بسم الله الرحمن الرحيم

الحلول المختارة لطلاب الهندسة والعمارة

العلوم الاساسية للمعماريين ٢

اعداد

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الاستاذ المساعد بكلية العلوم التطبيقية والهندسية بجامعة ام القرى

تمهيد

الحمد لله وحده والصلاة والسلام على من لا نبي بعده سيدنا محمد وعلى آله وصحبه

وبعد، فهذه مجموعة من المسائل المحلولة في مادة العلوم الأساسية للمعماريين ٢ لطلبة

الهندسة والعمارة اخترتها إبان تدريسي لهذه المادة لجميع شتات المنهج

المقرر وهي مأخوذة من كتاب "Fundamentals of Physics"

لمؤلفيه Halliday و Resnick الطبعة الثانية (١٩٨١م)

وقد قمت بتبويبها وفهرستها لتسهيل المراجعة فيها وفهمها واكتفيت

عند ذكر المسألة بذكر رقمها والصفحة التي وردت فيها في الكتاب المذكور

بعاليه المقرر لمادة العلوم الأساسية للمعماريين ٢ لطلاب العمارة

الإسلامية في كلية العلوم التطبيقية والهندسية بجامعة أم القرى.

والله أسأل أن يجعل هذا العمل حافزاً للطلاب للمزيد تقدماً

في الدراسة والتحصيل لنفع العباد والبلاد، كما وأسأله أن

لا يحرمني أجره في الآخرة والأولى.

كمال ... ١٤٠٩/٦/٢٨

الفهرس

الصفحة

الصفحة

الصفحة

$\frac{3}{10}$

$20\ mi = 20\ mi \cdot \left(\frac{5280\ ft}{mi}\right) \cdot \left(\frac{12\ in}{ft}\right) \cdot \left(\frac{2.54\ Cm}{in}\right) \cdot \left(\frac{1\ m}{100\ Cm}\right) \cdot \left(\frac{1\ Km}{1000\ m}\right) = 32.2\ Km$

$\frac{4}{10}$

$300\ Km = 300 * 1\ Km * \frac{1000\ m}{1\ Km} * \frac{100\ Cm}{1\ m} * \frac{1\ inch}{2.54\ Cm} * \frac{1\ ft}{12\ inch} * \frac{1\ Yd}{3\ ft} * \frac{1\ mi}{1760\ Yd}$

186.4 miles

$\frac{5a}{10}$

100 m is longer than 100 Yd

It is longer by $100\ m - 100\ Yd = 100\ (m - Yd) = 100\left(m - \frac{3*12*2.54}{100} m\right)$

$= 100\ (1 - .9144)\ m = 8.56\ m$

It is longer by $8.56 * 100 * \frac{1}{2.54} * \frac{1}{12}\ ft = 28.1\ ft$

$\frac{7a}{10}$

$1\ in^2 = 1 * (2.54\ Cm)^2 = 6.45\ Cm^2$

$\frac{12}{11}$

(a) $\frac{1\ g}{cc} = \frac{1\ g}{cc} \cdot \left(\frac{1000\ cc}{lit}\right) \cdot \left(\frac{1\ Kg}{1000\ g}\right) = 1\ Kg/lit$

(b) Average mass flow rate = mass / time = volume * density / time

$= 1\ lit * \frac{1\ Kg}{lit} / 10\ hr = 0.1\ Kg/hr = 0.1\ \frac{Kg}{hr} \cdot \frac{1\ hr}{3600\ sec} = 2.78 \times 10^{-5}\ Kg/sec$

$\frac{14}{11}$

$1\ \text{light-fermi} = \frac{1\ fermi}{\text{speed of light}} = \frac{10^{-15}\ m}{30\ Cm/ns} = \frac{10^{-15}}{30} \cdot \frac{m \cdot ns}{Cm} \cdot \left(\frac{100\ Cm}{m}\right)\left(\frac{10^{-9}\ sec}{ns}\right) = 3.3 \times 10^{-24}\ s$

$\therefore$ One light-fermi $= 3.3 * 10^{-24}$ seconds.

