NPS55Su74101

NAVAL POSTGRADUATE SCHOOL

Monterey, California

LPI--An Interactive Linear Programming Package

R. H. Shudde

October 1974

Approved for public release; distribution unlimited

Naval Postgraduate School
Monterey, California

Rear Admiral Isham Linder
Superintendent

Jack R. Borsting
Provost

Reproduction of all or part of this report is authorized.

This report was prepared by:

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS
BEFORE COMPLETING FORM

1. REPORT NUMBER
NPS55Su741001

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
LPI--An Interactive Linear Programming Package

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
R. H. Shudde

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, CA 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, CA 93940

12. REPORT DATE

13. NUMBER OF PAGES

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Linear Programming	Interactive Linear Programming
Separable Programming	Remote Terminal Linear Programming System
Wolfe's Algorithm	System, Linear Programming

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

LPI is an interactive linear programming (L.P.) package designed primarily for instructional usage with the Cambridge Monitor System on the IBM/360 Computer. LPI removes the computational burden from the student without depriving him of the decision-making processes necessary for the successful solution of a L.P. LPI is self-instructing as to its own use; a minimum of CP/CMS commands are required to interface the student with LPI. LPI will allow primal simplex and/or dual simplex pivoting; sensitivity analysis of the "cost" coefficients and

20. Continued

the "requirement" coefficients; the Separable Programming Algorithm; and the Wolfe Quadratic Programming Algorithm.

CONTENTS

I. INTRODUCTION AND PURPOSE

LPI is an interactive linear programming program written in FORTRAN IV for use with the Cambridge Monitor System (CP/CMS) as implemented for the IBM/360 computer. LPI is intended to supplement courses in which the methodology of linear programming is taught.

The use of the simplex methods (primal and dual) to solve a linear program (LP) requires the student to be familiar with a battery of procedural rules for "determining feasibility", "maintaining feasibility", "improving the objective value", "determining unboundedness", "recognizing optimality", etc. If the student is performing hand computations and "something" goes wrong, he is usually at a loss to know whether he has violated one of the procedural rules or has performed a mathematical blunder. If the student is solving a LP using a standard computer program, the procedural decisions are made in the computer program and the student loses the insight gained by having to make his own decisions. Further, the use of a standard computer program often burdens the student with learning a rigid set of "input" requirements of the program which, if violated, lead to a plethora of error messages which are usually incomprehensible to all but the computer specialist.

LPI was written for the express purpose of providing the student with the best of the two worlds; namely it removes the burden of hand computations while it provides a computer interactive means of solving LP problems. LPI will not solve a LP, the student must do this for himself. He may use standard procedural rules to solve the LP; he may freely investigate the consequences of violating one or more of the standard rules; he may develop his own criteria for proceeding. Unfortunately there are a few steps which are necessary to link to the computer; these have been kept to the bare essentials. Once the LPI environment has been entered, the system is self-explanatory[1] and practically user-proof.[2]

II. PROGRAM DESIGN CONSIDERATIONS

LPI was designed with the following objectives:

A. Minimize the amount of computer instructions required to "get on" and use the system. Necessary and sufficient instructions for the user are contained in Appendix A.

B. Minimize the chances of the user inadvertently "bombing out" of the system. Every user response is interrogated for validity. Non-valid responses are re-queried while distracting system generated error messages are suppressed.

C. Allow the user every opportunity to make corrections. The input elements are usually via the keyboard. The user is given the opportunity to correct typing errors before preceding.

D. Provide maximum recovery in the event of computer malfunction. To this end, a "restart file" is created to obviate retyping the input elements should the users virtual-computer be lost through a computer malfunction.

E. Keep the options limited for the novice user while allowing extended options for the advanced user. An attempt is made to restrict unfamiliar queries from the novice. This is particularly true for the sensitivity analysis options. There are certain options (such as tableau print-suppression) available to the advanced user which are not self-documented by LPI queries and responses.

[1] By "self-explanatory" it is meant that the LPI requirements are defined to the user by LPI itself. It does not mean that any of the simplex procedures are defined by LPI.

[2] There does not exist a completely user proof system. However, it is believed that the user of LPI cannot destroy the environment without a conscious and malicious effort.

F. Keep output formats clean when possible. When the entries in a tableau are of "reasonable" magnitude, fixed point formats are used. Should the fixed point boundaries be exceeded, LPI will automatically switch to a floating point format.

III. MATHEMATICAL CONSIDERATIONS AND USAGE

A. Standard Form

LPI may be used to solve any LP which is written in standard form:

$$\begin{matrix}\min\\ \max\end{matrix} \sum_{j=1}^{n} c_j x_j = z$$

subject to

$$\sum_{j=1}^{n} a_{ij} x_j = b_i \ , \qquad i = 1,\ldots,m$$

and

$$x_j \geq 0 \quad \text{for} \quad j = 1,\ldots,n \ .$$

The number of rows, m, is limited to 20 and the number of columns, n, is limited to 30.

All input information, the a_{ij}'s, the b_i's, and the c_j's is preserved in LPI for possible restarting or later modification. All of the pivoting and row transformations are performed in a separate matrix.

B. Starting Basis and Cost Coefficients

An initial tableau and starting basis are formed using artificial variables and the Charnes' M-method [1,2]. The cost coefficients of the artificial variables are set equal to M if z is to be minimized and are set equal to $-M$ if z is to be maximized, where $M > 0$.

For identification purposes, the artificial variables are subscripted 71 through 70 + m. The matrix of legitimate vectors is then searched for unit slack vectors (with zero cost coefficients) which can be substituted for artificial vectors in the starting basis. The number of artificial vectors in the initial basis is thus minimized.

The indirect cost minus the direct cost, $z_j - c_j$, is then computed for each legitimate vector. The $z_j - c_j$ which is a linear function of M, is printed as two rows: the constant term and the coefficient of M. If there are no artificial vectors in the basis, then the printing of the coefficient of M is suppressed.

C. Pivoting

There are two pivoting responses which become apparent to the LPI user and two which are "hidden." LPI queries: DO YOU WANT YOUR PIVOT CHECKED FOR MIN-RATIO VIOLATION?

1. If the user responds 'no', then the user may pivot on any non-zero element in the tableau by specifying the column and row coordinates of the pivot element. In other words, the user may find a new basic solution without regard to maintaining primal or dual feasibility. If the user wishes to perform dual simplex pivoting, then the response must be 'no'.
2. If the user responds 'yes', then the user must still specify the column and row coordinates of the pivot element. If the primal simplex min-ratio criterion is violated by the user's choice of row, then pivoting does not take place. The user is informed that the min-ratio criterion has been violated and he is requeried for a column and row number.
3. The two "hidden" responses are 'auto' and 'ntbl'. If the user responds 'auto' he is then queried for a pivot column. The row choice is automatically made using the primal min-ratio criterion and the entire new transformed tableau is displayed. The response

'ntbl' has the same affect as the 'auto' response except that most of the tableau printing is suppressed; the only elements that print are the basic x_j's and the $(z_j - c_j)$'s. With this option, one may rapidly solve a LP or use the Wolfe algorithm, for example, with a minimum of printing. At a later point in LPI, these responses may be overridden if desired.

4. When the user no longer desires to pivot, he should respond by hitting the 'carriage return' key when queried for a new pivot column. This response will enter the option mode if the user has not previously entered the sensitivity analysis mode through the option mode. If the sensitivity analysis mode is in effect, then control returns to the next sensitivity analysis query.

D. Optimal Solutions

LPI will not inform the user when optimality has been reached. The user must recognize the occurrence of any of the possible stopping criteria: no feasible solution, unbounded solution, maximum or minimum solution, or optimal solution with alternate primal or dual optima.

E. Option Mode

To enter the option mode, the user must respond as directed in the last paragraph on pivoting. In the event that the user inadvertently entered the option mode, his first option is to return to the pivoting query. The next option is to either perform an option or not. If not, then a new problem may be started. If an option is desired, LPI will either list the available options or allow the knowledgeable user to supply one or more option keywords. The options allow for printing the dual variables, the basis inverse, removing the min-ratio violation check (including the 'auto' and 'ntbl' pivoting options), modify and rework the problem. The user may also enter the sensitivity analysis mode at this point.

F. Sensitivity Analysis Mode

The sensitivity analysis options are well documented by LPI. Cost elements, c_j's and "right-hand-side" elements, b_i's, may be changed one at a time and in any order.

To replace c_j by $c_j + \Delta c_j$, the value of j and Δc_j must be specified. When Δc_j has been specified, the updated value of z and of all $z_j - c_j$ are printed. The user is then queried: PIVOT? If the user's response is 'yes', then he will be queried for a new pivot column and row, the users current pivot option will remain in effect. If the user's response is 'no', then he may change another cost or right-hand-side element.

To replace b_i by $b_i + \Delta b_i$, the value of i and Δb_i must be specified, the updated value of z and of all basic x_j's are printed. Then the pivot options of 'auto', 'ntbl' , or 'min-ratio' violation checking are replaced by 'no min-ratio' violation checking, so that dual simplex iterations may be performed. The user is then queried PIVOT? If the users response is 'yes' then he will be queried for a new pivot column and row number. If the user's response is 'no' then he may change another cost or right-hand-side element.

The user may leave the sensitivity analysis mode by responding 'quit' to the PIVOT? query or to the change in c_j or b_i query. Control is then passed back to the battery of option queries.

NOTE: Whenever a Δb_i or Δc_j is specified, the original b_i or c_j is changed accordingly. It is thus possible to generate on updated restart file by using the modify and rework option.

G. The Restart File

In the Naval Postgraduate School version of CP/CMS, the FORTRAN command READ($\underline{\ell}$,... is implemented as follows: If $\underline{\ell} = 5$, then the input to CP/CMS is via the typewriter (remote terminal). If $\underline{\ell}$ = 1,2,3,4, or 7, then the CP/CMS input is assumed to be via "file ft0$\underline{\ell}$f001' and the file is further assumed to be in 80 column card images. LPI will generate 'file ft04f001' as a restart file when the user has completed typing in his input. Should the CP/CMS system malfunction, this input file will be available to re-establish the users input data. When queried '...TYPE, READ, OR RESTART', the user may type 'restart' to automatically implement the READ($\underline{\ell}$,... command with $\underline{\ell}$ = 4).

