物理算題例解

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Solutions of Mathematical Problems in Physics

PART I

Statics and Kinetics

物理算題例解

上卷

力學之部

應試必備

英漢對照物理算題例解

第一集　上卷　力學之部

引言　中國近遘於外患，有識之士皆知我弱敵强之由，科學實司其機。我惟昧于物理化學，是以農工不振，軍器皆須仰仗外人。敵惟致力於此，故百業發達，武備更操勝算。爰時者遂有暫停文法等項，專辦農工醫諸科之議。而今歲投考數知名大學者，更以物理科爲獨多。誠明于當務之急矣。

顧理科之中莫不以數學爲門徑，而物理所包各項：如力學，光學，電學之類，尤須精于算術，方克得其精蘊，致諸實用。但習數學者未必盡諳物理，習物理者又未必悉精數學　故必有術以溝通之，然後可收合作之效，此斯篇之所以作也。

業者于教授之餘，體察各校數學題中鮮有涉及物理者；而講物理教師又每忽視書中算式，不令學生實習；縱令實習矣，學生中數學根底不深者反感困難焉。特搜集物理算題無慮數百則，一一演出擇其較易者列爲第一集，較難者編諸第二集，第一集分上下兩卷，上卷爲力學之部，餘隸下卷。淺者可供考高中之用，深者以備考大學者之需。然更望授算術者亦能採此爲參考，使習算術者亦獲物理之修養也。

Solutions of Mathematical Problems in Physics

CONTENTS

I. Uniform Motion and Average Velocity

等速運動與平均速度

1. A velocity of 60 mi. per hour is how many feet per second? 每小時 60 哩之速度，合每秒若干呎。

解 1 哩＝5280 呎 1 小時＝3600 秒

故 $\frac{60\times5280}{3600}$＝88 ft 即每秒速度爲 88 呎

2. Express a velocity of 10 m. per minute in centimeters per second. 每分 10 公尺之速度，每秒合幾公分。

解 1 分＝60 秒 1 公尺＝100 公分

故 $\frac{10\times100}{60}$＝16.66……cm 即每秒速度爲 16.66……公分

3. A train travels 100 mi. in two and one half hours. Calculate the average velocity in feet per second 一火車二小時半行百哩，試計其每秒之平均速度爲若干呎。

解 1 哩＝5280 呎 1 小時＝3600 秒

故 $\frac{100\times5280}{2.5\times3600}$＝58.66……ft 即每秒平均速度爲 58.66……呎

4. The speed of an electric car averages 20 ft. per second. How far will it travel in three hours? 某電車之平均速度每秒 20 呎，問三小時可行若干。

解 1 小時＝3600 秒

故 $20\times3600\times3=216000$ ft 即三小時共行二十一萬六千呎或 $40\frac{10}{11}$哩

5. A train whose length is 440 yd. has a velocity of 45 mi. per hour. How long will it take the train to pass completely over a bridge 100 ft. long? 一火車長 440 碼，速度每小時 45 哩，有橋長 100 呎，此車全身通過需若干小時。

解 1 哩＝5280 呎　　1 碼＝3 呎

故 $\frac{100+440\times3}{45\times5280}=\frac{1420}{45\times5280}=\frac{71}{11925}$ 小時

(或 $21\frac{13}{53}$秒)

6. A wheel 50 cm. in diameter revolves 600 times per minute. Express the speed of a point on its rim in centimeters per second. 一輪直徑長 50 公分，每分鐘旋轉 600 次，其輪邊一點每秒速度如何。(註：圓周＝π直徑，$\pi=3.1416$)

解 $\frac{\pi50\times600}{60}=500\pi$ 公分 即每秒的速度為

500π cm. 或 157008 cm.

7. Assuming that the radius of the earth is 4000 mi. and that it revolves on its axis once in exactly 24 hr.,

ascertain the speed of a point at the equator. 設地球之半徑爲 4000 哩，每 24 小時恰轉一次，試求其赤道一點之速度。（註：圓周＝2π半徑）

解 $\frac{4000\times 2\pi}{24}=\frac{4000\times 2\times 3.1416}{24}=1047.2$ m!

即每小時 1047.2 哩

II. Uniformly Accelerated Motion 等加速度運動

1. A train leaving a station has a constant acceleration of o. 4 m/sec². what will be its velocity at the end of the tenth second? At the end of 15 second? 一火車離站加速度每秒每秒 o. 4 公尺，其第 10 秒之末速度若何，其第 15 秒之速度若何。

解 依公式 $v=at$

十秒末之速度 $=.4\times 10=4$m 即四公尺

十五秒末之速度 $=.4\times 15=6$m 即六公尺

2. If the acceleration of an electric car is uniform and 2 ft./sec²., in how many seconds will it accumulate a velocity of 25 ft. per second? 一電車之等加速度爲每秒每秒 2 呎，若干秒後其速度爲 25 呎？

解 依公式 $v=at$ 故 $t=v\div a$

所求之秒＝25÷2＝12.5 秒

3. How far will the car in the above question move during the first 10 seconds? What will be its average velocity during this interval of time? 上題之車頭 10 秒間所行之距離若干，在此時間內其平均之速度幾何？

解 依公式 $d=\frac{1}{2}at^2$ 及 平均速度 $=\frac{at}{2}$

故 上題所行之距離 $=\frac{1}{2}\times 2\times 10\times 10=100$ 呎

其平均速度 $=\frac{2\times 10}{2}=10$ 呎

4. The acceleration of a car is 5 m. / sec^2. . What velocity will it acquire in going 100 m.? 一車之加速度爲每秒每秒 5 公尺，行 100 公尺時，其速度若干？

解 依公式 $d=\frac{1}{2}at^2$ 可得 $t=\sqrt{\frac{2d}{a}}$ 又公式 $v=at$

故 $t=\sqrt{\frac{2\times 100}{5}}=6.324$ 秒

其速度 $=6.324\times 5=31.62$ m. (由上列公式可推知 $v=\sqrt{2ad}$)

5. A body has uniformly accelerated motion. What is its acceleration if it passes over 300 cm. in 20 seconds? 一物體爲等加速度運動，若 20 秒間經過 300 公分，其加速度若干？

解 依公式 $d=\frac{1}{2}at^2$ 可得 $a=\frac{2d}{t^2}$

故 加速度 $=\frac{2\times 300}{20\times 20}=1.5$ cm.

6. A bicycle starts from rest at the top of a hill 150 ft. long and has a uniform acceleration of 1 ft. per second. What will be its velocity at the foot of the hill? 一自行車由靜止下山，坡長 150 呎，其等加速度爲每秒一呎，至山脚下時，其速度若干。

解 依公式 $d=\frac{1}{2}at^2$，$t=\sqrt{\frac{2d}{a}}=\sqrt{\frac{2\times150}{1}}=\sqrt{300}=17.32$ ft

又依公式 $v=at$

其速度 $=2\times17.32=34.64$ ft (或依 $v=\sqrt{2ad}$ 亦可)

7. A car was moving at the rate of 30 mi. per hour when the brakes was applied. What was the rate of retardation if the car came to rest in 10 seconds, the decrease in velocity being uniform? 一車每小時行 30 哩，時爲扳機所止，需時 10 秒，設其減速均等，應每秒若干。

解 依平均速度公式 $\frac{at}{2}=\frac{30\times5280}{2\times3600}=\frac{44}{2}$

故 $at=44$ $a=\frac{44}{10}=4.4$ 呎

(註：每小時 30 哩變每秒則 $=\frac{30\times5280}{3600}$ 呎)

8. A bicycle rider moving at the rate of 15 mi. per hour applies the brake which brings him to rest in moving 121 ft. Assuming that the velocity decreases uni-

formly, find the acceleration. 一人乘自行車每小時行 15 哩時，扳機止之，需行 121 呎後始停，設其減速均等，應每秒若干。

解 原速每秒$=\frac{15\times5280}{3600}$ ft$=$ 22 呎依平均速度公式及 $d=\frac{1}{2}at^2$ $at=22$ $121=\frac{1}{2}at^2$ $\therefore at^2=242$ 由$\frac{242}{22}=11=t$

故 知 $a=22\div11=2$ 即每秒減速 2 呎

9. A fly wheel is set in motion with a uniform acceleration of two revolutions per second per second. If the diameter of the wheel is 50 cm., what is the linear acceleration of a point on its rim? 一旋輪其等加速度每秒每秒兩轉，設此輪之直徑爲 50 公分，其邊上一點之加速度若干。

解 圓周$=\pi$直徑$=3.1416\times50$ cm

故 周邊一點之加速度$=2\times3.1416\times50$ cm.$=$ 314.16 公分

10. What is the velocity of a body having uniformly accelerated motion at the beginning of the t th second? What is the average velocity during the t th second? Show that the distance passed over during the t th second is $\frac{1}{2}$ a (2t-1). 一物體係等加速度運動，其 t 秒初之速度若何，在第 t 秒間其平均速度如何，並證明在第 t 秒間其所經過之距離爲 $\frac{1}{2}$ a (2t—1).

解 (1) t 秒初之速度即 t 前一秒末之速度＝a(t−1)

(2) 在 t 秒間之平均速度為 $\frac{a(t-1)+at}{2}=$

$\frac{2at-a}{2}=\frac{1}{2}a(2t-1)$

(3) 在 t 秒間所經之距離為

$\frac{1}{2}at^2-\frac{1}{2}a(t-1)^2=\frac{1}{2}a(2t-1)$

11. Apply the formula developed in the above Exercise to the conditions given in Exer. I, and calculate the distance passed over by the train during the fifth and the tenth second. 應用上題所證公式，計算第一題中火車在第五秒及第十秒所經過之距離。

解 依上證公式 $\frac{1}{2}a(2t-1)=d$

當 第五秒所行之距離 $=\frac{1}{2}\times .4\times(2\times5-1)=$ 1.8 m

當 第十秒所行之距離 $=\frac{1}{2}\times .4\times(2\times10-1)=$ 3.8 m

III. Simultaneous Motions and Velocities.

同時之運動與速度

1. A train approaches Chicago with the velocity of 30 km. per hour while a brakeman runs along the tops of the cars toward the rear at the rate of 5 km. per hour.

How rapidly is the brakeman approaching Chicago? 一列車向芝加哥行，每小時速度 30 km. 有一扳機者在車頂向車尾奔跑，每小時 5 km. 問此人向芝加哥之速度若干。

解 因其向車尾面行故此人速度應由車速中減去之

故此人向芝加哥之速度如下：

$$30-5=25 \text{ km}$$ 即每小時二十五公里

2 A boy is paddling a canoe along a river in the direction of the current, which has a velocity of 4 mi. per hour; if there were no current, the canoe would move 3.5 mi. per hour. How fast is the canoe moving? 一童沿河順流搖一獨木舟，水速每小時 4 哩，在靜水中舟速每小時 3.5 哩，現時此舟速度若干。

解 順流舟速應加水速

故此舟現在每小時速度為 $3.5+4=7.5$ 哩

3. Suppose the boy in Exer. 2 should double his effort and paddle upstream. How long would it take him to go 10 mi.? 設上題中童子將其搖力加倍，逆流而上，若行 10 哩，須時若干。

解 逆流舟速應減水速故行 10 哩所須之時為

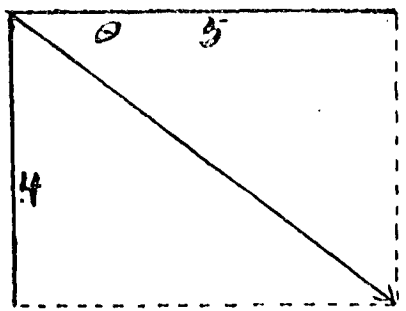
$$10\div(3.5\times2-4)=3\tfrac{1}{3} \text{ 小時}$$

4. A ship is moving east at the rate of 15 mi. per hour. If a person walks directly across the deck at the rate of 4 mi. per hour, with what velocity will he actually move? 一舟東行每小時 15 哩，一人橫穿舟面而行，每小時 4 哩問此人實在之速度若干。

解 人在舟上靜時與舟同速，至其橫行之速，與前進無關。

故此人前進之速仍爲舟之原速即每小時 15 哩。

5. A boat is rowed with a velocity of 4 mi. per hour, perpendicular to the current of a stream flowing 5 mi. per hour. Determine the direction of the motion and the velocity of the boat. 一舟搖行速度每小時 4 哩，與每小時速度 5 哩之水流作垂直面行，試定此舟之方向及其速度。



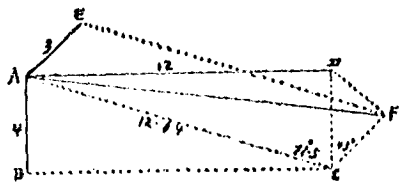
解 此舟向圖中所標之箭面行其速度 $=\sqrt{5^2+4^2}=6.4$ 強(哩)

方向 $\tan\theta=\frac{4}{5}$

$=.8$ $\theta=38°$ 40'

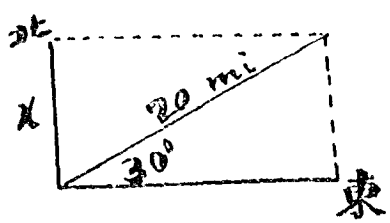
6. A ship headed due east under a power that can move it 12 mi. per hour enters an ocean current whose velocity is 4 mi. per hour south. If a person on deck walks northeast with a velocity of 3 mi. per hour, what is his actual velocity? 一艘首東向，有力使之每小時行 12 哩入洋流中，其速每小時 4 哩，南向，設船面一人向東北行，每小時之速度爲 3 哩。問其實在之速度若干。