$\frac{15}{11}$

$1\ year = 365.25\ days = 365.25 * 24\ hrs = 8766 * 3600\ sec = 3.15576 \times 10^7\ sec$

$\therefore \%\ error = \frac{(\pi - 3.15576) * 10^7}{3.15576 * 10^7} * 100 = -0.449\%$.

$\frac{19}{11}$

(a) $3.0 * 10^8\ \frac{m}{s} = 3.0 * 10^8\ \frac{m}{s} \cdot \left(\frac{100\ Cm}{m}\right) \cdot \left(\frac{1\ in}{2.54\ Cm}\right) \cdot \left(\frac{1\ ft}{12\ in}\right) \cdot \left(\frac{10^{-9}\ s}{ns}\right) = 0.98\ \frac{ft}{ns}$

(b) $3.0 * 10^8\ \frac{m}{s} = 3.0 * 10^8\ \frac{m}{sec} \cdot \left(\frac{1000\ mm}{m}\right) \cdot \left(\frac{1\ sec}{10^{12}\ ps}\right) = 0.3\ mm/\text{picosecond}$.

$\frac{5}{21}$ Assume east to be x and north y-axes

$\therefore$ putt 1 is $\langle 0, 12 \rangle$ ft & putt 2 is $6ft \angle -45^\circ = \langle \frac{6}{\sqrt{2}}, -\frac{6}{\sqrt{2}} \rangle$ ft

& putt 3 is $3ft \angle -135^\circ = \langle \frac{-3}{\sqrt{2}}, \frac{-3}{\sqrt{2}} \rangle$ ft

$\therefore$ Resultant putt is $\langle 0, 12 \rangle + \langle \frac{6}{\sqrt{2}}, -\frac{6}{\sqrt{2}} \rangle + \langle \frac{-3}{\sqrt{2}}, \frac{-3}{\sqrt{2}} \rangle = \langle \frac{3}{\sqrt{2}}, 12 - \frac{9}{\sqrt{2}} \rangle$

$= \langle 2.12, 5.64 \rangle$ ft $= 6.03 ft \angle 69.4^\circ$

$\therefore$ He could have done it in one putt if it was $6.0 ft$ 69.4° Northeast

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$\frac{10}{21}$ $7.3 \angle 250^\circ = 7.3 \langle \cos 250, \sin 250 \rangle = 7.3 \langle -.342, -.940 \rangle = \langle -2.50, -6.86 \rangle$ units.

$\frac{13}{21}$ $a = 10 \angle 30^\circ$, $b = 10 \angle 135^\circ$

$\therefore$ $r = a + b = 10 \angle 30^\circ + 10 \angle 135^\circ = 10 [\langle \cos 30^\circ, \sin 30^\circ \rangle + \langle \cos 135^\circ, \sin 135^\circ \rangle]$

$= 10 [\langle .866, .500 \rangle + \langle -.707, .707 \rangle] = \langle 1.589, 12.07 \rangle$ units

$= 12.17$ units $\angle 82.5^\circ$

$\frac{19}{21}$ $a = \langle 4, 3 \rangle$, $b = \langle -3, 7 \rangle$ $\therefore$ $a + b = \langle 4, 3 \rangle + \langle -3, 7 \rangle = \langle 1, 10 \rangle$

$= 10.05 \angle 84.3^\circ$ units

$\frac{23}{22}$ $A = \langle 3, 4 \rangle$, $B = \langle 5, -2 \rangle$

$\therefore$ (a) $A + B = \langle 3, 4 \rangle + \langle 5, -2 \rangle = \langle 8, 2 \rangle = 8.246 \angle 14.04^\circ$.

(b) $B - A = \langle 5, -2 \rangle - \langle 3, 4 \rangle = \langle 2, -6 \rangle = 6.325 \angle -71.6^\circ$.