The advanced LPI user may wish to prepare a data deck prior to his terminal session. The data deck may be read by LPI provided it is in the proper format and has the name "file ft0$\underline{\ell}$f001' where $\underline{\ell}$ = 1,2,3,4, or 7. If the data deck does not have the proper name, the user should consult the CP/CMS manual and learn how to use the CMS 'alter' command [3].

The format for an LPI data deck is given below in the proper input sequence.

1. First card:

   m = no. of rows, n = no. of columns

   (I2, 1X, I2)

2. Cost coefficients (one per card for as many cards as needed):

   j, c_j, $(\text{name})_j$

   (I2, 4X, F21.10, 5X, A4)

3. Delimiter card:

   One blank card, <u>or</u> one card with 00 in columns 1 and 2 denotes the end of the cost coefficient input.

4. Matrix elements (one per card):

   i, j, a_{ij}

   (I2, 1X, I2, 1X, F21.10)

5. Delimiter card:

   One blank card or one card with 00 in columns 1 and 2.

6. Right-hand-side elements:

   i, b_i

   (I2, 4X, F21.10)

7. Delimiter card optimal.

H. Error Handling

The most common error is that of the user inadvertently typing a non-numeric character in a data field which must consist of numeric characters only. This is the IHC215I-CONVERT error [4]. The FORTRAN error handling system will convert each erroneous character to a zero and generate an error message for each conversion. The diagnostic messages are suppressed in LPI by using the ERRSET subroutine [4] which is standard part of the FORTRAN error handling system. The user will not be aware of this conversion unless the numeric value generated is subsequently used as a row or column index and the index is out of the range allowed by LPI. In this case LPI will type a warning message to the user and requery. Generally this minimal error handling is sufficient. In all other cases, the user is given an opportunity to review all of the LP coefficients before proceeding. It is the users responsibility to detect such input errors.

The only other error message which is suppressed by means of ERRSET is the IHC218I - I/O ERROR. This error occurs if the user attempts to READ a non-existent data file or use the RESTART file when the restart file does not exist. LPI will detect such an error and a message will be typed which explains the probable sources of error to the user. An exit from LPI is then taken so that the user may take corrective action.

The "summary of errors" cannot be suppressed by any of the IBM standard routines. In order to suppress this final error message, a local subroutine KTT is used. A listing of this routine may be found in Appendix C. KTT should be implemented only by a resident CP/CMS systems programmer. KTT may be removed from LPI without affecting any of the LPI functions.

REFERENCES

1. Gass, S., "Linear Programming" 3rd ed. McGraw-Hill, 1969.

2. Hadley, C., "Linear Programming," Addison-Wesley, 1962.

3. Control Program-67/Cambridge Monitor System (CP/67/CMS). IBM Document GH20-0859.

4. IBM System/360 Operating System FORTRAN IV (G&H) Programmer's Guide Form C28-6817.

APPENDIX A

LPI USER INSTRUCTIONS

LOGIN, LINK, LOAD, EXECUTION, LOGOUT PROCEDURES:

In order to use LPI it is necessary to LOGIN to the Control Program (CP), LINK to the file on which LPI is stored, LOAD the Cambridge Monitor System (CMS), LOGIN the general user and LPI files, EXECUTE LPI and to LOGOUT of CMS and CP at the completion of EXECUTION. The commands below will enable you to do this.

(Those commands marked with an * are entered by the user.)

* Turn the terminal on, depress the RETURN key, and wait patiently for the system to respond

```
cp-67 online  xd.65  qsyosu
```

* Depress the ATTN key once. The roll bar will advance one line and the keyboard will unlock. Then enter:

```
*  login xxxxgnn
```

nn is the terminal number. Terminal numbers are painted on the right side of the terminal stand.

xxxx is your user identification number.

EX: 0405g07 is terminal 07 and user 0405

The system will respond with:

```
ENTER PASSWORD:
```

Then you enter:

```
*  npg
```

The system will then give:

```
ENTER 4-DIGIT PROJECT NUMBER FOLLOWED BY 4-CHARACTER COST CENTER CODE:
```

Then you enter:

```
*  aaaabbbb
```

aaaa is the assigned project number.

bbbb is your section designator (or code, for faculty members)

The system will respond with the message of the day, such as:

```
HELLO...GEN USERS LOGIN WITH TERM NO + OWN ID...DUFFY
```

then:

```
READY AT 12.13.42 on 04/21/74
```

You are now logged in to CP. Next you must LINK to the LPI file. This is done by entering:

```
* link 3024p 191 193
```

The system will respond:

```
ENTER PASSWORD:
```

Then you enter:

```
* linprog
```

The system will respond:

```
SET TO READ ONLY
```

Now you must LOAD CMS by entering:

```
* ipl cms
```

The system will respond:

```
CMS,.VERSION 01/21/74
```

Now you must LOGIN your general user file and the LPI file by entering:

```
* login 191
```

To which the system will respond:

```
R; T=0.01/0.10 12.15.52
```

Then enter:

```
* login 193 a,p
```

To which the system will respond:

```
** A (193) READ ONLY **
```

```
R; T=0.01/0.08  12.16.32
```

If you have gotten this far, take a deep breath and relax a minute before pushing on. You have succeeded in getting everything hooked up, now you are ready to execute the program.

Execute LPI by entering:

```
* begin
```

The system will respond with something like:

```
EXECUTION BEGINS...
GOOD AFTERNOON.  YOU WISH TO SOLVE A LINEAR PROGRAM...
```

You are on your own now.

Eventually you will be asked:

```
DO YOU WANT TO SOLVE ANOTHER PROBLEM:
```

Note - This is not the precise message, but is a typical message.

If you respond 'yes' you will start over again, if you respond 'no' the system will respond:

```
IT HAS BEEN A PLEASURE SERVING YOU.  HAVE A GOOD DAY.
R; T=0.01/0.07  13.15.16
```

Execution of the LPI Routine has ceased and now you can LOGOUT by entering:

```
* logout
```

The system will respond:

```
T=100.67/196.38  13.15.42
CP ENTERED, REQUEST, PLEASE.
CP
```

Then enter:

```
* log
```

The system will respond:

```
CONNECT=01.02.07 VIRTCPU=002.36.10  TOTCPU=003.51.34

LOGOUT AT 13.15.48  on 04/21/74
```

* Turn off the terminal, roll up the paper to a perforation point and tear off your output.

NOTE:

A useful feature of CP/CMS to keep in mind is the procedure to correct typing errors. You can effectively back space by typing the character @ as many times as spaces you want to go back. This will delete what you have already typed in these spaces. DO NOT USE THE BACKSPACE KEY. Delete an entire line by typing the character ¢ and then depressing the RETURN key. You can then start the line over again. This feature will work while responding to the LPI queries.

If you are familiar with the more lengthy LPI statements and wish to suppress them, you may do so as follows:

1. Wait until typing of the message starts.
2. Press the 'ATTN' key once. They typing will stop with the characters 'CP'.
3. Press the 'ATTN' key once more. Wait for the click which indicates that the keyboard has unlocked.
4. Type the characters 'kt'. The CMS command KT is an abbreviation for 'kill typing'.
5. Depress the RETURN key.
6. Again wait for the keyboard to unlock. If you know what the suppressed query is, you may type in the appropriate response, otherwise depress the RETURN key once more to let LPI take over.

