind-driven Ocean Circulation;* selected papers. PREREQUISITE: OC 4251.

OC 4253 DYNAMICAL OCEANOGRAPHY III (3-0). Introduction to thermodynamics with applications to ideal gases, to the atmosphere and to sea water. Equation of state for sea water. Thermohaline circulation: advection theories, convection theories, relation to wind-driven circulation. TEXTS: Stommel, *The Gulf Stream;* selected paper. PREREQUISITE: OC 4252.

OC 4260 SOUND IN THE OCEAN (3-0). Oceanographic effects on sound propagation, especially on absorption, reflection, refraction; scattering, ambient noise; operational aspects for Navy use. TEXTS: Departmental notes; selected references. PREREQUISITES: PH 3431; OC 3221.

OC 4340 MARINE GEOPHYSICS (3-0). Gravity, magnetism, seismicity, and other geophysical characteristics of the oceans and sea floor. Physical properties and composition of the sea floor. Structure of the earth's crust and upper mantle. Origin of the ocean basins and formation of major sea-floor features. TEXTS: Dobrin, *Geophysical Prospecting,* 2nd ed.; selected publications. PREREQUISITE: OC 3320

OC 4421 MARINE ECOLOGY (1-4). The habits, classification, development and adaptations of marine animals and plants with particular reference to ecology of Monterey Bay. The relationships of physical, chemical, geological, and biological factors of the environment to marine organisms. Primarily laboratory investigations and field work dealing with the intertidal areas, harbors, estuaries, and the near-shore pelagic and benthic environments of the associated organisms. TEXTS: Ricketts and Calvin, *Between Pacific Tides:* Light et al, *Intertidal Invertebrates of the Central California Coast.* PREREQUISITE: OC 3420.

OC 4422 MARINE FOULING (1-1). A study of the considerations of bio-organisms as involved in the bio-deterioration of engineering materials. Subjects included are marine fouling, wood and rock borers, and the effects of biological organisms on the corrosion of metals. TEXT: Class notes. PREREQUISITE 3420.

OC 4612 POLAR OCEANOGRAPHY (3-0). Marine geography of the Arctic; sea-ice observations, properties, formation, growth, deformation, and disintegration; sea-ice drift due to wind and currents. TEXT: *Sea Ice Manual* (unpublished). PREREQUISITE: OC 4211.

OC 4800 SPECIAL TOPICS IN OCEANOGRAPHY (3-0). Independent study of advanced topics in oceanography not regularly offered. PREREQUISITE: Consent of the department chairman and instructor.

OC 4802 OCEAN OPERATIONS II (3-1). Considerations of more complex aspects of oceanographic engineering operations, including such subjects as deep mooring techniques; platform and ship motions; large object towing forces; heavy lifts and line dynamics; wave loads on platforms and floating breakwaters; hydrodynamic aspects of falling objects; considerations of high pressure structural design. Participation in a laboratory exercise involving conducting an oceanographic engineering operation at sea. TEXT: Class notes. PREREQUISITE OC 3801.

OC 4803 PHYSICAL PROPERTIES OF MARINE SEDIMENTS (2-3). This course involved the elementary study of the physical behavior of marine sediments including such subjects as types of sediments; coring and testing equipment; general physical characteristics of sediments; methods of detailed physical and chemical analysis; in-situ testing; pressure effects; scour and fill; turbidity flows. Application is made to penetration and breakout of objects and to trafficability. TEXT: Class notes; PREREQUISITE: OC 3320

OC 4851 GEOPHYSICS: EARTH GRAVITY (3-2). Study of the earth's gravity field; size and shape of the earth; deflection of the vertical; isostasy. Gravity instruments, techniques, and data interpretation in geophysical exploration. Gravimetric field will be conducted in vicinity of Monterey. TEXTS: Heiskanen and Vening Meinesz, *The Earth and its Gravity Field;* Garland, *The Earth's Shape and Gravity;* Dorbin, *Geophysical Prospecting.* PREREQUISITES: MA 3132, MA 3181.

OC 4852 GEOPHYSICS: EARTH MAGNETISM AND ELECTRICITY (3-2). Introduction to the earth's magnetic and electrical fields. Theory, instruments, and field techniques in magnetic and electorial exploration. Field work will be conducted. TEXTS: Jacob, *The Earth's Core and Geomagnetism;* Jakowsky, *Exploration Geophysics.* PREREQUISITES: MA 3132, MA 3181.

OC 4853 GEOPHYSICS: SOUND AND SEISMICITY (4-0). Development of fundamental elastic wave equations; ray and normal mode theory; wave propagation in layered media; reflectivity, and attenuation; seismicity of the earth; mechanics of earthquakes; time-distance curves; geophysical interpretation of seismic records. TEXTS: Officer, *Introduction to the Theory of Seismology;* Grant and West, *Interpretation Theory in Applied Geophysics.* PREREQUISITES: OC 4260 or consent of the instructor.

OC 4860 PHYSICS OF THE EARTH (3-0). Physical properties and composition of the earth's interior; review of the theories of the earth's formation; study of the crustal structure through gravity, magnetic, seismic and other geophysical evidence TEXTS: Gutenberg, Physics of the Earth; Jacobs, Russell and Wilson, *Physics and Geology.* PREREQUISITES: OC 3320 or consent of the instructor.

OC 4900 SEMINAR IN OCEANOGRAPHY (3-0). Students in the oceanography curricula report results of their own original research and summarize recent literature in presentations for group discussion. TEXT: Selected publications.

OC 4901 SEMINAR IN OCEAN OPERATIONS (3-0). Students in the oceanography (Operations Option) curriculum report results of their own original research and summarize recent literature in presentations for group discussion. TEXT: Selected publications. PREREQUISITE: Preparation of a thesis for master's degree concurrently.

DEPARTMENT OF OPERATIONS ANALYSIS

JACK RAYMOND BORSTING, Professor of Operations Research, Chairman (1959)*; B.A., Oregon State Univ., 1951; M.A., Univ. of Oregon, 1952; Ph.D., 1959.

ALVIN FRANCIS ANDRUS, Associate Professor of Operations Research (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

JAMES K. ARIMA, Associate Professor of Operations Research, (1969)*; B.A., Univ. of Calif., Los Angeles, 1948; M.A., George Washington Univ., 1957; Ph.D., Northwestern Univ., 1962.

DONALD R. BARR, Associate Professor of Operations Research, (1966); B.A., Whittier College, 1960; M.S., Colorado State Univ., 1962; Ph.D., 1965.

EAMON BOYD BARRETT, Assistant Professor of Operations Research (1966); B.A., Univ. of Oregon, 1953; M.A., 1958; Ph.D., Stanford Univ., 1967.

RICHARD W. BUTTERWORTH, Assistant Professor of Operations Research, (1969)*; B.S., Univ. of Berkeley, 1966; M.S., 1967; Ph.D., 1969.

THOMAS D. BURNETT, Assistant Professor of Operations Research, (1969)*; B.S., Oregon State Univ., M.S., 1964; Ph.D., 1969.

RICHARD MAX BURTON, Assistant Professor of Operations Research (1967); B.S., Univ. of Illinois, 1961; M.B.A., 1963; D.B.A., 1967.

WILLIAM PEYTON CUNNINGHAM, Professor of Operations Research and Physics, (1946)*; B.S., Yale Univ., 1928; Ph.D., 1932.

JAMES D. ESARY, Associate Professor of Operations Research, (1970)*; A.B., Whitman College, 1948; M.A. Univ. of Calif., Berkeley, 1951; Ph.D., Univ. of Calif., Berkeley, 1957.

ROBERT L. FERGUSON, Assistant Professor of Operations Research, (1969)*; A.B., Univ. of Kansas 1956; D.B.A., Harvard Univ., 1970.

JAMES ALLEN FLOYD, Ensign, U.S. Naval Reserve; Instructor in Operations Research (1969)*; B.A., Northwestern Univ., 1967; M.S., Columbia University, 1968.

ROBERT NEAGLE FORREST, Associate Professor of Operations Research, (1964); B.S., Univ. of Oregon. 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

WERNER JAMES GIESEKE, Ensign, U.S. Naval Reserve; Instructor in Operations Research, (1969)*; B.S., Univ. of Ill., 1967; M.B.A., Cornell Univ., 1969.

HAROLD GREENBERG, Professor of Operations Research, (1967); B.A., Brooklyn College, 1949; M.S., New York Univ., 1958; Ph.D., 1964.

GEORGE EMIL HEIDORN, Assistant Professor of Operations Research, (1968)*; B.M.E., 1962, General Motors Inst.; M.S., 1967, Yale Univ.

JAMES EVERETT HIGGINS, Ensign, U.S. Naval Reserve; Instructor in Operations Research, (1969)*; B.S., North Carolina State Univ., 1967; M.S., Cornell Univ., 1969.

GILBERT THOREAU HOWARD, Assistant Professor of Operations Research, (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

CARL RUSSELL JONES, Associate Professor of Operations Research, (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

HAROLD JOSEPH LARSON, Associate Professor of Operations Research, (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

GLENN FRANK LINDSAY, Associate Professor of Operations Research, (1965); B.Sc., Oregon State Univ., 1960; M.Sc., The Ohio State Univ., 1962; Ph.D., 1966.

KNEALE THOMAS MARSHALL, Associate Professor of Operations Research, (1968); B.Sc., Univ. of London, 1958; M.S., Univ. of California, 1964; Ph.D., 1966.

ALAN WAYNE MCMASTERS, Assistant Professor of Operations Research, (1965); B.S., Univ. of California, 1957; M.S., 1962; Ph.D., 1966.

PAUL ROBERT MILCH, Associate Professor of Operations Research, (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

CLAIR ALTON PETERSON, Associate Professor of Operations Research, (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

GARY KENT POOCK, Assistant Professor of Operations Research, (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

FRED LORENZO PRESTON, JR., Ensign. U.S. Naval Reserve; Instructor in Operations Research, (1969)*; B.A., DePauw Univ., 1967; M.S., Case Western Reserve Univ., 1969.

ROBERT RICHARD READ, Associate Professor of Operations Research, (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California, 1957.

DAVID ALAN SCHRADY, Associate Professor of Operations Research, (1965); B.S.M.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

BRUNO SHUBERT, Assistant Professor of Operations Research, (1970)*; M.S., Czech Tech. Univ., Prague, Czechoslovakia, 1960; Ph.D., Charles Univ., Prague, Czech., 1964; Ph.D., Stanford Univ., 1968.

REX HAWKINS SHUDDE, Associate Professor of Operations Research, (1962); B.S., B.A., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California, 1956.

JAMES GROVER TAYLOR, Assistant Professor of Operations Research, (1968); B.S., Stanford Univ., 1961; M. S., 1962; Ph.D., 1966.

GARY ALLEN TUCK, Assistant Professor of Operations Research, (1966); B.A., Univ. of Oklahoma, 1955; M.S., 1964; Ph.D., 1966.

JOSEPH BRUCE TYSVER, Associate Professor of Operations Research, (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

WALTER MAX WOODS, Associate Professor of Operations Research, (1961); B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

PETER W. ZEBNA, Professor of Operations Research, (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956; Ph.D., Stanford Univ., 1959.

HANS ZWEIG, Associate Professor of Operations Research, (1970)*; B.A., Univ. of Rochester, N.Y., 1949; M.A., Brown Univ., Providence, R.I., 1952; Ph.D., Stanford Univ., Palo Alto, Calif., 1963.

*The year of joining the Postgraduate School Faculty is indicated in parentheses.

DEPARTMENT REQUIREMENTS FOR DEGREES IN OPERATIONS RESEARCH

Programs leading to degrees in Operations Research must be arranged in consultation with the Chairman, Department of Operations Analysis.

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

1. The basic requirements for the degree of Bachelor of Science in Operations Research consists of a minimum of 60 upper division quarter hours at the Naval Postgraduate School and including at least:

   a. 36 quarter hours of Operations Research/Systems Analysis and Probability and Statistics.

   b. 12 quarter hours outside the Department of Operations Analysis.

2. The student must maintain a QPR of at least 1.2 courses offered by the Department of Operations Analysis.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate level courses, including at most 8 quarter hours for a thesis.

   a. At least 18 quarter hours of 4000 level Operations Research/Systems Analysis courses.

   b. An elective sequence approved by the Department of Operations Analysis.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Analysis. This credit shall not count toward the requirement stated in 2 a.

DOCTOR OF PHILOSOPHY

1. Students wishing to be considered for doctoral work in Operations Research should announce their intentions as early as possible, preferably by the fifth quarter. The department chairman will examine the applicant's qualifications, modify his second year program, and monitor his progress. The schoolwide requirements are contained in the General Information Section of this catalogue.

2. If the applicant is selected, he must take at least 40 hours of graduate courses beyond the master's requirement and including the core sequences in stochastic processes and mathematical programming. He must be advanced to candidacy and write an acceptable thesis pertinent to an area of specialization selected from the following four: Stochastic Processes, Mathematical Programming, Decision Science, and Human Factors.

OPERATIONS ANALYSIS

OA 0001 SEMINAR (0-2). Guest Lecturers. Review of summer assignments, Thesis and research presentations. PREREQUISITE: None.

OA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2201 ELEMENTS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). An introductory course. Topics covered include, nature, origin, and contemporary status of operations analysis; problem formul. PREREQUISITE: PS 2501 or equivalent.

OA 2600 HISTORICAL INTRODUCTION TO OPERATIONS ANALYSIS (2-0). The origins of Operations Analysis in Britain are discussed and the relationship of Operations Research to fundamental and applied research is considered. The application of quantitative analysis and scientific methodology to military operations is introduced by the review of World War II studies of ASW and Air Warfare. PREREQUISITE: None.

OA 2601 INTRODUCTION TO DECISION ANALYSIS (2-0). This course provides an introduction to the vital role of models in operations research and systems analysis. The basic structure of decision problems is developed and interpreted in a variety of circumstances. The importance of inductive and deductive reasoning for model building is stressed. PREREQUISITE: None.

Upper Division or Graduate Courses

OA 3201 FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). An introduction to quality assurance elements including design reliability assessment, production assessment testing, environmental testing, system reliability demonstration. Introduction to hardware performance measures. Introduction to cost effectiveness analysis. Elements of probability and statistics developed as needed. PREREQUISITE: Differential and Integral Calculus.

OA 3202 METHODS OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). Methodology of operations analysis/-systems analysis. Statistical estimation, and hypothesis testing. Life testing plans, point and interval estimates and reliability parameters. Elements of systems analysis pertaining to redundancy, maintainability, and spares. The role of systems analysis in solving military problems. PREREQUISITE: OA 3201 or equivalent.

OA 3203 SURVEY OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). A survey of the military applications of operations analysis/systems analysis techniques of particular interest to the student. The applications usually covered are selected from decision, waiting lines resource allocation, replacement, cost-effectiveness, inventory theory, and search models. The techniques needed for these applications are developed as required and usually include topics in linear programming (including the simplex method), probability theory, nonlinear programming, statistics (including Bayesian and classical), dynamic programming and simulation. PREREQUISITE: PS 3411 or equivalent.

OA 3204 SYSTEMS ANALYSIS (4-0). The aim of this course is to present the nature, the aims, and limitations of analysis as it exists today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the field of interest of the class will be discussed. PREREQUISITE: PS 3411 or equivalent.

OA 3205 OPERATIONS RESEARCH FOR COMPUTER SCIENTISTS (4-0). An introduction to the methodology and techniques of operations research, with special emphasis on the computational aspects and on computer-related applications. Topics include linear programming, queueing theory, and PERT. Homework assignments include writing computer programs for some of the algorithms presented. PREREQUISITES: MA 2045, PS 3326, and CS 0110.

OA 3211 OPERATIONS ANALYSIS FOR MANAGEMENT I (4-0). Introduction to the philosophy and methodology of operations research. Survey of some of the more elementary techniques relating to decision making and optimization. PREREQUISITE: PS 3000.

OA 3212 OPERATIONS ANALYSIS FOR MANAGEMENT II (4-0). A continuation of OA 3211. Topics include: queueing, reliability, linear and dynamic programming, and gaming. PREREQUISITE: OA 3211.

OA 3213 INTRODUCTION TO LOGISTICS AND SUPPLY SYSTEMS (4-0). An introduction to logistic and supply management problems. Elements of inventory model building, allocation schemes. Emphasis on data source, collection, and reporting systems needed for management to operate supply systems economically. PREREQUISITE: OA 3211.

OA 3604 LINEAR PROGRAMMING (4-0). Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analysis, transportation algorithm, parametric linear programming, matrix payoff games, and integer linear programming. PREREQUISITE: MA 2042.

OA 3605 METHODS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). A first course designed to survey the methodology of operations research and systems analysis. Topics in this sequence include: dynamic programming, PERT and PERT/COST, queueing, reliability, maintenance, replacement, networks, stochastic models, and allocation of search. PREREQUISITE: OA 3604.

OA 3610 UTILITY THEORY AND RESOURCE ALLOCATION MODELS (4-0). The nature of individual preferences and their utility function representation in certain and risk environments. Introduction to utility functions (social welfare functions) for groups. The resource allocation problem of firms and economies interpreted as linear programming models. Introduction to non-linear resource allocation models. PREREQUISITES: MN 3141, OA 3604.

OA 3611 SYSTEMS ANALYSIS I (4-0). Principles of systems analysis and their relationship to the planning, programming, and budgeting system (PPBS), and the traditional OR models. Analysis of effectiveness measures and models. Cost estimating and analysis. Overall structure of cost-effectiveness models and decision criteria. Risk and uncertainty problems. PREREQUISITES: OA 3604, OA 3610, PS 3303.

OA 3612 SYSTEMS ANALYSIS II (4-0). This course is to provide an integrated view of the nature of operations analysis. Projects are extensively used to permit the student a wide ranging final internship in the practice of operations research and systems analysis. PREREQUISITE: Open only to students in their final quarter of the Masters Program.

OA 3620 INVENTORY I (3-0). A study of deterministic inventory models. Operating doctrines and their dependence upon costs. Constraints and optimization techniques. Periodic review models. PREREQUISITES: MA 2110, PS 3303 (may be taken concurrently).

OA 3621 INVENTORY II (4-0). A study of stochastic inventory models. Reorder point models with stochastic demands. Dynamic inventory models. Applications to logistics and Navy supply systems. PREREQUISITE: OA 3620.

OA 3653 SYSTEM SIMULATION (4-0). Computer Simulation as a problem solving technique. Subject areas covered include: Monte Carlo methodology; simulation programming in FORTRAN, GPSS and other available simulation languages; and design of simulation experiments and analysis of results. PREREQUISITES: CS 0110 or equivalent, PS 3302.

OA 3654 WAR GAMING (3-2). Consideration of the problems inherent in the construction and use of manual and computer war games. Problems in the analysis of results of such games. PREREQUISITES: OA 3653, PS 3302.