解 參看右圖 AF 線即表示此人實在之速度 AC=12.64



$$AF=\sqrt{160+9+2\times12.64\times3\cos(180°-116°.5)}$$
$$=\sqrt{202.82}=14.2 \text{ mi per hour}$$

7. A balloon is driven in a direction east by 30° north. How rapidly is it drifting north if its velocity is 20 mi. per hour? 一氣球向東 30° 偏北而行，設其速度每小時 20 哩問其向北之速度若干



解 依圖其向北之速度設爲 x

故 $\frac{x}{20}=\cos 60°$

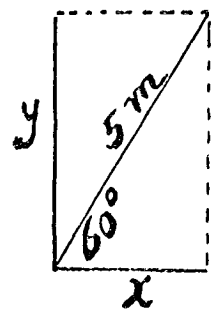
$x=20\cos 60°=20\times\frac{1}{2}=10$ 哩

8. A body moves down an inclined plane 5m. in length. If the angle between the incline and a horizental plane is 60°, what are the horizontal and vertical components of its motion? 一物體沿長 5m 之斜面而下，設斜面與地平成 60° 之角，此物之平面與垂直之分速各幾何？

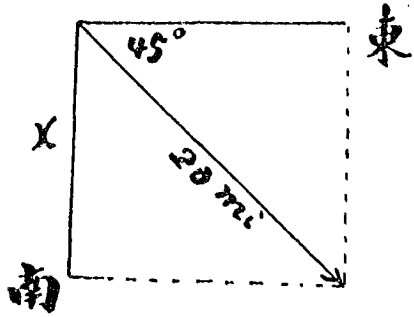
解 依圖設平面之分運動爲 x
垂直之分運動爲 y

$\frac{x}{5}=\cos 60°$ $x=5\times\frac{1}{2}=2.5\text{m.}$

$\frac{y}{5}=\text{Sin } 30°$ $y=5\times\frac{\sqrt{3}}{2}=4.33\text{m.}$



9. How rapidly is a bird approaching the equator when flying due southeast at the rate of 20 mi. per hour? 一鳥東南飛，每小時 20 哩，問其向赤道之速度若干？



解 依圖設其向赤道之速爲 x

故 $\frac{x}{20}=\cos 45°$

$x=20\times\frac{\sqrt{2}}{2}=$

14.1 mi.

IV FORCE 力

1. A 4 gram-rifle ball leaves a gun with a speed of 20,000 cm. per second. Compute its momentum. 一克之槍彈出口速度每秒 20,000 cm. 試計其運動量。

解 其運動量 $=1\times20000=20000$ C. G. S. 單位

2. Which has the larger momentum a man weighing 150 lb., walking 10 ft per second, or a boy weighing 60 lb. and running 25 ft. per second? 一人重 150 磅，每秒行十呎；一童重 60 磅，每秒跑 25 呎；二者之運動量孰大。

解 人之運動量$=150\times10=1500$ F. P. S. 單位

童之運動量$=60\times25=1500$ F. P. S. 單位

故二者相等。

3. Which has the greater momentum, a man weighing 160 lb. in a railway coach moving 30 mi. per hour, or a 2-ton stone moving 3 ft. per second? 一人重 160 磅，乘火車速度每小時 30 哩；一石重 2 噸，每秒行 3 呎；二者之運動量孰大。

解 人之運動量$=160\times30\times5280\div3600=7040$ F. P. S. 單位

石之運動量$=2\times2000\times3=12000$ F. P. S. 單位

石之運動量較大。

4. What force acting for 10 seconds upon a mass of 200 g. will produce a velocity of 5 cm. / sec.? 一力對於重 200 g. 之物體使其運動 10 秒，每秒速度 5 cm. 其運動量若干，

解 運動量$=200\times10\times5=10000$ C. G. S. 單位

5. A body whose mass is 20 g. is given an acceleration of 45 cm. / sec.^{2} What is the required force? 一物體重 20 g，每秒加速度爲每秒 45 cm. 須力若干。

解 依公式 $f=ma$ 力 $=20\times45=900$ C.G.S. 單位

6. What acceleration will be given to a mass of 25 g. by a constant force of 500 dynes? Over what distance will the body move in 5 seconds if the force continues to act? 一物體重 25 g. 若使永具 500 dynes 之力，其加速度須若干，此物在 5 秒間繼續進行，其經過之距離若干。

解 依公式 $f=ma$ $a=f\div m=500\div25=20$ cm. / sec^2.

又 依公式 $d=\frac{1}{2}at^2=\frac{1}{2}\times20\times5\times5=250$ cm.

7. If the force given in Exer. 6 ceases to act at the end of the 5th second, how far will the body move during the next 5 seconds? 設上題之力於第五秒之末中止，則以後五秒間，應行若干。

解 依公式 $v=at$ 求第五秒末之速度 $=20\times5=100$ cm / sec.

又 依牛頓第一公理及公式 $d=vt$ 故以後 5 秒間應行 $100\times5=500$ cm.

8. An elastic ball of clay whose mass is 200 g. has a velocity of 25 cm. / sec. when it collides with a similar ball at rest whose mass is 50 g. Find the velocity after collision. 有彈性之泥球一，其重量為 200 g. 其速度每秒 25 cm. 與一靜止之球重 50 g. 者相撞，求其撞後之速度。

解 未撞前第一球之運動量 $=200\times25$ C.G.S. 單位。

撞後則第二球與之同行，其運動量仍前，而體量則為二者之和。

故 搶後速度依公式 $f=mv$ $v=200\times25\div(200+50)=20$ cm. / sec.

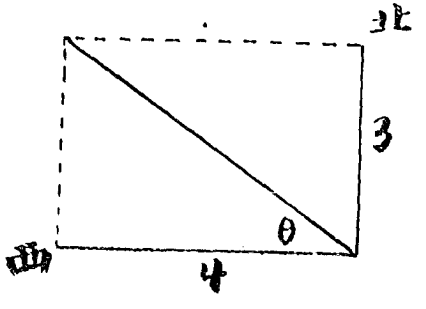
9. A projectile weighing 100 lb. is fired with a velocity of 1200 ft. per second from a gun weighing 8 T. Find the velocity with which the gun starts to move back ward. 百磅之彈，由一重八噸之砲放出，其速度每秒1200呎，試求此砲倒退之速度。

解 彈之運動量$=100\times1200$ F. P. S. 單位

砲倒退之速度$=100\times1200\div8\times2000=7.5$呎

V. EQUILIBRANT AND RESULTANT 平衡與合力

1. Find the magnitude and the direction of the resultant of two forces, 3 lb. acting north and 4lb. acting west, applied at the same point. 一力三磅向北，一力四磅向西，同施於一點，試求二力之合力及合力之方向。



解 其方向如箭所示

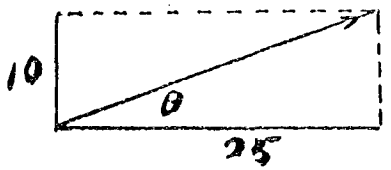
其合力之量$=\sqrt{4^2+3^2}=\sqrt{25}$

$=5$ 磅 方向 tan

$\theta=\frac{3}{4}=.75$

$\theta=36°\ 53'$

2. A ball is acted upon simultaneously by two forces, one of 10 kg. directed upward, the other of 25 kg. directed east along a horizontal line. Find the resultant in both magnitude and direction. 二力一重 10 kg. 向上，一重 25 kg. 向東，同時對於一球而施，求其合力之方向與其量。



解 合力方向如箭所示

其合力之量＝

$\sqrt{25^2+10^2}=\sqrt{725}$

＝26.92 kg.

方向 $\tan\theta=\frac{10}{25}=.4$ $\theta=21°\ 49'$

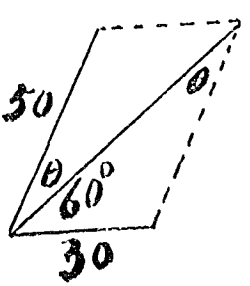
3. The angle between a force of 50 dynes and one of 30 dynes is 60°. Find the resultant and the equilibrant in both magnitude and direction. 一力 50 dyne，一力 30 dyne，成 60° 角，試求其合力及其平衡力之量與方向。

解 其合力之方向如圖箭所示其平衡力之方向與之相反 其合力之量

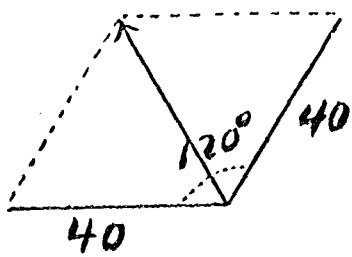
$=\sqrt{30^2+50^2+2\times30\times50\times\cos 60°}$

$=\sqrt{4900}=70$ dyne（依幾何鈍角對邊定理） 其平衡力之量亦＝70dyne. 方向 $\sin\theta=30\times\frac{1}{2}\times\frac{1}{70}=\frac{3}{14}$ $\theta=12°\ 22'$

$60°-\theta=47°\ 38'$

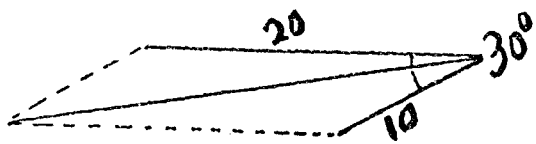


4. The angle between two equal forces of 40 lb. each is 120°. Find the resultant. 二力各爲 40 磅，成 120° 之角，求其合力。



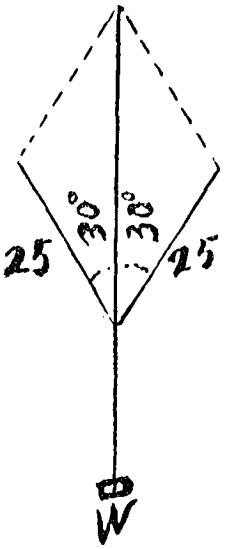
解 其合力之量＝
$\sqrt{2\times40^2-2\times40^2\times\frac{1}{2}}$
＝40 磅（依幾何銳角三角形對邊定理）

5. A boat is pulled by two ropes making an angle of 30°. If one force is 10 lb. and the other 20 lb., what is the resultant? 二繩成 30° 角，拉一舟，一力 10 磅，一力 20 磅，求其合力。



解 其合力依幾何鈍角△對邊定理
$=\sqrt{10^2+20^2+2\times10\times20\cos30°}=25.42$ 磅

6. A weight is suspended by two cords applied at the same point and each making an angle of 30° with a vertical line. If the tension in each is 25 lb., what is the weight supported? 二繩繫一重量，同施於一點，相交對於一垂直線各成 30° 角，設其力各爲 25 磅，求其所繫之重幾何。



解 參看附圖所繪之重 w 必等於二者之合力，始成平衡。

故 $w=\sqrt{25^2+25^2+2\times25\times25\cos60°}$

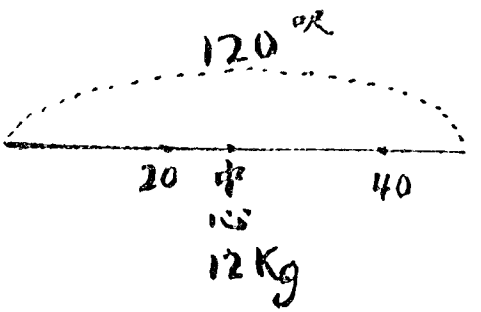
$=43.3$ 磅（依幾何銳角定理）

VI. PARALLEL FORCES

平行力

1. A uuiform bar of wood weighing 12 kg. is 120 cm. long; two hooks are placed on oppsite sides of the center at distances of 40 cm. and 20 cm. respectively. What forces applied to the hooks will support the bar?

一均一木杆重 12 kg. 長 120 cm. 有二鈎在中心之兩傍一距心 40 cm. 一距心 20 cm. 二鈎各須力若干始可支持此杆。



解 參看左圖設距心 20 cm. 之鈎負重=x 則距心 40 cm. 之鈎負重=12−x

依平行定理 20 x=40 (12−x)

20 x=480−40 x 又12−x=12−8=4 kg.

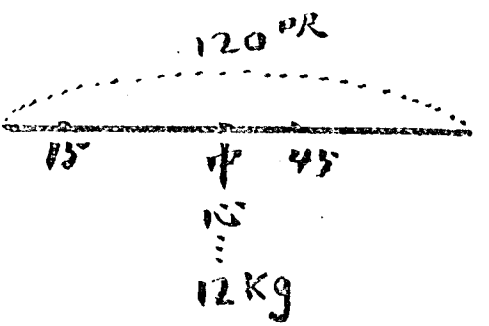
60 x=480 x=8 kg.