APPENDIX B

SAMPLE TERMINAL SESSION

```
begin
IF YOU ENCOUNTER ERRORS IN LINPROG, PLEASE REPORT THEM TO PROF. SHUDDE,
R-201B.  BRING YOUR CONSOLE PRINT-OUT FOR DOCUMENTATION.
EXECUTION BEGINS...

GOOD AFTERNOON.
YOU WISH TO SOLVE A LINEAR PROGRAM, I PRESUME.  VERY WELL, I WILL PROMPT
YOU FOR ENTRIES & TRY TO KEEP YOU OUT OF TROUBLE.
MAXIMUM SIZE IS CURRENTLY 20-BY-30, FOR AX = B ONLY.
TYPE IN YOUR RESPONSES UNDER THE XXX'S.  RIGHT ADJUST ALL INTEGER VALUES.
IMPLIED DECIMAL POINT IS SHOWN, BUT USE YOUR OWN TO MINIMIZE ERRORS.
YOU NEED TO ENTER ONLY THE NON-ZERO ELEMENTS, BUT YOU MUST ENTER YOUR OWN
SLACK VARIABLES, BUT NO ARTIFICIAL VARIABLES.
WHEN YOU ARE THROUGH WITH A SECTION, HIT THE "RETURN" KEY.
THE "MAX" OR "MIN" ENTRY AFFECTS ONLY THE SIGN OF THE ARTIFICIAL VARIABLES,
WHICH ARE SUBSCRIBED STARTING WITH 71.
WHEN YOU HAVE A BASIC SOLUTION, I WILL NO LONGER PRINT THE M-COEFFICIENTS
FOR THE ARTIFICIAL VARIABLES.
PIVOT ON ANY NON-ZERO ELEMENT.  YOU MAY USE ANY PIVOTING CRITERIA THAT
YOU WANT.
IT'S UP TO YOU TO RECOGNIZE YOUR SOLUTION!
     GOOD LUCK .......

DO YOU WISH TO TYPE IN YOUR TABLEAU, READ IN FROM YOUR OWN FILE, OR RESTART
FROM A SYSTEM WIPE-OUT?
THIS PROGRAM GENERATES 'FILE FT04F001' FOR RESTARTING.
RESPOND WITH -- TYPE, READ, OR RESTART.
type

INPUT THE SIZE OF THE A-MATRIX BELOW.

XX - NUMBER OF ROWS
02

XX - NUMBER OF COLUMNS.
05

NROW =  2  NCOL =  5
IF YOU WISH TO CORRECT EITHER OF THE ABOVE, RESPOND WITH "YES" NOW..
IF YOU WISH TO PROCEED, HIT THE "RETURN" KEY.


IF NEEDED, DO YOU WANT THE M-COEFFICIENTS SET UP FOR A MIN OR MAX PROBLEM?
min

OBJECTIVE FUNCTION (COL. NAME OPTIONAL)
```

```
 C
 O
 L ELEMENT  NAME
XX XXXXXXX. XXXX
01 3@¢
01 2.       a-1
02 5.       a-2
03 7.       a-3
04 7.¢
04 0.       s-1
05 0.       s-2


A-MATRIX

 R  C
 O  O
 W  L ELEMENT
XX XX XXXXXXX.
01 01 3.
01 02 1.
01 03 2.


01 04 -1.
02 10 1.
YOUR INDEX IS OUT OF RANGE.  TRY AGAIN.
02 01 1.
02 02 3.
02 3¢
02 03 4.
02 05 -1.


B-VECTOR

 R
 O
 W ELEMENT
XX XXXXXXX.
1 150.
YOUR INDEX IS OUT OF RANGE.  TRY AGAIN.
01 150.
02 250.


                B         1          2          3           4           5
                        A-1        A-2        A-3         S-1         S-2
OBJ FUNCT               2.0000     5.0000     7.0000      0.0         0.0
 1          150.0000    3.0000     1.0000     2.0000     -1.0000      0.0
 2          250.0000    1.0000     3.0000     4.0000      0.0        -1.0000

THIS IS YOUR INPUT.  DO YOU HAVE CHANGES TO MAKE?  YES, NO, OR RESTART.
no
```

```
 RESTART FILE CREATED

 DO YOU WANT YOUR PIVOT CHECKED FOR MIN-RATIO VIOLATION?
 no

 THEN - HERE WE GO.  JUST BE CAREFUL OF YOUR PIVOTING CRITERIA.


 TABLEAU NUMBER      0

                  B          1          2          3          4          5
                            A-1        A-2        A-3        S-1        S-2
 1 X(71)     150.0000     3.0000     1.0000     2.0000    -1.0000     0.0
 2 X(72)     250.0000     1.0000     3.0000     4.0000     0.0       -1.0000
OBJ FUNCT      0.0       -2.0000    -5.0000    -7.0000     0.0        0.0
M-COEFF.     400.0000     4.0000     4.0000     6.0000    -1.0000    -1.0000

XX - PIVOT COLUMN?
03
XX - PIVOT ROW?
02


 TABLEAU NUMBER      1

                  B          1          2          3          4          5
                            A-1        A-2        A-3        S-1        S-2
 1 X(71)      25.0000     2.5000    -0.5000     0.0       -1.0000     0.5000
 2 X( 3)      62.5000     0.2500     0.7500     1.0000     0.0       -0.2500
OBJ FUNCT    437.5000    -0.2500     0.2500     0.0        0.0       -1.7500
M-COEF.       25.0000     2.5000    -0.5000     0.0       -1.0000     0.5000

XX - PIVOT COLUMN?
01
XX - PIVOT ROW?
01


 TABLEAU NUMBER      2

                  B          1          2          3          4          5
                            A-1        A-2        A-3        S-1        S-2
 1 X( 1)      10.0000     1.0000    -0.2000     0.0       -0.4000     0.2000
 2 X( 3)      60.0000     0.0        0.8000     1.0000     0.1000    -0.3000
OBJ FUNCT    440.0000     0.0        0.2000     0.0       -0.1000    -1.7000

XX - PIVOT COLUMN?
02
XX - PIVOT ROW?
02
```

```
 TABLEAU NUMBER      3

              B          1          2          3          4          5
                         A-1        A-2        A-3        S-1        S-2
 1 X( 1)     25.0000     1.0000     0.0         0.2500    -0.3750     0.1250
 2 X( 2)     75.0000     0.0        1.0000      1.2500     0.1250    -0.3750
OBJ FUNCT   425.0000     0.0        0.0        -0.2500    -0.1250    -1.6250

XX - PIVOT COLUMN?


YOU INDICATE THAT YOU'RE THROUGH PIVOTING.  ARE YOU QUITE SURE?
yes

THERE ARE NUMEROUS OPTIONS THAT YOU MAY PERFORM AT THIS TIME.  DO YOU WISH TO
USE ONE OR MORE OF THEM?
no

HOW ABOUT STARTING A NEW PROBLEM THEN?
no

ABOUT ALL THAT IS LEFT IS TO CALL IT A DAY.  DO YOU WANT TO QUIT,?  IF NO,
THEN WE WILL REVIEW THE OPTIONS.
yes

I GUESS I SHOULD HAVE ASKED YOU THAT IN THE FIRST PLACE.  SORRY ABOUT THAT...
IT HAS BEEN A PLEASURE SERVING YOU.

...HAVE A GOOD DAY!...
R; T=1.09/3.22 13.34.47
```