OA 3655 METHODS FOR COMBAT DEVELOPMENT EXPERIMENTATION (4-0). Introduction to the intent, design, procedures, analysis, and reporting of field experiments. Rationale for combat experiments, criteria selection, statistical analysis, and interpretation of results. PREREQUISITES: OA 3604, PS 3303.

OA 3656 OPERATIONS RESEARCH PROBLEMS IN SPECIAL WARFARE (4-0). The applicability of operations research to unconventional warfare and counterinsurgency. Normative and descriptive models. Consideration of special problems with emphasis on problem formulation. PREREQUISITES: OA 3604, PS 3303.

OA 3657 HUMAN FACTORS IN SYSTEMS DESIGN I (4-0). The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. PREREQUISITES: OA 3604, PS 3303.

OA 3658 HUMAN FACTORS IN SYSTEMS DESIGN II (3-0). A continuation of OA 3657, Man-machine interface and man's motor and sensory capacities. PREREQUISITES: OA 3657, OA 3604, or consent of instructor.

OA 3660 ANALYSIS OF OPERATIONAL DATA (3-1). Analysis of real world operational data. The processing and interpretation of incomplete operational data. Problems will be chosen from current military problems. PREREQUISITES: PS 3303, OA 3604, OA 3653.

OA 3664 THEORY OF PATTERN RECOGNITION (3-0). Survey of principles governing the design of pattern recognition and detection devices of both the adaptive and non-adaptive type. Basic visual and auditory anatomy, along with the concepts and theories applicable to solving man's visual behavior problems in his role as a photo interpreter, radar operator, sonor operator or similar vigilance and tracking tasks. PREREQUISITE: PS 3303 or equivalent.

OA 3671 CYBERNETICS AND ANALYSIS OF INFORMATION SYSTEMS (4-0). Application of various OR/SA techniques to complex man-machine environments. Special emphasis upon the use of computer-based models in case study situations. Consideration of both data base problems and programmed decision-making. Attention to the problems which attend the implementation of such techniques as CPM and PERT. PREREQUISITES: OA 3611, OA 3654.

OA 3704 STOCHASTIC MODELS I (4-0). Markov chains. Basic concepts, transition probabilities, and classification characteristics of Markov chains, random walks, and branching processes. Applications to basic systems models and queues. PREREQUISITES: PS 3303.

OA 3900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 3910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presenatation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

OA 3930 READING IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 3940 SEMINAR IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of instructor.

Graduate Courses

OA 4613 THEORY OF SYSTEMS ANALYSIS (4-0). Systems analysis (cost-effectiveness analysis) formulated as commensurable and invommensurable incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing and decentralization of the decision-making problem. PREREQUISITES: OA 3611, OA 4631 (or concurrently).

OA 4615 ECONOMETRICS (4-0). An introduction to the construction of testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavior. PREREQUISITES: PS 3303, OA 3610. Macroeconomic theory desirable.

OA 4622 SEMINAR IN SUPPLY SYSTEMS (4-0). A survey of supply systems, not only from an inventory point of view, but also as a critical area in logistics. Topics for discussion will be selected from the current literature and will be chosen according to students' interests. Periodically, experts in the supply field will provide guest lectures on current research areas. PREREQUISITES: OA 3621, OA 3704, or consent of instructor.

OA 4631 NONLINEAR AND DYNAMIC PROGRAMMING (4-0). Introduction to modern optimization techniques and multistage decision processes. Topics include: Kuhn-Tucker theory, quadratic programming, stochastic programming, chance-constrained programming, gradient and search methods, and dynamic programming. PREREQUISITES: OA 3604, MA 2110.

OA 4632 MATHEMATICAL PROGRAMMING (4-0). The bounded variable algorithm, decomposition principle, primal-dual algorithm. Special topics such as linear fractional programming, stochastic programming, chance-constrained linear programming, theory of degeneracy procedures, and the generalized transportation problem. Applications: PERT and PERT/COST, warehouse problem, caterer problem, assignment problems, overtime production, etc. PREREQUISITE: OA 3604.

OA 4633 NETWORK FLOWS AND GRAPHS (3-0). Survey of solution techniques for problems which can be formulated in terms of flow in networks. Elements of graph theory, max-flow min-cut theorem, shortest route, minimum cost flows, out-of-kilter algorithm, optimum flows with gains and multi-commodity network flows. Application to transportation problems, critical path scheduling, production scheduling, and inventory problems. PREREQUISITE: 3604.

OA 4634 GAMES OF STRATEGY (4-0). Continous games on the unit square, n-person games, non-zero sum games, and introduction to differential games. Applications and case studies. PREREQUISITES: OA 3604, PS 3303, or equivalent.

OA 4635 NONLINEAR PROGRAMMING (4-0). Continuation of OA 4631. Fritz John Theory. Complimentary pivot theory. Beale's method. Approximate methods. Further results in gradient and search methods. Duality in non-linear programming. Optimal control problems. PREREQUISITE: OA 4631.

OA 4636 DYNAMIC PROGRAMMING (4-0). A continuation of OA 4631. Basic theory of Dynamic Programming with applications. Recursive equations, computational methods and refinements, stochastic and adaptive decision making and infinite stage systems are discussed. PREREQUISITE: OA 4631 or consent of instructor.

OA 4642 ADVANCED TOPICS IN WAR GAMING AND SIMULATION (3-2). A greater-depth coverage of material introduced in OA 3653 and OA 3654. Advanced techniques of model development and simulation experimentation. Discussion of current research. Actual topics selected will depend on interests of students and instructor. This course is particularly appropriate for those doing theses in this area. PREREQUISITES: OA 3654 and consent of instructor.

OA 4651 SEARCH THEORY AND DETECTION (4-0). Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITE: PS 3303 or equivalent.

OA 4652 OPERATIONS RESEARCH PROBLEMS IN NAVAL WARFARE (3-0). Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communication, and ECM problems. PREREQUISITE: OA 4651.

OA 4662 RELIABILITY AND WEAPONS SYSTEM EFFECTIVENESS MEASUREMENT (4-0). Component and System reliability functions and their point and interval estimates under various sampling plans. Review of selected MIL-STD reliability documents and the WSEIAC reports. Reliability and System effectiveness measurement and analysis of the Fleet Ballistic Missile Weapon System and other selected Weapons systems. Measurement indices for Weapons System Effectiveness. PREREQUISITE: OA 4705 (may be taken concurrently) or equivalent.

OA 4673 UTILITY THEORY (3-0). General concept of utility and its measurement. Survey and critique of the current literature dealing with the concept and measurement of utility. Applications to problems of human relations. PREREQUISITE: OA 3610.

OA 4680 HUMAN PERFORMANCE EVALUATION (4-0). Experimental considerations, strategy, and techniques in evaluating human performance characteristics and capabilities. Detailed examination of special methods to include multivariate designs, psychophysical methods, and psychophysiological methods. Review of important variables affecting human performance and criteria, measures of effectiveness, and figures of merit as indicants of performance quality. PREREQUISITE: OA 3657.

OA 4705 STOCHASTIC MODELS II (4-0). Poisson processes. Renewal theory and semi-Markov processes. Stochastic models of complex military systems and applications in economics, communications and inventory models. Maintenance policies. PREREQUISITE: OA 3704.

OA 4706 STOCHASTIC MODELS III (4-0). The course will cover selected topics in queuing theory relevant to applications. Included will be deterministic queues, priority queuing systems with applications such as cm computer time sharing, inequalities and approximations for general single server queues, multi-channel and tandem queue approximations, and heavy traffic queues with applications of the diffusion process. PREREQUISITE: OA 4705.

OA 4900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 4910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

OA 4930 READING IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 4940 SEMINAR IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of instructor.

Probability and Statistics

Upper Division Courses

*PS 2000 ELEMENTARY PROBABILITY AND STATISTICS (4-0).

PS 2301 PROBABILITY (4-0). Axiomatic development of probability and its use in model building. Random variables and their probability distributions. Moments and other characteristics of probability laws and their importance in formulating and solving operations analysis problems. Jointly distributed random variables and their use in defining behavior of complex systems. PREREQUISITE: A previous course in differential and integral calculus.

*PS 2315 DATA REDUCTION AND ERROR ANALYSIS (4-0).

*PS 2501 INTRODUCTION TO PROBABILITY AND STATISTICS I (4-0).

*PS 2502 INTRODUCTION TO PROBABILITY AND STATISTICS II (4-0).

Upper Division or Graduate Courses

*PS 3000 MANAGEMENT STATISTICS (5-0).

*PS 3011 PROBABILITY AND STATISTICS FOR MANAGEMENT I (4-0).

*PS 3012 PROBABILITY AND STATISTICS FOR MANAGEMENT II (4-0).

PS 3302 PROBABILITY AND STATISTICS (4-1). Independence and conditional distributions. Stochastic inequalities, approximations, and limit properties, and their use in operations analysis/systems analysis. Derived distributions of functions of random variables. Random sampling and distribution of sampling statistics with application to model building and Bayesian techniques. PREREQUISITE: PS 2301.

PS 3303 STATISTICS (4-1). Confidence interval estimation and hypothesis testing. Regression and correlation analysis. Elements of the analysis of variance. Nonparametric inference. Applications to reliability, quality assurance, and operations analysis problems. PREREQUISITE: PS 3302.

*PS 3401 INTERMEDIATE PROBABILITY AND STATISTICS I (4-0).

*PS 3402 INTERMEDIATE PROBABILITY AND STATISTICS II (4-0).

*PS 3411 PROBABILITY THEORY I (4-0).

*PS 3412 PROBABILITY THEORY II (4-0).

*PS 3421 NONPARAMETRICS THEORY II (4-0).

*PS 3441 ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS (4-0).

*PS 3451 STATISTICS FOR BUSINESS AND MANAGEMENT (4-0).

PS 3510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: PS 3303 or consent of the instructor.

Graduate Courses

*PS 4001 ADVANCED PROBABILITY THEORY (3-0).

*PS 4002 ADVANCED STATISTICS AND DECISION THEORY (3-0).

PS 4306 APPLIED STATISTICS (4-0). Multivariate analysis with applications. Multiple comparisons. Bayesian and classical classification classification models. Outliers. Use of digital computer in multivariate problems. PREREQUISITE: PS 3303.

PS 4321 DESIGN OF EXPERIMENTS (3-1). Theory of the general linear hypotheses. Analysis of variance. Planning of experiments. Randomized block and Latin squares. Simple factorial experiments. PREREQUISITE: PS 3303 or consent of instructor.

PS 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (3-1). Attribute and variables sampling plans. MIL. STD. sampling plans with modificaions. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: PS 3303.

PS 4323 DECISION THEORY (3-0). Basic concepts. Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluations trials. PREREQUISITE: PS 3303.

*PS 4325 ADVANCED DESIGN OF EXPERIMENTS (4-0).

*PS 4327 RANDOM FUNCTIONS (4-0).

PS 4431 ADVANCED PROBABILITY (3-0). Convergence almost surely, in probability and in quadratic mean. Distribution function and characteristic functions. Infinitely divisible laws. Strong and weak laws of large numbers. Classical central limit problems, moder central limit problems. PREREQUISITE: MA 3606, MA 3172, and consent of the instructor.

PS 4432 STOCHASTIC PROCESSES I (4-0). The Kolmogorov Theorem. Analytic properties of sample functions. Continuity and differentiability in quadratic mean. Stochastic integrals. Stationary processes. PREREQUISITE: PA 4431.

PS 4433 STOCHASTIC PROCESSES II (4-0). Continuation of PS 4432. Stationary and non stationary normal processes. Diffusion and random walks. Crossing problems. Martingales, limit theorems and the invariance principle. PREREQUISITE: PS 4432.

PS 4440 TIME SERIES ANALYSIS (4-0). Second order stationary processes. Harmonic analysis of correlation functions. Filters and spectral windows. Ergotic properties. Problems of inference in time series analysis. Introduction to the analysis of multivariate processes. Course should be taken concurrently with PS 4432.

PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: PS 3303 or consent of the instructor.

*See listing under Mathematics Department.

DEPARTMENT OF PHYSICS

OTTO HEINZ, Professor of Physics, Chairman (1962)*; B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); Chairman (1970-1971), B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles es, 1948; Ph.D., 1951.

AUSTIN ROGERS FREY, Professor Emeritus and Distinguished Professor (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

LAWRENCE EDWARD KINSLER, Professor Emeritus (1946); B.S., California Institute of Technology, 1931; Ph.D., 1934.

ROBERT LOUIS ARMSTEAD, Associate Professor of Physics (1970); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1965.

FRANZ AUGUST BUMILLER, Professor of Physics (1962); M.S., Univ. of Zurich, 1951; Ph.D., 1955.

FRED RAMON BUSKIRK, Associate Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

NATALE MAURO CEGLIO, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Physics (1969); B.S., Columbia University, 1967; M.S., Massachusetts Institute of Technology, 1969.

ALFRED WILLIAM MADISON COOPER, Associate Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's University of Belfast, 1961.

JOHN NIESSINK COOPER, Professor of Physics (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

ALAN BERCHARD COPPENS, Assistant Professor of Physics (1964); B.Eng.Phy., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., 1965.

EUGENE CASSON CRITTENDEN, JR., Professor of Physics (1953); Cornell Univ., 1934; Ph.D., 1938.

WILLIAM PEYTON CUNNINGHAM, Professor of Physics (1946); B.S., Yale Univ., 1928; Ph. D., 1932.

HARVEY ARNOLD DAHL, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

JOHN NORVELL DYER, Professor of Physics (1970); B.A., Univ. of California at Berkeley, 1956; Ph.D., 1960.

EDGAR B. DALLY, Associate Professor of Physics (1970) B.A. (1953) and M.S. (1955) Miami University; Ph.D. Stanford University (1961).

ANTHONY IRVING ELLER, Assistant Professor of Physics (1969); A.B., Harvard, 1960; M.S., University of Rochester, 1963; Ph.D., University of Rochester, 1966.

GARRETT AQUILA GARRETTSON, Lieutenant (junior grade), U. S. Navy; Assistant Professor in Physics (1969); M.S., Stanford University 1966; Ph.D., Stanford University, 1969.

HARRY ELIAS HANDLER, Professor of Physics (1958); B.A., Univ. of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

DON EDWARD HARRISON, JR., Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

SYDNEY HOBART KALMBACH, Professor of Physics (1947); B.S., Marquette Univ., 1934; M.S., 1937.

RAYMOND LEROY KELLY, Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

RICHARD LIPES, Lieutenant, U. S. Naval Reserve; Assistant Professor in Physics (1969); B.S., Massachusetts Institute of Technology, 1964; Ph.D., California Institute of Technology, 1969.

WILLIAM ARNALL LITTLE, Lieutenant, U.S. Navy; Assistant Professor in Physics (1970); B.S. (1965) M.S. (1967) and Ph.D. (1969), Georgia Institute of Technology.

HERMAN MEDWIN, Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S., Univ. of California at Los Angeles, 1948; Ph.D., 1953.

EDMUND ALEXANDER MILNE, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

JOHN ROBERT NEIGHBOURS, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

WILLIAM REESE, Associate Professor of Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

JOHN DEWITT RIGGIN, Professor of Physics (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

GEORGE WAYNE RODEBACK, Associate professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

JAMES VINCENT SANDERS, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

GORDON EVERETT SCHACHER, Associate Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

FRED RICHARD SCHWIRZKE, Associate Professor of Physics (1967); B.S., University of Rostock, 1950; M.S., University of Karlsruhe, 1953; Ph.D., University of Karlsruhe, 1959.

THEODORE JOSEPH WILLIAMSON, Assistant Professor of Physics (1967); B.S., Univ. of Washington, 1964; M.S., 1965; Ph.D., 1967.

KARLHEINZ EDGAR WOEHLER, Associate Professor of Physics (1963); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

WILLIAM BARDWELL ZELENY, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S., Syracuse Univ. 1958; Ph.D., 1960.

**The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN PHYSICS BACHELOR OF SCIENCE IN PHYSICS

1. A major in physics must include a minimum of 45 quarter hours in physics, including required courses and electives, a minimum of 24 quarter hours in mathematics, and the equivalent of a course in general chemistry. In addition a minimum of 17 quarter hours of elective credits must be chosen from the natural sciences or engineering, other than physics or mathematics. Ninety quarter hours must be clearly of upper division level.

2. The following specific requirements must be met: (courses marked with an asterisk must include a laboratory).

Subject	*Approximate Quarter Hrs.*
General Physics*	13
Analytical Mechanics	7
Electricity and Magnetism	6
Modern Physics*	10
	36

The math courses shall include differential equations and vector analysis.

3. The student must maintain grade point averages of at least 1.2 in both physics and mathematics.

MASTER OF SCIENCE IN PHYSICS

1. Each student's program of study must have a minimum of 30 quarter hours of physics courses (not including thesis) distributed between courses in the 3000 and 4000 series; of this 30 hours at least 15 hours must be from the 4000 series. Upon approval of the chairman of the physics department a maximum of 4 hours of courses taken in another department may be applied toward satisfying the above requirements. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 20 hours entirely of 4000 level physics courses. In addition, all students must engage in research in at least 3 quarters and present an acceptable thesis.

2. In addition to the courses normally leading to a B.S. in Physics, the following specific course requirements must be successfully completed for a student to earn the degree of M.S. in physics:

a. Thermodynamics and Statistical Mechanics - The Student must take a two-quarter sequence or present equivalent preparation in this area.

b. A course in Advanced Mechanics or Quantum Mechanics.

c. A course in Electromagnatism at the 4000 level.

d. An advanced course in Modern Physics.

e. Specialization to include at least two advanced courses, in one of the following areas:

1. Acoustics
2. Atomic Physics
3. Nuclear Physics
4. Plasma Physics
5. Solid State Physics
6. Underwater Physics
7. Other, subject to Department approval

DOCTOR OF PHILOSOPHY

The Ph.D. degree is offered in the Physics Department in several areas of specialization which currently include Acoustics, Atomic Physics, Nuclear Physics, Plasma Physics, Solid State Physics and Theoretical Physics.

Requirements for the degree may be grouped into 3 catagories: courses, thesis research, and examinations in major and minor fields and languages.

The required examinations are described elsewhere in this catalog in the section Requirements for the Doctor's Degree. In addition to the school requirements the department requires a preliminary examination to show evidence of acceptability as a doctoral student.

The usual courses to be taken by the candidate include Advanced Mechanics, Classical Electrodynamics, Quantum Mechanics, Statistical Physics. (PH 4171, 4371, 4971, 4972, 4973, 4571, 4572.) Suitable electives are to be chosen in physics and the minor fields, mainly from the list of graduate level courses.

Any prospective candidate should consult with the Graduate Student Advisor in the Physics Department for guidance in setting up the course of study.