$\frac{27}{22}$ (a) $a \cdot b = |a| \cdot |b| \cdot \cos \angle_a^b = 10 * 6 * \cos 60 = 30$

(b) $|a \times b| = |a| \cdot |b| \cdot \sin \angle_a^b = 10 * 6 * \sin 60 = 52.0$ & the direction is normal to both a & b (rule of thread)

$\frac{36}{22}$ $a = \langle 3, 3, -3 \rangle$, $b = \langle 2, 1, 3 \rangle$

$\therefore$ $a \cdot b = 3*2 + 3*1 - 3*3 = 6 + 3 - 9 = 0 = |a| \cdot |b| \cdot \cos \angle_a^b$

$\therefore$ $\cos \angle_a^b = 0$ $\therefore$ $\angle_a^b = 90^\circ$

$\frac{38}{22}$ $A = \langle 3, 5 \rangle$, $B = \langle -2, 4 \rangle$

(a) $|A \times B| = 3*4 - 5*(-2) = 22$ (direction as thread rule)

(b) $A \cdot B = 3*(-2) + 5*4 = -6 + 20 = 14$

(c) $(A + B) \cdot B = \langle 1, 9 \rangle \cdot \langle -2, 4 \rangle = -2 + 36 = 34$

42/23

(a) $N \times W$ is Up

(b) $D \cdot S = 0$

(c) $E \times U$ is South

(d) $West \cdot West = 1$

(e) $S \times S = 0$

43/23

$A = \langle 3, 3, -2 \rangle$, $B = \langle -1, -4, 2 \rangle$ & $C = \langle 2, 2, 1 \rangle$

(a) $A \cdot (B \times C) = \langle 3, 3, -2 \rangle \cdot \langle -8, 5, 6 \rangle = -24 + 15 - 12 = -21$

(b) $A \cdot (B + C) = \langle 3, 3, -2 \rangle \cdot \langle 1, -2, 3 \rangle = 3 - 6 - 6 = -9$

(c) $A \times (B + C) = \langle 3, 3, -2 \rangle \times \langle 1, -2, 3 \rangle = \langle 5, -11, -9 \rangle$

4/38

Total displacement $= 60 \times \frac{40}{60} \angle 0^\circ + 60 \times \frac{20}{60} \angle 45^\circ + 60 \times \frac{50}{60} \angle 180^\circ$

$= 40 \langle 1, 0 \rangle + 20 \langle \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \rangle + 50 \langle -1, 0 \rangle = \langle 40 + \frac{20}{\sqrt{2}} - 50, \frac{20}{\sqrt{2}} \rangle$

$= \langle 4.142, 14.14 \rangle$ Km $= 14.74$ Km $\angle 73.7^\circ$

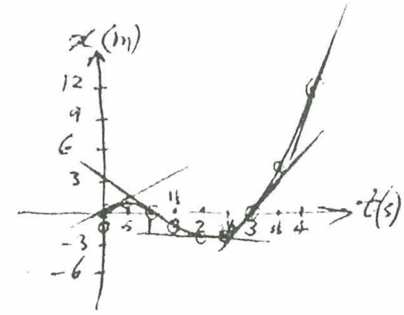
Total time $= (40 + 20 + 50)/60 = 1.833$ hrs

$\therefore$ Average velocity $= \frac{\text{Total displacement}}{\text{Total time}} = \frac{14.74}{1.833}$ Km/hr $\angle 73.7^\circ = 8.04 \frac{\text{Km}}{\text{hr}} \angle 73.7^\circ$

$\therefore$ Average velocity of train is 8.04 Km/hr 73.7° North of East.

9/38

$x = 3t - 4t^2 + t^3$



$\therefore$ (a) The initial velocity of the object is about 3 m/s.

(b) velocity at $t = 1$ sec is about -3 m/s.

" " $t = 2$ sec " $= -\frac{1}{2}$ m/s $= -.5$ m/s

" " $t = 3$ sec " $= 6$ m/s

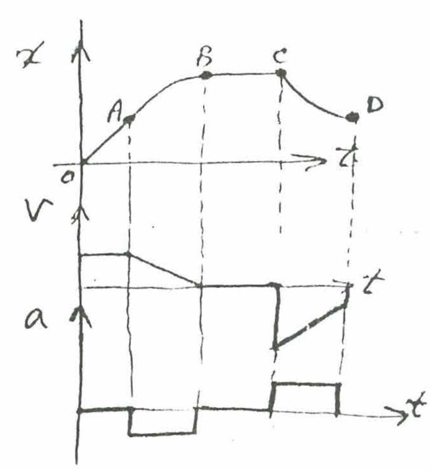
" " $t = 4$ sec " $= \frac{6}{1/4} = 24$ m/s. (Correct answers are $3, -2, -1, 6, 19$ m/s).