APPENDIX C

LPI Listing

```
C     INTERACTIVE LINEAR PROGRAMMING RCUTINE. SHLDDE APR '74
C
      IMPLICIT REAL*8(A-H,O-Z)
      INTEGER*4 YES/'YES '/,NO/'NO  '/,MIN/'MIN '/,MAX/'MAX '/
     1 ,REWORK/'REWO'/,MODIFY/'MODI'/,DUAL/'DUAL'/,INVERS/'INVE'/,
     2 RATIO/'RATI'/,SENS/'SENS'/,DONE/'DONE'/,ALTC/'AUTO'/
     3 ,TYPE/'TYPE'/,READ/'READ'/,REST/'REST'/,BLNK/'    '/,LABL(51)
     4 ,STOP/'STOP'/,QUIT/'QUIT'/,OBJ/'OBJ'/,RHS/'RHS'/,STO/'STO'/
     5 ,QUI/'QUI'/,NOTBL/'NTBL'/
      COMMON /TABL$/A(22,51),T(22,51),IBV(20)
      COMMON /STAT$/NROW,NCOL,NROW1,NRCW2,NCOL1,NCOL2,NCOLM
C
      CALL ERRSET(218,256,-1,1)
      CALL ERRSET(215,256,-1,1)
      INTPE = 4
C
      WRITE(6,6000)
 6000 FORMAT('1GOOD AFTERNOON.'/' YOU WISH TO SOLVE A LINEAR PROGRAM, I
     1PRESUME.  VERY WELL, I WILL PROMPT YOU FOR ENTRIES & TRY'
     2,' TO KEEP YOU OUT OF TROUBLE.'/' MAXIMUM SIZE IS CURRENTLY'
     3,' 20-BY-30, FOR AX = B ONLY.'/
     3' TYPE IN YOUR RESPONSES UNDER THE XXX''S.'
     4,' RIGHT ADJUST ALL INTEGER VALUES.'/' IMPLIED DECIMAL POINT'
     5,' IS SHOWN, BUT USE YOUR OWN TC MINIMIZE ERRORS. '/
     6' YOU NEED TO ENTER ONLY THE NON-ZERO ELEMENTS, BUT YOU MUST'
     6,' ENTER YOUR OWN SLACK VARIABLES, BUT NC ARTIFICIAL VARIABLES.'/
     7 ,' WHEN YOU'
     7,' ARE THROUGH WITH A SECTION, HIT THE "RETURN" KEY.'/' THE "MAX"'
     8,' OR "MIN" ENTRY AFFECTS ONLY THE SIGN OF THE ',
     9 'ARTIFICIAL VARIABLES, WHICH ARE SUBSCRIPTED STARTING WITH 71.'/
     1' WHEN YOU HAVE A BASIC SOLUTION, I WILL NC LONGER PRINT THE '
     2,'M-COEFFICIENTS FOR THE ARTIFICIAL VARIABLES.'/
     3' PIVOT ON ANY NON-ZERO ELEMENT. YOU MAY USE ANY'
     4,' PIVOTING CRITERIA THAT YOU WANT.'/
     5' IT''S UP TO YOU TO RECOGNIZE YOUR SOLUTICN '/
     6'      GOOD LUCK .......')
C
C     INITIALIZE A-MATRIX
 1010 REWIND 5
 1020 DO 1030 J = 1,51
      LABL(J) = BLNK
      DO 1030 I = 1,22
      A(I,J) = 0.D0
 1030 CONTINUE
 1040 REWIND 5
      WRITE(6,6001)
 6001 FORMAT('0DO YOU WISH TO TYPE IN YOUR TABLEAU, READ IN FROM ',
     1 'YOUR OWN FILE, OR RESTART FROM A SYSTEM WIPE-OUT?'/
     2 ' THIS PROGRAM GENERATES ''FILE FT04F001'' FOR RESTARTING.'/
     3 ' RESPOND WITH -- TYPE, READ, CR RESTART.')
```

```
      READ(5,5004,END=1040) NRES                                        LPI00510
      IF (NRES .EQ. TYPE) GC TO 1130                                    LPI00520
      IF (NRES .EQ. READ) GO TO 1060                                    LPI00530
      IF (NRES .EQ. REST) GO TO 1050                                    LPI00540
      IF (NRES .EQ. STOP) GO TO 2130                                    LPI00550
      WRITE(6,6020)                                                     LPI00560
      GC TO 1040                                                        LPI00570
 1050 INFILE = 4                                                        LPI00580
      GO TO 1070                                                        LPI00590
 1060 REWIND 5                                                          LPI00600
      WRITE(6,6002)                                                     LPI00610
 6002 FORMAT('OFROM WHAT FILE DC YOU WISH TO REAC? YOUR CHOICES ARE - ',LPI00620
     1 '1,2,3,4 OR 7')                                                  LPI00630
      READ(5,5000,END=1040) INFILE                                      LPI00640
 5000 FORMAT(I1)                                                        LPI00650
      IF (1 .LE. INFILE .AND. INFILE .LE. 4) GO TO 1070                 LPI00660
      IF (INFILE .EQ. 7) GO TO 1070                                     LPI00670
      IF (INFILE .EQ. STOP) GO TO 2130                                  LPI00680
      WRITE(6,6003) INFILE                                              LPI00690
 6003 FORMAT(' SORRY, FILE ',I4,' IS NOT ALLOWEC. TRY AGAIN..')         LPI00700
      GO TO 1060                                                        LPI00710
 1070 CONTINUE                                                          LPI00720
      REWIND INFILE                                                     LPI00730
      READ(INFILE,5003,END=1120) NROW,NCOL                              LPI00740
      IF (NROW .LT. 1 .OR. NROW .GT. 20) GO TO 1120                     LPI00750
      IF (NCOL .LT. 1 .OR. NCOL .GT. 30) GO TO 1120                     LPI00760
      NCOL1 = NCOL + 1                                                  LPI00770
      NROW1 = NROW + 1                                                  LPI00780
 1080 READ(INFILE,5001,END=1120) I,TEMP,NAME                            LPI00790
 5001 FORMAT(I2,4X,F21.10,5X,A4)                                        LPI00800
      IF (I .EQ. 0) GO TO 1090                                          LPI00810
      IF (I .LT. 0 .OR. I .GT. NCOL) GC TO 1120                         LPI00820
      A(NROW1,I) = TEMP                                                 LPI00830
      LABL(I) = NAME                                                    LPI00840
      GO TO 1080                                                        LPI00850
 1090 READ(INFILE,5002,END=1120) I,J,TEMP                               LPI00860
 5002 FORMAT(I2,1X,I2,1X,F21.10)                                        LPI00870
      IF (I .EQ. 0) GO TO 1100                                          LPI00880
      IF (I .LT. 0 .OR. I .GT. NROW) GO TO 1120                         LPI00890
      IF (J .LE. 0 .OR. J .GT. NCOL) GC TO 1120                         LPI00900
      A(I,J) = TEMP                                                     LPI00910
      GO TO 1090                                                        LPI00920
 1100 READ(INFILE,5001,END=1110) I,TEMP                                 LPI00930
      IF (I .EQ. 0) GO TO 1110                                          LPI00940
      IF (I .LT. 0 .OR. I .GT. NROW) GO TO 1120                         LPI00950
      A(I,NCOL1) = TEMP                                                 LPI00960
      GC TO 1100                                                        LPI00970
 1110 WRITE(6,6004)                                                     LPI00980
 6004 FORMAT('OYOUR DATA HAS BEEN SUCCESSFULLY READ IN. YOU WILL ',     LPI00990
     1 'BE ASKED FOR NEW ELEMENTS SHORTLY.'/                            LPI01000
     2 ' RESPOND BY HITTING THE ''RETURN'' KEY.')                      LPI01010
       GO TO 1170                                                       LPI01020
C                                                                       LPI01030
 1120 REWIND 5                                                          LPI01040
      WRITE(6,6005)                                                     LPI01050
 6005 FORMAT('0YOUR DATA HAS NOT BEEN SUCCESSFULLY READ. THE MOST '     LPI01060
     1 ,'PROBABLE CAUSE IS THAT ONE OF YOUR'/                           LPI01070
     2 ' ROW OR COLUMN NUMBERS IS OUT OF RANGE. I ASSUME YOU WILL ',    LPI01080
     3 'WANT TO EDIT YOUR DATA BEFORE CONTINUING.'                      LPI01090
     4 /' ALSO CHECK TO SEE THAT YOUR LOGIN & LINK COMMANDS',           LPI01100
     5 ' ARE EXACTLY AS SPECIFIED'/' JOB TERMINATED.')                  LPI01110
      GO TO 2140                                                        LPI01120
C     INPUT MATRIX SIZE                                                 LPI01130
 1130 REWIND 5                                                          LPI01140
      WRITE(6,6006)                                                     LPI01150
 6006 FORMAT('0INPUT THE SIZE OF THE A-MATRIX BELOW.')                  LPI01160
 1140 REWIND 5                                                          LPI01170
      WRITE(6,6007)                                                     LPI01180
 6007 FORMAT('0XX - NUMBER OF ROWS')                                    LPI01190
      READ(5,5003,END=1140) NROW                                        LPI01200
 5003 FORMAT(I2,1X,I2,1X,F7.0)                                          LPI01210
      IF (1 .LE. NROW .AND. NROW .LE. 20) GO TO 1150                    LPI01220
      WRITE(6,6008)                                                     LPI01230
 6008 FORMAT(' YOUR RESPONSE IS OUT OF MY RANGE. TRY AGAIN.')           LPI01240
      GO TO 1010                                                        LPI01250
 1150 REWIND 5                                                          LPI01260
      WRITE(6,6009)                                                     LPI01270
 6009 FORMAT('0XX - NUMBER OF COLUMNS.')                                LPI01280
      READ(5,5003,END=1150) NCOL                                        LPI01290
      IF(1 .LE. NCOL .AND. NCOL .LE. 30) GO TO 1160                     LPI01300
      WRITE(6,6008)                                                     LPI01310
      GO TO 1150                                                        LPI01320
 1160 REWIND 5                                                          LPI01330
      WRITE(6,6010) NROW,NCOL                                           LPI01340
 6010 FORMAT('0NROW = ',I2,'  NCOL = ',I2/                              LPI01350
     1' IF YOU WISH TO CORRECT EITHER OF THE ABOVE, RESPOND'            LPI01360
     2,' WITH "YES" NOW..'/' IF YOU WISH TO PROCEED, HIT THE '          LPI01370
     3,'"RETURN" KEY.')                                                 LPI01380
      READ(5,5004,END=1170) NRES                                        LPI01390
 5004 FORMAT(A4)                                                        LPI01400
      IF (NRES .EQ. STOP) GO TO 2130                                    LPI01410
      GO TO 1140                                                        LPI01420
 1170 REWIND 5                                                          LPI01430
C                                                                       LPI01440
C     BOOKKEEPING                                                       LPI01450
C     ILBL = 2 IF COLUMN LABELS ARE SPECIFIED. ILBL = 1 CTHERWISE       LPI01460
C     IPRT = 1 IF NORMAL FIXED POINT OUTPUT FORMATS ONLY HAVE BEEN      LPI01470
C                REQUIRED. IPRT = 2 OTFERWISE.                          LPI01480
      ILBL = 1                                                          LPI01490
      IPRT = 1                                                          LPI01500
      NROW1 = NROW + 1                                                  LPI01510
      NROW2 = NROW + 2                                                  LPI01520
      NCOL1 = NCOL + 1                                                  LPI01530
      NCOL2 = NCOL + 2                                                  LPI01540
      NCOLM = NCOL1 + NROW                                              LPI01550
C     SETUP IDENTITY MATRIX TO STORE INVERSE & DLAL VARIABLES           LPI01560
      DO 1180 I = 1,NROW                                                LPI01570
      J = NCOL1 + I                                                     LPI01580
 1180 A(I,J) = 1.D0                                                     LPI01590
C                                                                       LPI01600
C     MIN OR MAX??                                                      LPI01610
C                                                                       LPI01620
      WRITE(6,6011)                                                     LPI01630
 6011 FORMAT('0IF NEEDED, DO YOU WANT THE M-COEFFICIENTS SET UP FOR A MILPI01640
     1N CR MAX PROBLEM?')                                               LPI01650
      READ(5,5004,END=1170) LPTPE                                       LPI01660
      IF(LPTPE .EQ. MIN .OR. LPTPE .EQ. MAX) GO TO 1190                 LPI01670
      IF (LPTPE .EQ. STOP) GO TO 2130                                   LPI01680
      WRITE(6,6020)                                                     LPI01690
      GO TO 1170                                                        LPI01700
C                                                                       LPI01710
 1190 REWIND 5                                                          LPI01720
C     INPUT L.P. DATA                                                   LPI01730
      WRITE(6,6012)                                                     LPI01740
 6012 FORMAT('0OBJECTIVE FUNCTION (COL. NAME CPTICNAL)'//'  C'/'  C'/   LPI01750
     1 '  L ELEMENT  NAME'/' XX XXXXXXX. XXXX')                         LPI01760
 1200 CONTINUE                                                          LPI01770
      READ(5,5005,END=1220) J,TEMP,NAME                                 LPI01780
 5005 FORMAT(I2,1X,F7.0,2X,A4)                                          LPI01790
      IF (J .LT. 1 .OR. J .GT. NCOL) GO TO 1210                         LPI01800
      A(NROW1,J) = TEMP                                                 LPI01810
      LABL(J) = NAME                                                    LPI01820
      GO TO 1200                                                        LPI01830
 1210 WRITE(6,6013)                                                     LPI01840
 6013 FORMAT(' YOUR INDEX IS OUT OF RANGE. TRY AGAIN.')                 LPI01850
      GO TO 1200                                                        LPI01860
 1220 REWIND 5                                                          LPI01870
      WRITE(6,6014)                                                     LPI01880
 6014 FORMAT('0A-MATRIX'//'  R  C'/'  O  O'/'  W  L ELEMENT'/           LPI01890
     1 ' XX XX XXXXXXX.')                                               LPI01900
 1230 CCNTINUE                                                          LPI01910
      READ(5,5003,END=1250) I,J,TEMP                                    LPI01920
      IF(J .LT. 1 .OR. J .GT.NCOL) GO TO 1240                           LPI01930
      IF(I .LT. 1 .OR. I .GT. NROW) GO TO 1240                          LPI01940
      A(I,J) = TEMP                                                     LPI01950
      GO TO 1230                                                        LPI01960
 1240 WRITE(6,6013)                                                     LPI01970
      GO TO 1230                                                        LPI01980
 1250 REWIND 5                                                          LPI01990
      WRITE(6,6015)                                                     LPI02000
```

```
6015 FORMAT('OB-VECTOR'//'  R'/'  O'/'  W ELEMENT'/                     LPI02010
     1 ' XX XXXXXXX.')                                                  LPI02020
 1260 CONTINUE                                                          LPI02030
      READ(5,5005,END=1280) I,TEMP                                      LPI02040
      IF(I .LT. 1 .OR. I .GT. NROW) GO TO 1270                          LPI02050
      A(I,NCCL1) = TEMP                                                 LPI02060
      GO TO 1260                                                        LPI02070
 1270 WRITE(6,6013)                                                     LPI02080