PHYSICS LABORATORIES

The physics laboratories are equipped to carry on instructional and research work in nuclear physics, low temperature and solid state physics, plasma physics, atomic physics and spectroscopy, and acoustics.

In low temperature and solid state physics the equipment includes nitrogen liquifiers, a Collins helium liquefier, He^3 refrigeration equipment to reach temperatures below 1° K, a 12 inch uniform field electromagnet, microwave gear for spin resonance and maser studies, and high frequency pulse acoustic equipment for phonon studies.

The plasma physics equipment includes a large plasma system, diagnostic equipment for studies of plasma dynamics, a steady state plasma source with magnetic fields up to 10,000 gauss and a giant pulse laser. The spectroscopy equipment includes a large grating spectrograph, a large prism spectrograph, and an infrared spectrophotometer.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test tanks, and instrumentation for investigation in underwater sound comprise the underwater acoustics laboratory.

The spectroscopic data center contains a comprehensive compilation of the known energy levels and atomic spectrum lines in the vacuum ultraviolet range.

The AGN 201 reactor with a power level of 1000 watts provides teaching and research facilities in nuclear physics, nuclear power and radio-chemistry.

A two million volt Van de Graaff generator is used both in nuclear and solid state research.

A 100 Mev electron linear accelerator with 5 microamp beam current is used in nuclear physics research as well as radiation effects in microcircuits.

PHYSICS

PH 0110 REFRESHER PHYSICS (5-3). Review of basic concepts of mechanics, electricity and magnetism. The International System of Units. Forces and motion. Conservation of momentum and energy. Concepts of electric and magnetic fields. Lorentz force. Vector algebra. Physical applications of simple calculus. Approximation techniques. TEXT: Sears & Zemansky, *College Physics, Complete Edition.*

PH 0499 ACOUSTICS COLLOQUIUM (0-1). Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: PH 3452 or equivalent.

PH 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

PH 0999 PHYSICS COLLOQUIUM (0-1). Discussion of topics of current interest in the field of physics and student thesis reports.

Lower Division Courses

PH 1005, PH 1006, and PH 1007 comprise a series of courses intended for students with limited backgrounds in mathematics.

PH 1005 ELEMENTARY PHYSICS I (4-2). Mechanics, Heat, and Sound. Lectures, problem sessions, and laboratory. Physical quantities and the concepts of motion, force, momentum, and energy. The mechanics of gases, heat transfer, and thermodynamics. Simple harmonic motion and propagation of sound. TEXT: Sears and Zemansky, *College physics,* or equivalent.

PH 1006 ELEMENTARY PHYSICSS II (3-2). Electricity and Magnetism. Electrostatics, electric current, and magnetism. Lectures, problem sessions, and laboratory. TEXT: Sears and Zemansky, *College Physics,* or equivalent. PREREQUISITE: PH 1005.

PH 1007 ELEMENTARY PHYSICS III (4-2). Optics and Modern Physics. Lectures, problem sessions and laboratory dealing with geometrical optics, mirrors and lenses. Atomic structure, optical spectra, radioactivity and nuclear structure. TEXT: Sears and Zemansky, *College Physics,* or equivalent. PREREQUISITES: PH 1005 and PH 1006.

PH 1011, PH 1012, and PH 2017 comprise a series of courses intended primarily for Engineering Science students with a prior knowledge of calculus.

PH 1011 BASIC PHYSICS I (4-0). Mechanics, Heat, and Sound. Review of Newtonian Mechanics. Conservation laws. Rotational motion. Thermal properties of gases, liquids and solids. Laws of Thermodynamics. Wave motion and propagation of sound. TEXT: Resnick-Halliday. *Physics,* Part I. PREREQUISITES: Courses in College Physics and College Mathematics through calculus.

PH 1012 BASIC PHYSICS II (4-0). Electricity and Magnetism. Electrostatics stressing Gauss's Law and the theory of electric fields and potentials. Alternating current. Elecromagnetism. TEXT: Halliday-Resnick, *Physics,* Part II. PREREQUISITE: PH 1011.

PH 1015, PH 1016, and PH 2017 comprise a series of courses intended primarily for BS students and provides a knowledge of the principles of physics and a scientific background for the study of engineering.

PH 1015 BASIC PHYSICS I (5-3). Mechanics, Heat, and sound. Lectures, problem sessions, and laboratory. Concepts of force, motion, energy, momentum, thermal properties of gases, liquids, and solids, and wave motion. TEXT: Halliday-Resnick, *Physics,* Part 1. PREREQUISITE: One term of calculus.

PH 1016 BASIC PHYSICS II (4-3). Electricity and Magnetism. Lectures, problem sessions, and laboratory. Electrostatics, electromagnetism, and electrochemistry. Direct and alternating currents. TEXT: Halliday-Resnick, *Physics,* Part II. PREREQUISITE: PH 1015.

PH 1041 REVIEW OF MECHANICS AND OPTICS (4-2). First quarter of a sequence of fundamental physics for student in Electrical Engineering and Electronics. (The sequence includes PH 1041, PH 2241, PH 2641, and PH 3741.) The first course subject matter includes: kinematics, particle dynamics, energy and momentum conservation, rotational motion, oscillations, geometrical optics. The laboratory will be devoted to guided problem-solving. TEXTS: Resnick and Halliday, *Physics for Students of Science and Engineering,* Parts I and II.

PH 1051 REVIEW OF VECTOR MECHANICS AND OPTICS (4-2). A review of the basic concepts of elementary vector mechanics and geometrical optics, including: statics, motion in one dimension and in a plane, particle dynamics, energy, momentum, rotational dynamics, and the laws of reflection and refraction applied to lenses, mirrors, and prisms. The laboratory sessions are devoted to guided problem-solving. TEXT: Resnick-Halliday, *Physics,* Parts I and II. PREREQUISITES: Previous courses in general physics and calculus.

Upper Division Courses

PH 2017 BASIC PHYSICS III (4-2). Optics and Modern Physics (PH 2017 is the third course for both the PH 1011, PH 1012, and the PH 1015, PH 1016 series of Basic Physics.) Lectures, problem sessions, and laboratory. Geometrical optics, mirrors and lenses. Interference and diffraction. Special relativity, quantum effects of waves and particles, structure of the hydrogen atom, nuclear structure, and nuclear reactions. TEXTS: Halliday-Resnick, *Physics,* Part II, and Weidner and Sells, *Elementary Modern Physics.* PREREQUISITES: PH 1011 and PH 1012 or PH 1015 and PH 1016.

PH 2121 ANALYSIS OF PHYSICAL MODELS I (4-0). The first in a sequence of two courses (PH 2121, PH 2122), designed for students in the Operations Analysis curriculum. The course emphasizes the process of constructing analytical models for the treatment of real physical systems. Projectile motion, rocket motion, orbits, the motions of charged particles in electromagnetic fields, and harmonic motion are treated. The predictions of theory are compared to experiment, using models of increasing sophistication. TEXT: Instructor's Notes.

PH 2122 ANALYSIS OF PHYSICAL MODELS II (4-2). The second in a sequence of courses (PH 2121, PH 2122), designed for students in the Operations Analysis curriculum. Wave motion is introduced and interference and diffraction are considered for a variety of situations involving electromagnetic and acoustic waves. The similarities in the predictions of a wave theory for diverse phenomena are emphasized. The implications of a wave theory of light are stressed. The Special Theory of Relativity is introduced; relativistic kinematics developed and non-relativistic kinematics shown to be an approximation. Photons and the predictions of a particle theory of light are discussed. The meaning of wave-particle duality and the difficulties of constructing consistent models complete the course. TEXT: *Instructors notes.* PREREQUISITE: PH 2121.

PH 2151 MECHANICS I (4-0). Kinematics, dynamics, moving reference systems, and the central force problem. TEXT: Symon, *Mechanics,* 2nd ed. PREREQUISITES: PH 1051, Calculus, Vector Algebra and Ordinary Differential Equations (the latter may be taken concurrently).

PH 2152 MECHANICS II (4-0). Motion of a system of particles, conservation laws, generalized coordinates, Lagrangian mechanics. Remaining topics as time will allow: approximations, rigid body motion, gravitational potential theory. TEXT: Symon, *Mechanics,* 2nd ed. PREREQUISITE: PH 2151.

PH 2241 WAVES AND PARTICLES (4-0). Second quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. Wave propagation, interference, diffraction, polarization. Electromagnetic waves. Photoelectric and Compton effects. Wave particle dualism. Black body radiation, spectra. TEXTS: *Instructor's Notes;* Young: *Optics and Modern Physics;* Weidner and Sells: *Elementary Modern Physics.* PREREQUISITES: PH 1011 or PH 1051.

PH 2251 WAVES AND PARTICLES (4-2). A course designed to provide the background and fundamental ideas in modern physics which are utilized in atomic, molecular, solid state, and nuclear physics. Wave properties; propagation, interference, diffraction, polarization. Electromagnetic waves. The special theory of relativity. Photoelectric and Compton effects. Wave-particle dualism; de Broglie hypothesis; electron diffraction; wave packets. Continuous and line spectra; black-body radiation; hydrogen atom spectrum. TEXTS: Eisberg, *Fundamentals of Modern Physics;* Instructor's Notes. PREREQUISITES: PH 2151, MA 2161.

PH 2351 ELECTROMAGNETISM I (4-0). Electrostatic field and potential; dielectrics; solution of Laplace equation; magnetic fields of steady currents; electromagnetic induction; magnetic polarization in materials, Maxwell equations. TEXTS: Corson and Lorrain, *Introduction to Electromagnetic Fields and Waves;* Reitz and Milford, *Foundations of Electro-magnetic Theory.* PREREQUISITES: MA 2161 or PH 1051.

PH 2352 ELECTROMAGNETISM II (3-0). Plane electromagnetic waves in free space; propogation of electromagnetic waves in matter; reflection and refraction; guided waves. TEXTS: Corson and Lorrain, *Introduction to Electromagnetic Fields and Waves;* Reitz and Milford, *Foundations of Electromagnetic Theory.* PREREQUISITE: PH 2351.

PH 2551 THERMODYNAMICS (3-0). (may be taught as CH 2401) Fundamental theory of thermodynamics and applications to physical systems. First and second laws of thermodynamics; entropy; thermodynamic potentials; applications to gases, liquids, radiation, and magnetic materials; equilibrium. TEXT: Vanderslice, Schamp, and Mason, *Thermodynamics,* PREREQUISITES: PH 1051 and Calculus of Several Variables.

PH 2641 ATOMIC PHYSICS (4-2). Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Bohr model, Schroedinger equation, exact solution for hydrogen atom, electron spin, periodic table, atomic spectra, transition probabilities, Einstein coefficients and stimulated emission, molecules and molecular spectra, classical and quantum statistical distribution functions. TEXT: Richtmeyer, Kennard & Cooper, *Modern Physics.* PREREQUISITE: PH 2241 or PH 2251.

PH 2810 SURVEY OF NUCLEAR PHYSICS (4-0). A course designed to introduce the student to the ideas of nuclear physics, with emphasis on neutron physics and reactors. Atomic nature of matter; wave-particle duality: the nuclear atom. Basic nuclear properties; reactions, neutrons and fission. Reactors. TEXTS: Weidner and Sells, *Elementary Modern Physics;* Murray, *Introduction to Nuclear Engineering.*

Upper Division or Graduate Courses

PH 3157 PHYSICS OF CONTINUA (4-0). The continuum hypothesis. Cartesian tensors. The concept of stress. Deformation. Conservation of mass, momentum and energy. Theory of constituative equations. Applications to fluid mechanics, solid mechanics and wave phenomena. TEXT: Scipio, *Principles of Continua With Applications.* PREREQUISITE: PH 2151.

PH 3250 UNDERWATER OPTICS (3-2). The nature of light; optical imaging systems and their limitations; dispersion and scattering of light; transmission and absorption of light in water; underwater visibility. TEXT *Class notes.* PREREQUISITE: PH 2017, or completion of a one-year course in general physics.

PH 3280 PHYSICAL OPTICS (4-2). Wave phenomena and wave propagation, superposition principle and interference, dispersion, polarization. Stokes vector representation, Kirchoff integral. TEXT: Stone, *Radiation and Optics.* PREREQUISITE: Consent of Instructor.

PH 3421 UNDERWATER ACOUSTICS (4-2). A course taught primarily for students in operations analysis curricula. An anaalytical survey of acoustics with an emphasis on sound propagation in the ocean. Topics include: Simple harmonic oscillations; Wave equation in an ideal fluid; Simple harmonic solutions for plane and spherical waves; Radiation of sound; Propagation effects due to boundaries, inhomogeneities and sound absorbing processes; Development of the basic models for sonar; Transducers for underwater sound. Laboratory experiments on underwater acoustics, spectrum analysis and transducers. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics,* Urick, *Principles of Underwater Sound for Engineers.* PREREQUISITES: A course in mechanics and a course in differential equations.

PH 3431 PHYSICS OF SOUND IN THE OCEAN (4-2). A survey of physical acoustics with an emphasis on propagation in the ocean, taught primarily for students in oceanography curricula. Topics treated include: simple harmonic motion; the acoustic wave equation in fluids and its solutions for both plane and diverging waves; ray acoustics; radiation of sound; reflection from boundaries; normal mode propagation; effects due to inhomogeneities and to sound absorption; an introduction to models for sonar systems; transducers for underwater sound. Laboratory experiments on underwater acoustics, spectrum analysis and transducers. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Urick, *Principles of*

Underwater Sound for Engineers. PREREQUISITES: A course in general physics and a course in differential equations.

PH 3451 FUNDAMENTAL ACOUSTICS (4-1). Mechanics of free, forced, and damped simple vibratory systems. Mechanical impedance. Development of, and solutions to the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Specific acoustical behavior of the piston source. Radiation impedance. Lumped acoustic elements and propagation in pipes. Steady state response of acoustic waveguides. Group and phase velocities. Normal Modes. Laboratory experiments on selected topics. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Instructor's Notes. PREREQUISITES: PH 2151 and MA 2161.

PH 3452 UNDERWATER ACOUSTICS (4-2). Loudspeakers and microphones. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean: the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems. Laboratory experiments on selected concepts. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Urick, *Principles of Underwater Sound for Engineers.* PREREQUISITE: PH 3451.

PH 3461 EXPLOSIVE SHOCK WAVES (4-0). Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Shock loads on ships and blast loads on structures. Damage mechanism and principles of protection against damage. TEXTS: Instructor's Notes; Cole, *Underwater Explosions;* Kinney, *Shocks in Air.* PREREQUISITES: PH 2152, PH 2551 or CH 2401.

PH 3463 SPECIAL TOPICS IN UNDERWATER ACOUSTICS (3-2). A terminal course following PH 3452 for those students who do not pursue a graduate level program. Topics may include additional material in underwater acoustics, transducer theory, non-linear phenomena in acoustics, explosive waves in water, noise and vibration control. Laboratory experiments on related material. TEXT: *Instructor's notes.* PREREQUISITE: PH 3452 or equivalent.

PH 3561 INTRODUCTORY STATISTICAL PHYSICS (4-0). Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and raidation. TEXT: Kittel, *Thermal Physics.* PREREQUISITES: PH 2152, PH 2551 or CH 2401, PH 3651.

PH 3651 ATOMIC PHYSICS (4-2). Properties of the electron, the nuclear atom, the Bohr theory of the hydrogen atom, atomic energy levels, the Schroedinger Equation and properties of its solutions, application of the Schroedinger Equation to the square potential well and to the hydrogen atom, angular momentum operators, electron spin, identical particles, the Pauli Principle, multielectron atoms, the Periodic Table, the vector model of the atom and complex spectra, the Zeeman effect, Einstein coefficients and stimulated emission of radiation, X-ray spectra and Bragg's law, TEXTS: Eisberg, *Fundamentals of Modern Physics;* Richtmeyer, Kennard & Cooper, *Introduction to Modern Physics;* PREREQUISITES: PH 2251, PH 2351 and MA 2161.

PH 3652 ELEMENTS OF MOLECULAR, SOLID STATE, AND NUCLEAR PHYSICS (4-2). Molecular bonds, excited states of molecules, molecular spectra. Bonding in crystals. Conduction in solids, band theory. Semiconductors. Fundamentals of nuclear physics, radioactivity and the decay law. Interactions of high energy charged particles and photons with matter. TEXTS: Richtmeyer, Kennard and Cooper, *Introduction to Modern Physics;* Enge, *Introduction to Nuclear Physics;* Instructor's Notes. PREREQUISITE: PH 3651.

PH 3687 PHYSICS OF ELECTRON INTERACTION IN GASES (3-0). This course stresses the basic electronic processes in gases, fundamental to the physics and chemistry of the upper atmosphere and to the operation of electron devices including the gas laser. Topics covered include elastic collisions, free and ambipolar diffusion, mobility, excitation and ionization, charge transfer, emission from surfaces, recombination, high frequency and d.c. breakdown, sheaths, the glow and arc discharges, radiation, application to the gas laser. TEXT: Brown, *Introduction to Electrical Discharges in Gases;* McDaniel, *Collision Phenomena in Gases.* PREREQUISITES: PH 2641 or PH 3651 or consent of the Instructor.

PH 3741 ELECTRONIC PROPERTIES OF METALS AND SEMI-CONDUCTORS (4-2). Fourth quarter in the sequence of fundamental physics for students in Electrical Engineering and Electrones. Crystals and lattice properties X-ray diffraction, free-electron theory, electrical conductivity, band theory. Brillouin zones, effective mass, holes, intrinsic and impurity semi-conductors, diodes, transistors, thermoelectric effects, minority carriers, modern devices. TEXTS: Kittel, *Introduction to Solid State Physics,* 3rd ed., and McKelvey, *Solid State and Semiconductor Devices.* PREREQUISITES: PH 2641 or PH 3651.

PH 3921 CONCEPTUAL MODELS OF MODERN PHYSICS (4-0). A review of recent developments in physics selected to illustrate the principles of model-building and the general methodology of science. The topics selected include: special relativity, wave particle duality, nuclear reactions, and fundamental particles. TEXTS: Weidner and Sells, *Elementary Modern Physics;* Beiser, *Concepts of Modern Physics.* PREREQUISITE: PH 2122.

PH 3951 INTRODUCTION TO QUANTUM MECHANICS (4-0). The general principles of quantum mechanics. Schroedinger equation. Harmonic oscillator. Angular momentum, many particle systems, electron spin, the Pauli exclusion principle. Time independent and time dependent perturbation, and the semi-classical theory of radiation applied to atomic transitions. TEXT: Park, *Introduction to Quantum Theory.* PREREQUISITES: PH 2351, MA 2161, PH 3651 (may be taken concurrently).