2. In order to support the bar in Exer. I. what forces applied at points respectively 45 cm. and 15 cm. from the en ls of the bar will be required? 上題之桿若在距左端 15 cm. 距右端 45 cm. 處支之，須力各若干。

解 參看附圖設左端負重=x 則右端負重 = 12 −x

依平行力定理 45 x=15(12−x) 45x=180−15 x

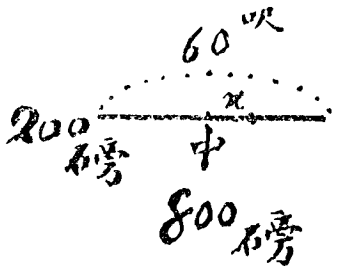
60 x=180



x=3 kg 12−x=9 kg.

即左端負重 =3 kg. 右端負重=9 kg.

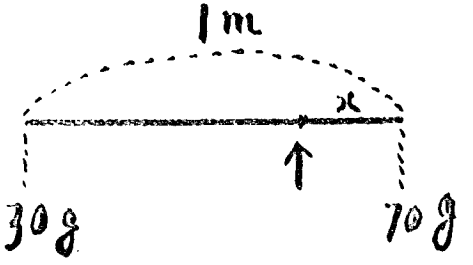
3. A beam of uniform size if is 60 ft. long and weighs 800 lb.; a man at one end supports 200 lb. Find the magnitude and point of application of the other required force. 一杆形體均勻，長 60 呎，重 800 磅，一人肩一端負重 200 磅，試求他人應肩之點及其負重若干。



解 參看左圖他人應肩之重
=800−200=600 磅而
其距中心之長=x，依平
行力定理 600 x=200
×30 x=10 呎

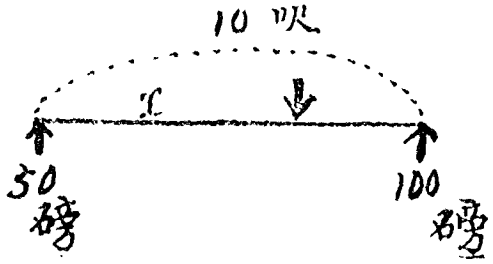
4. Two parallel forces of 30 g. and 70 g. are applied at the ends of a bar 1 m. long. Find what weight will be supported and its location on the bar, neglecting the weight of the bar itself. 二平行力一爲 30 g. 一爲 70 g. 施於長 1 m 之杆之兩端，設杆爲無重，此二力所支之重若干，並求各力所施之點。

解 支力爲 30+70
=100 g 支點距
70 g 之端=x 則
距 30 g之端=1
−x
故 70 x=30(1−x)
70x=30−30x
100x=30



$$x=\frac{3}{10}\text{m} \quad 1-x=\frac{7}{10}\text{m}$$

5. A boy and a man are carrying a weight of 150 lb. on a bar 10 ft, in length. If the forces are applied at the ends of the bar, where must the load be placed in order that the boy may have to carry only 50 lb? 一童與一人用長10呎之杆，負重150磅，設支點在兩端，欲使此童負重50磅，則重點應在何處。

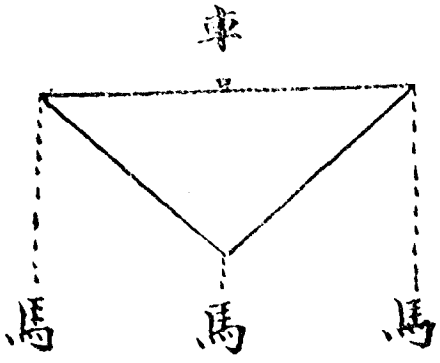


解 童既負重50磅則人應負重100磅設重點距童爲x. 則距人爲 10−x

故 $50x=100(10-x)$ $50x=1000-100x$

$150x=1000$ $x=6\frac{2}{3}$ 呎 $10-x=3\frac{1}{3}$ 呎

6. Draw a diagram showing a method for attaching three horses to a load so that they must pull equally. 有重載欲使三馬拉之其力均等試作圖以示其法



解 法以橫杆中心聯於重載，使二馬拉兩端，一馬居中，而使其繩亦繫於兩端，如是則其力自均矣。

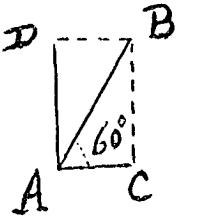
VII. RESOLUTION OF FORCES

力之分解

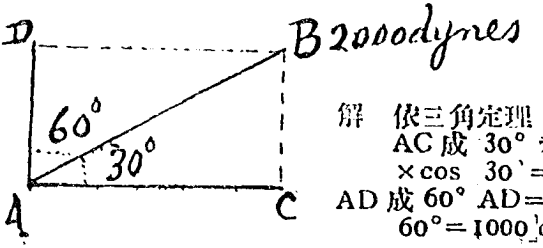
1. If the force represented by the line AB, Fig. A, is 1000 lb., and the angle BAC, 60°, find the components AC and AD. A 圖中 AB 代力 1000 磅 BAC 角爲 60° 試求其分力 AC,AD 之量·

解 原圖 AD 係爲鐵軌所抵抗故失其力，然依式求之應爲 AD=1000 $\times \sin 60° = 1000 \times \frac{\sqrt{3}}{2} = 500 \times 1{,}732 = 866$ 磅，至於 AC 爲有效之力， $AC = 1000 \times \cos 60°$ $AC = 1000 \times \frac{1}{2} = 500$ lb.

Fig A

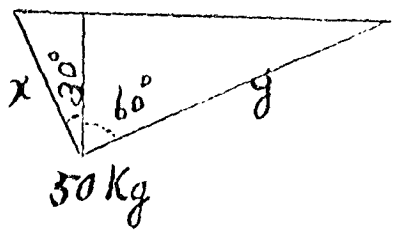


2. Resolve a force of 2000 dynes into two components making angles of 30° and 60° with the given force. 有力 2000 dyne 試按 30° 及 60°分爲二力



解 依三角定理
AC 成 30° 者 AC=2000 $\times \cos 30° = 1732$ dynes
AD 成 60° AD=2000 $\times \cos 60° = 1000$ dyne

3. A weight of 50 kg. is suspended by two cords making angles of 30° and 60° respectively with the vertical. Find the force exerted by each cord. 重 50 kg 以二繩豬之，一與垂線成 30°，一與之成 60°，試求各繩所豬之力。



解 參看附圖 以成 30° 角之繩所豬之力 = x 以成 60° 角之繩所豬之力=y

$$\frac{x}{50}=\cos.\ 60°=\frac{1}{2} \quad 又\frac{y}{50}=\sin\ 30°=\frac{\sqrt{3}}{2}$$

$$x=\frac{50}{2}=25\text{ kg.}\quad y=25\sqrt{3}=43.3\text{ kg.}$$

4 If the mass of the car in Exer. I is 20,000 lb., and the resistance offered by the rails may be neglected, what is the acceleration of the car? 設第一題中車重爲 20000 磅，而鐵軌視爲無阻力者，則此力給與火車之加速度爲若干。

解 第一題中 AC 有效之力=500 磅，依 F.P.S. 單位變爲 poundal 則=500×32.16 poundal. 又依 f=ma 公式求 a (加速度)=f÷m=500×32.16÷20000=.804 ft. per sec. per sec.

VIII. Circular Motion.

圓運動

1. A body whose mass is 50 g. moves in a circle whose radius to 40 cm. with a velocity of 20 cm /sec. What is the required centripetal force? 一物體重 50 g 成圓運動，其半徑爲 40 cm. 其速度爲 20 cm. 一秒，其向心力若干。

解 依公式 向心力 $= \frac{mv^2}{r} = \frac{50 \times 400}{40} = 500$ dynes

2. A stone leaves a sling with a velocity of 50 ft. per second. If the mass of the stone is 2 oz. and the radius of the circle 4 ft., what was the pull exerted on the cords of the sling; 一繩繫一石，石離繩時之速度每秒 50 呎，設石重 2 喱，其所作之圓運動之半徑爲 4 呎其拉繩之力若干。

解 離心力與向心力相反而量相等

故其拉繩之力 $= \frac{2}{16} \times \frac{50 \times 50}{4} = 78.125$ poundals

IX. WORK. 工

1. Calculate the work done by a force of 25 dynes acting through a distance of 120 cm. 有力 25 dynes, 經過 120 cm. 試計其工量若干。

解 依公式 $w=fd$ 工$=25\times120=3000$ erg
(工單位)

2. Express in ergs and gram-centimeters the work done in lifting a mass of 5 g. through a vertical height of 100 cm. 一物重 5g 設舉之至 100 cm. 之高，試計其 ergs 及 gram-centimeters 之數。

解 1g$=980$ dynes
故此工$=5\times980\times100=490000$ ergs
又此工$=5\times100=500$ gram-centimeters

3. A horse has to exerts an average force of 200 lb. in moving a loaded cart a distance of a mile. Find the amount of work done. 一馬拉一載重之車，行 1 哩，馬力平均 200 磅，計其工量若干。

解 1 哩$=5280$ 呎
故此馬之工 $=200\times5280=1056000$ foot-pounds
(若按 poundals 計可以 32.16 乘之)

4. What amount of work is done when one cubic meter of water is elevated to a height of 10 m.? 一立方米之水舉高至 10 米，其工若干。

解 1 立方米$=100^3$ cm. 1 米$=100$ cm.

工$=1000000\times100\times980$ ergs

$=98000000000$ ergs

5. How much work is done per second by an engine that in one hour lifts 10,000 bricks each weighing 4 lb. to the top of a building 50 ft. in height? Find the necessary horse power. 一機器一小時舉重 4 磅之磚 10000 塊，至 50 呎高之房頂，求其每秒之工及馬力。

解 1 馬力$=550$ foot-pounds

此機器之工$=\frac{10000\times4\times50}{3600}=555\frac{5}{9}$呎磅

$=1\frac{1}{99}$馬力

6. A man shovels 3 T. of coal from a wagon box into a bin 6 ft. above the coal in the wagon. How much work is involved in the process? 一人由車鏟煤 3 噸入一箱中，距煤高 6 呎，其所作之工若干。

解 此人所作之工$=3\times2000\times6=36000$ 呎磅

7. What must be the power of an engine that hoists 50 T. of ore per hour from a mine 300 ft. deep? 一機器每小時舉礦質 50 噸，礦深 300 呎，須工若干。

解 此機器所作之工$=\frac{50\times2000\times300}{3600}$

$=8333\frac{1}{3}$ 呎磅

8. A pumping engine is capable of raising 300 cu. ft. of water every minute from a mine 132 ft. in depth. If a cubic foot of water weighs 62.5 lb., what must be

the power of the engine? 一抽水機由深 132 呎之礦中每分可吸水 300 立方呎，設一立方呎之水重 62.5 磅，問此機所作之工若干。

解 此機所作之工 $= \frac{132 \times 300 \times 62.5}{60}$

$= 41250$ 呎磅

9. How long will it take a 3-H.P. engine to elevate 5000 bu. of wheat 50 ft.? (A bushel of wheat weigh 60 lb.) 一機器具有 3 馬力，欲使之舉小麥 5000 斗，高至 50 呎，須時若干。(每斗重 60 磅)

解 須時 $= \frac{50 \times 5000 \times 60}{3 \times 550 \times 3600} = 2\frac{52}{99}$ 小時

10. A train is moving with a velocity of 30 mi. per hour. If the resistance to the motion is 1500 lb., calculate the power utilized. 一火車每小時行 30 哩，設阻力為 1500 磅，試計其應用之工。

解 應用之工 $= \frac{30 \times 5280 \times 1500}{3600} = 66000$ 呎磅

11. The motors of an electric car develop 200 H.P. With what velocity can the car run against a uniform resistance of 2200 lb.? 一電車之發動機有馬力 200，設阻力為 2200 磅，其勝過此阻力之速度應為幾何。

解 其速度 $= \frac{200 \times 550}{2200} = 50$ 呎 (每秒)

X. POTENTIAL AND KINETIC ENERGY

地位能力與動力（亦作勢能與動能）

1. Calculate the potential energy given to mass of 25 g. by lifting it through a vertical height of 10 m. Express the result in Kilogram-meters. 一物重 25 g. 舉之直高 10 m. 試計其地位能力，而以 Kilogram-meters 表示之。

解 其地位能力$=\frac{25\times 10}{1000}=.25$ Kilogram-meters

2. A ball moving with a velocity of 3500 cm /sec, has a mass of 250 g. Find its kinetic energy in ergs. How much work must a boy do in order to stop it? 一球重 250 g. 速度每秒 3500 cm. 試求其動力以 ergs 計之，一童欲止之，須工若干。

解 其動力依公式$=\frac{1}{2}mv^2$ ergs

$=\frac{1}{2}\times 250\times 3500\times 3500$

$=1531250000$ ergs

童子止之其工與之等。

3. Compare the kinetic energy of the ball in Exer. 2 with that of a mass of 25,000 g. whose velocity is 350 cm./sec. 將上題球之動力，與一物重 25000 g. 速度每秒 350 cm. 之動力，比較之。

解 此物之動力 $=\frac{1}{2}\times 25000\times 350\times 350$ ergs

$=1531250000$ ergs

與上球相同。

4. What is the kinetic energy of a 5-gram bullet just as it is leaving the muzzle of a gun with a velocity of 30,000 cm/sec.? 一彈重 5 g. 初離槍口之速度，每秒 30000 cm. 求其動力。

解 其動力 $=\frac{1}{2}\times 5\times 30000\times 30000$

$=2250000000$ ergs

5, To what height would the bullet in Exer. 4 have to be taken in order to have an equal amount of potential energy? 上題之彈若使其地位能力與上等量，須携至高若干。

解 先化 5 g 得 5×980 dynes

再求其高 $=\frac{225000000}{5\times 980}=459183\frac{33}{49}$ cm.