      GO TO 1260                                                        LPI02090
C                                                                       LPI02100
C     END DATA INPUT                                                    LPI02110
 1280 REWIND 5                                                          LPI02120
C                                                                       LPI02130
C     PRINT OUT ALL INPUT                                               LPI02140
      DO 1290 J = 1,NCOL                                                LPI02150
      IF (LABL(J) .NE. BLNK) ILBL = 2                                   LPI02160
 1290 CONTINUE                                                          LPI02170
      MPRT = (NCOL + 9)/10                                              LPI02180
      DO 1301 JPRT = 1,MPRT                                             LPI02190
      M2 = 10 * JPRT                                                    LPI02200
      M1 = M2 - 9                                                       LPI02210
      M2 = MINO(M2,NCOL)                                                LPI02220
      ITBL = 1                                                          LPI02230
      WRITE(6,6026) (I,I = M1,M2)                                       LPI02240
      IF(ILBL .EQ. 2) WRITE(6,6016) (LABL(J),J = M1,M2)                 LPI02250
 6016 FORMAT(19X,10(6X,A4))                                             LPI02260
      WRITE(6,6101) (A(NROW1,J),J=M1,M2)                                LPI02270
 6101 FORMAT(' OBJ FUNCT ',10X,10F10.4)                                 LPI02280
      DO 1300 I = 1,NROW                                                LPI02290
      WRITE(6,6017) I,A(I,NCCL1),(A(I,J),J=M1,M2)                       LPI02300
 6017 FORMAT(1X,I2,8X,11F10.4)                                          LPI02310
 1300 CONTINUE                                                          LPI02320
 1301 CONTINUE                                                          LPI02330
C                                                                       LPI02340
C     QUERY FOR INPUT CHANGES                                           LPI02350
 1310 REWIND 5                                                          LPI02360
      WRITE(6,6018)                                                     LPI02370
 6018 FORMAT('0THIS IS YOUR INPUT. DO YOU HAVE'                         LPI02380
     1 ,' CHANGES TO MAKE?  YES, NO, OR RESTART.')                      LPI02390
      READ(5,5004,END=1310) NRES                                        LPI02400
      IF (NRES .EQ. YES) GO TO 1190                                     LPI02410
      IF (NRES .EQ. NO) GO TO 1320                                      LPI02420
      IF (NRES .EQ. REST) GO TO 1040                                    LPI02430
      IF (NRES .EQ. STOP) GO TO 2130                                    LPI02440
      WRITE(6,6020)                                                     LPI02450
 6020 FORMAT('0SAY AGAIN..')                                            LPI02460
      GO TO 1310                                                        LPI02470
C                                                                       LPI02480
C     WRITE DATA FOR RESTART                                            LPI02490
 1320 CONTINUE                                                          LPI02500
```

```
      REWIND 4                                                          LPI02510
      WRITE(4,5003) NROW,NCOL                                           LPI02520
      DO 1330 J = 1,NCOL                                                LPI02530
      TST = A(NROW1,J)                                                  LPI02540
      IF (TST .EQ. 0.D0 .AND. ILBL .EQ. 1) GO TO 1330                   LPI02550
      WRITE(4,5001) J,TST,LABL(J)                                       LPI02560
 1330 CONTINUE                                                          LPI02570
      WRITE(4,7704)                                                     LPI02580
 7704 FORMAT(80X)                                                       LPI02590
      DO 1350 I = 1,NROW                                                LPI02600
      DO 1340 J = 1,NCOL                                                LPI02610
      TST = A(I,J)                                                      LPI02620
      IF (TST .EQ. 0.D0) GO TO 1340                                     LPI02630
      WRITE(4,5002) I,J,TST                                             LPI02640
 1340 CONTINUE                                                          LPI02650
 1350 CONTINUE                                                          LPI02660
      WRITE(4,7704)                                                     LPI02670
      DO 1360 I = 1,NROW                                                LPI02680
      TST = A(I,NCOL1)                                                  LPI02690
      IF (TST .EQ. 0.D0) GO TO 1360                                     LPI02700
      WRITE(4,5001) I,TST                                               LPI02710
 1360 CONTINUE                                                          LPI02720
      END FILE 4                                                        LPI02730
      WRITE(6,6021)                                                     LPI02740
 6021 FORMAT('ORESTART FILE CREATED')                                   LPI02750
 1370 REWIND 5                                                          LPI02760
C                                                                       LPI02770
C          INITIALIZE OPTIONS                                           LPI02780
C     MRATIO = 1 FOR NO PIVOT VIOLATION CHECKING                        LPI02790
C            = 2 FOR PIVOT VIOLATION CHECKING ONLY                      LPI02800
C            = 3 FOR AUTOMATIC PRIMAL PIVOT COMPUTATION                 LPI02810
C     NOPRT = 1 FOR FULL TABLEAU PRINTING                               LPI02820
C           = 2 FOR XB & ZJ-CJ PRINTING ONLY                            LPI02830
      MRATIO = 1                                                        LPI02840
      NOPRT = 1                                                         LPI02850
      ISENS = 1                                                         LPI02860
C     CHECK PRIMAL PIVOTING?                                            LPI02870
      WRITE(6,6022)                                                     LPI02880
 6022 FORMAT('ODO YOU WANT YOUR PIVOT CHECKED FOR MIN-RATIO VIOLATION?')LPI02890
      READ(5,5004,END=1370) NRES                                        LPI02900
      IF (NRES .EQ. NO) GO TO 1410                                      LPI02910
      IF (NRES .EQ.YES) GO TO 1390                                      LPI02920
C     "AUTO" SETS MRATIO = 3 & NOPRT = 1                                LPI02930
      IF (NRES .EQ. AUTO) GO TO 1380                                    LPI02940
C     "NOTBL" SETS MRATIO = 3 & NOPRT = 2                               LPI02950
      IF (NRES .EQ. NOTBL) GO TO 1379                                   LPI02960
      IF (NRES .EQ. STOP) GO TO 2130                                    LPI02970
      WRITE(6,6020)                                                     LPI02980
      GO TO 1370                                                        LPI02990
 1379 NOPRT = 2                                                         LPI03000
 1380 MRATIO = 3                                                        LPI03010
      GO TO 1400                                                        LPI03020
 1390 MRATIC = 2                                                        LPI03030
 1400 WRITE(6,6023)                                                     LPI03040
 6023 FCRMAT('OOK. I WILL RESTRICT YOUR PIVOTING TO THE PROPER ROW.')   LPI03050
      IB = 1                                                            LPI03060
      GC TO 1420                                                        LPI03070
 1410 CONTINUE                                                          LPI03080
      WRITE(6,6024)                                                     LPI03090
 6024 FORMAT('OTHEN - HERE WE GO. JUST BE CAREFUL OF YOUR '             LPI03100
     1 ,'PIVOTING CRITERIA.')                                           LPI03110
 1420 CCNTINUE                                                          LPI03120
C     NTBL = TABLEAU NUMBER                                             LPI03130
C     IART = 2 IF NO ARTIFICIAL VECTORS ARE BASIC. IART = 1 OTHERWISE.  LPI03140
      IART = 1                                                          LPI03150
      NTBL = 0                                                          LPI03160
C                                                                       LPI03170
C     INITIALIZE WORKING MATRIX                                         LPI03180
C                                                                       LPI03190
 1430 DO 1440 I = 1,NROW                                                LPI03200
 1440 IBV(I) = I + 70                                                   LPI03210
 1450 CONTINUE                                                          LPI03220
      DO 1460 J = 1,NCOLM                                               LPI03230
      T(NROW1,J) = -A(NROW1,J)                                          LPI03240
      T(NROW2,J) = 0.DO                                                 LPI03250
      DO 1460 I = 1,NROW                                                LPI03260
      T(I,J) = A(I,J)                                                   LPI03270
 1460 CONTINUE                                                          LPI03280
      IF (MRATIO .EQ. 1)GO TU 1490                                      LPI03290
      DO 1480 I = 1,NROW                                                LPI03300
      IF (T(I,NCOL1) .GE. 0.DO) GO TO 1480                              LPI03310
      DC 1470 J = 1,NCOLM                                               LPI03320
 1470 T(I,J) = -T(I,J)                                                  LPI03330
 1480 CONTINUE                                                          LPI03340
 1490 CONTINUE                                                          LPI03350
C     START TEST FOR UNIT VECTORS                                       LPI03360
      DO 1510 J = 1,NCOL                                                LPI03370
      IFL = 0                                                           LPI03380
      DO 1500 I = 1,NROW                                                LPI03390
      IF (T(I,J) .EQ. 0.DO) GO TC 1500                                  LPI03400
      IF (T(I,J) .NE. 1.DO) GO TO 1510                                  LPI03410
      IFL = IFL + 1                                                     LPI03420
      IF (IFL .GT. 1) GO TO 1510                                        LPI03430
      II = I                                                            LPI03440
 1500 CONTINUE                                                          LPI03450
      IF (IFL .EQ. 0) GO TO 1510                                        LPI03460
      IF (T(NROW1,J) .NE. 0.DO) GO TC 1510                              LPI03470
      IBV(II) = J                                                       LPI03480
 1510 CONTINUE                                                          LPI03490
C     ENC TEST FOR UNIT VECTORS                                         LPI03500
```

```
C      START SETUP OF M-COEFFICIENTS
       IF (LPTPE .EQ. MIN) GO TO 1530
       DO 1520 J = 1,NCOL1
       DO 1520 I = 1,NROW
       IF (IBV(I) .LT. 71) GO TO 1520
       T(NROW2,J) = T(NROW2,J) - T(I,J)
 1520  CONTINUE
       GC TO 1550
 1530  DO 1540 J = 1,NCOL1
       DO 1540 I = 1,NROW
       IF (IBV(I) .LT. 71) GO TO 1540
       T(NROW2,J) = T(NROW2,J) + T(I,J)
 1540  CCNTINUE
C
C      OUTPUTSECTION
C
 1550  WRITE(6,6025) NTBL
 6025  FORMAT(//'0 TABLEAU NUMBER ',I4)
       IF (IART .EQ. 2) GO TO 1556
       DO 1555 I = 1,NROW
       IF (IBV(I) .LT. 71) GO TO 1555
       GO TO 1556
 1555  CONTINUE
       IART = 2
 1556  CONTINUE
       DO 1560 I = 1,NROW1
       DO 1560 J = 1,NCOL1
       IPRT1 = ICHK(T(I,J))
       GO TO (1560,1590,1610), IPRT1
 1560  CONTINUE
       MPRT = (NCOL + 9)/10
       DO 1583 JPRT = 1,MPRT
       M2 = 10 * JPRT
       M1 = M2 - 9
       M2 = MINO(M2,NCOL)
       WRITE(6,6026) (I,I = M1,M2)
       IF (ILBL .EQ. 2) WRITE(6,6016)(LABL(J),J=M1,M2)
 6026  FORMAT('0',16X,'B',10I10)
       IF (NOPRT .EQ. 2) GO TO 1571
       DO 1570 I = 1,NROW
       WRITE(6,6027) I,IBV(I),T(I,NCOL1),(T(I,J),J=M1,M2)
 6027  FORMAT(1X,I2,1X,'X(',I2,')',2X,11F10.4)
 1570  CONTINUE
 1571  WRITE(6,6028) T(NROW1,NCOL1),(T(NROW1,J),J=M1,M2)
 6028  FORMAT(' OBJ FUNCT ',11F10.4)
       GC TO (1580,1583),IART
 1580  WRITE(6,6029) T(NROW2,NCOL1),(T(NROW2,J),J=M1,M2)
 6029  FCRMAT(' M-COEFF.  ',11F10.4)
 1583  CONTINUE
 1581  IF (NOPRT .NE. 2) GO TO 1660
```

```
      WRITE(6,6100)                                                     LPI04010
 6100 FORMAT('0',12X,'X-VECTOR')                                        LPI04020
      DO 1582 I = 1,NROW                                                LPI04030
      WRITE(6,6027) I,IBV(I),T(I,NCOL1)                                 LPI04040
 1582 CONTINUE                                                          LPI04050
      GO TO 1660                                                        LPI04060
 1590 GO TO (1600,1630),IPRT                                            LPI04070
 1600 IPRT = 2                                                          LPI04080
      WRITE(6,6030)                                                     LPI04090
 6030 FORMAT('OOUCH    YOU''VE SQUEEZED ME OUT OF SPACE TO PRINT.',     LPI04100
     1 ' I''LL HAVE TO GIVE YOU A NEW FORMAT'/)                         LPI04110
      GO TO 1630                                                        LPI04120
 1610 GO TO (1620,1630),IPRT                                            LPI04130
 1620 IPRT = 2                                                          LPI04140
      WRITE(6,6031)                                                     LPI04150
 6031 FORMAT('OYOU HAVE SOME SMALL MATRIX ELEMENTS. I''LL GIVE YOU',    LPI04160
     1 ' A NEW FORMAT SO YOU CAN READ THEM'/)                           LPI04170
 1630 CONTINUE                                                          LPI04180
      MPRT = (NCOL+8)/9                                                 LPI04190
      DO 1653 JPRT = 1,MPRT                                             LPI04200
      M2 = 9 * JPRT                                                     LPI04210
      M1 = M2 - 8                                                       LPI04220
      M2 = MINO(M2,NCOL)                                                LPI04230
      WRITE(6,6033) (I,I = M1,M2)                                       LPI04240
 6033 FORMAT('0',17X,'B',9I11)                                          LPI04250