Graduate Courses

PH 4161 FLUID MECHANICS I (4-0). Fundamental concepts of continuum mechanics. Fluid mechanical models. Euler equation and solution of potential flow problems. Navier-Stokes equation. TEXTS: Instructor's Notes; Li and Lam, *Principles of Fluid Mechanics.* PREREQUISITES: MA 2161 and Mechanics.

PH 4162 FLUID MECHANICS II (3-0). Laminar boundary lary, hydrodynamic stability, turbulence, and hydrodynamic noise. Fluid dynamic discontinuities, shock waves, and the method of characteristics. TEXTS: Schlichting, *Boundary*

Layer Theory; Instructor's Notes. PREREQUISITE: PH 4161.

PH 4171 ADVANCED MECHANICS (4-0). Hamilton's principle. The equations of motion in Lagrangian and Hamiltonian form. Rigid body motion. Canonical transformation, Poisson brackets, Hamilton-Jacobi theory. Small oscillations. Classical perturbation theory. TEXT: Goldstein, *Classical Mechanics.* PREREQUISITES: PH 2152, PH 2352.

PH 4353 ELECTROMAGNETISM III (3-0). Classical radiation theory. Scalar and vector potentials, radiation from a dipole, classical theory of Bremsstrahlung, Thompson scattering, field due to fast electron. Selected topics: relativity, scattering from a random medium, Rayleigh scattering. TEXT: Marion, *Classical Electromagnetic Radiation.* PREREQUISITE: PH 2352.

PH 4371 CLASSICAL ELECTRODYNAMICS (3-0). Tensors in special relativity. Classical relativistic electromagnetic field theory. The Lienard-Wiechert potentials, Lorentz electron theory. TEXTS: Landau and Lifshitz, *Classical Theory of Fields;* Barut, *Electrodynamics and Classical Theory of Fields and Particles.* PREREQUISITES: PH 4353 and familiarity with the special theory of relativity and Lagrangian Mechanics.

PH 4453 PROPAGATION OF WAVES IN FLUIDS(4-0). An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields, incoherence and coherence; applications of the Helmholtz Integral; probability density functions, correlations and frequency spectra of sound scattered from rough boundaries; macrosonics, including non-linear propagation and shock wave phenomena. TEXTS: Instructor's notes and selected references in books such as: Beckmann and Spizzichino, *The Scattering of Electromagnetic Waves from Rough Surfaces;* Lindsay, *Mechanical Radiation;* Morse and Ingard, *Theoretical Acoustics;* Tolstoy and Clay, *Ocean Acoustics;* Cole, *Underwater Explosions.* PREREQUISITES: PH 3452 or consent of instructor.

PH 4454 TRANSDUCER THEORY AND DESIGN(3-2). A treatment of the fundamental phenomena basic to the design of transducers for underwater sound and specific examples of their application. Topics include piezoelectric, magnetostrictive and hydromechanical effects. Laboratory experiments on measurement techniques, properties of transducer materials and characteristics of typical transducer types. TEXT: Instructor's notes and selected references. PREREQUISITE: PH 3452 or equivalent and PH 3157.

PH 4455 ADVANCED ACOUSTICS LABORATORY (0-3). Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4456 SEMINAR IN APPLICATIONS OF UNDERWATER SOUND (3-0). A study of current literature on applications of acoustics to problems of naval interest. PREREQUISITE: PH 4453 or consent of instructor.

PH 4571 STATISTICAL PHYSICS I (3-0). Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble theory, microcanonical, canonical, and grand canonical ensemblies, quantum statistics. TEXT: Huang, *Statistical Mechanics.* PREREQUISITES: PH 2152, PH 3651, PH 2551.

PH 4572 STATISTICAL PHYSICS II (3-0). A continuation of PH 4571 with applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and irreversible processes. Text: Huang, *Statistical Mechanics.* PREREQUISITE: PH 4571.

PH 4630 SPACE PHYSICS I - PHYSICS OF THE UPPER ATMOSPHERE (4-0). Structure of the upper atmosphere. Atmospheric absorption in the infrared, visible and ultraviolet. The ionosphere. Geomagnetic field and the raidation belts. Disturbances of the upper atmosphere. Magnetic field, the magnetopause and solarwind. Experimental instrumentation in space research. TEXTS: Hines et al, *Physics of the Earth's Upper Atmosphere;* Hess, *Introduction to Space Science.* PREREQUISITES: PH 3652 and PH 3352 or consent of the instructor.

PH 4631 SPACE PHYSICS II - PHYSICS OF THE SOLAR SYSTEM (4-0). Solar interior and surface. Solar magnetic field, sunspots and flares. Emissions from the sun. Introduction to stellar evolution and cosmology. TEXTS: Brandt, *Solar System Astrophysics;* Hess, *Introduction to Space Science.* PREREQUISITE: Consent of the instructor.

PH 4661 PLASMA PHYSICS I (4-0). Introduction to the physical and mathematical concepts fundamental to various branches of plasma physics and space physics such as ionospheric communications advanced propulsion, and controlled fusion. Topics covered include single particle motions in electromagnetic fields, orbit theory, collision phenomena, breakdown in gases, and diffusion. The Boltzmann equation and the macroscopic momentum and energy transport equations are discussed. The magnetohydrodynamic and the two-fluid plasma models are considered. TEXTS: Tanobaum, *Plasma Physics;* Rose and Clark, *Plasmas and Controlled Fusion;* Uman, *Introduction to Plasma Physics.* PREREQUISITES: PH 4353, PH 3561, PH 3651, or the equivalent.

PH 4662 PLASMA PHYSICS II (3-0). A continuation of Plasma Physics I. Applications of the hydromagnetic equations to the study of macroscopic motions of a plasma. Effect of coulomb interactions, relaxation times and runaway electrons. Small amplitude plasma waves, shock waves. Radiation from plasmas, including bremsstrahlung and cyclotron radiation. Plasma instabilities. TEXTS: Tanenbaum, *Plasma Physics;* Rose and Clark, *Plasmas and Controlled Fusion;* Uman, *Introduction to Plasma Physics.* PREREQUISITES: PH 4661 or equivalent.

PH 4681 ADVANCED PLASMA PHYSICS (3-0). Selected topics in plasma physics, such as waves in anisotropic plasmas, turbulence and fluctuations, collisionless shock waves. PREREQUISITES: PH 4662 or consent of the instuctor.

PH 4685 ADVANCED ATOMIC PHYSICS (3-0). Selected topics in atomic spectroscopy and atomic collistions. Classical and quantum description fo the collision process, transition probabilities and line braodening mechanism. TEXTS: Shore and Menzel; *Principles of Atomic Spectra;* McDaniel, *Collision Phenomana in Ionized Gases.* PREREQUISITES: PH 3651 and consent of the instructor.

PH 4750 RADIATION EFFECTS IN SOLIDS (5-0). The effects of nuclear radiation and the effects of shock waves on the properties of solids: interaction of radiation with solids, displacement of atoms in solids and the effects on solid state properties; effects on electrons in the solids; effects of shock compression of solids, behavior beyond the elastic limit, phase changes. TEXTS: Dienes and Vineyard, *Radiation Effects in Solids;* Instructor's Notes. PREREQUISITES: PH 3461, PH 3561, PH 3652.

PH 4751 PHYSICS OF SOLIDS I (3-0). Theory of the structure and properties of solids; crystal symmetry and the anisotropy of physical properties, binding in solids, imperfections, lattice vibrations, lattice specific heat, magnetic properties. TEXT: Kittel, *Introduction to Solid State Physics.* PREREQUISITES: PH 3561, PH 3651, PH 3951 or PH 4971.

PH 4752 PHYSICS OF SOLIDS II (3-2). A continuation of PH 4751 with laboratory experiments relating to both terms. Electronic properties of solids: free electron theory, transport properties, band theory, Brillouin zones, effective mass, physics of semiconductors and solid state devices, optical properties, super-conductivity, ferromagnetism. TEXTS: Kittel, *Introduction to Solid State Physics;* Ziman, *Electrons in Metals.* PREREQUISITE: PH 4751.

PH 4760 SOLID STATE PHYSICS (4-2). Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy , lattice vibration, dislocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. TEXT: Kittel, *Introduction to Solid State Physics,* 3rd ed. PREREQUISITE: PH 3651.

PH 4781 APPLICATIONS OF SOLID STATE PHYSICS I (3-0). Detailed studies of selected topics in modern applications of solid state physics. Typical courses might include: radiation effects in electronic devices, infrared detectors, dielectric and magnetic properties. PREREQUISITES: PH 3561, PH 3741 or PH 4760.

PH 4782 APPLICATIONS OF SOLID STATE PHYSICS II (3-0). Detailed studies of selected topics in modern applications of solid state physics. PH 4781 and PH 4782 can be taken in alternate years or in different quarters of the same year. PREREQUISITES: PH 3561, PH 3741 or PH 4760.

PH 4790 THEORY OF QUANTUM DEVICES (3-0). Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, internal fields: application to specific electronic devices, parametric amplifiers, magnetic instruments. TEXTS: Siegman, *Microwave Solid State Masers;* Pake, *Paramagnetic Resonance;* Heavens, *Optical Masers;* Bloembergen, *Nonlinear Optics.* PREREQUISITES: PH 2641 or PH 3651.

PH 4851 NUCLEAR PHYSICS (4-2). Nuclear forces; the deuteron; low energy scattering. Nuclear models; spin and moments. Nuclear reactions; fission; reactors. Weak interactions; beta-decay. TEXTS: Enge, *Introduction to Nuclear Physics,* Elton, *Introductory Nuclear Theory.* PREREQUISITES: PH 3652, PH 2352, PH 3951.

PH 4881 ADVANCED NUCLEAR PHYSICS I (3-0). Selected topics in nuclear and particle physics. The particular subjects covered will depend on the needs of the students and choice of the Instructor. PREREQUISITES: PH 4851, PH 3951, or PH 4971.

PH 4882 ADVANCED NUCLEAR PHYSICS II (3-0). A continuation of PH 4881. PREREQUISITE: PH 4881.

PH 4885 REACTOR THEORY (3-0). The diffusion and slowing down of neutrons. Homogeneous thermal reactors; time behavior; reactor control. Multigroup theory. Heterogeneous systems and perturbation theory. TEXTS: Glasstone and Edlund, *The Elements of Nuclear Reactor Theory;* Murray, *Nuclear Reactor Physics.* PREREQUISITE: PH 4851.

PH 4971 QUANTUM MECHANICS I (3-0). Matrix formulation of quantum mechanics. Stationary states of the square well, the harmonic oscillator, and the hydrogen atom. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITES: PH 3651 and PH 4171.

PH 4972 QUANTUM MECHANICS II (3-0). Addition of angular momenta. Time independent and time dependent perturbation theory. Partial wave analysis of scattering. Identicals particles and spin. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITE: PH 4971.

PH 4973 QUANTUM MECHANICS III (3-0). Atoms and molecules, properties and solutions of relativistic particle wave equations. TEXTS: Schiff, *Quantum Mechanics;* Bjorken and Drell, *Relativistic Quantum Mechanics.* PREREQUISITE: PH 4972.

PH 4981 QUANTUM FIELD THEORY I (3-0). Quantization of scalar, spinor, and massless vector fields. TEXT: Schweber, *Introduction to Relativistic Quantum Field Theory.* PREREQUISITES: PH 4371 and PH 4973.

PH 4982 QUANTUM FIELD THEORY II (3-0). Interacting Fields. The S-matrix and renormalization. Strong, electromagnetic, and weak interactions. Introduction to dispersion relations. Text: Schweber, *Introduction to Relativistic Quantum Field Theory.* PREREQUISITE: PH 4981.

PH 4991 RELATIVITY AND COSMOLOGY (3-0). Introduction to the general theory of relativity. The three classical tests of the general theory. The Schwarzschild singularity. Cosmological models. TEXTS: Eddington, *The Mathematical Theory of Relativity;* Bondi, *Cosmology.* PREREQUISITE: PH 4371.

PH 4993 PHYSICAL GROUP THEORY (3-0). Invariance of quantum mechanical systems to certain groups of transformations. Topics to be selected from finite rotation groups and crystal symmetries, the continuous rotation group in three dimensions, transformation groups associated with elementary particle symmetries. PREREQUISITE: PH 4972.

PH 4998 READING IN ADVANCED PHYSICS (2-0 to 4-0). Supervised reading in one of the fields of advanced physics selected to meet the needs of the student. May be repeated for credit in a different field. PREREQUISITE: Consent of the Instructor.

PH 4999 ADVANCED SEMINAR (1-0 to 3-0). A seminar in recent developments in basic and applied physics, conducted by faculty members with student participation. PREREQUISITE: The student should have graduate standing and the consent of the instructor.

NAVY MANAGEMENT SYSTEMS CENTER

ROBERT WARING McNITT, Rear Admiral, U.S. Navy; Director; B.S., Naval Academy, 1938; M.S., Massachusetts Institute of Technology, 1947.

HERMAN PAUL ECKER, Professor; Executive Director (1957)*; B.A., Pomona College, 1948; M.A., Claremont Graduate School, 1949; Ph.D., 1967.

ROGER STERLING CLARK, Lieutenant Commander, U.S. Navy; Assistant Director, Administration and Assistant Professor (1966)*, B.S., Univ. of California at Berkeley; M.S. Naval Postgraduate School, 1966.

SHERMAN WESLEY BLANDIN, JR., Assistant Professor (1968)*; B.S. Naval Academy, 1944; B.S. Georgia Institute of Technology, 1952; M.S., 1953.

GEORGE KENNER CANTRELL, Lieutenant Colonel, U.S. Air Force; Associate Professor (1969)*; B.A., Eastern New Mexico Univ., 1941; M.S. Univ. of New Mexico, 1947; Ph.D., Univ. of Denver, 1960.

JOHN EDWARD DAWSON, Associate Professor (1966)*; B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954, Ph.D. (pending).

EDWIN JOHN DORAN, Major, U.S. Marine Corps; Assistant Professor (1969)*; B.A., Univ. of Pennsylvania, 1955; M.S., Naval Postgraduate School, 1968.

EDWARD JOSEPH FREED, Ensign, U.S. Navy; Instructor (1969)*; B.S., Boston College, 1966; M.B.A., Wharton School of Finance and Commerce, Univ. of Pennsylvania, 1968.

PHILLIP GERARD HARTMAN, Lieutenant Commander U.S. Navy; Instructor (1969)*; B.S., Univ. of Wisconsin, 1957; M.S., Naval Postgraduate School, 1969.

WILLIAM ANSELM KEARNS, Jr., Commander, U.S. Navy; Instructor (1968)*; B.S. New York Maritime College, 1954; B.S., Naval Postgraduate School, 1964.

ALBERT JOSEPH MARTIN, JR., Lieutenant, U.S. Army; Assistant Professor (1969)*; B.A., Univ. of Delaware, 1964; M.B.A., 1966; Ph.D., Ohio State University, 1969.

WILLIAM ALAN MAUER, Associate Professor (1966)*; A.B., San Jose State College, 1955; M.S., Agricultural and Mechanical College of Texas, 1957; Ph.D., Duke Univ., 1960.

ROBERT JOSEPH NETRO, Commander, U.S. Navy; Assistant Professor (1968)*; B.S., Naval Postgraduate School, 1964; M.S., 1968.

NORMAN PLOTKIN, Assistant Professor (1969)*; B.S., Univ. of California at Los Angeles, 1948; B.F.S., Georgetown Univ., 1950; M.S., Claremont Graduate School, 1966; Ph.D.. 1969.

IVON WILLIAM ULREY, Professor (1966)*; B.S., Ohio State Univ., 1931; M.B.A., New York Univ., 1937; Ph.D., Ohio State Univ., 1953.

ROBERT von PAGENHARDT, Professor, (1967)*; A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., (pending).

CARLTON LEROY WOOD, Professor (1966)*; B.A., Univ. of Washington, 1932; M.A., Columbia Univ., 1944; Ph.D., Heidelberg Univ., 1936.

*The year of joining the Postgraduate Faculty is indicated in parentheses.

The Navy Management Systems Center was established as a separate Naval Activity in February, 1966, for the purpose of fulfilling Department of Defense requirements for educating high level military and civilian personnel working in planning, programming, budgeting, systems analysis or resource management activities of Departmental or Agency Headquarters, and selected major commands. Quotas to the Defense Management Systems Course are controlled by the sponsoring agency; i.e., the Departments of Army, Navy, Air Force, and the Office of the Secretary of Defense.

In addition, the Navy Management Systems Center conducts a four-week Management Course for Commanding Officers, Executive Officers and others directly concerned with Navy shore station management. The purpose of this course is to provide those responsible for managing shore station complexes the most modern management concepts in such areas as facility management, resource management systems, systems and operations analysis, organization and personnel management, and public affairs. Quotas to the Navy Shore Station Management Systems Course are controlled by the Bureau of Naval Personnel, Pers C-3.

The Center has also conducted short courses for foreign governments in their countries and in Monterey.

Faculty members of the Center are a part of the regular faculty of the Postgraduate School.

DEFENSE MANAGEMENT SYSTEMS COURSE

The Planning-Programming-Budgeting System developed since 1961 by the Office of the Secretary of Defense has provided a framework for examining various force mixes, allocation of resources, and relationships to military capabilities.

The objective of the Defense Management Course is to provide an appreciation of the conceipts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of management, including requirements sutdies, systems analysic cost/effectiveness, cost estimating and analysis.

Students are not expected to become experts or technicians in the various disciplines and subjects included in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analyses for decisionmaking, understanding of the principles, methods and techniques used, and awareness of the interfaces between management requirements of the Department of Defense components and the Office of the Secretary of Defense.

The objective of the Navy Shore Station Management Systems Course is to provide Navy Commanding Officers, Executive Officers, and senior staff assistants an understanding of the most modern management concepts, procedures, and techniques as applied in the shore station environment. The relationship to the Defense Planning-Programming-

Budgeting System and higher level objectives are stressed in order to focus attention on the necessary transition in outlook from command afloat to management ashore. The course covers organization and mission accomplishment, resources management, Navy budgeting and financial management, information and control systems, facilities management, behavioral science, and public affairs. Throughout the course emphasis is placed on the application of economic analyses and quantitative methods to improve the overall management of Navy shore stations.