6. Compute the kinetic energy of a 5-pound mass moving with a velocity of 25 ft. per second. Express the result in foot-pounds. 有物重 5 磅，每秒速度 25 呎，試計其動力，而以呎磅表之。

解 其動力 $=\frac{1}{2}\times 5\times 25^2=1562.5$ foot-poundals

$=1562.5\div 32.16=48.58$ 呎磅强

7. A constant force of 200 dynes acts upon a mass of 5 g. Calculate (1) the acceleration, (2) the velocity produced in 3 seconds, and (3) the kinetic energy. What is the distance through which the force acts during the 3 seconds? 有力 200 dynes 施於重 5 g. 物之上，(一)試計加速度，(二)試計其 3 秒間所生之速度，(三)試計其動力，又在此三秒間其所經之距離若干。

解 (一) 其加速度依 $f=ma$ 公式 $a=\frac{200}{5}=40$ cm/sec².

(二) 其三秒間之速度依 $v=at$ 公式 $v=40\times 3=120$ cm/sec.

(三) 其動力 $=\frac{1}{2}mv^2=\frac{1}{2}\times 5\times 120^2=36000$ ergs.

又 其經過之距離 $=\frac{1}{2}at^2=\frac{1}{2}\times 40\times 9=180$ cm.

8. In order to move a load up a hill 250 ft. long, a horse exerts a constant pull of 125 lb. How much work is done? If the load weighs 900 lb., to what height would an equivalent amount of work lift it? 一馬出力 120 磅，拉載上山，長 250 呎，作工幾何。設載重 900 磅，用同此之工可舉之高若干。

解 其工$=125\times 250=31250$ 呎磅

$$舉高=\frac{31250}{900}=34\frac{13}{18}\text{呎}$$

9. A stone whose mass is 50 kg. is placed on the top of a chimney 30 m. in height. Calculate the amount of work that must be performed in kilogram-meters and

foot-pounds. 一石重 50 kg. 放於高 30 m 煙筒之頂，試計其工，以 kilogram-meters 及 foot-pounds 表之。

解 其工 $=50\times30=1500$ kilogram-meters

即 $=\frac{1500\times98000000}{13550000}=10848.7$ 强 foot-pounds

10. Compute the amount of work done per minute by a pumping engine that forces 100,000 gal. of water into a reservoir 120 ft. high every 10 hr. Assume the density of water to be 62.5 lb. per cubic foot. 一壓水機每十小時可提水 100000 加侖，使升高 120 呎至一水池中，試計其每分所作之工，設每立方尺之水重 62.5 磅。

解 一加侖 $=231$ 立方吋

$$\text{其工}=\frac{231}{1728}\times100000\times62.5\times120\times\frac{1}{10\times60}$$

$=167100.69$ foot pounds (呎磅)

11. If a rifle ball whose mass is 8 g. has a velocity of 35000 cm./sec., how far will it penetrate a block of wood that offers a uniform resistance of 1000,000 g.? 設一槍彈重 8 g. 每秒行 35000 cm. 穿一木塊，平均阻力爲 100000 g. 能入木深若干。

解 此彈之動力 $=\frac{1}{2}\times8\times35000\times35000$ ergs. 設入木深 $=x$. 木之阻力工 $=100000\times980\ x$

二工力相等

$$\text{故 } x=\frac{8\times35000\times35000}{2\times100000\times980}=50 \text{ cm.}$$

12. The elevation of a tank containing 25,000 gal. of water is 75 ft. Find the potential energy of the

water. 一水槽蓄水 25000 gal. 高 75 ft. 求水之地位能力.

解 參看第 10 題

$$\text{此地位能力}=\frac{231}{1728}\times 25000\times 62.5\times 75$$

$$=2134592.01 \text{ foot-pounds}$$

XI. GRAVITATION AND WEIGHT 地心吸力與重量

1. How far above the earth's surface would a body weigh one half as much as at the surface. 一物重較在地面減半時，須距地面若干.

解 設距地心=x 地球半徑=4000 mi

$1 : \frac{1}{2}=x^2 : 4000^2$

$x=5656.8$ 哩

距地面=5656.8−4000=1656.8 哩

2. What would a 100-pound body weigh at a distance of 200 mi. above the earth's surface? 重 100 磅之物，若在距地面 200 哩處，應重若干.

解 設重=x $x : 100=4000^2 : 6000^2$

$$x = 44\frac{4}{9} \text{磅}$$

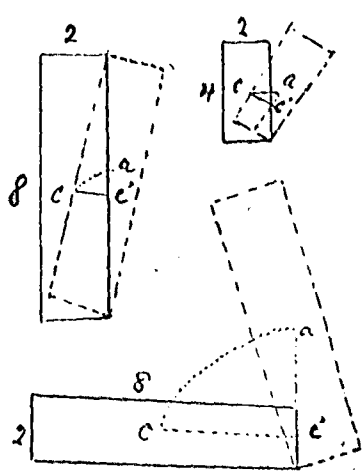
3. An aeronaut ascends 5 mi. in a balloon. If his weight at the surface is 150 lb., what will it be at that height? 一飛行者乘氣球升高 5 哩，設其身在地面重 150 磅，在 5 哩高處應重若干。

解 設重=x　　$x : 150 = 4000^2 : 4005^2$

$x = 149.62$ 磅

XII. STABILITY 穩定性

1. Calculate the stability in foot-pounds of a 4-pound brick placed in three different positions shown below. Assuming the dimensions to be 2×4×8 in. 一四磅重之磚，其長寬厚爲 8 吋 4 吋 2 吋，依三種不同方法放置之，試各求其穩定性。



解 (1) $T_1 = \frac{.11}{12} \times 4 = .036$ 呎磅 (最易推倒)

(2) $T_2 = \frac{.24}{12} \times 4 = .08$ 呎磅

(3) $T_3 = \frac{3.11}{12} \times 4 =$ 1.02 呎磅 (最爲穩定)

XIII. FREELY FALLING BODIES AND PROJECTILES

自落物體及拋射物

1. A body falls freely from a certain height and reaches the ground in 5 seconds. What velocity is required? From what height must it fall? 一物由某高處自落，抵地須時 5 秒，應須速度若干，其高若干。

解 公式 $v=gt$ $g=980$ cm.

其速度 $v=980\times5=4900$ cm/sec.

其高度 $d=\frac{1}{2}gt^2=\frac{1}{2}\times980\times25=12250$ cm.

2. How long does it take a body to fall 100 ft.? 200 ft.? 一物落下 100 呎，或 200 呎，各須時若干。

解 $g=32.16$ 呎 依 $d=\frac{1}{2}gt^2$ $t=\sqrt{\frac{2d}{g}}$

故 100 呎須時 $t=\sqrt{\frac{2\times100}{32.16}}=2.5$ 秒

200 呎須時 $t=\sqrt{\frac{2\times200}{32.16}}=3.5$ 秒

3. A mass of 50 g. falls for 3 seconds from a state of rest. Calculate its kinetic energy. 一物重 50 g. 由靜止落下 3 秒，試計其動力。

解 先求其速度 $v=gt=980\times3=2940$ cm/sec.

再求其動力 $=\frac{1}{2}mv^2=\frac{1}{2}\times50\times2940^2$

$=216100000$ ergs

4. A mass of 50 lb. falls from an elevation of 20 ft. Calculate its kinetic energy in foot-pounds at the time it reaches the ground. Compare the kinetic energy in foot-founds at the time it reaches the ground. Compare the kinetic energy with the potential energy of the body before falling. 一物重 50 磅，由高 20 呎下落至地，試按呎磅計其動力，並計其未落時之地位能力而比較之。

解 法同上，先求 $v=\sqrt{2gd}$ $v^2=2gd=2\times32.16\times20$

(1) 其動力 $=\frac{1}{2}mv^2=\frac{1}{2}\times50\times2\times32.16\times20$ foot-poundals 以 32.16 除之則 $=50\times20=1000$ foot-pounds (呎磅)

(2) 其地位能力 $=50\times20=1000$ foot-pounds (呎磅)

(1) (2) 二者相等

5. How far must a body fall in order to acquire a velocity of 500 ft. per second? 一物欲得每秒 500 呎之速度，須由高若干下落。

解 由公式 $d=\frac{v^2}{2g}$

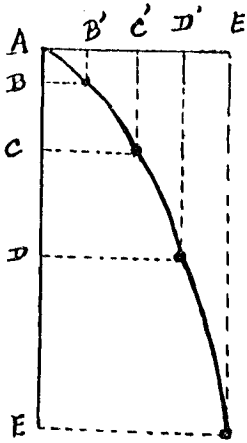
則知其距離 $=\frac{500\times500}{2\times32.16}=3886.83$ 呎

6. A book falls from a table 3 ft. in height. Find velocity of the book when it reaches the floor. 桌高 3 呎，書自其上落下，試求其至地板時之速度。

解 其速度 $v=\sqrt{2gd}=\sqrt{2\times32.16\times3}$

$=13.89$ ft/sec.

7. A stone is dropped from a train whose velocity is 30 mi. per hour. Show by a diagram the path traced by the stone. 一火車每小時行 30 哩，一石自車上落下。試作一圖以示此石所經之軌迹。



解 此車每秒行$=\frac{30\times5280}{3600}=$

44 呎

軌迹圖附於左 { 橫線表其速
縱線表地心吸力
曲線即其軌迹

8. Find the kinetic energy of 10-gram mass after it has fallen from rest a distance of 1960 cm., assuming g. to be 980 cm./sec^2.一物重 10 g. 由靜而動，落下 1960 cm. 設地心吸力爲 980 cm./sec^2. 求其動力。

解 依 $v=\sqrt{2gd}$ $v^2=2gd=2\times980\times1960$

其動力 $=\frac{1}{2}mv^2=\frac{1}{2}\times10\times2\times980\times1960$

$=19208000$ ergs

9. The velocity of a body falling freely from rest was 200 ft. per second. From what height did it fall? 一物自靜面下落，每秒行 200 呎，問其由高若干面墜。

解 依公式 $d=\frac{v^2}{2g}=\frac{200\times200}{2\times32.16}$

高 $=621.89$ 呎

10. Compare the velocity of a body after falling 64.32 ft. with that of a train runnig 30 mi. per hour. 一物已落 64.32 呎，一火車每小時行 30 mi. 試比較二者之速度。

解 物之速度每秒 $v=\sqrt{2gd}=$

$\sqrt{2\times32.16\times64.32}=64.32$ ft.

火車之速度每秒 $=\frac{30\times5280}{3600}=44$ ft.

物較火車爲速。

11. A bullet is fired vertically upward from a gun with a velocity of 25,000 cm./sec. Disregarding the resistance of the air, how many seconds will the bullet continue to rise? How high will it rise? 一彈向上直射，每秒速度 25000 cm. 設不計空氣阻力，此彈能上升若干秒，并可升若干高。

解 依公式 $t=\frac{v}{g}$ 其上升之時$=\frac{25000}{980}=25.51$ 秒。

又依公式 $d=\frac{v^2}{2g}$ 其上升之高$=\frac{25000\times25000}{2\times980}$

$=318816.32$ cm.

12. If the bullet in Exer. II encountered no resistance due to the air, how many seconds would pass before it returned to earth? 前題之彈設無空氣阻力，應于幾秒復返地面。

解 彈之升降所須之時相同。

故由上降至地，亦須時 25.51 秒。

(若計其往返共須之時則爲此數之 2 倍)，

13. The wieght of a pile-driver is lifted 10 ft. and allowed to fall. With how much greater velocity will it strike if lifted 20 ft.? With how much greater energy? 一打樁機器之錘舉高至 10 呎令其下落，若舉高至 20 呎，則其速度較前多若干，其能力亦較前多若干。

解 命前者之速度$=v_1=\sqrt{2gd_1}=$

$\sqrt{2\times32.16\times10}=25.36$ ft./sec.

後者之速度 $=v_2=\sqrt{2gd_2}=$

$\sqrt{2\times32.16\times20}=35.86$ ft./sec.

後較前速 10.5 ft./sec.

又前者之能力爲 $f_1=\frac{1}{2}mv_1^2=\frac{1}{2}\times2\times32.16\times10$ m $=321.6$ m

後者之能力爲 $f_2=\frac{1}{2}mv_2^2=\frac{1}{2}\times1\times32.16\times20$ m $=643.2$ m

後者較前者多 321.6 m foot-poundals

14. A stone thrown over a tree reaches the earth in 3 seconds. What is the height of the tree? 一石由樹頂落下，3秒至地，樹高幾何。

解 樹高 $= d = \frac{1}{2} gt^2 = \frac{1}{2} \times 980 \times 9 = 4410$ cm.

15. A boy fires a rifle ball vertically upwards and hears it fall upon the ground in 20 seconds. How high does it rise? What was its initial velocity? 一童向上直放一彈，聞其墜地聲在20秒後，彈升高若干，初速度若干。

解 彈往返須時20秒則升降各須10秒

其升高 $= d = \frac{1}{2} gt^2 = \frac{1}{2} \times 980 \times 100 = 49000$ cm.

其速度 $= v = gt = 980 \times 10 = 9800$ cm./sec.