      IF (ILBL .EQ. 2) WRITE(6,6032) (LABL(I),I = M1,M2)                LPI04260
 6032 FORMAT(20X,9(7X,A4))                                              LPI04270
      IF (NOPRT .EQ. 2) GO TO 1641                                      LPI04280
      DO 1640 I = 1,NROW                                                LPI04290
      WRITE(6,6034) I,IBV(I),T(I,NCOL1),(T(I,J),J=M1,M2)                LPI04300
 6034 FORMAT(1X,I2,1X,'X(',I2,')',2X,1P10E11.3)                         LPI04310
 1640 CONTINUE                                                          LPI04320
 1641 WRITE(6,6035) T(NROW1,NCOL1),(T(NROW1,J),J=M1,M2)                 LPI04330
 6035 FORMAT(' OBJ FUNCT ',1P10E11.3)                                   LPI04340
      GO TO (1650,1653),IART                                            LPI04350
 1650 WRITE(6,6036) T(NROW2,NCOL1),(T(NROW2,J),J=M1,M2)                 LPI04360
 6036 FORMAT(' M-COEFF.  ',1P10E11.3)                                   LPI04370
 1653 CONTINUE                                                          LPI04380
 1651 IF (NOPRT .NE. 2) GO TO 1660                                      LPI04390
      WRITE(6,6100)                                                     LPI04400
      DO 1652 I = 1,NROW                                                LPI04410
      WRITE(6,6034) I,IBV(I),T(I,NCOL1)                                 LPI04420
 1652 CONTINUE                                                          LPI04430
C                                                                       LPI04440
C     INPUT PIVOT INFO. & TEST FOR INVALIDS.                            LPI04450
C                                                                       LPI04460
 1660 CONTINUE                                                          LPI04470
      WRITE(6,6037)                                                     LPI04480
 6037 FORMAT('0XX - PIVOT COLUMN?')                                     LPI04490
      READ(5,5006,END=1800)  IPIVCO                                     LPI04500
```

```
5006 FORMAT(I2)                                                         LPI04510
     IF(IPIVCO .GE. 1 .AND. IPIVCO .LE. NCOL) GO TO 1670                LPI04520
     WRITE(6,6038)IPIVCO                                                LPI04530
6038 FORMAT(' YOU DON''T HAVE A COLUMN ',I2,'. TRY AGAIN')              LPI04540
     GO TO 1660                                                         LPI04550
1670 CONTINUE                                                           LPI04560
     IF (MRATIO .EQ. 3) GO TO 1690                                      LPI04570
     WRITE(6,6039)                                                      LPI04580
6039 FORMAT(' XX - PIVOT ROW?')                                         LPI04590
     READ(5,5006,END=1800) IPIVRO                                       LPI04600
     IF (IPIVRO .GE. 1 .AND. IPIVRO .LE. NROW) GO TO 1680               LPI04610
     WRITE(6,6040)IPIVRO                                                LPI04620
6040 FORMAT(' SORRY, ROW ',I2,' DOESN''T EXIST')                        LPI04630
     GO TO 1670                                                         LPI04640
1680 DIV = T(IPIVRO,IPIVCO)                                             LPI04650
     GO TO (1750,1710,1690), MRATIO                                     LPI04660
1690 IPIVRO = 0                                                         LPI04670
     TMIN = 1.D50                                                       LPI04680
     DO 1700 I = 1,NROW                                                 LPI04690
     DTST = T(I,IPIVCO)                                                 LPI04700
     IF (DTST .LT. 1.D-10) GO TO 1700                                   LPI04710
     TST = T(I,NCOL1)/DTST                                              LPI04720
     IF (TST .GE. TMIN) GO TO 1700                                      LPI04730
     IPIVRO = I                                                         LPI04740
     DIV = DTST                                                         LPI04750
     TMIN = TST                                                         LPI04760
1700 CONTINUE                                                           LPI04770
     IF (IPIVRO .NE. 0) GO TO 1760                                      LPI04780
     WRITE(6,6041)                                                      LPI04790
6041 FORMAT('0YOUR PIVOT COLUMN DOES NOT HAVE A POSITIVE ELEMENT.',    LPI04800
    1  ' ..UNBOUNDED MAYBE??')                                          LPI04810
     GO TO 1660                                                         LPI04820
1710 IF (DIV .GT. 0.D0) GO TO 1720                                      LPI04830
     WRITE(6,6042)                                                      LPI04840
6042 FORMAT('0YOUR PIVOT IS NOT POSITIVE')                              LPI04850
     GO TO 1660                                                         LPI04860
1720 RTST = T(IPIVRO,NCOL1)/DIV                                         LPI04870
     DO 1730 I = 1,NROW                                                 LPI04880
     IF (I .EQ. IPIVRO) GO TO 1730                                      LPI04890
     TT = T(I,IPIVCO)                                                   LPI04900
     IF (TT .LE. 0.D0) GO TO 1730                                       LPI04910
     IF (T(I,NCOL1)/TT .LT. RTST) GO TO 1740                            LPI04920
1730 CONTINUE                                                           LPI04930
     GO TO 1750                                                         LPI04940
1740 WRITE(6,6043)                                                      LPI04950
6043 FORMAT('0YOU HAVE VIOLATED THE MIN-RATIO REQUIREMENT')             LPI04960
     GO TO 1660                                                         LPI04970
1750 CONTINUE                                                           LPI04980
     IF (DABS(DIV) .GE. 1.D-10) GO TO 1760                              LPI04990
     WRITE(6,6044)                                                      LPI05000
```

```
 6044 FORMAT('OPIVOT ELEMENT CLOSE TO OR EQUAL TC ZERC. TRY AGAIN..')
      GC TO 1660
C
C     TRANSFORM TC NEW TABLEAU
C
 1760 CCNTINUE
      IBV(IPIVRO) = IPIVCO
      DO 1770 J = 1,NCOLM
 1770 T(IPIVRO,J) = T(IPIVRO,J)/DIV
      DO 1790 I = 1,NROW2
      IF(I .EQ. IPIVRO) GO TO 1790
      CM = -T(I,IPIVCO)
      IF (CM .EQ. 0.DO) GO TO 1790
      DO 1780 J = 1,NCOLM
      T(I,J) = T(I,J) + T(IPIVRO,J)*CM
 1780 CCNTINUE
 1790 CCNTINUE
C
C     END TRANSFORMATICN TO NEW TABLEAU
C
      NTBL = NTBL + 1
      GC TO 1550
 1800 REWIND 5
      IF (ISENS .EQ. 2) GO TO 1890
      WRITE(6,6045)
 6045 FORMAT('OYOU INDICATE THAT YOU''RE THROUGH PIVOTING.',
     1 ' ARE YOU QUITE SURE?')
      READ(5,5004,END=1800) NRES
      IF (NRES .EQ. YES) GO TO 1810
      IF (NRES .EQ. NO) GO TO 1660
      IF (NRES .EQ. STOP) GO TO 2130
      WRITE(6,6020)
      GO TO 1800
 1810 REWIND 5
      WRITE(6,6046)
 6046 FORMAT('OTHERE ARE NUMEROUS OPTIONS THAT YCU MAY PERFORM AT THIS '
     1 ,'TIME. DO YOU WISH TO USE ONE CR MORE OF THEM?')
      READ(5,5004,END=1810) NRES
      IF (NRES .EQ. NO) GO TO 2100
      IF (NRES .EQ. YES) GO TO 1820
      IF (NRES .EQ. STOP) GO TO 2130
      WRITE(6,6020)
      GC TO 1810
 1820 REWIND 5
      WRITE(6,6047)
 6047 FORMAT('ODO YOU WANT YOUR OPTIONS ITEMIZED ALONG WITH THEIR ',
     1 'KEYWORD?'/' IF NO, THEN YOU MAY JUST TYPE THE KEYWORD.')
      READ(5,5004,END=1820) NRES
      IF (NRES .EQ. STOP) GO TO 2120
      IF (NRES .NE. YES) GO TO 1840
      WRITE(6,6048)                                                     LPI05510
 6C48 FORMAT('OBELOW ARE LISTED THE KEYWORDS FOLLOWED BY THEIR ',       LPI05520
     1 'FUNCTION.'/,                                                    LPI05530
     2 ' RESTART - REWORK THIS SAME PROBLEM FROM THE START.'/           LPI05540
     3 ' MODIFY - MODIFY ONE OR MORE INPUTS TO THIS PROBLEM ',          LPI05550
     4       '& START AFRESH.'/                                         LPI05560
     5 ' DUAL  - IF YOU CAN''T FIND THE DUAL VARIABLES IN YOUR ',       LPI05570
     6   'TABLEAU, THEY WILL BE PRINTED.' /                             LPI05580
     7 ' INVERSE - THE INVERSE OF YOUR CURRENT BASIS WILL BE PRINTED.   LPI05590
     8 '/' RATIO - REMOVE THE MIN-RATIO VIOLATION CHECK & CONTINUE.'/   LPI05600
     9 ' SENSITIVITY - PERFORM SENSITIVITY ANALYSIS OPTIONS.'/          LPI05610
     1 ' DONE - WHEN YOU WISH TO LEAVE THIS SECTION OR START A NEW',    LPI05620
     2 ' PROBLEM.')                                                     LPI05630
C                                                                       LPI05640
 1830 REWIND 5                                                          LPI05650
      READ(5,5004,END=1820) NRES                                        LPI05660
 1840 IF (NRES .EQ. REST) GO TO 1050                                    LPI05670
      IF (NRES .EQ. MODIFY) GO TO 1170                                  LPI05680
      IF (NRES .EQ. DUAL) GO TO 1850                                    LPI05690
      IF (NRES .EQ. INVERS) GO TO 1860                                  LPI05700
      IF (NRES .EQ. RATIO) GO TO 1870                                   LPI05710
      IF (NRES .EQ. SENS) GO TO 1880                                    LPI05720
      IF (NRES .EQ. NO) GO TO 1830                                      LPI05730
      IF (NRES .EQ. DONE) GO TO 2100                                    LPI05740
      IF (NRES .EQ. STOP) GO TO 2120                                    LPI05750
      WRITE(6,6020)                                                     LPI05760
      GO TO 1820                                                        LPI05770
 1850 CONTINUE                                                          LPI05780
      CALL PRNT1                                                        LPI05790
      GO TO 1830                                                        LPI05800
 1860 CONTINUE                                                          LPI05810
      CALL PRNT2                                                        LPI05820
      GO TO 1830                                                        LPI05830
 1870 MRATIO = 1                                                        LPI05840
      NOPRT = 1                                                         LPI05850
      GO TO 1660                                                        LPI05860
 1880 CONTINUE                                                          LPI05870
      ISENS = 2                                                         LPI05880
      WRITE(6,6049)                                                     LPI05890
 6049 FORMAT('OYOU MAY DO SENSITIVITY ANALYSIS ON THE OBJECTIVE ',      LPI05900
     1 'FUNCTION AND/OR THE RIGHT-HAND-SIDE ELEMENTS.'/                 LPI05910
     2 ' YOU MAY CHANGE ONLY ONE ELEMENT AT A TIME.',                   LPI05920
     3 ' WHEN QUERIED, TYPE IN ''OBJ'' OR ''RHS'', THE ELEMENT '/       LPI05930
     4 '  NUMBER (ROW OR COL. NO.), & THE AMOUNT THAT THE ELEMENT IS',  LPI05940
     5 ' TO BE INCREASED (NEGATIVE FOR DECREASE).'/                     LPI05950
     6 ' I WILL PRINT THE UPDATED ELEMENTS & THE NEW OBJ. FCTN. ROW ',  LPI05960
     7 '(ZJ - CJ), OR THE NEW X''S.'/                                   LPI05970
     8 ' YOU WILL BE QUERIED "PIVOT?", TO WHICH YOU MAY RESPOND ONE ',  LPI05980
     9 'OF THE FOLLOWING KEYWORDS--'/                                   LPI05990
     1 '  YES  - YOU WISH TO MAKE AN ITERATION'/                        LPI06000
     2 '  NO   - YOU WANT TO CHANGE ANOTHER "B" OR "C" ELEMENT'/          LPI06010
     3 '  DUAL - PRINT THE DUAL VARIABLES NOW, THEN RE-QUERY'/             LPI06020
     4 '  INVE - PRINT THE INVERSE MATRIX NOW, THEN RE-QUERY'/             LPI06030
     5 '  QUIT - YOU WANT TO LEAVE THE SENS. ANAL. MODE & DO SOMETH',     LPI06040
     6 'ING ELSE'/                                                          LPI06050
     7 '  STOP - YOU''VE HAD IT FOR THE DAY')                               LPI06060
 1890 REWIND 5                                                              LPI06070
      WRITE(6,6050)                                                         LPI06080
 6050 FORMAT('OOBJ'/' RHS NO ELEMENT'/' XXX XX XXXXXXX.')                  LPI06090
 1900 REWIND 5                                                              LPI06100
      READ(5,5007,END=1890) NRES,IX,TEMP                                    LPI06110
 5007 FORMAT(A3,1X,I2,1X,F7.0)                                              LPI06120
      IF (NRES .EQ. OBJ) GO TO 1980                                         LPI06130
      IF (NRES .EQ. RHS) GO TO 1910                                         LPI06140
      IF (NRES .EQ. QUI) GO TO 2090                                         LPI06150
      IF (NRES .EQ. STO) GO TO 2130                                         LPI06160
      WRITE(6,6020)                                                         LPI06170
      GO TO 1900                                                            LPI06180
C                                                                           LPI06190
C     RHS - VARIATIONS                                                      LPI06200
C                                                                           LPI06210
 1910 CONTINUE                                                              LPI06220
      IB = 2                                                                LPI06230
      IF (1 .LE. IX .AND. IX .LE. NROW) GO TO 1920                          LPI06240
      WRITE(6,6008)                                                         LPI06250
      GO TO 1900                                                            LPI06260
 1920 CONTINUE                                                              LPI06270
      A(IX,NCOL1) = A(IX,NCOL1) + TEMP                                      LPI06280
      IPRT = 1                                                              LPI06290
      ICOL = IX + NCOL1                                                     LPI06300
      DO 1930 I = 1,NROW1                                                   LPI06310
      TT = T(I,NCOL1) + T(I,ICOL)*TEMP                                      LPI06320
      T(I,NCOL1) = TT                                                       LPI06330
      IF (ICHK(TT) .NE. 1) IPRT = 2                                         LPI06340
 1930 CONTINUE                                                              LPI06350
      IF (IPRT .EQ.2) GO TO 1960                                            LPI06360
      DO 1940 I = 1,NROW                                                    LPI06370
      IF (ICHK(A(I,NCOL1)) .NE. 1) GO TO 1960                               LPI06380
 1940 CONTINUE                                                              LPI06390
      WRITE(6,6051)                                                         LPI06400