SCHEDULE OF CLASSES FOR FY 71

9 Jul – 17 Jul 70	No.71-1	F/G DMSC
19 Jul – 14 Aug 70	No.71-2	DMSC 4 wk
26 Jul – 31 Jul 70	No.71-3	DMSC (Sem – Output)
16 Aug – 11 Sep 70	No.71-4	DMSC 4 wk
23 Aug – 28 Aug 70	No.71-5	NMSC 1 wk (South Europe)
13 Sep – 9 Oct 70	No.71-6	NMSC 4 wk
11 Oct – 6 Nov 70	No.71-7	DMSC 4 wk
9 Nov – 20 Nov 70	No.71-8	NATO
9 Nov – 20 Nov 70	No.71-9	NMSC 2 wk (Monterey)
29 Nov – 4 Dec 70	No.71-10	DMSC (Sem)
29 Nov – 4 Dec 70	No.71-11	NMSC 1 wk (Hawaii)
10 Dec – 18 Dec 70	No.71-12	F/G DMSC
3 Jan – 2 Apr 71	No.71-13	NMSC 3 mos
3 Jan – 15 Jan 71	No.71-14	NMSC 2 wk (Wash., D.C.)
17 Jan – 12 Feb 71	No.71-15	DMSC 4 wk
14 Feb – 12 Mar 71	No.71-16	DMSC 4 wk
14 Mar – 9 Apr 71	No.71-17	DMSC 4 wk
18 Apr – 14 May 71	No.71-18	DMSC 4 wk
2 May – 28 May 71	No.71-19	NMSC 4 wk
16 May – 11 Jun 71	No.71-20	DMSC 4 wk
6 Jun – 2 Jul 71	No.71-21	DMS (MAP) 4 wk
13 Jun – 18 Jun 71	No.71-22	NMSC 1 wk (Norfolk)
20 June – 15 Jun 71	No.71-23	NMSC 1 wk (Great Lakes)

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961-1965	1966	1967	1968	1969	Total
Bachelor in Arts	....	....	....	180	113	89	57	49	488
B.S. in Aeronautical Engineering	73	212	212	181	34	16	4	6	738
B.S. in Chemistry	....	....	3	3	1	....	....	3	10
B.S. In Communications Engineering	....	....	42	95	24	21	....	....	182
B.S. in Electrical Engineering	62	115	98	253	43	38	37	27	673
B.S. in Engineering Electronics	94	177	92	172	42	39	....	....	616
B.S. in Engineering Science	....	....	....	....	....	....	56	44	100
B.S. in Environmental Science	....	....	....	12	....	....	....	....	12
B.S. in Management	....	....	....	53	1	....	....	....	54
B.S. in Mcdhanical Engineering	43	116	52	82	24	15	8	2	342
B.S. in Meteorology	16	104	77	108	21	13	11	2	352
B.S. in Operations Research	....	....	....	....	....	....	22	12	34
B.S. in Physics	....	15	36	75	16	12	3	2	159
Bachelor of Science	....	56	94	583	117	116	6	3	975
Total Baccalaureat Degrees	288	795	706	1,797	436	359	204	150	4,735
M.S. in Aeroelectronics	....	....	....	4	....	3	....	....	7
M.S. in Aeronautical Engineering	....	....	....	36	24	20	20	26	126
M.S. in Chemistry	....	....	16	5	9	3	7	9	49
M.S. in Communications Engineering	....	....	....	....	6	5	....	....	11
M.S. in Material Science	....	....	....	5	4	3	2	....	14
M.S. in Electrical Engineering	7	34	46	86	21	28	52	97	371
M.S. in Engineering Acoustics	....	....	....	....	....	....	....	6	6
M.S. in Engineering Electronics	68	120	78	104	19	21	....	....	410
M.S. in Management	....	....	....	406	89	116	104	147	862
M.S. in Management/Data Processing	....	....	....	22	22	44	....	....	88
M.S. in Computer Science	....	....	....	....	....	....	....	13	13
M.S. in Computer Systems Mgmt.	....	....	....	....	....	....	39	68	107
M.S. in Mechanical Engineering	20	36	48	49	11	18	19	32	233
M.S. in Meteorology	23	19	40	53	18	12	8	10	183
M.S. in Operations Research	....	....	....	63	45	44	58	53	263
M.S. in Oceanography	....	....	....	....	12	11	40	23	86
M.S. in Physics	....	25	104	135	23	31	27	24	369
Master of Science	....	17	65	102	15	3	17	10	229
Total Master's Degrees	118	251	397	1,070	318	362	393	518	3,427
Aeronautical Engineer	....	....	....	4	6	8	8	6	32
Electrical Engineer	....	....	....	....	....	....	10	15	25
Mechanical Engineer	....	....	....	....	....	....	....	4	4
Doctor of Philosophy	....	....	1	14	7	2	4	6	34
Total Degrees	406	1,046	1,104	2,885	767	731	619	699	8,257

GRADUATES OF THE NAVAL POSTGRADUATE SCHOOL IN 1968

DIPLOMAS OF COMPLETION COMPUTER SCIENCE

FRIEDSAM, Bruce A., LT, USN

DIPLOMAS OF COMPLETION COMPUTER SYSTEMS MANAGEMENT

HOLMES, Robert L., LT, USNR
RUSSELL, Robert E., LT, USN

DIPLOMAS OF COMPLETION ELECTRICAL ENGINEERING

JAMES, Fred L., CAPT, USMC
KOHLER, Charles L., LT, USN

DIPLOMAS OF COMPLETION MANAGEMENT

DONOGHUE, Margaret C., LCDR, USN
KRIEG, William C., LT, USN
WEEMS, Bailey E., LT, USN

DIPLOMAS OF COMPLETION MATHEMATICS

WILKINSON, Alfred J. Jr., ENS, USN

DIPLOMAS OF COMPLETION METEOROLOGY

OTIS, Robert B., LT, USN
VELASCO, Pedro R., LCDR, Philippine Navy

DIPLOMAS OF COMPLETION METEOROLOGY CURRICULUM NO. 371

ALFRED, Larry R., LTJG, USNR
BOUCKE, Steven R., LTJG, USNR
DALRYMPLE, Douglas H., LTJG, USNR
FLETCHER, David D., LTJG, USNR
FOSTER, Kent W., LTJG, USNR
GREULING, Garry L., LTJG, USNR
GRZYBOWSKI, Stanley, Jr., LTJG, USNR
McCALLISTER, Michael A., LTJG, USNR
MOTTRAM, Charles R., LTJG, USNR
TRAPP, Arthur K., LTJG, USNR
UPTON, Thomas G., LTJG, USNR
WEIGANT, Phillip N., LTJG, USNR
WOOLDRIDGE, Francis R., LTJG, USNR

DIPLOMAS OF COMPLETION NUCLEAR ENGINEERING (EFFECTS)

PELLETIER, Armand M., CPT, USA

DIPLOMAS OF COMPLETION OCEANOGRAPHY

BLEAKLEY, Andrew, Jr., LCDR, USN
BOWERS, Robert L., LCDR, USN
BOYD, James S., LT, USN
CROOKS, Stephen C., LT, USN
DEAN, David T., LT, USN.
ESTELL, William A., Jr., LT, USN
EYLAR, Frederick P., LCDR, USN
HANSEN, Thomas P., LCDR, USN
HOUK, Donald R., LT, USN
KEITHLEY, Charles L., Jr., LT, USN
LANGE, Peter S., LT, USN
MATTHEWS, William B., CDR, USN
PASSARELLA, Anthony H., LT, USN
RANES, George J., LCDR, USN
SANDEFER, Howard L., LT, USN
VOGLER, Velma R., LT, USN

DIPLOMAS OF COMPLETION OPERATIONS RESEARCH

HENZY, Charles R., LCDR, USN

DIPLOMAS OF COMPLETION STAFF COMMUNICATIONS

EMMERSON, Milo E., LCDR, USN
HEILAND, Charles E., LCDR, USN
HOLTZSCHUH, Jacob R., LCDR, USN
LOEFFLER, William H., CDR, USN
REED, Richard L., LCDR, USN

ACADEMIC DEGREES

BACHELOR OF ARTS

BAINS, Carroll D., LT, USN
BARNHILL, Hugh K., LT, USN
BERNARDIN, Peter A., LCDR, USN
BEST, James B., LT, USN
BETHEA, Carl L., LCDR, USN
BOLAND, Bruce R., LCDR, USN
CATALDO, John, LT, USN
COLE, Gerald L., LT, USN
COLEMAN, Ernest B., CDR, USN
DeLOACH, Jesse H., LT, USN
DONNEGAN, Richard , LCDR, USN
ECKERD, Kenneth C., CDR, USN
FERRY, James M., LCDR, USN
GILLIAMSEN, Donald A., LCDR, USN
GLADE, Gerald L., LCDR, USN
GOSCHKE, Erwin A., CDR, USN
GREGORY, Donald G., CDR, USN
GREGORY, Kenneth R., LCDR, USN
GRODER, Robert E., CDR, USN
HALL, Thomas J., LCDR, USN
HERSLEY, Janet L., LT, USN
HIGGINS, Thomas G., CDR, USN
JENSEN, Carl T., LCDR, USN
JOHNSON, Robert A., LCDR, USN
JUMPER, Eugene A., Jr., LCDR, USN
KELLER, William E., Jr., LCDR, USN
LAIR, James A., LT, USN
LIMBAUGH, John R., LT, USN
MARTIN, Charles W., Jr., LCDR, USN
MESTER, Richard L., LCDR, USN
MOORE, Harrison M., LCDR, USN
MOORE, Milton W., Jr., CDR, USN
OSTRANDER, Gary L., LT, USN
OYLER, Donald R., LCDR, USN
PALMER, Edward J., LCDR, USN
PIELSTICK, Blake H., LCDR, USN
PIETROWSKI, Joseph L., LCDR, USN
PROMERSBERGER, Edward S., LCDR, USN
ROBERTS, James J., LCDR, USN
RUOTOLO, Anthony P., LCDR, USN
RYAN, Patrick F., LCDR, USN
SMITH, Peter T., LCDR, USN
SOMMERS, Carl W., II, LCDR, USN
SPENCER, Barry W., LCDR, USN
STAUTS, Frank L., LT, USN
STOECKEL, Anthony W., LCDR, USN
TIETGEN, Charles A., Jr., LCDR, USN
WACK, Charles G., LCDR, USN
WALTER, Dale J., LCDR, USN
WARD, John H., LCDR, USN
WARRINGTON, Robert G., LT, USN
WEEKS, Alan L., CDR, USN
WING, Rodney C., LCDR, USN
WINN, Frank N., LCDR, USN
WRIGHT, Robert E., LCDR, USN
YAEGER, Ernest F., LCDR, USN
ZETTERBERG, Forrest L., LT, USN

BACHELOR OF SCIENCE

BRUNNER, Lois M.
EULENSTEIN, Karl H., LCDR, USN
PISTOLESSI, Vincent J., LCDR, USN
POUNDS, Philip C., Jr., LCDR, USN
TAYLOR, Charles C., CDR, USN
TOMENENDAL, Robert J., LCDR, USN

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

BARTOLETT, Frank S., III, LT, USN
MENNING, Frederick H., Jr., MAJ, USMC
SHOWER, Albert J., Jr., LT, USN
WILLIAMS, Gary O., LT, USN

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

BENFORD, Eddie, LT, USN
BOWER, Bruce B., LCDR, USN
BROWN, Bruce G., MAJ, USMC
CANHAM, Lester F., Jr., LT, USN
COSSABOON, Everett E., CAPT, USMC
ELDEM, Ilker, LT, Turkish Navy
FAIRCHILD, Chauncey R., MAJ, USMC
FISHBURN, Charles G., LT, USN
GEHRING, Donald H., CDR, USN
HANCOCK, John B., LT, USN
HARRISON, Kenneth P., MAJ, USMC
HILLER, David W., LT, USCG

HUMPHREY, William B., LT, USN
JONES, Milton H., LT, USN
KIDD, Lawrence A., LT, USCG
KLEMENTZ, Robert W., LT, USN
MARTINEZ, Antonio M., LT, Colombian Navy
MATELLINI, Dante, LT, Peruvian Navy
McINTYRE, David S., MAJ, USMC
MELAND, Ole-Jorgen, LCDR, Royal Norwegian Navy
MIKKELSEN, Sigmund, LCDR, Royal Norwegian Navy
OZER, Ergin, LT, Turkish Navy
REICHART, Harold L., Jr., LCDR, USN
REIMANN, Lyle F., LCDR, USN
RICHARDSON, James C., Jr., LT, USN
ROSSER, Theodore N., LT, USN
SANTIVEJKOOL, Preecha, LCDR Royal Thai Navy
SHROYER, David K., Jr., MAJ, USMC
STERLING, John C., LCDR, USN
TAYLOR, Gaylen D., LCDR, USN
TUZGIRAY, Erkal, LT, Turkish Navy
UNDERWOOD, Walter J., LT, USN
UYGUNLAR, Yasar, LT, Turkish Navy
VASQUEZ DIAZ, Alfredo, LCDR, Venezuelan Navy
VITALI, Henry R., LTCOL, USMC
WALDER, Edward F., LCDR, USN
WISHART, Thomas T., LT, USN

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

AHLGREN, Kenneth L., LCDR, USN
ARMSTRONG, Clarence E., LCDR, USN
BARTON, Jere A., LT, USN
BESS, George D., LCDR, USN
BOCKLER, James M., LT, USN
COLLIGAN, Thomas R., CDR, USN
COPPESS, Robert Y., CDR, USN
CRAWFORD, Bobby C., CDR, USN
DALY, Paul S., LCDR, USN
DeCLERCQ, Keith L., LT, USN
DENSMORE, Ronald E., LT, USN
DONNELLY, Verne G., LCDR, USN
EDWARDS, James C., LCDR, USN
FERRAZZANO, Fred J., CDR, USN
FOLTA, Daniel A., LCDR, USN
FRANZEN, Richard D., LCDR, USN
GROFF, Peter J., LCDR, USN
HOWE, John E., LCDR, USN
HUBBARD, Henry L., LCDR, USN
HUHN, Samuel P., LCDR, USN
HUTH, Vincent J., LT, USN
KATZEN, Murry, LCDR, USN
KLETTER, David M., LCDR, USN
KNAUB, Leroy H., LT, USN
KOLB, John R., LCDR, USN
KRAUS, Kenneth E., LCDR, USN
LIGHTSEY, James L., LCDR, USN
LIU, Pei-Ying, CDR Republic of China Navy

LIVINGSTON, Robert N., CDR, USN
LUCKEN, Frank E., LCDR, USN
MATTSON, John A., LCDR, USN
McLAURIN, John C., Jr., LT, USN
MILLS, Melvin W., LT, USN
MOSSER, John H., Lt, USN
ORMOND, George, Jr., LCDR, USN
ORTMANN, Dean A., CDR, USN
PARTEN, Gary L., LT, USN
POYET, Elmer F., LCDR, USN
RETTIG, Godfrey A., LCDR, USN
RICHMOND, Donald G., LT, USN
ROGERS, Theodore F., LT, USN
RUTH, Paul A., LT, USN
SCHEITER, Gene L., LCDR, USN
SCHIMMING, John G., LCDR, USN
SEIBERT, Markley R., LCDR, USN
SMITH, Robert F., LT, USN
SMITH, Vernon C., LCDR, USN
SPENCER, Charles H., LCDR, USN
STARBUCK, Thomas H., LCDR, USN
STEELE, Richard H., LT, USN
SULLIVAN, Joseph C., LT, USN
TIBBS, John C., LCDR, USN
TUCKER, Thomas A., CDR, USN
VON PERBANDT, Louis K., LCDR, USN
WEIERMANN, Donald H., LT, USN
WHITT, Eugene N., LT, USN

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

BARRAZA, Carlos A., LT, Colombian Navy
BYRNE, Fernando B., LT, Peruvian Navy
INNES, Alexander R., LCDR, USN
LYSAGHT, Claude O., LCDR, USN
ORRISS, David A., LT, USN
POSSO, Victor M., LT, Peruvian Navy
STINSON, William A., LT, USN
TAM, Vo Thanh, LTJG Vietnamese Navy

BACHELOR OF SCIENCE IN METEOROLOGY

BLACKMAR, Fredrik S., III, LCDR, USN
CAREY, William F., LT, USN
FLOWER, John R., LCDR, USN
GARTHNER, John P., LT, USNR
GRAHAM, Ian K., LT, USNR
HEYL, William E., CDR, USN
HILLYARD, William F., LT, USN
JENSEN, James L., Jr., LT, USN
McKINLAY, Archibald V., LCDR, USN
STANSBURY, Frederick A., LT, USN
WALTER, Clyde M., LCDR, USN

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

ALEKSIC, Walter P., MAJ, USMC
BOYER, Larry A., LT, USN
CHILDRESS, Herbert J., Jr., COL, USA
DIRVIANSKIS, Arunas, LCDR, USN
GRAVES, Robert J., LT, USNR
HODGES, Stanley W., LTC, USA
IKEDA, Kenneth K., MAJ, USA
JORDAN, Dennis R., LCDR, USN
KANGAS, John K., CAPT, USMC
KOUBA, George E., LT, USN
KUMMEROW, Ray G., LTCOL, USMC
LENGAUER, George T., MAJ, USMC
MERCADO, Carlos E., LT, USN
NISS, Robert J., LT, USN
PERALES, Sergio R., CAPT, USA
SCHROLLER, Kermit W., LT, USN
SCHNEIDER, Henry J., LCDR, USN
SHORT, Richard H., LT, USN
SWINBURNE, Herbert H., Jr., CAPT, USMC
THIEL, Alphonse A., LT, USN
VOORHEES, Theodore B., MAJ, USA
WHITFIELD, Howard M., MAJ, USMC

BACHELOR OF SCIENCE IN PHYSICS

AGUSTIN, Carlos L., LT Philippine Navy
FINKELSTEIN, Milton M., LT, USN
NORTHRUP, Paul W., LT, USN

MASTER OF SCIENCE

BLISS, Ronald J., ENS, USN
BURTON, Thomas G., ENS, USN
CARPENTER, John D., LT, USN
GREGOR, Richard A., LT, USN
HAMILTON, William H., Jr., ENS, USN
JOHNSON, Patricia C.
LASSWELL, John D., ENS, USN
LAWVER, Allen E., ENS, USN
LEISER, Thomas C., ENS, USN
MACK, Jacob G., III, LT, USN
MOORE, Timothy B., ENS, USN
POTTS, James S., ENS, USN
SEELINGER, James L., ENS, USN
SIMONSEN, Bernard L., ENS, USN
TADYCH, Russell J., ENS, USN
WARD, Paul C., ENS, USN
WRIGHT, Clinton E., ENS, USN

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

BAKER, Owen C., MAJ, USMC
BECK, Gary L., LT, USN
BRINGHURST, William, Jr., LT, USN
CASTLE, Robert W., Jr., LT, USN
HICKMAN, Harold W., Jr., ENS, USN
JACOBS, Gerald K., ENS, USN
JONES, Robert H., CDR, USN
KIEFFER, John A., Jr., 2nd LT, USMC
KNUDSON, Thomas C., ENS, USN
MERRICK, Martin P., LT, USN
MILLER, Anthony D., MAJ, USMC
NIELSEN, David J., ENS, USN
PHELPS, J. Price, Jr., ENS, USN