XIV. PENDULUM 擺

1. Find the period of a pendulum 80 cm. long, when g. equals 980 cm./sec^2. 一擺長80 cm. $g = 980$ cm./sec^2. 求其週期。

解 週期 $t = \pi \sqrt{\frac{l}{g}} = 3.1416 \times \sqrt{\frac{80}{980}} = 3.1416 \times \frac{2}{7} = .8976$ 秒

2. Calculate the length of a simple pendulum that beats half seconds at a place where the acceleration is 981 cm./sec². 在加速度 g=981 cm./sec² 之地，有一單擺每半秒擺一次，試計其長。

解 依 $t=\pi\sqrt{\frac{l}{g}}$ l（擺長）$=\frac{981}{4\pi^2}$

$=24.78$ cm.

3. The pendulum of a clock has a period of a quarter second. Find its length if g is 980 cm./sec². 一鐘擺其週期爲四分之一秒，設 g=980 cm./sec². 求其長。

解 $\frac{1}{4}=\pi\sqrt{\frac{l}{g}}$ 擺長 $l=\frac{980}{16\pi^2}=6.2$ cm.

4. How long is a simple pendulum that makes 65 single vibrations per minute? 每分單擺 65 次者，擺長若干。

解 依式 $\frac{60}{65}=\pi\sqrt{\frac{l}{g}}$

擺長 $l=\frac{12^2}{13^2}\times\frac{980}{\pi^2}=.846$ cm.

5. What is the value of g where a simple pendulum 99 .2 cm. leng makes 60 single vibrations per minute? 有擺長 99.2 cm. 每分鐘單擺 60 次，求 g 之值。

解 $t=\frac{60}{60}=1$ $1=\pi\sqrt{\frac{99.2}{g}}$ $g=\pi^2\times 99.2$

$g=979.07$ cm./sec².

6. An Arctic explorer finds that the length of the seconds pendulum at a certain place is 99.6 cm. What is the value of g at this place? 一北極探險者，發現在某地點每秒單擺一次之擺長 99.6 cm. 求此地 g 之值。

解 同上 $l=\pi\sqrt{\frac{99.6}{g}}$ $g=\pi^2\times 99.6$

$=983.02$ cm./sec^2.

7. A simple pendulum is to make 45 single vibration per minute. If g. is 980 cm./sec^2. , what must be its length? 一擺單擺每分 45 次，設 $g=980$ cm./sec.^{2}求其長。

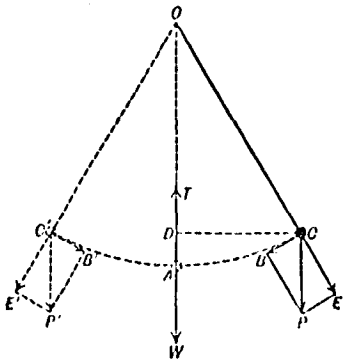
解 $\frac{60}{45}=\pi\sqrt{\frac{l}{980}}$，$l=\frac{60^2}{45^2}\times\frac{980}{\pi^2}=320.6$ cm.

8. It is found at a certain place that a simple pendulum 90 cm. long makes 64 single vibrations per minute. Find the value of g. at this place. 有擺長 90 cm. 在某地每分單擺 64 次，求此地 g 之值。

解 $\frac{60}{64}=\frac{15}{16}$ $\frac{15}{16}=\pi\sqrt{\frac{90}{g}}$ $g=\frac{16^2}{15^2}\times$

$\pi^2\times 90=1010.6$ cm/sec.^{2}

9. A pendulum whose bob weighs 100 g. is drawn aside until the distance AD is 4 cm. How much energy is stored in the bob? How much work was done upon it? 一擺之球重 100 g. 傍拉至 C. 使 AD 長 4 cm. 此球之地位能力若干，所施之工若干。

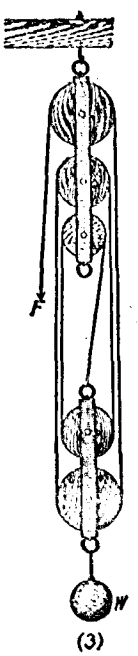


解 圖如左 此球僅較前高 4 cm.

故其地位能力=100×980×4=392000 ergs

所施之工亦與之相等

XV. THE PULLEY 滑車



(3)

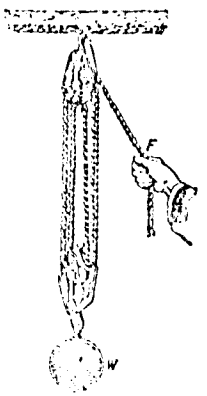
1. Diagram a set of pulleys by means of which an affort of 100 lb. can support a load of 500 lb. 試作一副滑車圖，使 100 磅之力可提重 500 磅。

解 圖如左 因 w=n F

現 500=n×100 n=5

圖中與 F 平行者恰爲 5 倍。

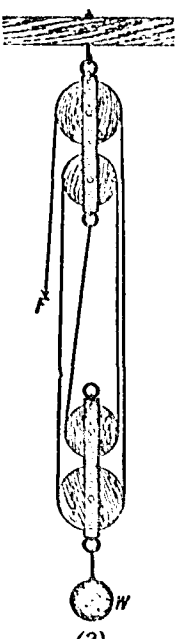
2. What is the mechanical advantage of the system of pulleys shown in the Fig.? Find the effort requied to balauce a weight of 1200 lb. 下圖中所示之滑車機械之利益若何，設有重 1200 磅，求一力與之相平衡。



解 參看左圖 依 w=nF
圖中平行力有 6 故 6 F=1200
F=200 磅

即須力 200 磅。

3. Each of two pulley blocks contains two sheaves. Show by a diagram how to arrange these into a system that will enable an effort of 76 kg. to move a resistance of 300 kg. 動靜滑車各二，欲使 75 kg. 之力抵抗 300 kg. 試以圖示之。



(2)

解 圖如左 因 w=nF 300=n×75
n=4
圖中平行力適為 4 倍

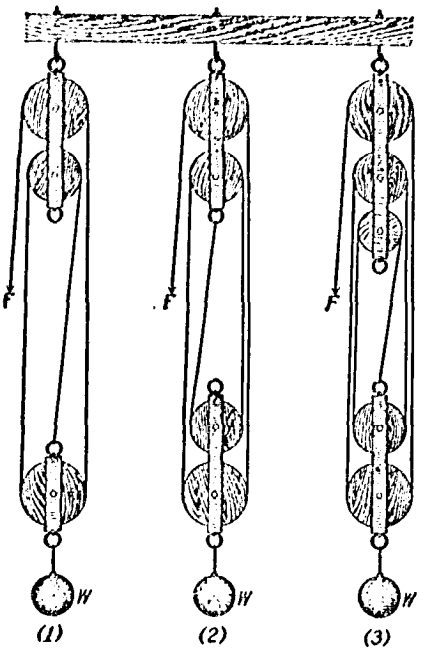
4. Show by diagram the best arrangement of two bloocks, one containing two sheaves, the other containing one. Ascertain the mechanical advantage. 靜滑車一，動滑車二，最善辦法若何，以圖示之，其利益若何。

解 圖如左 依 $w=nF$ $n=3$ 其利益$=3:1$

(1)

5. In each case shown in Fig. 5 let the effort be applied to the movable blook and the resistance W to the end of the rops in place of F. If the effort F moves 1 ft., how far will W be moved? State the advantage secured in each instance.

(Fig. 5 見 44 頁)



(5) 圖所示如以力 F 拉動滑車下，而以重 W 拉于繩端，設力動一呎重應動若干，試按圖各別列出，并陳其利益。

(1) 依 $F=\frac{1}{n}W$ $n=3$ 故 F 動 1 呎 W 須動 $\frac{1}{3}$ 呎 其利益爲 3 : 1.

(2) $n=3$ 故 F 動 1 呎 W 動 $\frac{1}{4}$ 呎其利益 = 4 : 1.

(3) $n=5$ 故 F 動 1 呎 W 動 $\frac{1}{5}$ 呎其利益 = 5 : 1,

6. In a pulley system consisting of a continuous cord attached at one end to a movable block containing one sheave, the rope passes through a fixd block having two sheaves. Find the effort required to support a block of marble weighing a ton. 連續之繩繫于動滑車一，靜滑車二，欲起一石重一噸，須力若干。

解 如 (4) 圖 $W=n\,F$

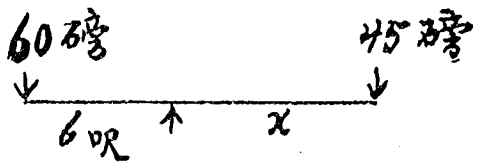
$3\,F=W=1$ ton $=2000$ lb.

$$F=\frac{2000}{3}=666\frac{2}{3}\text{磅}$$

XVI. The Lever 槓杆

1. Two boys weighing respectively 60 and 45 lb balance on opposite ends of a boards. If the futcrum is 6 ft. from the larger boy, how far is it from the smaller one? 二童一重 60 磅，一重 45 磅，坐于板之兩端，而成平衡，設支點距重者爲 6 呎，距輕者爲若干。

槓杆題一



解 設距輕者爲 x

$45x=60\times6$

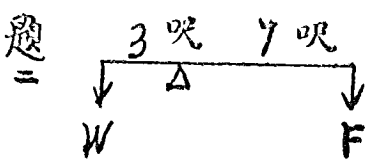
$x=8$ 呎

2. The arms of a lever of the first class are 8 ft. and 7 ft. What is the greatest weight that a force of 60 lb. can support? 第一類槓杆之二臂，一爲 3 呎，一爲 2 呎，力爲 60 磅，最重能支若干。

解 $3W=7\times60$

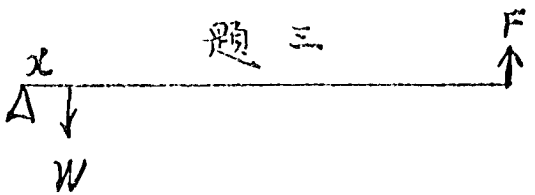
$W=140$ 磅

題二



3. A lever of the second class is required to support a weight of 500 kg.; the effort to be applied is only 50 kg. If the bar is 20 ft. long, where should the weight be attached? 第二類槓杆欲支重 500 kg. 力爲 50 kg. 杆長 20 呎，重應在何處。

題三

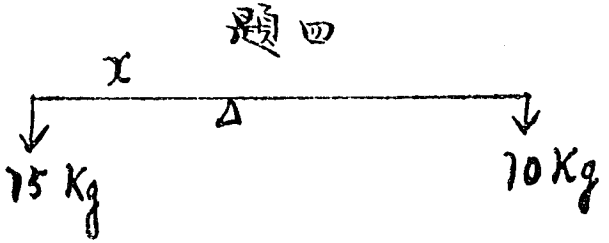


解 W 應距支點之處=x $500x=50\times20$

$x=2$ 呎

4. Two masses weighing respectively 10 and 15 kg. balauce when placed at opposite ends of a bar 2 m. long. Where is the fulcrum? 二物一重 10 kg. 一重 15 kg. 在一長 2 m 杆之兩端成平衡，求其支點。

題四



解 設支點距 15 kg 爲 x $15x=10(2-x)$

$25x=20$

$x=.8$ m.

5. The short arm of a lever is 30 cm. the long arm 270 cm. If the end of the long arm moves 1 cm., how far will the end of the short arm move? 一槓杆長部分=270 m. 短部分=30 m. 設長端移動 1 cm. 短端應移動若干。

解 長端移動時，短端亦隨之而動，惟長端所行之軌迹與短端所行之軌迹，係依其半徑之平方爲比例。

故 $x : 1 = 30^2 : 270^2$

$$x = \frac{1}{81} \text{呎}$$

XVII. THE WHEEL AND ALXE 輪軸

1. The radius of a wheel 3 ft., and that of its axle 12 in. What effort would be required to overcome a resistance of 600 lb? 輪之半徑=3 呎，軸之半徑=12 吋，欲勝抵抗 600 磅，須力幾何。

解 依公式 $FR = Wr$

$$F \times 3 = 600 \times 1$$

力 $F = 200$ 磅

2. How much work would be done upon the resistance in moving it a distance of 10 ft.? How much work would have to be done upon the wheel? 倘移動此抵抗力至 10 呎，須工若干，在輪上施力，則須工若干。

解 若移動抵抗力至 10 呎，則須工=600×10
=6000 呎磅。
若施力於輪祇須轉 3×10 呎=30 呎，而其工
爲 30×200 亦=6000 呎磅。

3. The arm of a capstan measured from the center, is 2 m.; the radius of the barrel is 25 cm. What effort would be required to produce a tension of 500 kg. in the rope attached to the barrel? 一絞盤其臂距心 2 m. 轉筒之半徑=25 cm. 設筒周之繩伸力 500 kg. 應用力若干。

解 $2F=.25\times500$

$F=.25\times250$

$=62.5$ kg.