 6051 FORMAT('0',12X,'X-VECTOR  B-VECTOR')                                  LPI06410
      DO 1950 I = 1,NROW                                                    LPI06420
      WRITE(6,6027) I,IBV(I),T(I,NCOL1),A(I,NCOL1)                          LPI06430
 1950 CONTINUE                                                              LPI06440
      WRITE(6,6052) T(NROW1,NCOL1)                                          LPI06450
 6052 FORMAT('OVALUE OF OBJ. FCTN. = ',F10.4)                               LPI06460
      GO TO 2060                                                            LPI06470
 1960 WRITE(6,6051)                                                         LPI06480
      DO 1970 I = 1,NROW                                                    LPI06490
      WRITE(6,6034) I,IBV(I),T(I,NCOL1),A(I,NCOL1)                          LPI06500
 1970 CONTINUE                                                           LPI06510
      WRITE(6,6056) T(NROW1,NCOL1)                                       LPI06520
      GO TO 2060                                                         LPI06530
C                                                                        LPI06540
C     COST VARIATIONS                                                    LPI06550
C                                                                        LPI06560
 1980 CONTINUE                                                           LPI06570
      IF (1 .LE. IX .AND. IX .LE. NCOL) GO TO 1990                       LPI06580
      WRITE(6,6038) IX                                                   LPI06590
      GO TO 1900                                                         LPI06600
 1990 CONTINUE                                                           LPI06610
      A(NROW1,IX) = A(NROW1,IX) + TEMP                                   LPI06620
      DO 2000 I = 1,NROW                                                 LPI06630
      IIX = I                                                            LPI06640
      IF (IBV(I) .EQ. IX) GO TO 2010                                     LPI06650
 2000 CONTINUE                                                           LPI06660
      T(NROW1,IX) = T(NROW1,IX) - TEMP                                   LPI06670
      GO TO 2030                                                         LPI06680
 2010 DO 2020 J = 1,NCOLM                                                LPI06690
      IF (J .EQ. IX) GO TO 2020                                          LPI06700
      T(NROW1,J) = T(NROW1,J) + TEMP*T(IIX,J)                            LPI06710
 2020 CONTINUE                                                           LPI06720
C                                                                        LPI06730
 2030 IPRT = 1                                                           LPI06740
      DO 2040 J = 1,NCOL                                                 LPI06750
      IF (ICHK(T(NROW1,J)) .NE. 1) GO TO 2050                            LPI06760
      IF (ICHK(A(NROW1,J)) .NE. 1) GO TO 2050                            LPI06770
 2040 CONTINUE                                                           LPI06780
      IF (ICHK(T(NROW1,NCOL1)) .NE. 1) GO TO 2050                        LPI06790
      WRITE(6,6053)                                                      LPI06800
 6053 FORMAT('0 J',5X,'C(J)',7X,'Z(J)-C(J)')                             LPI06810
      WRITE(6,6054) ((J,A(NROW1,J),T(NROW1,J),LABL(J)),J=1,NCOL)         LPI06820
 6054 FORMAT(1X,I2,2F12.4,3X,A4)                                         LPI06830
      WRITE(6,6052) T(NROW1,NCOL1)                                       LPI06840
      GO TO 2060                                                         LPI06850
C                                                                        LPI06860
 2050 CONTINUE                                                           LPI06870
      WRITE(6,6053)                                                      LPI06880
      WRITE(6,6055) ((J,A(NROW1,J),T(NROW1,J),LABL(J)),J=1,NCOL)         LPI06890
 6055 FORMAT(1X,I2,1P2E12.3,3X,A4)                                       LPI06900
      WRITE(6,6056) T(NRCW1,NCOL1)                                       LPI06910
 6056 FORMAT('0VALUE OF OBJ. FCTN. = ',1PE12.3)                          LPI06920
C                                                                        LPI06930
C     QUERY                                                              LPI06940
C                                                                        LPI06950
 2060 REWIND 5                                                           LPI06960
      WRITE(6,6057)                                                      LPI06970
 6057 FORMAT('0PIVOT?')                                                  LPI06980
 2070 READ(5,5004,END=2060) NRES                                         LPI06990
      IF (NRES .EQ. STOP) GO TO 2130                                     LPI07000
      IF (NRES .EQ. NO)  GO TO 1890                                     LPI07010
      IF (NRES .EQ. QUIT) GO TO 2090                                    LPI07020
      IF (NRES .EQ. YES) GO TO 2080                                     LPI07030
      IF (NRES .EQ. DUAL) GO TO 2071                                    LPI07040
      IF (NRES .EQ. INVERS) GO TO 2072                                  LPI07050
      WRITE(6,6020)                                                     LPI07060
      GO TO 2070                                                        LPI07070
 2071 CALL PRNT1                                                        LPI07080
      GO TO 2060                                                        LPI07090
 2072 CALL PRNT2                                                        LPI07100
      GO TO 2060                                                        LPI07110
 2080 IF (MRATIO .EQ. 1) GO TO 1550                                     LPI07120
      IF (IB .EQ. 1) GO TO 1550                                         LPI07130
      MRATIO = 1                                                        LPI07140
      NOPRT = 1                                                         LPI07150
      WRITE(6,6058)                                                     LPI07160
 6058 FORMAT('0I WILL NO LONGER CHECK YOUR PIVCTING FOR VIOLATIONS ',   LPI07170
     1 'SINCE YOU ARE CHANGING B-VECTOR ELEMENTS & YOU'/                LPI07180
     2 ' WILL PROBABLY NEED TO USE DUAL SIMPLEX PIVOTING.')             LPI07190
      GO TO 1550                                                        LPI07200
 2090 CONTINUE                                                          LPI07210
      ISENS = 1                                                         LPI07220
      GO TO 1800                                                        LPI07230
C*********CONTINUE INPUT HERE*********                                  LPI07240
 2100 REWIND 5                                                          LPI07250
      WRITE(6,6059)                                                     LPI07260
 6059 FORMAT('0HOW ABOUT STARTING A NEW PROBLEM THEN?')                 LPI07270
      READ(5,5004,END=2100) NRES                                        LPI07280
      IF(NRES .EQ. YES) GO TO 1020                                      LPI07290
      IF (NRES .EQ. STOP) GO TO 2120                                    LPI07300
      IF (NRES .EQ. NO) GO TO 2110                                      LPI07310
      WRITE(6,6020)                                                     LPI07320
      GO TO 2100                                                        LPI07330
 2110 REWIND 5                                                          LPI07340
      WRITE(6,6060)                                                     LPI07350
 6060 FORMAT('0ABOUT ALL THAT IS LEFT IS TO CALL IT A DAY. ',           LPI07360
     1 'DO YOU WANT TO QUIT,? IF NO, TFEN WE WILL REVIEW'               LPI07370
     2,' THE OPTIONS.')                                                 LPI07380
      READ(5,5004,END=2110) NRES                                        LPI07390
      IF(NRES .EQ. YES) GO TO 2120                                      LPI07400
      IF(NRES .EQ. NO) GO TO 1800                                       LPI07410
      IF (NRES .EQ. STOP) GO TO 2120                                    LPI07420
      WRITE(6,6020)                                                     LPI07430
      GO TO 2110                                                        LPI07440
 2120 CONTINUE                                                          LPI07450
      REWIND 5                                                          LPI07460
      WRITE(6,6061)                                                     LPI07470
 6061 FORMAT('0I GUESS I SHOULD HAVE ASKED YOU THAT IN THE FIRST PLACE.'LPI07480
     1 ,'  SORRY ABOUT THAT...'/' IT HAS BEEN A PLEASURE SERVING YOU.') LPI07490
 2130 CONTINUE                                                          LPI07500
```

```
      WRITE(6,6062)                                                     LPI07510
 6062 FORMAT('0...HAVE A GOOD DAY ...')                                 LPI07520
C     THE FOLLOWING CALL WILL KILL THE SUMMARY ERROR TYPING, IF ANY.    LPI07530
C       KTT IS A NPS ROUTINE FOR CP/CMS                                 LPI07540
 2140 CONTINUE                                                          LPI07550
      CALL KTT                                                          LPI07560
      STOP                                                              LPI07570
      END                                                               LPI07580
      SUBROUTINE PRNT1                                                  LPI07600
      IMPLICIT REAL*8 (A-H,O-Z)                                         LPI07610
C                                                                       LPI07620
      COMMON /TABL$/A(22,51),T(22,51),IBV(20)                           LPI07630
      COMMON /STAT$/NROW,NCOL,NRCW1,NROW2,NCOL1,NCOL2,NCOLM             LPI07640
C                                                                       LPI07650
      WRITE(6,6025)                                                     LPI07660
 6025 FORMAT('O DUAL VARIABLES.'/)                                      LPI07670
      DO 10 J = NCOL2,NCOLM                                             LPI07680
      IF (ICHK(T(NROW1,J)) .NE. 1) GC TO 40                             LPI07690
   10 CONTINUE                                                          LPI07700
      WRITE(6,6026) (I,I = 1,NROW)                                      LPI07710
 6026 FORMAT(8X,11I10)                                                  LPI07720
      WRITE(6,6027) (T(NROW1,J),J=NCOL2,NCOLM)                          LPI07730
 6C27 FORMAT(11X,11F10.4)                                               LPI07740
      RETURN                                                            LPI07750
   40 CONTINUE                                                          LPI07760
      WRITE(6,6028) (I,I = 1,NROW)                                      LPI07770
 6028 FORMAT(8X,10I11)                                                  LPI07780
      WRITE(6,2007) (T(NROW1,J),J = NCCL2,NCOLM)                        LPI07790
 2007 FORMAT(11X,1P10E11.3)                                             LPI07800
      RETURN                                                            LPI07810
C                                                                       LPI07820
      ENTRY PRNT2                                                       LPI07830
      WRITE(6,6029)                                                     LPI07840
 6C29 FORMAT('OINVERSE MATRIX'/)                                        LPI07850
      DO 50 I = 1,NROW                                                  LPI07860
      DO 50 J = NCOL2,NCOLM                                             LPI07870
      IF (ICHK(T(I,J)) .NE. 1) GO TO 70                                 LPI07880
   50 CONTINUE                                                          LPI07890
      WRITE(6,6026) (I,I=1,NROW)                                        LPI07900
      CO 60 I = 1,NROW                                                  LPI07910
      WRITE(6,2005) I,(T(I,J),J = NCCL2,NCOLM)                          LPI07920
 2005 FORMAT(1X,I2,8X,11F10.4/(11X,11F10.4))                            LPI07930
   60 CCNTINUE                                                          LPI07940
      RETURN                                                            LPI07950
   70 CONTINUE                                                          LPI07960
      WRITE(6,6028) (I, I = 1,NROW)                                     LPI07970
      DO 80 I = 1,NROW                                                  LPI07980
      WRITE(6,2006) I,(T(I,J),J = NCOL2,NCOLM)                          LPI07990
 2006 FORMAT(1X,I2,8X,1P10E11.3/(11X,1P10E11.3))                        LPI08000
   80 CONTINUE                                                          LPI08010
      RETURN                                                            LPI08020
      END                                                               LPI08030
      FUNCTION ICHK(A)                                                  LPI08050
      IMPLICIT REAL*8(A-H,O-Z)                                          LPI08060
      ICHK=1                                                            LPI08070
      B=CABS(A)                                                         LPI08080
      IF (A .GE. 1.D5 .OR. A .LE. -1.D4) ICHK=2                         LPI08090
      IF (B .LT. 1.D-4 .AND. B .GE. 1.D-8) ICHK=3                       LPI08100
      RETURN                                                            LPI08110
      END                                                               LPI08120
```

```
KTT      CSECT                                                          KTT00010
         USING *,R4                                                     KTT00020
         SAVE  (14,04)                                                  KTT00030
         LR    R4,R15                                                   KTT00040
         ST    R13,SAVAR+4                                              KTT00050
         LA    R13,SAVAR                                                KTT00060
         OI    562,X'40'                                                KTT00070
         L     R13,SAVAR+4                                              KTT00080
         LM    R14,R4,12(R13)                                           KTT00090
         LA    R15,0                                                    KTT00100
         BR    R14                                                      KTT00110
         CMSREG                                                         KTT00120
SAVAR    DS    18F                                                      KTT00130
         END                                                            KTT00140
```