SMITH, Michael J., ENS, USN
SULLIVAN, John G., ENS, USN
SWEENEY, Charles J., Jr., LCDR, USN
TAFT, Denis J., LCDR, USN
VAN SICKLE, Garth A., ENS, USN
WENDT, Terrill J., ENS, USN
WILLIAMS, David D., LT, USN

MASTER OF SCIENCE IN CHEMISTRY

ABBOTT, William A., LCDR, USN
COLE, Leslie W., MAJ, USA
CRAWFORD, Leslie P., LT, USN
KENNEDY, James M., Jr., MAJ, USA
LINDSAY, Larry A., CPT, USA
MONK, William W., LT, USN
ROSS, Chester G., Jr., CPT, USA

MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

ANDREWS, Ernest L., Jr., LT, USN
BAKER, David J., LT, USN
BARNES, Harry G., Jr., CDR, USN
BIVINS, Howard V., LT, USN
BLACKWELL, Logan C., CDR, USN
COLEMAN, Jon S., LT, USN
CROEBER, Hans R., LCDR, USN
FINLEY, Hugh D., CDR, USN
FRANCIS, Wayne H., LT, USN
HARLOW, Charles E., LCDR, USN
HERTZLER, Gerald A., LT, USN
JOHNSON, Daniel C., CDR, USN
JOHNSON, John L., LT, USN
KEITH, Frederick W., Jr., LCDR, USN
KERNAN, William H., CDR, USN
KINNEY, Ben J., LCDR, USN
KNEPELL, Thomas G., LT, USN
KOCH, William A., LCDR, USN
LESTER, Edwin T., LT, USN
LOVEDAY, William G., Jr., LCDR, USN
LYNE, George C., CDR, USN
NUSS, Gary B., LCDR, USN
PACE, Earl H., LCDR, USN
PETERS, William A., LCDR, USN
PHILLIPS, Max F., CAPT
Canadian Armed Forces
PUCCINI, Joseph E., CDR, USN
REED, John D., LCDR, USN
SCHLECK, Peter J., LCDR, USN
SEEBIRT, James E., LT, USN
SHARP, David R., LT, USN
SIMS, Clifford M., Jr., CDR, USN
SMITH, Roger W., LT, USN
STERRITT, James W., LCDR, USN
STOCK, Merlyn L., LCDR, USN
SWANSON, Peter S., CDR, USN
TOMLIN, Joseph M., LT, USN
VANNI, Ralph J., LCDR, USN
WALLACE, David T., CDR, USN
WELTE, James C., LT, USN

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

AKITA, Richard M., LT, USN
ALTHOUSE, Thomas S., LT, USN
BECHTEL, William D., LT, USCG
BRENTON, Robert J., LT, USN
BYGLER, Kenneth, LT, USN
CADENA, Jorge E., LT,
Colombian Navy
CLARK, Gary D., CAPT, USMC
CLEARY, Francis P., LT, USN
COX, Charles C., LT, USN
DESROSIERS, Richard A., LT, USN
DORRIAN, Leonard V., LT, USCG
FLETCHER, William B., III, LCDR, USN
FUNK, Ronald C., LT, USN
GLAVIS, George O., LT, USN
HAMON, Richard W., LT, USN
HAROLD, Douglas W., Jr., LT, USN
HARRIS, Andrew D., CAPT, USMC
HOBLER, William J., LCDR, USN
HUEBNER, Ray E., CAPT, USMC
HYDE, Wilton H., MAJ, USMC
JEFFERS, Paul R., LT, USN
JIMENEZ, Fernando R., LT,
Peruvian Navy
KOKE, Herbert E., LCDR, USN
KROMER, Ronald C., LT, USN
KULIGOWSKI, Theodore J., LCDR, USN
LARKIN, Robert J., LT, USN
LESZCYNSKI, Vincent J., LCDR, USN
LOHSE, Hans J., LCDR,
Federal German Navy
MacDOUGALL, Donald G., LT, USN
McFARLAND, Robert C., LT, USCG
MITCHELL, Larry G., CAPT, USMC
MOCK, Sanford N., LT, USN
POST, Jerry L., LT, USN
POWERS, Byron L., Jr., LT, USN
RAUTH, James A., LT, USN
RISLER, Eugene S., III, CAPT, USMC
RUDOLPH, Francis A., Jr., CDR, USN
RUIVO, Fernando M.P., LT,
Portuguese Navy
SCALF, Fred R., Jr., LT, USN
SCHILMAN, Richard D., LT, USN
SHOEMAKER, William B., Jr., LT, USN
SHRUM, Richard E., LT, USCG
SIMPLEMAN, Louis L., CAPT, USMC
SKINNER, Garland F., LT, USN
SMITH, Wayne J., LT, USN
STAPLES, Robert D., CAPT, USMC
STARK, William C., LT, USN
STONE, Thomas E., LT, USN
WALKER, John A., Jr., LT, USN
WELLS, Richard P., LT, USN
WEN-T'AO, Chang, LCDR,
Chinese Navy
WILLIMON, Henry P., Jr., LT, USN

MASTER OF SCIENCE IN MANAGEMENT

ABSHIRE, Ronald M., MAJ, USMC
AULT, William U., LCDR, USN
BAILEY, Grover C., III. LT, USN
BAKER, James H., LCDR, USN
BATDORF, Paul D., LCDR, USN
BENTON, Archie E., CDR, USN
BIKAKIS, Charles N., CAPT, USMC
BOOTHE, Allen P., LCDR, USN
BROCKWELL, Sterling M., Jr., LCDR, USN
BURGER, Henry K., CDR, USN
BURGESS, Richard S., MAJ, USMC
CARY, Kenneth H., Jr., LT, USCG
CLARITY, Michael G., LCDR, USN
CLARK, Charles F., LCDR, USN
COFFMAN, Harold L., LTCOL, USMC
CONNOLLY, James J., MAJ, USMC
DESMARAIS, Normand D., LT, USN
DEZER, Charles N., III, LTCOL, USMC
DOBBINS, John B., Jr., CDR, USN
DONAHOO, Newell T., LTCOL, USMC
DORAN, Edwin J., MAJ, USMC
EMERY, William M., CDR, USN
EVANS, George F., LCDR, USN
FESTA, Donald, MAJ, USMC
FITTS, William D., III, MAJ, USMC
FOUCHT, Richard A., CDR, USN
GANZ, James G., LT, USN
GELKE, John J., LCDR, USN
GILMORE, Gordon R., LCDR, USN
GLADIN, Jack R., LCDR, USN
GORENFLO, Louis W., LCDR, USN
GRAESSLE, Ernest J., LCDR, USN
GROSSOEHME, Clyde, LCDR, USN
GRUEL, Carl A., LCDR, USCG
HENNEBERRY, Paul D., LCDR, USCG
HERN, William R., LT, USN
HINES, David R., MAJ, USMC
HOOPES, Ronald G., LCDR, USN
HOWLAND, William B., LCDR, USCG
HUGHES, Ray S., CDR, USN
HUNTER, Robert M., CAPT, USMCR
JONES, Harry L., CDR, USN
KALLIES, Richard H., CDR, USN
KEE, William D., Jr., LT, USN
KEPPEL, Henry E., Jr., CDR, USN
KERR, Richard G., CDR, USCG
KERRIGAN, Robert J., LCDR, USN
KIRKPATRICK, James D., LCDR, USN
KIRKWOOD, Kenneth K., CDR, USN
KLINE, Edward J., CAPT, USMC
KRAEMER, Kenton K., LCDR, USN
LAYTON, Donald M., CDR, USN
LEDDER, William R., CDR, USN
LEIGHTLEY, Albert L., II, LT, USN
LORD, Charles W., LCDR, USN
LOVELAND, Gary N., CAPT, USMC
MAYO, Norman A., LCDR, USN
McCARTY, John E., LT, USCG
McDANIEL, Roderick D., LCDR, USN
McHUGH, Vincent J., LT, USN
McNEEL, Ted C., MAJ, USMC
MILLIGAN, Richard D., LCDR, USN
MURPHY, Henry T., Jr., LT, USN
MURRAY, Edward P., LT, USN
NELSON, Paul C., LCDR, USN
NETRO, Robert J., CDR, USN
O'CONNELL, John F., CDR, USN

OLSON, Glenn A., MAJ, USMC
OUTLAW, Thurber A., Jr., CDR, USN
PARO, Eugene E., LTCOL, USMC
PATTILLO, Elmer F., LTCOL, USMC
PIERCE, Ray E., CDR, USN
POWDERMAKER, Mark M., LT, USCGR
PRESSLEY, Joseph L., LT, USN
QUARLES, James M., LT, USN
RAMSDEN, Donald H., LT, USCG
RATH, Arthur R., LT, USN
RICKETTS, Myron V., CDR, USN
RODHOUSE, Thomas E., CAPT, USMC
ROTHWELL, Richard B., CAPT, USMC
RUCKER, William A., LCDR, USN
SANDER, Richard E., CDR, USN
SCHNETZLER, Estill, CDR, USN
SCLICHTER, Edward F., LT, USN
SHIRLEY, Ronald G., CDR, USN
SILVA, Francis F., LCDR, USCG
SMITH, Ralph A., III, CDR, USN
SOCHA, Albert R., CDR, USN
SPENCER, John R., CDR, USN
SPROAT, John R., LT, USCG
STEADLEY, Alfred M., LCDR, USN
STEVENS, John M., CAPT, USMC
STRAHM, Kenneth A., LCDR, USN
STRONG, Bruce W., LCDR, USN
SUMMERS, Theodore, LTCOL, USMC
THOMLEY, Robert R., MAJ, USMC
TYSON, Joseph F., LCDR, USCG
WALDER, Edward F., LCDR, USN
WHEELER, James B., CDR, USN
WILSON, Thomas H., CDR, USN
WOOD, Charles D., MAJ, USMC
WOOD, Lewis I., CDR, USN
WUERCH, George P., MAJ, USMC
WULFF, Wilhelm A., LCDR, USCG

MASTER OF SCIENCE IN MATERIAL SCIENCE

HERING, Frederic S., LT, USN
YEHYA, Mohammad A., CDR, Pakistani Navy

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

BRECKENRIDGE, Donald R., LT, USN
BRUNO, Marco J., LT, USN
BURGES, Rufus T., LT, USN
CARSON, William G., LCDR, USN
COSTELLO, Robert G., LT, USN
CUNANAN, Carlito Y., LT, Philippine Navy
ELLER, John C., LT, USN
FANTIN, Jon R., LT, USN
HARLEY, James H., LT, USN
HARTMAN, William A., LT, USN
JOHNSON, Larry D., LT, USN
KESLER, Kenneth L., LT, USN
KNIGHT, John M., LT, USN
LOVELAND, Kenneth W., LT, USN
MALONE, John P., LT, USN
PHASOOK, Sompong, LCDR, Royal Thai Navy
RUTHERFORD, Paul F., LT, USN
SAMPSEL, Michael M., LT, USN
UMBERGER, Paul J., LT, USN

MASTER OF SCIENCE IN METEOROLOGY

BEAULIEU, Eugene L., LT, USN
DANFORTH, William L., LT, USN
JACOBS, Ralph E., LT, USNR
KALINYAK, Paul P., LCDR, USN
KESEL, Philip G., LT, USN
LEVINGS, William H., III, LT, USN
MORFORD, Dean R., CDR, USN
OAKES, Dudley G., LT, USN

MASTER OF SCIENCE IN OCEANOGRAPHY

BARDESCHEWSKI, Walter P., LT, USN
BURROW, James B., Jr., LT, USN
CARSWELL, Michael S., LCDR, USN
CHAMPION, Robert H., LT, USN
CRAMER, Thomas H., LT, USN
DOOLEY, John J., LT, USN
DORMAN, Craig E., LT, USN
DOYLE, Ronald J., LCDR, USN
DUNLAP, Calvin R., III, LT, USN
ERCHUL, Ronald A., LT, USN
EUBANKS, Glen E., LT, USN
FREEHILL, Robert L., LT, USN
GLENN, Walter L., Jr., LT, USN
GROSFILS, Eric F., LT, USN
HOLLY, Richard W., LT, USN
HONHART, David C., LT, USN
I'ANSON, Lawrence W., Jr., LCDR, USN
KLINEDINST, Paul R., Jr., LCDR, USN
KOLODZIEJ, John S., LT, USN
MARQUIS, Richard I., LT, USN
MAYS, Michael E., LT, USN
McMILLAM, John G., LCDR, USN
MORITZ, Carl A., Jr., LT, USN
MOYNIHAN, Martin J., LT, USCG
NJUS, Ingmar J., LT, USN
NUNN, Silas O., III, LCDR, USN
ONORATI, Roger P., LT, USN
ORTENGREN, Ralph W., Jr., LT, USN
PAQUIN, James E., LT, USN
PHILIPPS, George, LCDR, USN
RAMZY, James R., CDR, USN
ROBERTS, Charles K., LT, USN
SCHLANK, John J., Jr., CDR, USN
SEARS, Johnny M., LCDR, USN
STEELE, Boyden T., LT, USN
TARANTO, Richard, LT, USNR
WAER, Richard D., LT, USN
WALLIN, Steven R., LT, USN
YESKE, Lanny A., LT, USN
YOUNG, Ernest T., Jr., LCDR, USN

MASTER OF SCIENCE IN OPERATIONS RESEARCH

ABBEY, Donald L., LT, USN
ABLOWICH, Ronald E., CAPT, USMC
ALLEN, Thomas H., Jr., LTCOL, USMC
ALLISON, Kenneth L., LCDR, USN
AUCELLA, John P., LT, USN
BESECKER, John A., LCDR, USN
BOES, Richard W., MAJ, USA
BOHLS, Robert J., CPT, USA
BROWN, Earl E., MAJ, USMC
BURNELL, Robert W., MAJ, USA
BURNS, William C., Jr., CPT, USA
CHENAULT, Richard F., MAJ, USMC
CLARK, David G., LT, USN
COOK, John M., LT, USN
DAESCHNER, William E., LT, USN
EASTERBROOK, John E., CPT, USA
ENKBOLL, Richard E., LCDR, USN
FRANKS, Francis J., MAJ, USA
GARVEY, Richard E., CPT, USA
GILLESPIE, Clarke M., Jr., CPT, USA
GIROUARD, Richard J., CPT, USN
HAGAN, Craig A., MAJ, USA
HEGERICH, Robert L., MAJ, USA
HENRY, John R., III, MAJ, USA
HEY, John M., MAJ, USMC
HOBART, Charles W., CPT, USA
HUFFMAN, Kenneth A., LT, USN
KEIM, Clarence H., LCDR, USN
LANIGAN, John D., CAPT, USMC
LELAND, Edwin S., Jr., MAJ, USA
LOCKETT, Joseph J., LT, USN
MacGREGOR, Harry G., MAJ, USA
McGRATH, John, CPT, USA
McNEILL, J. BRUCE, LT, USN
MIKKELSON, David W., MAJ, USA
MILLER, William S., Jr., LTCOL, USMC
MODINE, Kent A., CPT, USA
MOORE, Johnnie R., CDR, USN
MORAN, Maurice J., LT, USN
O'BRIEN, Paul W., CAPT, USMC
O'CONNELL, James T., Jr., MAJ, USA
PATTERSON, Bernard L., LT, USN
SCHOTTLE, Howard T., LT, USN
SCHWABE, William L., LT, USNR
SINGER, Edward A., LT, USN
SPARKS, Donald L., CPT, USA
STERNER, George R., LT, USN
STORY, William E., LT, USN
THOMAS, James P., LCDR, USN
TUGGLE, Ralph E., LCDR, USN
TULLY, Albert P., LT, USN
VENZKE, Gene A., MAJ, USA
VICK, Gerald A., CPT, USA
VOGT, Robert L., MAJ, USMC
WEBSTER, John A., Jr., LCDR, USN
WERTZ, Peter D., LCDR, USN
WEST, Frederick J., LT, USN
WILSON, Gifford D., MAJ, USA

MASTER OF SCIENCE IN PHYSICS

ANDREWS, Roger C., CPT, USA
ARMSTRONG, Jesse W., LT, USN
CARTER, Thomas L., CAPT, USMC
COHEN, Steven R., LT, USN
CONNOR, George H., Jr., MAJ, USA
COURTNEY, Wallace C., LCDR, USN
DAVIS, William J., CAPT, USAF
FERRITER, Nicholas M., LT, USN
FOWLER, Richard C., LT, USN
GOODWIN, James C., Jr., LCDR, USN
GORDON, Robert H., LT, USN
KELLER, Douglas G., LT, USN
McCLANAHAN, Ted, LT, USN
MERVINE, Lowrie R., LT, USN
MILLER, Royce D., MAJ, USA
NAKAYAMA, Homer S., LT, USN
OATES, Anthony B., LT, USN
OLSON, Phillip R., LT, USN
ORLICKI, George A., CAPT, USA
RIDGELY, Philip J., LT, USN
RING, Henry M., LT, USN
SCHEIBLE, Jack W., LCDR, USN
SENDEK, Joseph M., LCDR, USN
SLYE, Richard E., LCDR, USN
THOMAS, Kinnison H., LCDR, USN
TULLINGTON, Bernard J., Jr., MAJ, USA
WOOLERY, Edgar F., CDR, USN

AERONAUTICAL ENGINEER

CHRANS, Larry J., LT, USN
GALLO, Salvatore F., LCDR, USN
HEINZ, William J., LT, USN
JOHNSON, Ronald B., LT, USN
LENSINI, Martin J., CAPT, USMC
LLOYD, Robert C., LT, USN
McDONALD, William M., LT, USN
SWIFT, James K., LT, USN

ELECTRICAL ENGINEER

BATTENBURG, John A., CDR, USN
BYGLER, Kenneth, LT, USN
HOLMES, Stacy V., LT, USN
LOHSE, Hans J., LCDR,
Federal German Navy
POST, Jerry L., LT, USN
RAUTH, James A., LT, USN
SKETOE, James G., CAPT, USMC
SMITH, Wayne J., LT, USN
TAYLOR, John F., LT, USN
WICKENS, Justin H., CAPT, USMC

DOCTOR OF PHILOSOPHY

BUSH, Thomas O., LT, USN
KIMBLE, Charles D., LCDR, USN
STURM, Edward J., LT, USN
WARDLE, Norval L., LT, USN

GRADUATES OF THE NAVAL POSTGRADUATE SCHOOL IN 1969

DIPLOMAS OF COMPLETION COMPUTER SYSTEMS MANAGEMENT

BARRINGER, Larry E., LCDR, USN
BURIN, Michael, LTCOL, USMC
BUTTS, Whitmore S., Jr., LCDR, USN
DOMBROWSKI, Katherine M., LT, USN
ENGMAN, Lee M., LT, USN
HANSON, Robert C., LT, USN
HODAPP, Charles A., LT, USN
KIDD, George N., LT, USN
MILLER, Bryce N., CDR, USN
POREMBA, Stanley, Jr., LCDR, USN
SANDERS, James E., CAPT, USN