4. The pedal of a bicycle describes a circle whose radius is 7 in. If the radius of the attached sprocket wheel is 3 in., find the pull of the chain when the foot pressure is 45 lb. 自行車足蹬之拐作圓半徑 7 吋，而足下之齒輪半徑 3 吋，若足之壓力 45 磅，由鍊而生之力若干。

解 $3F=7\times45$

$F=105$ 磅

5. If the front spocket of a bicycle contains 21 teeth, and the rear one 7, how far will one turn of the pedal move 28-inch wheel along the ground? Find the number of turns of the pedal per mile. 設自行車足下齒輪有 21 齒，而後輪軸上之齒輪有 7 齒。若車輪半徑爲 28 吋，足蹬拐每轉一次，車輪行若干，並求車行 1 哩，足蹬拐應旋轉若干次。

解 足踏拐每轉 1 次，足下齒輪亦轉一次，而後輪軸上之齒輪須轉 3 次（因 $3\times7=21\times1$）．即後輪亦轉 3 次，行 3×28 吋$=84$ 吋$=7$ 呎，若行 1 哩，則足踏之拐須轉 $\frac{5280}{7}=754\frac{2}{7}$ 次．

6. The length of the crank is 10 in., and the radius of w is 6 in., wheel w is bolted to S, whose radius is 3 in.; and S is attached to W, whose radius is 20 in. One turn of the crank produce how many revolutions of the wheel W? a point on the rim of W moves how much faster than the crank? 拐長 10 吋，小輪 w 之軸半徑 6 吋，此輪連於 S 軸半徑 3 吋，S 係大輪 W 之軸，大輪半徑 20 吋，拐轉 1 次，大輪轉若干次，大輪上之一點較拐快若干．

解 拐轉 1 次 w 小輪亦轉 1 次，
而 S 軸須轉 2 次．$(6\div3=2)$
W 大輪亦轉 2 次．
W 大輪上之 1 點轉 2 次時行
$2\times\pi\times2\times20$ in.
拐轉 1 次其頂端行 $\pi\times2\times10$ in.
故大輪之一點較拐速 60 π in.

7. The large wheel of a sewing machine is 12 in. in diameter, and the small one to which it is bolted is 3 in. On up-and-down movement of the treadle produces how

many stitches? 一縫機大輪直徑 12 吋，小輪與之聯，其直徑 3 吋，足踏板一上一下能縫若干針。

解 大輪周$=12\pi$

小輪周$=3\pi$

大輪轉 1 次

小輪轉 $\frac{12\pi}{3\pi}=4$ 次即四針。

XVIII. THE INCLINED PLANE, SCREW, AND WEDGE

斜面螺絲釘與劈

1. A ball weighing 10 lb. rests upon an inclined plane. If the height of the plane is 6 in. and the length is 30 in., what effort acting parallel to the plane will be required to hold the ball in equilibrium? 一球重 10 磅停于斜平板，設板之高度$=6$ 吋，其長$=30$ 吋，欲使球平衡，與板平行之力須若干。

解 公式 $F\times l=W\times h$

$30F=6\times 10$

與板平行力 $F=2$ 磅

2. On an icy slope of 45°, what force is required to haul a sled and load weighing a ton, neglecting friction? 冰之斜面成 45° 角，一雪車及載重 1 噸，須力若干，阻力不計。

解 高=1 長=$\sqrt{2}$=1.401

1.401×力=2000×1

力=2000÷1.401=1401 磅

3. The radius of the wheel of a letter press is 12 in., the pitch of its screw, 1/4 in. Neglecting friction, what pressure is produced by an effort of 50 lb? 壓字機輪之半徑= 12 吋，其螺紋之高=$\frac{1}{4}$ 吋，若阻力不計，用力 50 磅，生出壓力若干。

解 依公式 $F\times 2\pi\times r=W\times s$

$50\times 2\pi\times 12=W\times\frac{1}{4}$

壓力 W=15079.68 磅。

4. Neglecting friction, what constant force must a team of horses exert in hauling a load of coal weighing 3000 lb. up an incline of 30? 一斜坡成 30° 角，一車裝煤重 3000 磅，一排馬拉之，須用力若干，阻力不計。

解 依公式 $F\times l=W\times h$ 設 h=1 l=2

(因 $\sin 30°=\frac{1}{2}$)

故 2F=3000

F=1500 磅

5. In a machine the effort of 50 lb. descends 20 ft., while a weight is raised 10 in. What is the weight? 一機器用力 50 磅，下降 20 呎，而重量則上升 10 吋，問重若干。

解 10 W=50×20×12

W=120 磅

6. What is the mechanical advantage of a screw press of which the pitch of the screw is 5 mm. and the diameter of the circle described by the effort 50 cm.? 一螺絲柱壓力機，其螺絲之高=5 mm. 力柄作圓直徑=50 cm. 所得之利益若干。

解 其利益$=\frac{2\pi r}{S}=\frac{2\pi\times25\times10}{5}$

$=314.16$ 倍

7. A smooth railroad track rises 50 ft. to the mile. A car weighing 20 T. would require how much force to keep it from moving down the slope? 一平滑之鐵道每1哩高50呎，車重20噸，須力若干始免車溜下。

解 依式 $F\times l=W\times h$

$5280\ F=20\times2000\times50$

$F=378\frac{26}{33}$磅

XIX. EFFICIENCY OF A MACHINE 機器之實效

1. Calculate the efficiency of a wheel and axle when an effort of 20 lb. acting through 30 ft. lifts a weight of 80 lb. 7 ft. 一副輪軸，用力20磅，經行30呎，舉重80磅，經行7呎，試求其實效。

解 用力所作之工$=20\times30=600$呎磅

起重所奏之工$=80\times7=560$呎磅

故其實效 $=\frac{560}{600}=.93$

2. On account of the loss of energy due to friction in a pulley system, an effort of 70 kg. acting through 30 m. moves a resistance of 340 kg. through 5.5 m. What is the efficiency of the machine? 在某滑車系上，因摩擦力致能力有損失，用力 70 kg. 經行 30 m. 移動抗力 340 kg. 經行 5.5 m. 試計此機之實效。

解 施工=70×30

奏效=340×5.5

實效=1870÷2100=.89

3. What is the efficiency of a screw if an effort of 5 kg. applied at the end of an arm 1 m. long produces a pressure of 4000 kg., the pitch of the screw being 4 mm.? 一螺絲壓機，螺絲高度=4 mm.設用力 5 kg. 于一臂，其長=1 m. 生出壓力4000 kg. 試計其實效。

解 施工=5×1000×2×3.1416

奏效=4000×4

實效=2000÷3927=.509

4. The efficiency of an inclined plane is 50%. If the length of the plane is 20 ft. and its height 4 ft., what effort acting parallel to the plane will be required to move a body weighing 500 lb? 一斜板之實效率爲百分之 50. 板長=20 呎，板之高度=4 呎，若沿此板移動重 500 磅之物，須力若干。

解 依斜面公式 $20F=4\times500$

$F=100$

但其實效率爲 50% 故 $100\div.50$

$=200$ 磅 (用力須二百磅)

XX. PRESSURE OF LIQUIDS

液體壓力

1. Find the entire force exerted against the bottom of a rectangular vessel 5 × 8 cm. and filled with water to a depth of 15 cm. 一長方桶面長 5 cm. 寬 8 cm. 注水高 15 cm. 桶底之總壓力若干·

解 桶容積 $=5\times8\times15=600$ 立方 cm.

但 1 立方 cm 之水 $=1$ g.

故總壓力 $=600$ g.

2. Find the pressure per square foot at the bottom of a pond 10 ft. in depth. 一池深 10 呎，試計其底每平方呎之壓力·

解 水一立方呎重 62.5 磅

池之深 $=10$ 呎

故其底之壓力每平方呎 $=62.5\times10=625$ 磅

3. A cylindrical glass jar 5 cm. in diameter is filled to a depth of 5 cm. with mercury. Find the force against the bottom and the pressure per unit area. The

density of mercury is 13.6 g. per cubic centimeter. 一圓柱體之玻璃筒，直徑 5 cm. 注以水銀，深 5 cm. 筒底每單位面積之壓力若干，水銀密度每立方 cm. 爲 13.6 g.

解 圓柱筒之容積$=\pi\times\left(\frac{5}{2}\right)^2\times 5$

筒底水銀每一平方 cm 之壓力

$$=\frac{\pi\times\left(\frac{5}{2}\right)^2\times 5\times 13.6}{\pi\times\left(\frac{5}{2}\right)^2}=68\text{ g.}$$

4. A tank is 4 ft. wide, 8 ft. long, and 3 ft. deep. Compute the force exerted against one end and the bottom when the tank is full of water. 一筒寬 4 呎，長 8 呎，深 3 呎，若滿注以水，試計其一側之壓力及底壓力。

解 任一側之壓力$=\frac{8\times 4\times 3}{2}\times 62.5=3000$ 磅

底壓力$=8\times 4\times 3\times 62.5=6000$ 磅

5. At the depth of 10 m. of sea water, what is the pressure in grams per square centimeter? (The density of sea water is 1.026 g. per cubic centimeter.) 在海水中深 10 m 處，每平方 cm. 之壓力若干。(海水之密度爲每立方 cm 重 1.026 g.)

解 在海水深 10 m 處每平方 cm 之壓力

$=1.026\times 10\times 100=1026$ g.

6. At a depth of 25 ft. of sea water, what is the pressure per square inch? 在海水深 25 呎處，每平方吋之壓力若干。

解 是處壓力每平方吋

$$= \frac{62.5}{1728} \times 1.026 \times 25 \text{ 磅} = 7.43 \text{ 磅}$$

7. A cubic inch of mercury weighs 0.49 lb. Compute the force exerted against the bottom and one side of of a glass tank 4 in. wide, 6 in. long, and 5 in. deep when full of mercury. 一立方吋之水銀重 .49 磅，一玻璃長方筒寬 4 吋長 6 吋深 5 吋，試計其側壓力，底壓力各若干，筒中係滿裝水銀。

解 其側壓力 $= 4 \times 6 \times \frac{5}{2} \times .49 = 29.4$ 磅

其底壓力 $= 4 \times 6 \times 5 \times .49 = 58.8$ 磅

8. Find the force exerted against the bottom of a cubical vessel whose volume is I liter when the vessel is filled with mercury. 一立方容器內盛 I liter. 設滿注水銀，其底之壓力若干。

解 I liter = 1000 立方 cm. 水銀密度 13.6

故此容器底之壓力 $= 1000 \times 13.6$

$= 13600$ g.

9. What depth of water will produce a pressure of 1 lb. per square inch? 欲生每平方吋一磅重之壓力水深須若干。

解 一立方呎之水=62.5 磅 一立方呎=1728 立方吋

故 1 磅之壓力 (每平方吋)須深=$\frac{1728}{62.5}$ = 29.24 吋

10. What is the pressure per square centimeter at the bottom of a column of mercury 76 cm. height? 一水銀柱高 76 cm. 其底每平方 cm. 之壓力若干·

解 底壓力=13.6×76

=1033.6 g.

11. To what height would a mercurial column be supported by a pressure of 1000 g. per square centimeter? 有每平方 cm. 1000 g. 之壓力，可使水銀柱高至若干·

解 高=$\frac{1000}{13.6}$ =74.19 cm.

12. A gauge connected with the water mains of a city showed a pressure of 65 lb. per square inch. What was the height of the water in the standpipe above the level of the gauge? 一水壓表與市中水管相連指出每平方吋壓力爲 65 磅，立管中之水距水表平面高若干·

解 改平方吋爲平方呎其壓力爲 65×144 磅

其高=65×144÷62.5

=148.96 呎

13. A diver is working at a depth of 45 ft. How much is the pressure of water per square inch upon the surface of his body? 一潛水者于水深 45 呎處工作，其體面每平方吋之壓力若干·

解 其每平方呎之壓力=45×62.5÷1728

=1.62 磅

14. A rectangular block of wood is placed under water so that its upper face, which is 8×10 cm, is 20 cm. below the surface. If the thickness of the block is 4 cm., what is the force exerted by the liquid against each of its faces? 一長方木塊置于水中，其表面寬 8 cm. 長 10 cm. 在水下 20 cm. 設木之厚爲 4 cm. 水對于木之各面壓力幾何·

解 (1) 對于木塊上面之壓力$=8\times10\times20=$
1600 g.

(2) 對于木塊側面之壓力$=8\times10\times\frac{20+4}{2}=$
960 g.

(3) 對于木塊底面之壓力$=8\times10\times(20+4)$
$=1920$ g.

15. How much is the force aganist a dam 20 ft. long and 10 ft high when the water rises to its top? 一壩長 20 呎，高 10 呎，倘水漲至壩頂，壩所當之力若干·

解 壩之面積$=20\times10=200$ 方呎
水高$=10$ 呎
故壩面壓力$=200\times\frac{10}{2}\times62.5=62500$ 磅·

16. A hole in the botton of a ship which draws 30 ft. of water is temporarily covered with a piece of canvas. How much is the pressure againt the canvas from the outside? 舟底一孔吸水 30 ft. 若暫以帆布掩之，外面壓布之力若干·

解 以孔之面積爲 1 方呎。

水高=30 呎。

$$外面壓力=1\times\frac{30}{2}\times62.5=937.5 \text{ 磅}$$
(每平方呎)

17. The water level is at the top of a dam 30 ft. high. Compute the pressure per square foot at the bottom of the dam. How much is the pressure halfway down? 壩高 30 呎，水與之齊，試計壩底之壓力，及壩中道之壓力。

解 $$底壓力=\{1\times30\div2\}\times62.5=937.5 \text{ 磅}$$
(每方呎)

$$中道壓=1\times\frac{30}{2\times2}\times62.5=468.75 \text{ 磅}$$
(每方呎)

18. If the dam in Exer. 17. is 100 ft. long, how much is the total force against its surface? 上題之壩，若長 100 呎，其表面之總壓力若干。

解 $$總壓力=30\times100\times\frac{30}{2}\times62.5$$
$$=2812500 \text{ 磅}$$

19. A cone-shaped vase has a base of 100 cm.^{2} and is filled with water to a depth of 45 cm. Find the force and pressure per square centimeter acting on the bottom. 一圓錐形之瓶，其底之面積爲 100 平方 cm. 注以水，深 45 cm. 試求其底部每平方 cm. 之壓力。

解 底壓力每平方 cm=1×45=45 g.