Initial Distribution

	# of copies
Defense Documentation Center Cameron Station Alexandria, Virginia 22314	2
Dean of Research (Code 023) Naval Postgraduate School Monterey, California 93940	1
Library (Code 0212) Naval Postgraduate School Monterey, California 93940	2
Dean of Continuing Education (Code 024)	1
Office of Continuing Education (Code 500) Naval Postgraduate School Monterey, Calfornia 93940	2
Professor D. A. Schrady, Chairman (Code 55) Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	1
Professor D. G. Williams, Director (Code 0211) W. R. Church Computer Center Naval Postgraduate School Monterey, California 93940	1
Dr. William F. Brown, Director Computer Center Ball State University Muncie, Indiana 47306	1
Library, (Code 55) Department of Operations Research and Administrative Sciences Naval Postgraduate School Monterey, California 93940	3
Library (Code 0211) W. R. Church Computer Center Naval Postgraduate School Monterey, California 93940	3
Professors A. F. Andrus D. R. Barr D. C. Boger	1 each

G. H. Bradley

G. G. Brown

R. W. Butterworth

P. M. Carrick

R. S. Elster

R. N. Forrest

D. P. Gaver

J. K. Hartman

G. T. Howard

J. P. Hynes

C. R. Jones

M. B. Kline

H. J. Larson

P. A. W. Lewis

G. F. Lindsay

K. T. Marshall

A. W. McMasters

P. R. Milch

G. L. Musgrave

S. H. Parry

W. M. Raike

R. A. Stephen

J. G. Taylor

A. R. Washburn

B. R. Webster

H. H. Zweig

Department of Operations Research
and Administrative Sciences
Naval Postgraduate School
Monterey, California 93940

Professor G. L. Barksdale 1
" V. R. Kodres 1
Department of Mathematics
Naval Postgraduate School
Monterey, California 93940

Professor R. H. Shudde 12
Department of Operations Research
and Administrative Sciences
Naval Postgraduate School
Monterey, California 93940