DIPLOMAS OF COMPLETION ELECTRICAL ENGINEERING

BELMORE, Richard K., LT, USN
BRADY, Charles R., LT, USN
ISON, William B., Jr., LT, USN
LAWSON, Urbie A., LT, USN
MOOREHEAD, William S., LT, USN

DIPLOMAS OF COMPLETION ENGINEERING SCIENCE

HOKANSON, Anders, Jr., LT, USN
KNIGHT, Daniel, LT, USN

DIPLOMAS OF COMPLETION IMMEDIATE GRADUATE EDUCATION PROGRAM

BELL, John F., LTJG, USN
BOGERT, James A., LTJG, USN
DINGA, John P., LTJG, USNR
EDWARDS, Arthur L., LTJG, USN
EDWARDS, Wilbur E., LTJG, USN
O'DELL, Edward J., LTJG, USN
SPENGLER, Richard P., LTJG. USN

DIPLOMAS OF COMPLETION MANAGEMENT

COFFIN, William M., LTJG, USN
HOPSON, Bennie R., LT, USNR
WHITNEY, Gerald A., LTJG, USN

DIPLOMAS OF COMPLETION METEOROLOGY

ERICKSON, Lawrence E., LT, USN
SMITH, David C., LT, USNR
VAN SICKLE, Kenneth L., LT, USN

DIPLOMAS OF COMPLETION METEOROLOGY NO. 371

BELLEMER, Gordon A., LTJG, USNR
BRACHER, Christian C., LTJG, USNR
BRUNS, Warren A., LTJG, USNR
DUNHAM, Thomas C., LTJG, USNR
ELIAS, William T., LTJG, USNR
GARDNER, Stowe T., LTJG, USNR
HACK, Walter A., LTJG, USNR
HALE, Ronald E., LTJG, USNR
HUFF, Roger P., LTJG, USNR
HUMMEL, Edward P., LTJG, USNR
LEARY, Richard K., LTJG, USNR
SCHWARTZ, Mayer D., LTJG, USNR
UNFRIED, Douglas E., LTJG, USNR
WALLACE, Richard T., LTJG, USNR

DIPLOMAS OF COMPLETION OCEANOGRAPHY

BORDEN, Douglas H., Jr., CDR, USN
DATTILO, Frank, III, LT, USN
HAYDOCK, Donald G., LCDR, USN
JENKINS, Wendal L., LCDR, USN
KALINOSKI, Edward F., LT, USN
KIRK, Francis M., Jr., LT, USN
PIERCE, George E., LCDR, USN
WURTS, Edward V., III, LT, USN
ZARETKI, John P., LT, USN

DIPLOMAS OF COMPLETION OPERATIONS RESEARCH

BUZZEL, Carlisle W., Jr., CDR, USN
LENHART, George D., MAJ, USA

DIPLOMAS OF COMPLETION PHYSICS

POTTER, Stanley B., MAJ, USA

DIPLOMAS OF COMPLETION STAFF COMMUNICATIONS

ANDREWS, Michael K., LT, USN
BLEYNAT, Edward L., LCDR, USN
COMISKEY, Michael R., LCDR, USN
HAGAN, Wayne E., LCDR, USN
JOHNSON, Kenneth M., LT, USN
KREBS, Richard F., LT, USNR
O'DONNELL, Francis X., LT, USN
RICE, Roy J., LCDR, USN
ROKOWSKI, Ernest L., LCDR, USN
SANDERS, Charles J., LT, USNR
SUTTON, Gwynn R., LT, USN
TOLLEFSEN, Thomas S., LT, USN

ACADEMIC DEGREES

BACHELOR OF ARTS

AIKEN, William P., LT, USN
ARTUSO, Michael A., CDR, USN
ASTORINO, Gerald P., LCDR, USN
ATKINS, Raymond C., LT, USN
BEEMAN, Ray N., Jr., LT, USN
BENSON, Patricia C., LT, USN
BOWERS, Richard F., LCDR, USN
BRUCE, Rowlett H., Jr., LCDR, USN
CARTWRIGHT, Jackson E., LCDR, USN
CATE, Thomas R., Jr., CDR, USN
CATRON, Jerry M., LCDR, USN
CLEVELAND, Robert M., LCDR, USN
COSTELLO, Donald H., LCDR, USN
DEE, James D., Jr., LDCR, USN
DUCHESNE, Robert E., LT, USN
EASON, William G., LCDR, USN
FLYNN, William J., LCDR, USN
FREDERICK, Keith J., LCDR, USN
FUNDERBURK, Jeryl D., LCDR, USN
GURKE, Donald L., LCDR, USN
JONES, Jerry D., CDR, USN
KING, Charles C., LCDR, USN
KOESTER, Earl C., II, CDR, USN
LOW, Joseph L., LCDR, USN
MATT, George E., Jr., LCDR, USN
MIEFERT, Milton D., Jr., LCDR, USN
MOORE, Earle G., CDR, USN
MORAN, Thomas J., LCDR, USN
OVERSTREET, George H., LCDR, USN
PAISLEY, John B., III, CDR, USN
PAPIO, E.M., CDR, USN
PEARL, Harlan R., CDR, USN
PETITT, William E., LT, USN
PHILLIPS, Joseph L., LT, USN
POWELL, Daniel G., LCDR, USN
PYLE, Roger G., CDR, USN
RANDOLPH, William L., LT, USN
RICE, Robert P., CDR, USN
RUSSELL, Earl H., LCDR, USN
SHAPERO, Allen L., LCDR, USN
SINGLETON, Harold L., LT, USN
SMITH, Leo L., Jr., LT, USN
SMITH, William C., LCDR, USN
SQUIBB, Rodney K., LCDR, USN
STOREY, Edward L., LCDR, USN
STUBBS, Darryl A., LT, USN
THESING, Kenneth L., LT, USN
WALÇK, Claude W., CDR, USN
WEBER, Richard M., CDR, USN

BACHELOR OF SCIENCE

BURNETT, William M., CDR, USN
CONAWAY, Larry J., LT, USNR
TAYLOR, Herbert W., LT, USN

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

EDDINS, Charles W., LT, USN
INGRAM, Isom I., LT, USN
JONES, Patrick J., CAPT, USMC
REED, Gary A., LT, USN
SMITH, Michael O., LT, USN
TOWNSEND, William J., LCDR, USN

BACHELOR OF SCIENCE IN CHEMISTRY

FRANTZ, Calvin C., MAJ, USMC

KOSLOWSKI, Stanley C., LT, USN
PEKCELEN, Sina, LTJG
Turkish Navy

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

AKIN, Mehmet, LTJG
Turkish Navy
BARAN, Savas Umit, LTJG
Turkish Navy
BEZRUTCH, Rudolph A., LT, USN
BURROWS, Robert G., LCDR, USN
CHAUNCEY, Gregory A., LT, USN
CROTTEAU, Robert A., LTJG, USN
GARWICK, Gerald G., CAPT, USMC
HAFNER, Arnold N., CAPT, USMC
HARDEN, Harold E., LT, USN
HESS, Sigurd F., LCDR
Federal German Navy
JOVER, Hernani M., LT
Philippine Navy
KATRIS, Prokopios, LT
Royal Hellenic Navy
KUNKEL, Henry L., MAJ, USMC
LARA, Juan F., LCDR
Venezuelan Navy
MacKENZIE, Franklin F., LCDR, USN
MacMILLAN, A. Ian, LT
Canadian Forces
NEEDHAM, James S., MAJ, USMC
NELSON, Garry D., 2nd LT, USMC
PRATHER, Jerauld S., LT, USN
RHINEBECK, George C., LCDR, USN
SCHULTZ, Konrad G., LT
Federal German Navy
STARKWEATHER, Dana W., LT, USCG
VILLALBA, Luis G.H., LTJG
Ecuadorian Navy
WALSTON, Kenneth R., LCDR, USN
WILLIAMS, Jack R., LT, USN
YUKSEL, Erol, LTJG
Turkish Navy
ZIMMERMAN, Ralph A., MAJ, USMC

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

ABRAHAMSEN, David L., LT, USN
AKIN, Hurston B., LCDR, USN
BETTS, William M., LCDR, USN
BOYD, Richard M., LCDR, USN
CHALMERS, William C., LCDR, USN
CHEESER, Marvin B., Jr., LT, USN
CONNELLY, James H., Jr., LCDR, USN
DANAHER, Robert J., LT, USN
DAWSON, Phillip E., Jr., LCDR, USN
DICKSON, John A., CDR, USN
DUNLAP, James H., LCDR, USN
EATON, Donald R., LCDR, USN
EGAN, Robert W., LCDR, USN
FANNON, James E., Jr., LCDR, USN
GARRETT, Roger D., LCDR, USN
GRAHAM, David B., LT, USN
HAMMAN, Kenneth A., LCDR, USN
HARTRANFT, Richard, J., CDR, USN
HULLANDER, Robert A., CDR, USN
HUNTER, Wallace R., LCDR, USN
JOHNSON, Billie D., CDR, USN
KORTHE, James D., LCDR, USN
LACEY, John S., Jr., LT, USN
LACY, William A., LCDR, USN
LAMBERTH, Billy C., LCDR, USN
MacDONALD, Richard W., LCDR, USN
MARSHALL, Norman G., CDR, USN
McCORMICK, Gerald J., LCDR, USN
McDONALD, Gerald W., LCDR, USN
MERKLER, George J., CDR, USN
MOUSER, Hugh P., LCDR, USN
MOWERY, Gary W., LT, USN
MURRAY, James C., LCDR, USN
NAHLOVSKY, Richard E., LCDR, USN
PULLINGER, William A., LT, USN
ROBISON, Delma C., Jr., LCDR, USN
RUST, Robert S., LT, USN
SAMMONS, Charles E., LT, USN
SCOFFIELD, Gary A., LCDR, USN
SWITZER, Robert J., CDR, USN
THAYER, Albert J., CDR, USN
THORPE, Paul J., LCDR, USN
TRYGSLAND, Arnold L., CDR, USN
WANNER, Theodore M., LCDR, USN

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

NAKSORN, Sathaphorn, LCDR
Royal Thai Navy
PEREZ, Pablo P., LTJG
Philippine Navy

BACHELOR OF SCIENCE IN METEOROLOGY

GUZMAN S., Fernando, LTJG
Chilean Navy
SWAN, Thor O., LT, USN

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

CICOLANI, Angelo G., LCDR, USN
COOPER, George T., LT, USN
FRANKLIN, Ted G., LT, USN
KELDAY, John J., MAJ, USMC
KOBAR, Michael L., LT, USN
MCCAIN Charles M., MAJ, USMC
MCRANEY, Curtis D., MAJ, USMC
NYSTROM, Stephen C., LT, USN
PENNINGTON, Chad A., LT, USN
RUTEMILLER, Oren G., LCDR, USN
WHITE, Charles L., CDR, USN
WILLIAMS, Michael V., LT, USN

BACHELOR OF SCIENCE IN PHYSICS

FORD, William R., MAJ, USA
GRIFFIN, Linwood, III, CPT, USA

MASTER OF SCIENCE

CULLEN, James S., LTJG, USN
DAVIS, William R., LTJG, USN
HENNINGER, Ernest H., LTJG., USN
HOLMES, Robert A., LTJG, USN
JONES, James D., 2nd LT, USMC
KNODE, Ronald B., LTJG, USN
PYRZ, Kenneth E., LTJG, USN
RINALDI, Ronald A., LTJG, USN
SVENDSGAARD, David J., LT, USN
SWEENEY, Orval L., LTJG, USN

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

ALLEN, Terry J., LTJG, USN
BATES, Robert C., LT, USN
BROWN, George E., Jr., LT, USN
BULMAN, Melvin J., LTJG, USN
CASWELL, David W., CDR, USN
CHAMBERS, Russel A., CAPT, USMC
COREY, Robert O., Jr., LTJG, USN
DITCHEY, Robert L., LT, USN
DUNCAN, Thomas J., LT, USN
ESDAILE, Stewart G., CAPT
Canadian Armed Forces
GASTROCK, Barry A., LT, USN
HOOD, John M., Jr., LT, USN
KIEL, Joseph A., LT, USN
KOCH, Larry N., LT, USN
LAACK, Dennis R., LT, USN
MERCER, Thomas A., LT, USN
OBER, William T., II, LTJG, USN
PENARANDA, Federico A., LCDR
Chilean Navy
RICHARDE, Henry M., Jr., LT, USN
SALLEE, Fred M., LTJG, USN
STROUSE, Robert D., 2nd LT, USMC
VORHOFF, Gilbert H., Jr., LTJG, USN
WALLACE, David W., LTJG, USN
WATSON, Randolph G., LT, USN
WILLETTS, Leo J., Jr., LT, USN
WISLER, Larry S., LTJG, USN

MASTER OF SCIENCE IN CHEMISTRY

FAGAN, Ward F., MAJ, USA
FUKUMOTO, George M., LTC, USA
HUNT, John W., MAJ, USA
GISCH, Robert G., LTJG, USN
McCORRY, John H., LCDR, USN
MIDAS, Michael T., Jr., LCDR, USN
NIERMAN, William C., LTJG, USN
NOBLE, Donald S., LT, USN
PEKCELEN, Sina, LTJG
Turkish Navy

MASTER OF SCIENCE IN COMPUTER SCIENCE

AKERS, Max N., LCDR, USN
ARNOLD, Robert J., LT, USNR
BACON, Roger F., Sr., LCDR, USN
COOPER, John D., Jr., LCDR, USN
FRELICH, Alan W., LT, USN
GENTRY, Donald G., LT, USN
GOODMAN, Ronald M., LT USNR
HENRY, Robert L., LCDR, USN
HOLIFIELD, Claude M., Jr., MAJ, USMC
LEAHY, John F., III, LT, USN
MASSA, Lawrence L., LCDR, USN
PIVONKA, Leo M., LT, USNR
ROTH, Michael C., LT, USN

MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

AGAMAITE, James N., LT, USN
ALLISON, Paul, CDR, USN
ALTAMIRANO, Hugo M., LCDR Uruguayan Navy
ARNOLD, Larry J., LT, USN
BATZEL, Thomas J., LT, USN
BATZLER, John R., CDR, USN
BLACK, Jerry H., LT, USN
BOYD, Robert L., LCDR, USN
BOYER, Philip A., III, LT, USN
BRYANT, William R., CDR, USN
CARPENTER, Harry U., Jr., LTCOL, USMC
CARPENTER, Thomas M., CAPT, USMC
CISZEWSKI, Robert A., LT, USN
COLLEY, Michael C., LCDR, USN
CORNETT, Kenneth H., LCDR, USN
CRAWFORD, Charles W., LT, USN
DAVIS, Robert T., II, LT, USN
DECKER, Joel P. W., LT, USN
EVANS, Thomas G., CDR, USN
FERGUSON, Jerry E., LT, USN
FOSTER, Edward B., MAJ, USMC
GADDIS, Carl K., LCDR, USN
GENTRY, Harry R., MAJ, USMC
HALL, James B., LT, USN
HANKEY, Joan R., LT, USN
HARRIS, Donald E., Jr., LCDR, USN
HAUGEN, Ronald G., LT, USN
HAYS, George E., Jr., LT, USN
HYMAN, William M., LT, USN
KAMPFER, John B., MAJ, USA
KETTERING, Alvah J., MAJ, USMC
KITTOCK, Kenneth E., LCDR, USN
KIVLEN, Alexander L., CDR, USN
KOZLOWSKI, Neil L., LT, USN
KRONZ, James C., LT, USN
KURKA, George J., CPT, USA
LETTINGTON, Thomas F., LCDR, USN
LEWIS, John H., LCDR, USN
LIGON, Samuel J., Jr., LCDR, USN
MADEIRA, Renato P., LT Portuguese Navy
MARTIN, Gene H., LTCOL, USMC
MAYERS, John J., MAJ, USA
McGONAGLE, Leo E., LT, USN
MERRITT, Frederick D., CDR, USN
MERZ, Vincent P., LT, USN
MITCHELL, Richard F., LT, USN
MONISH, Aubrey R., LT, USN
MOORE, Richard C., CDR, USN
MOSHER, Thomas F., CDR, USN
MOYNAHAN, Michael J., LT, USN
MURRAY, Michael A., LT, USN
RAMSAY, Robert W., Jr., LCDR, USN
RAY, Donald J., LT, USN
REEMELIN, Thomas E., LT, USN
REILLY, Iain, CPT, USA
RUESE, Edward F., CDR, USN
SANDERS, Frederick H., LCDR, USNR
SANDERS, Tommy L., LCDR, USN
SHRECKENGAUST, James A., LCDR, USN
SIBURT, Forrest N., Jr., LT, USN
SKINNER, Albert G., LCDR, USN
SMITH, Clay R., Jr., MAJ, USA
STANGLE, William J., LCDR, USN
TOBIN, Paul E., Jr., LT, USN
WALTERS, Claude J., LT, USN
WILDER, Richard L., LCDR, USN
WILKINSON, John G., Jr., LT, USN
WOLFARTH, William M., Jr., MAJ, USA