20. The water in a reservoir supplying a city is 150 ft. above an opening made in a pipe being laid along a street. Find the pressure in pounds per square inch required to prevent the water from running out. 一水池供市中以水，街中水管開一口，水高于口者 150 呎，欲防口出水，每方时須施壓力若干磅·

解 每方时壓力$=1\times150\times\frac{62.5}{1728}$

$=8.31$ 磅

21. A glass tube 1 m. long is filled with mercury (density 13.6 g. per cubic centimeter) Find the pressure against the close end of the tube in grams per square centimeter when the tube is (1) vertical and (2) inclined at an angle of 45°. 一玻璃管長 1 m. 注以水銀，(密度每立方 cm. 重 13.6 g.)試求管底每方 cm. 之壓力以 g. 計之 (1) 管垂直時若干·(2) 管斜成 45° 時若干·

解 (1) 管垂直时每平方 cm. 之壓力$=1\times100\times13.6=1360$ g.

(2) 成 45° 時每平方 cm 之壓力$=1\times\frac{100\times\sqrt{2}}{2}\times13.6=952.68$

22. A column of water is lifted 25 ft. in a pipe. Calculate the pressure per square inch that it exerts against the bottom of the pipe. 一水柱由管舉高 25 呎，試計管底每方时之壓力·

解 管底每方时之壓力$=25\times12\times\frac{62.5}{1728}$

$=10.85$ 磅

XXI. THE HYDRAULIC PRESS

水壓機

1. The area of the small piston of an hydraulic press is 2 cm.^{2} and that of the large one 80 cm.^{2} How much force will 50 kg. applied to the former produce upon the latter? 水壓機之小活栓面積=2 方 cm. 大者=80 方 cm. 以 50 kg. 施于小者，大者生力若干。

解 小者每方 cm$=\frac{50}{2}=25$ kg.

大者生出之力$=25\times80=2000$ kg.

2. The small piston of an hydraulic press is operated by a lever of the second class 4 ft. in length, and the piston rod attached 12 in. from the fulcrum. If the diameters of the pistons are 1 in. and 8 in. respectively, how great an effort will produce a force of 2 T.? 一水壓機其小活栓由一第二類之橫杆長 4 呎者鼓動之，栓之柱距支點 12 吋，設小者直徑爲 1 吋，大者爲 8 吋，欲生 2 噸之力，須用力若干。

解 設應用之力$=F$ 而小活栓所生之力$=F_1$

先依橫杆定理 $4F=1\times F_1$ $\therefore F=\frac{F_1}{4}$

又依水壓定理 $\frac{F_1}{\pi(\frac{1}{2})^2}\times\pi\left(\frac{8}{2}\right)^2=2\times2000$

$64F_1=4000$

$\therefore F_1=56.25$ 磅 $\therefore F=14.06$ 磅

3. If the effort applied to the small piston in Exer. 2 moves through 1 ft., how much will the large piston be raised? 上題施於小活栓之力設移動 1 呎，大活栓應移動若干。

解 由上題知原力被大栓所生者爲$\frac{1}{256}$故原力移動一呎大栓亦祇移上$\frac{1}{256}$呎

或由 F 與 2 噸之比亦可見之

4. A piston moves in a cyclinder that is in communication with a water system whose pressure is 65 lb. per square in. If a force of of 1 T. is to be developed by the piston, what is the least diameter that it can have? 圓筒中有一活栓，與水壓機相連，其壓力=65 磅（每方吋）。設此栓能生力 1 噸，此栓至小之直徑須若干。

解 設活栓之半徑=r 直徑=2r

$$65\times\pi\ r^2=2000$$

$$r^2=2000\div(65\times\pi)$$

$$r=3.12\text{ in}$$

$$\text{直徑}=6.24\text{ in}$$

5. Pressure againt a piston 20 cm. in diameter is produced by a column of water 30 m. high. Calculate the force against the piston and the work performed when the piston moves 4 m. 一活栓直徑 20 cm.，水深 30 m. 壓之使生力，試計栓面壓力，併計其移動 4 m. 時所作之工若干。

解 栓面之壓力$=3.1416\times\left(\frac{20}{2}\right)^2\times30\times100$

$=942480$ g.

工作 $=942480\times4\times100\times980$

$=36945260000$ ergs

6. Give suitable dimensions to the piston and lever of an hydraulic press in order that an effort of 1 lb. may produce a force of 3000 lb. 在一水壓機中有槓杆及活栓欲使一磅之力生出 3000 磅之力，其裝置應如何，活栓之大小若干。

解 設槓杆爲第二種長 4 呎，小活栓連于距支點一呎之處，則 1 磅之力到小活栓即變爲 4 磅，又設小活栓之半徑爲半吋，大活栓之半徑爲 x

$\frac{4}{\pi\times(\frac{1}{2})^2}\times\pi x^2=3000$ $x=13.69$ 吋 依上各數即可構造此機。

XXII. ARCHIMEDES' PRINCIPLE.

亞放米的斯定理

1. A stone weighing 400 g. under water weighs 480 g. in air. What mass and volume of water does it dis-

place? What is the volume of the stone? 一石在水中重 400 g. 在空中重 480 g. 所排水重及水積若干，石之體積若干。

解 所排之水＝480－400＝80 g. (重)

＝80 c. cm. (水積)

石之體積亦＝80 c. cm.

2. What is the volume of a metal cylinder that weighs 30 g. in air and 19 g. when immersed in water? 一金屬圓筒在空中重 30 g. 在水中重 19 g. 此筒之容積若干。

解 此筒之容積等于所排之水。

故＝30－19＝11 c. cm.

3. A solid weighs 20 lb. in air and 12 lb. when suspended under water. What is the weight of an equal volume of water? What is the volume of the body in cubic inches? 一固體在空中重 20 磅，懸于水中重 12 磅，等積之水重若干，此物之積爲若干立方吋。

解 (1) 等積之水重＝20－12＝8 磅

(2) 此物之積 $=\frac{8}{62.5}\times 1728$ 立方吋

＝221.184 立方吋

4. A body weighing 50 g. in air weighs 35 g. when immersed in water and 38 g. when immersed in oil. Find the mass and volume of the oil displaced. 一物在空中重 50 g. 在水中重 35 g. 在油中重 38 g. 求所排油之重與積。

解 此物之積=50−35=15 c cm.

所排油之積亦=15 c. cm.

所排油之重 =50−38=12 g.

5. A block of iron weighing 12 g. and a piece of wood weighing 4 g. are fastened together and weighed in water; their weight when immersed is 7.5 g. If the iron alone weighs 10.2 g. when immersed in water, what is the volume of the wood? 一鐵塊重 12 g. 一木片重 4 g. 同繫于水中，衡之共重 7.5 g. 設鐵在水中獨重 10.2 g. 木之積若干.

解 鐵之積=12−10.2=1.8 c. cm.

鐵與木之積=12+4−7.5=8.5 c. cm.

木之積=8.5−1.8=6.7 c. cm

6. A block of wood is flocated in a vessel full of oil. If 200 g. is the weight of the oil displaced, what is the weight of wood? 一木塊浮于滿注油器之中，設所排之油爲 200 g. 木塊重若干.

解 木塊之重=所排之油

=200 g.

7. A boat that weighs 450 lb. displaces how many cubic feet of water? 一舟重 450 磅，排水若干立方呎.

解 所排之水=$\frac{450}{62.5}$=7.2 立方呎

8. A ferry-boat weighing 700 tons takes on board a train weighing 550 tons. Express the total displacement

in cubic feet. 一渡船重 700 噸，載一列車重 55 噸，其所排之水共計若干立方呎。

解 排水共$=\frac{700+500}{62.5}\times 2000$ 立方呎

$=38400$ 立方呎

9. What is the volume of a man weighing 150 lb. if he floats with 1/20 of his body above water? 一人浮身$\frac{1}{20}$于水上，設本重 150 磅，試求其體積若干。

解 浮于水者$=\frac{1}{20}$ 沒于水者$=\frac{19}{20}$

所排水積$=150\times\frac{1}{62.5}$ $=2.4$ 立方呎

此人體積$=2.4\div\frac{19}{20}$ $=3\frac{1}{19}$ 立方呎

XXIII. DENSITY AND SPECIFIC GRAVITY. 密度與比重

1. A piece of lead weighs 56.75 g. in air and 51.73 g. when suspended in water. Find the volume and density of the lead. 鉛一塊重 56.75 g.（在空中）。若在水中懸而秤之則重 51.73 g. 試求此鉛之密度與比重。

解 鉛之密度$=\frac{56.75}{56.75-51.73}=\frac{56.75}{5.02}=$

11.3 强（每 c. cm.）

其比重亦$=11.3$ 强

2. A cylinder of aluminum weighs 28.35 g. in air and 17.85 g. when immersed in water. Calculate the volume and density of the metal. Compute the sp. gr of aluminum. 一鋁製圓筒在空中重 28.35 g. 在水中重 17.85 g. 試求鋁之體積，密度與比重。

解 其容積=28.35−17.85=10.5 c. cm.

其密度=$\frac{28.35}{10.5}$=2.9 c. cm

其比重=2.9

3. A piece of glass weighing 45 g. in air weighs 22.5 g. in water and 23.75 g. in oil. Calculate the densities of the glass and the oil. 玻璃一塊在空中重 45 g. 在油中重 23.75 g. 在水中重 22.5 g. 試求玻璃與油之密度

解 玻璃之密度=$\frac{45}{22.5}$ (45−22.5=22.5)

=2 c. cm.

油之密度=$\frac{45-23.75}{45-22.5}=\frac{21.25}{22.5}$=.94 c. cm.

4. What would be the weight of the glass in Exer. 3 when immersed in a liquid whose density is 0.922 g. per cubic centimeter? 某液體之密度=.922 g. (每 c. cm) 上題之玻璃置于其中，應重若干。

解 $\frac{45-x}{45-22.5}$=.922 45−x=.922×22.5

x=45−20.745

=24.255 g.

5. The density of marble is 2.7 g. per cubic centimeter. What is the weight of a rectangular block 1 m. long, 40 cm. wide, and 15 cm. thick? Compute the sp. gr. of marble. What is its mass per cu. ft.? 大理石之密度爲 2.7 g. 每 c. cm. 一長方大理石柱長 1 m. 寬 40 cm. 厚 15 cm. 其重若干，其比重若干，每立方呎重若干。

解 (1) 大理石柱之重 $=100\times4\times15\times2.7=g$ 16200 g.

(2) 大理石之比重 $=2.7$

(3) 每立方呎之重 $=2.7\times62.5$

$=168.75$ 磅

6. Silver is 10.4 times as heavy as an equal volume of water. What will 20 g. of silver weigh when immersed in water? 銀爲同積水 10.4 倍重，若 20 g. 之銀在水中重若干。

解 設在水中重 W

則 $\frac{20}{20-W}=10.4$ $10.4\,W=188$

$W=18.07$ g.

7. Ice is 0.9 as heavy as an equal volume of water. If a piece of ice weighing 500 g. floats on water, what is the volume of the submerged portion? What is the volume of the ice? 冰之比重爲 .9，設有冰 500 g. 浮于水上，其沒水者若干，冰之全積若干。

解 (1) 沒于水之部分 $=1\times500=500$ c. cm.

(2) 冰之全積 $v=\frac{500}{.9}=555\frac{5}{9}$ c. cm.

8. A bar of wood weighing 100 g. floats on water with 0.82 of its volume submerged; when placed in oil, 0.90 of its volume is submerged. Calculate the sp. gr. and density of the oil. 木棍重 100 g. 浮于水中，沒水者爲全積 .82. 易置油中，則沒于油者爲全積 .90. 試求油之比重與密度。

解 所排之水=.82 v × 1 g. (v=木積 x=油之密度)

所排之油=.90 v × x g.

∴ 100÷.90×v×x=100÷.82×v×1

$$\therefore \quad x=\frac{.82}{.90}=.91$$

9. A piece of paraffin weighs 69 g. in air and when attached to a sinker and suspended in water, 85.8 g. If the weight of the sinker in water is 95.7 g., what is the volume and density of the paraffin? 一塊蠟油重 69 g. (在空中). 同重物懸水中共重 85.8 g. 若重物在水中重 95.7 g. 此蠟油之積及比重各若干。

解 85.8−95.7=−9.9

$$\text{其密度}=\frac{69}{69-(-9.9)}=\frac{69}{78.9}$$

=.82 g.c. cm.

其比重=.82

其容積=69÷.82=84.4 c. cm.

10. The weight required to sink a Nicholson hydrometer to the mark on the stem is 45 g.; when a piece of marble is placed in the upper pan, the weight required is 15.3 g. and with marble in the submerged pan 26.3 g. Find the density of the marble. 一尼可生水表使沉至標點，須加重 45 g. 置大理石一塊于上盤，則僅須 15.3 g. 若置石于水下盤中，須重 26.3 g. 求大理石之密度。

解 其密度 $=\frac{45-15.3}{26.3-15.3}=\frac{29.7}{11}=27$ c. cm.

$\left(\text{依公式 } D=\frac{W_1-W_2}{W_3-W_2}\right)$

11. Find the density of paraffin from the following data:

Weight required to sink Nicholson hydrometer to mark 56.4 g.

Weight to sink hydrometer with paraffin in upper pan 45.6 g.

Weight required with paraffin in submerged pan 57.6 g.

依下列所示之數，計算蠟油之密度。

使尼可生表至標點須加重 56.4 g.

使此表至標點蠟在上盤須加重 45.6 g.

蠟在下盤須加重 57.6 g.

解 其密度 $=\frac{56.4-45.6}{57.6-45.6}=\frac{10.8}{12}=.9$ c. cm.

12. The density of mercury is 13.59 per cubic centimeter. If a cubic foot of water weighs 62.5 lb., what is

the weight of a cubic inch of mercury? 水銀密度=13.59 c. gm. 設使一立方呎水重 62.5 磅，一立方吋之水銀重若干。

解 一立方吋水銀=$\frac{62.5\times13.59}{1728}$=.491 磅

XXIV. ATMOSPHERIC PRESSURE. 大气壓力

1. The column of mercury in a barometer stands at a height of 74.5 cm. What is the height in inches? 氣壓表中水銀柱高 74.5 cm. 以吋計之應若干。

解 1 cm.=.3937 in.

74.5 cm.=.3937×74.5 in.

=29.33 in.

2. How high a column of water could be supported by atmospheric pressure when the barometer reads 75 cm.? 气壓表所示爲 75 cm. 此气壓能支水柱若干高。

解 水銀比重=13.59

故此气壓可支水柱 13.59×75=1019.25 cm.

3. When the barometer reads 74 cm., what is the atomspheric pressure expressed in grams per square centimeter? in dynes per square centimeter? 气壓表示 74 cm. 每平方 cm. 面積气壓之重若干 g，每平方爲若干 dynes.

解 $74 \times 13.59 = 1005.66$ g.

$74 \times 13.59 \times 980 = 985546.8$ dynes.

4. If the pressure of the air is 15 lb. square inch, calculate the total force exerted upon a person the area of whose body surface is 16 square ft. 气壓每方吋=15磅，人身表面=16 方呎，試計其全身之總壓力。

解 總壓力 $= 144 \times 15 \times 16$

$= 34560$ 磅

5. A soap bubble has a diameter of 4 in. Calculate the force exerted by the air against its entire surface when the barometer reads 29 in. A cubic inch of mercury weighs 0.49 lb. 一膜泡直徑 4 吋，气壓=29 in. 一立吋水銀=.49 磅，試計膜泡表面之壓力。

解 球面 $= \pi \times 4^2$ 方吋

散其全面壓力 $= \pi \times 16 \times 29 \times .49$

$= 714.27$ 磅

XXV. PRESSURE OF GASES

气體壓力

1. If the volume of a certain gas is 200 cm^3. when its pressure is 1000 g. per square centimeter, what volume will it occupy when its pressure has been in-

creased to 1200 g. per square centimeter? 一种气積=200 立方 cm. 其壓力每方 cm.=1000 g. 至其壓力增至每方 cm.=1200 g. 時，其容積若何·

解 依公式 $PV=P'V'$

$$1200\ V=1000\times 200$$

$$V=1000\times 200\div 1200$$

$$=\frac{500}{3}=166\frac{2}{3}\text{ c. cm.}$$

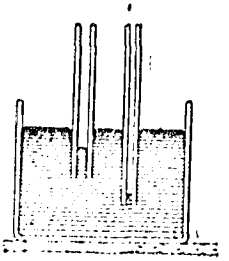
2. The volume of an air bubble at a depth of 1 m. of mercury is 1 cm³: What will be its volume when it reaches the surface if the barometer reading is 75 cm.? 一气泡之積在深 1 m. 之水銀底=1 立方 m. 設氣壓 =75 cm. 時昇至表面。容積若何。

解 依公式 $PV=P'V'$

$$75\ V=(100+75)\times 1$$

$$V=\frac{175}{75}=2\frac{1}{3}\text{ c. cm.}$$

3. A gas is often confined in a tube, as shown in Fig. 3, whose open end is beneath the surface of some liquid. How much is the pressure of the gas confined in such a tube in a vessel of mercury when the surface in the tube is 25 cm. below the level of the liquid outside, the barometer reading 75 cm.? 某气體納入管中如圖 3 所示 (A) 管口在一液體之中，設液爲水銀，氣壓爲 75 cm. 若管中表面較外面低下 25 cm. 時，其壓力幾何·



解 其壓力=75−25

=50 cm. (水銀)

(3) 圖

4. If the volume of the gas under the conditions given in Exer. 3 is 15 cm.^{3}, what will be its volume if the tube is elevated until the surfaces are at the same level? 設上題所述之管在彼時其气積=15 c. cm. 若使管裏水銀面與外邊水銀面相平時，其容積若何·

解 依公式 $75\ V=50\ V'$

$$V=\frac{50}{75}V'$$

即爲 15 c. cm. 之 $\frac{2}{3}$

即=10 c cm.

5. In B, Fig. (3) the surface of the mercury in the tube is 25 cm. above that of the mercury on the outside. If the atmospheric pressure is 75 cm., what is the pressure of the confined gas? (3) 圖 B, 管中水銀面較外面高 25 cm. 設气壓爲 75 cm. 管中气壓若干·

解 管中气壓=75+25

=100 cm.

6. Under the conditions given in Exer. 5 the volume of the gas confined in the tube is 50 cm^3. What volume

will the gas occupy when the surfaces are brought to the same level? 依上題 (5) 管中氣積=50 c. cm. 若使管內外水銀面相平，其氣積若何。

解 依公式 75 V=100 V′

$$V=\frac{100}{75}V'$$

即爲 50 c. cm. 之 $1\frac{1}{3}$

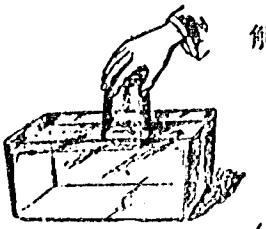
即=$66\frac{2}{3}$ c. cm.

7. The volume of an air bubble 136 cm. under water is 0.5 cm^3. Barometer reading is 75.4 cm. Calculate (1) the pressure to which the bubble is subjected, and (2) the volume it will have as it emerges from the water. 一气泡在水深 136 cm. 處其容積=.5 c. cm. 气壓=75.4 cm. (1) 試計气泡所受之壓力 (2) 試求其出水後之容積。

解 (1)气泡所受之壓力=$75.4+\frac{136}{13.6}$=85.4 cm.

(2)出水後之容積=$\frac{85.4\times.5}{75.4}$= 566 c. cm.

8. To what depth would the inverted tumbler in Fig. 8, have to be taken in order to become half filled with water if the barometer reading is 75 cm.? (8) 圖中之盃倒立水中，設氣壓=75. 欲使水達盃之半，應使其入水深若干。



解 設所求之深=d

$$\left(75+\frac{d}{13.6}\right)\frac{1}{2}V=75\ V$$

$$d=75\times 13.6$$

$$=1020\ cm.$$

(8) 圖

9. A gas tank whose capacity is 3.5 cu. ft. is filled with illuminating gas until the pressure is 225 lb. per square inch. How many cubic feet of gas at atmopheric pressure will be required in the filling of the tank? (Assume one atmosphere to be 15 lb. per square inch.) 一煤气筒內容 3.5 立呎，滿裝煤气，使气壓每方吋=225 磅，須用平常气壓之煤氣若干？(常气壓每方吋=15 磅)

解 依公式 $15\ V=3.5\times 225$

$$V=\frac{3.5\times 225}{15}$$

$$=52.5\ 立呎$$

XXVI. CHANGES IN DENSITY

密度之變更

1. Hydrogen, whose density is 0.09 g. per liter under one atmosphere, is condensed in a steel cylinder

until the pressure is 15 atmospheres. Calculate the density of the gas in the cylinder. 輕氣在一气壓之下每一 liter 之密度=.09 g. 現使凝集于一鋼筒之中，气壓大至 15. 倍，試求輕气在筒中之密度·

解 依公式 Dp=dP

$$1\times D=15\times .09$$

$$D=1.35 \text{ g. per liter}$$

2. Illuminating gas is condensed in a reservoir until its density has increased from 0.75 g. per liter to 4.5 g. per liter. Calculate the pressure in the reservoir. Express the result in atmospheres. 煤氣聚于桶中，使其密度由 .75 g. per liter 至 4.5 g. per liter 試求桶中之壓力，以气壓表示之·

解 依公式 Pd=pD

$$.75P=1\times 4.5$$

$$P=\frac{4.5}{.75}=6 \text{ 气壓}$$

3. If 4 liters of air at ordinary atmospheric pressure are admitted into a vacuum of 10 liters capacity, what will be the pressure and density of the air? (Under one atmosphere the density of air to 1.29 g. per liter.) 設在常气壓下 4 liters 之空气，入于眞空器 10 liters 之中·此時空气之壓力與密度各若干·(空气在 1 气壓下每 liter 之密度=1.29 g.)

解 依公式 PV=P′V′ $10P=4\times 1$ $P=.4$ 气壓

又依公式 pD=Pd $1\times d=.4\times 1.29$

$$=.516 \text{ g. per liter}$$

4. What is the weight of the quantity of illuminating gas condensed in a cylindrical tank of 3 cu. ft. capacity until the pressure is 225 lb. per square inch! (The density of the gas under one atmosphere of pressure is 0.5 g. per liter.) 煤气聚于 3 立呎容積之圓筒中，使其每方吋之壓力=225 磅，則其重若干。(煤气之密度每 1 liter 在常气壓下=.75 g.)

解 常气壓每方吋=15 225÷15=15 倍

故其密度必爲 15×.75 g. per liter

故其重量 $\frac{3\times1728\times16.387}{1000}\times15\times.75$

=955,69 g.

5. If the gas shown in the tubes in Fig. (3). A and B, is air, what is the density of it under the conditions given in Exercises 3 and 5 of § XXV 設下圖 A. B. 管中爲空气，則其密度依 XXV 節第 3 與第 5 =題計之，應爲若干。

解 依(3) P=50(A管)d_1:1.29=50 : 75

$$d_1 = \frac{129\times50}{75} = .86 \text{ g.}$$

Per liter

依(5) P=100(B管)d_2:1.29=100 : 75

$$d_2 = \frac{100\times1.29}{75} = 1.27 \text{ g.}$$

Per liter

XXVII. BUOYANCY OF AIR

空气浮力

1. A balloon whose capacity is 1000 m^3. is filled with hydrogen. If the weight of the bag, basket, and ropes is 235 kg., what additional weight can the balloon lift? 一气球容積=1000 m^3. 裝滿輕气，設篮包繩等物共重 235 kg. 此氣球尙能另舉若干重量。

解 气球所排之空氣=1.29×1000=1290 kg.

气球中輕氣及其裝置等共重= 09×1000+235 kg.=325 kg.

故尙可載重 1290—325=965 kg.

2. What will be the lifting capacity of the ballon in Exer. I when filled with illuminating gas? 若上題气球中裝以煤气，能另舉重若干。

解 所排之空气仍=1290 kg.

球中煤气及裝置=75×100。+235=985 kg.

尙能舉重=1290—984=305 kg.

3. A kilogram weight of brass (density 8.3 g. per cm^3.) will weigh how much in vacuum? 一千克之銅（密度 8.3 g. per cm^3.）在真空中應重若干。

解 所排空气=$\frac{1000}{8.3}\times\frac{1.29}{1000}$=.15 g.

此銅在真空中重=1000+.15=1000.15 g.

XXVIII. THE AIR BRAKE AND SUBAQUEOUS PRESSURE

气壓機與水底壓力

1. If the pressure against the 8-inch piston of an air brake is 75 lb. per square inch, how much force drives the piston forward? 气壓機之活栓直徑 8 吋，每方吋之壓力爲 75 磅，須力若干始能推進活栓。

解 $力=\pi\times\left(\frac{8}{2}\right)^2\times 75$

$=3769.92$ 磅

2. A diver sinks 68 ft. below the surface of water. Under how many atmospheres is he working? 一人沉水下 68 呎，所受爲大气壓力若干。

解 每方吋空气壓力＝15 磅

68 呎下水之壓力$=68\times 12\times\frac{62.5}{1728}=27.96$

故此人所受之壓每方吋$=15+27.96$

$=42.96$ 磅

3. A caisson is sunk until the bottom is 51 ft. below water level. Under what pressure must the laborers work? 一箱沉水，箱底至水下 51 呎，負箱者所受壓力若干。

解 每方吋气壓＝15 磅

51呎下水壓$=51\times 12\times\frac{62.5}{1728}=22.13$

工人所受壓力每方吋$=15+22.13$

$=37.13$ 磅