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

ALLEN, Richard O., Jr., LCDR, USN
BARTOL, John H., Jr., LT, USN
BIERMAN, Edward D., MAJ, USMC
BOND, William H., MAJ, USMC
BROBERG, Harold L., CAPT, USMC
BURNS, Arthur E., CAPT, USMC
CHESSON, John W., CAPT, USMC
CHWATEK, Walter T., MAJ, USMC
COURVILLE, James D., LTJG, USN
CROTTEAU, Robert A., LTJG, USN
CRUMLY, William A., LT, USNR
DAVIS, John P., LTJG, USN
DESENS, Robert B., LT, USN
DIETZLER, Andrew J., LT, USN
D'PAOLA L., Jesus E., LCDR Venezuelan Navy
DUBAC, Carl H., MAJ, USMC
DUKAT, Frank, LT, USN
DUMAS, Jeffrey M., LTJG, USN
DONALDSON, William J., LT, USN
DURKEE, Andrew F., Jr., LT, USCG
DYER, James R., LTJG, USN
ELDEM, Ilker, LT Turkish Navy
ENRIGHT, Patric S., CAPT, USMC
ERB, Robert S., LTJG, USN
FENTON, Robert E., LT, USCG
FERGUSON, Robert D., LT, USN
FLOOM, MARVIN H., Jr., 2nd LT, USMC
FOCHT, George A., CAPT, USMC
FRANSON, Alvin, LT, USN
FULK, Gerald A., CDR, USN
GOODMAN, Gill R., LT, USCG
GRANT, Gary M., LTJG, USN
GRASSER, Philip F., LT, USN
GRAY, Lawrence A., LTJG, USN
HAGEE, Michael W., 2nd LT, USMC
HALL, Eugene M., LCDR, USN
HASSARD, Roger W., LT, USCG
HENRY, Charles A., MAJ, USMC
HOOD, John T., LT, USN
HOPKINS, Raymond J., LTJG, USN
HOSKING, William J., LT, USNR
HSIUNG, Yun Lan, LCDR Chinese Navy
HUELSEKOPF, Gert-Wolfgang, LCDR Federal German Navy
JAMERSON, Clifford L., LT, USN
KALASHIAN, Michael A., 2nd LT, USMC
KATRIS, Procopios A., LT Royal Hellenic Navy
KELLEM, Carl W., LT, USN
KISLACK, Arthur, LT, USN
KJELLANDER, Jon P., LTJG, USN
KLEYN, Frederick G., LT, USN
KNIGHT, Windall R., LT, USN
KRAUSS, Willi K.A., LCDR Federal German Navy
KULESZ, James J., Jr., LT, USN
LANDAZURI, Ruben J., LT Ecuadorian Navy
LARA, Juan F., LCDR Venezuelan Navy
LAU, James, CAPT, USMC
LEE, Ronald A., LT, USN
LESEMANN, Donald F., LT, USN
LINDSAY, James H., Jr., LT, USN
McCUNE, George B., LCDR, USN
McGOUGH, Charles R., LTJG, USN
MILES, Larry E., LT, USN
MYATT, James A., CAPT, USMC
MYERS, David L., LTJG, USN
NALE, James F., LT, USN
NEWCOMB, William L., LT, USN
NEWTON, Eugene D., LT, USN
NICHOLS, Roger A., LCDR, USN
NILSEN, Tor R., LCDR Royal Norwegian Navy
OFFENBERG, Jerome W., LT, USNR
O'NEILL, Vincent E., CPAT, USMC
OZER, Ergin, LT, Turkish Navy
PALM, Peter E., LT, USN
PETERSON, Robert L., LTJG, USN
POLK, Michael R., LTJG, USN
RAY, Roy L., LT, USN

REGENER, Donald F., LTJG, USN
ROEDER, Bernard F., Jr., LT, USN
ROZELLE, Edward C., LT, USN
SAGERIAN, Ara, LT, USN
SAXMAN, Jonathan H., LTJG, USN
SCHMIDT, William C., LT, USN
SHAPIRO, Bruce L., MAJ, USMC
SHIELDS, Russell K., LCDR, USN
SIEREN, Gerald J., LT, USN
SPITZER, Norbert J., MAJ, USMC
TARNOPILSKY, Walter, CAPT, USMC
TAYLOR, Alec P., Jr., LCDR, USN
TUZGIRAY, Erkal, LT
Turkish Navy
TYNER, Jimmie C., LT, USN
UYGUNLAR, Yasar, LT
Turkish Navy
WAFF, William B., LT, USCG
WALSH, Philip J., CAPT, USMC
WASHAM, Eric L., LTJG, USN
WELLBORN, Raymond B., LCDR, USN
WILLMAN, Carl E., LT, USN
ZIMMERMAN, Claus E., LT, USN

MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

GRIFFITHS, David J., LT, USN
LILLY, David E., LT, USN
MACFARLANE, Byron N., LCDR, USN
ROUDEBUSH, Jackie L., LCDR, USN
SCIGULINSKY, Kenneth F., LT, USN
WRIGHT, Arthur S., LCDR, USN

MASTER OF SCIENCE IN MANAGEMENT

ABRAHAM, Louis R., MAJ, USMC
ADAMS, Gene A., MAJ, USMC
ANDERSEN, Thomas C., LCDR, USN
ANDERSON, Duane E., CDR, USN
ANDERSON, Joseph S., Jr., LCDR, USN
APPLEGATE, Terry B., LT, USN
ARNOLD, David N., LT, USCG
AUERBACH, Ralph W., Jr., CDR, USN
AUGUSTINE, Grant, III, CDR, USN
BABBIN, Robert R., MAJ, USMC
BALDSING, Harold J.S., LCDR
Royal Ceylon Navy
BASSETT, Melvin S., CDR, USN
BEALL, James M., Jr., LT, USN
BEAUCHAMP, Glen T., LTCOL, USMC
BENNETT, Floyd E., LT, USN
BERKES, Leslie J., LTJG, USN
BLANTON, Harold L., Jr., LTCOL, USMC
BLIGH, James E., CDR, USN
BOBOLA, Edward, LT, USN
BOGER, Dan C., LTJG, USN
BRASIL, Mauro, CDR
Brazilian Navy
BREM, Eugene S., LCDR, USNR
BRENNAN, George D., MAJ, USMC
BREWTON, Edward A., LCDR, USN
BRONAUGH, Joseph T., LCDR, USCG
BUCKLEY, John E., LCDR, USN
BUFFONI, Thomas J., LCDR, USN
BUGBEE, James F., MAJ, USMC
BURKE, Kevin J., LT, USN
BURNS, Charles E., LCDR, USN
BURTON, Joseph T., CDR, USN
BUTSKO, Frank N., MAJ, USMC
CAHILL, Allen L., LT, USN
CARDER, Denny M., LCDR, USN
CHARLES, Robert S., MAJ, USMC
CHRISTIANSEN, Von O., CDR, USN
COOPER, Grant A., LCDR USN
COSTELLO, Peter M., Jr., CDR, USN
CROSSON, William E., CDR, USN
CULWELL, Charles L., CAPT, USN
DALEY, John J., Jr., LTCOL, USMC
DISCENZE, Joseph H., LT, USCG
DOSER, Joseph G., MAJ, USMC
DRY, Melvin S., LTJG, USN
DUTTON, Bruce M., LCDR, USN
EARNER, William A., Jr., LT, USN
EARNST, Rossell A., CDR, USN
EDWARDS, Leslie R., CDR, USN
EKLUND, Robert G., MAJ, USA
ELPERS, William W., LCDR, USN
EMAL, Janice A., LCDR, USN
EPPLING, David C., LCDR, USN
FEDOR, John D., LT, USN
FERNALD, Lloyd W., Jr., LCDR, USN
FLANARY, Thomas N., II, CDR, USN
FOX, Robert F., LCDR, USN
FURMANSKI, John A., CDR, USN
GARTEN, Ronald C., MAJ, USMC
GIBOWICZ, Charles, Jr., LCDR, USN
GODSEY, Shirley T., LCDR, USN
GOULD, John F., Jr., LTCOL, USMC
GRIGGS, William J., Jr., MAJ, USMC
HAAS, Charles E., LT, USCG
HALL, Gordon B., Jr., LCDR, USN
HAMILTON, Francis, Jr., MAJ, USMC
HANTZ, Francis A., CDR, USN
HARR, David J., LTJG, USN
HARRIS, Emerson M., CDR, USN
HARTMAN, Phillip G., LCDR, USN
HASKINS, John B., LT, USN
HAUHART, James N., LT, USN
HENDERSON, Donald, CAPT, USN
HIGLEY, Warren A., CDR, USN
HILL, Nordean T., LCDR, USN
HINES, John C., CDR, USN
HINSEN, Kenneth L., CDR, USN
HOUGHTON, Thomas C., LTJG, USN
JONES, Duncan H., MAJ, USMC
KARTALIS, Andrew, CDR, USN
KEEGAN, Arthur E., LCDR, USN
KELLEY, Frederick A., LT, USCG
KELLY, Robert F., Jr., LT, USN
KINDBOM, Lawrence G., LCDR, USCG
KNAPP, Emmett J., LCDR, USN
KRAMER, Robert L., CDR, USN
LAKE, Roger A., LTJG, USN
LAW, James E., LCDR, USN
LECROY, Floyd G., LT, USN
LEDER, Frederick D., LTCOL, USMC
LIPPERT, Keith W., LTJG, USN
LONGERBONE, James H., LTJG, USN
LUCAS, Terry L., LCDR, USCG
MAANAVI, Noureddin, LT
Imperial Iranian Navy
MARCH, Daniel P., LT, USN
MARKS, James W., MAJ, USMC
MARTIN, Robert W., Jr., LTCOL, USMC
MARTIN, Walter P., LT, USN
MATTESON, Thomas T., LCDR, USCG
McCLINTOCK, Harry C., CDR, USN
McHUGH, Richard G., LT, USN
McKEAN, John T., LCDR, USCG
MENIKHEIM, Douglas K., LT, USN
MERGNER, Arthur, Jr., LT, USCG
MURCHISON, L. Conway, Jr., LCDR, USN
MURPHY, Lorraine M., CDR, USN
MURRAY, Thomas O., Jr., LT, USN
NEWTON, George L., LTCOL, USMC
NEWTON, Samuel L., LTJG, USN
NYCE, Barbara R., LT, USN
PARRISH, Donald E., CDR, USN
PERRILL, Frederick E., LT, USN
PEACOCK, Marvin E., MAJ, USMC
PETERSON, Perry M., MAJ, USMC
PHENIX, Robert P., CDR, USN
POMPONIO, Bruno A., CDR, USN
RICHARDSON, Paul F., LTJG, USN
ROBINSON, Joe D., 2nd LT, USMC
SCHMIDT, John A., LCDR, USN
SENEFF, Gerald N., LT, USN
SEYL, Stephen J., LT, USN
SIMPSON, William A., LTCOL, USMC
SPOONER, David F., LTJG, USN
STEADMAN, Willard G., LCDR, USN
STEFFEN, Werner H., LCDR, USNR
STEIL, James J., LCDR, USN
STEVENSON, Jerry P., MAJ
Canadian Armed Forces
STEWART, Keith A., LCDR, USN
STODDARD, Roy C., LCDR, USNR
STOUFER, Donald A., LT, USN
STRACHWITZ, Hubert J., LCDR, USN
STRAND, John A., CDR, USN
SULLIVAN, George E., III, LCDR, USN
THOMPSON, Fred E., LCDR, USN
TREAGY, Paul E., Jr., CDR, USN
TRICE, William H., CAPT, USMC
TUTTLE, John M., MAJ, USMC
TVEITA, Reynold C., CDR, USN
ULLMAN, Robert C., LT, USN
VAN SAUN, Arthur, LT, USN
VASILIK, Kenneth J., LCDR, USN
WHEELER, David E., LCDR, USN
WILSON, Paul A., Jr., MAJ, USMC
WYATT, John M., LCDR, USN
YONKERS, David P., LT, USN

YOUNG, Sue E., CDR, USN
ZIMOLZAK, Frank, LTCOL, USMC

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

AKAD, Deniz, LT, Turkish Navy
BALLBACK, Leonard J., LT, USN
BERNS, Thomas H., LTJG, USN
BURROW, Barry V., LTJG, USN
CHALOUPKA, Allan B., LTJG, USN
CHANG-SHENG, Li, CDR Chinese Navy
DARNELL, Carlton H., LT, USN
DAVIS, Martin D., LT, USN
EWERS, Benjamin J., LTJG, USN
GOOGINS, Bruce R., LT, USN
GUNGOR, Nihat, LT Turkish Navy
HICKOX, Oscar J., Jr., LT, USN
JONES, Dennis R., LT, USN
KIESS, Dean W., LT, USN
KILMARTIN, Hugh E., Jr., LTJG, USN
LAPICOLA, John J., LTJG, USN
LYONS, John T., LTJG, USN
McHUGH, Michael L., LTJG, USN
MOSTELLER, William L., LT, USN
NOLAN, Bruce R., LCDR, USN
PESTORIOUS, Thomas D., LTJG, USN
RICHARDSON, Daniel C., LCDR, USN
RODRIGUEZ C., Luis E., LT Venezuelan Navy
ROWE, Gary L., LT, USCG
SAGER, David A., LTJG, USN
SAWYER, William J., LTJG, USN
SLACK, William M., LT, USNR
SOWESBY, Roger L., LT, USN
VITERI C., Marco, LT Ecuadorian Navy
VON SUSKIL, James D., LTJG, USN
WEEKS, Steven B., LTJG, USN
WESTBROOK, Richard E., LT, USN

MASTER OF SCIENCE IN METEOROLOGY

ANAWALT, Richard A., LT, USN
CLARK, Bruce A., LCDR, USN
COLEMAN, Randy J., LT, USN
DALEY, Michael J., LT, USN
HARRISON, Edward J., Jr., LT, USN
NEWMAN, Robert L., CDR, USN
ONUR, Nejat, CDR, Turkish Navy
OWENS, Thomas, LT, USN
STENDER, Richard H., LT, USN
WILLOUGHBY, Hugh E., LTJG, USN

MASTER OF SCIENCE IN OCEANOGRAPHY

BOWMAN, William T., LT, USN
CASTER, William A., LT, USCG
CHACE, Alden B., Jr., LT, USN
DAVIS, Gary M., LTJG, USN
DENHAM, Denny J., LT, USNR
DUSTRUP, John M., LT, USN
ETTLE, Robert E., LCDR, USCG
GERST, Anthony L., LT, USN
GOWANS, George K., LCDR, USN
GRIFFIN, Paul A., LT, USN
HOHENSTEIN, Clyde G., LCDR, USN
HUNT, Paul D., Jr., LT, USN
IVEY, C. Gresham, Jr., LCDR, USN
KING, John D., LT, USN
LABYAK, Peter S.,LT, USN
LENNOX, Richard J., LT, USN
MUNDHENKE, David J., LT, USN
REED, James R., LTJG, USN
ROBINSON, David D., LT, USN
STURR, Henry D., Jr., LCDR, USN
TAYLOR, "B" "J", Jr., LT, USN
THAXTON, David R., LT, USN
VAN BRACKLE, Vernon L., Jr., LT, USN

MASTER OF SCIENCE IN OPERATIONS RESEARCH

AARDAL, Marvin R., LT, USN
ALFORD, John W., LT, USN
ALLISON, William T., MAJ, USA
ARICK, John C., CAPT, USMC
ARRISON, James M., III, LT, USN
BACKUS, Larry A., CAPT, USMC
BAGBY, James L., Jr., LT, USN
BELL, Merlin G., LT, USN
CARTY, John J., MAJ, USMC
CHRISTY, Donald E., CAPT, USMC
COLEMAN, Alton H., LTC, USA
COOLEY, John S., LTJG, USN
COVEY, Robert W., LT, USN
CRISWELL, Daniel L., LTC, USA
CROCKETT, William A., MAJ, USA
CRUMLY, Jerry M., LT, USN
CYR, Joseph H., Jr., LCDR, USN
DOLLARD, John A., LT, USN
DRAKE, William B., Jr., LCDR, USN
FASTABEND, Gerald E., LTJG, USN
HARRINGTON, Basil D., CDR, USCG
HENDREN, Jasper P., LT, USN
HILT, John W., Jr., LT, USN
HULING, John M., Jr., LT, USN
KINGSLEY, Stephen S., CDR, USN
KREKEL, Lyman E., LCDR, USN
KRUMM, Leroy G., LCDR, USCG
LIEBERMAN, Jay E., LTJG, USN
MARTIN, Bernard M., MAJ, USA
MASSEY, Scott S., Jr., LT, USN
MISSAL, Joseph B., CPT, USA
MOMM, James A., LT, USN
MORONEY, Joseph M., LT, USN
NUGENT, Richard O., MAJ, USA
ORNEK, Ozden, LTJG Turkish Navy
PALMER, Paul C., Jr., MAJ, USA
READ, Dennis S., LCDR, USN
RICEMAN, John P., CPT, USA
RILEY, Francis J., Jr., LTJG, USN
ROBINSON, Richard T., LTC, USA
SANTOS, Leonard B., LCDR, USN
SHERIDAN, Thomas R., LT, USN
SPANE, Robert J., LT, USN
SPAULDING, Stanley L., LTC, USA
STOLGITIS, William C., LT, USN
STUBSTEN, Eugene M., LT, USN
SULLIVAN, Edward F., LT, USN
TENNEY, Stuart L., LT, USN
TINSLEY, James H., MAJ, USMC
WEST, Arvid E., Jr., LTC, USA
WHITE, William W., CPT, USA
YEOSOCK, John J., MAJ, USA
YUFER, Kenneth L., LT, USN

MASTER OF SCIENCE IN PHYSICS

BEAM, James C., LCDR, USN
COLE, Richard W., LTJG, USN
COTE, Joseph R., MAJ, USA
DE LEUIL, Wood R., MAJ, USA
DETTMANN, Terry R., LTJG, USN
ELSBERRY, Robert T., 1st LT, USAF
FINNO, Roy S., CPT, USA
FLETCHER, Michael H., LTJG, USN
GENSTIL, Stephen M., LTJG, USN
HAYCRAFT, Thomas J., MAJ, USA
HEAD, Herbert W., CPT, USA
HIGGINS, Robert M., MAJ, USA
KADLICK, Richard M., LTJG, USN
KELLER, Charles L., LCDR, USCG
MAYO, Ned H., LCDR, USN
MONSON, William A., LT, USCG
MOORE, Walter L., Jr., LCDR, USN
PEASE, Alfred A., LTJG, USN
PORTER, Robert L., LT, USN
RAYNIS, James B., MAJ, USA
SMELLEY, Allan R., LT, USN
SMYTH, Norman R.A., LT Canadian Forces
SNOTHERLY, Everrette V., Jr., LT, USN
SPIEL, Donald E.

AERONAUTICAL ENGINEER

GASTROCK, Barry A., LT, USN
KIEL, Joseph A., LT, USN
KOCH, Larry N., LT, USN
LAACK, Dennis R., LT, USN
WATSON, Randolph G., LT, USN
WILLETTS, Leo J., Jr., LT, USN

ELECTRICAL ENGINEER

DESENS, Robert B., LT, USN
FERGUSON, Robert D., LT, USN
FOCHT, George A., CAPT, USMC
FULK, Gerald A., CDR, USN
HOOD, John T., LT, USN
LEE, Ronald A., LT, USN
LINDSAY, James H., Jr., LT, USN
NICHOLS, Roger A., LCDR, USN

OZER, Ergin, LT, Turkish Navy
ROUDEBUSH, Jackie L., LCDR, USN
ROZELLE, Edward C., LT, USN
SAGERIAN, Ara, LT, USN
SPITZER, Norbert J., MAJ, USMC
TUZGIRAY, Erkal, LT, Turkish Navy
ZIMMERMAN, Claus E., LT, USN

MECHANICAL ENGINEER

BALLBACK, Leonard J., LT, USN
DAVIS, Martin D., LT, USN
KIESS, Dean W., LT, USN
WESTBROOK, Richard E., LT, USN

DOCTOR OF PHILOSOPHY

CROMER, Charles C., LCDR, USN
DESPARD, Ronald A., LCDR, USN
JOHNSON, Roy M.
JOHNSON, William L.
OREJUELA, Henry, LT, USN
WERTHER, Manfred H., LCDR Federal German Navy

INDEX

For Your Convenience

NOTES & MEMORANDA

HERALD PRINTERS, MONTEREY, CALIFORNIA