12/38

(a)

Interval	Velocity	Acceleration
OA	+	0
AB	+	−
BC	0	0
CD	−	+

(b) Assuming AB and CD to be parabolic, No.



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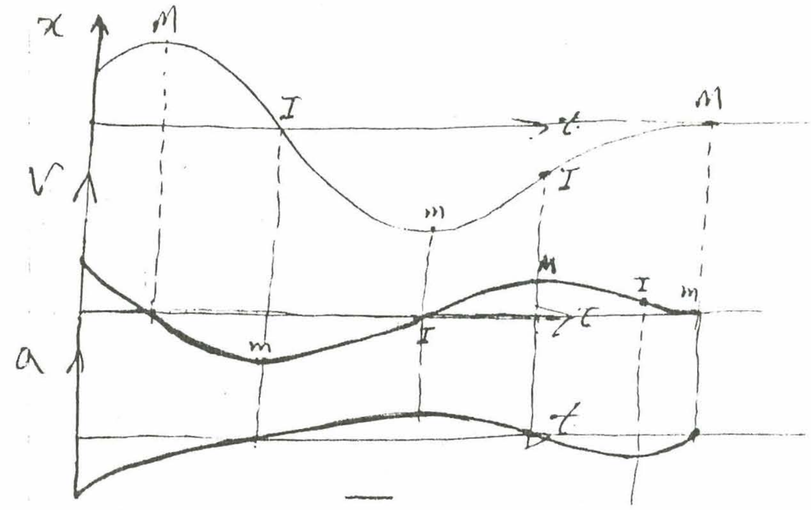


18/39

$v^2 = v_0^2 + 2as$, $v_0 = 0$, $v = 360$ Km/h , $S = 1.8$ Km

$\therefore (360)^2 = 0^2 + 2\,a*(1.8) = 3.6\,a$ $\therefore a = \frac{360^2}{3.6} = 36000$ Km/h^2 =

$= \frac{36000 * 1000\ m}{(3600\ s)^2} = \frac{10000}{3600}$ m/s^2 $= \frac{100}{36}$ m/s$^2 \simeq 2.8$ m/s^2 min. acc.

23/39

(a) $a = \frac{v^2 - v_0^2}{2s} = \frac{50^2 - 30^2}{2 * 160} = 5$ m/s^2.

(b) $t = \frac{v - v_0}{a} = \frac{50 - 30}{5} = 4$ seconds.

(c) $t = \frac{v - v_0}{a} = \frac{30 - 0}{5} = 6$ seconds

(d) $s = \frac{v^2 - v_0^2}{2a} = \frac{30^2 - 0^2}{2*5} = \frac{900}{10} = 90$ m

27/39

$v^2 = v_0^2 + 2as$, $v = 4*10^6$ m/s , $v_0 = 1.0 \times 10^4$ m/s , $a = 1$cm $= .01$m

$\therefore (4*10^6)^2 = (1.0*10^4)^2 + 2a*.01$ $\therefore a = (16*10^{12} - 10^8)/(.02) = 8*10^{14}$ m/s^2.

34/40

Assuming constant brake-force, $\therefore S = v_0 t + \frac{1}{2} a t^2$, $S = 110$ ft,

$v_0 = 35$ mi/h , $t = 4S$ $\therefore 110 = 35 * 1760 * 3 * \frac{4}{3600} + \frac{1}{2} a \cdot (4)^2$

(a) $\therefore a \simeq -12$ ft/s^2 $\therefore$ His deceleration before impact was 12 ft/s^2.

(b) $v = v_0 + at = 35 - 12 \cdot \frac{3600}{1760*3} * 4 = 2.3$ mi/hr

$\therefore$ The car was travelling at impact at 2.3 mi/h

37/40

$v^2 = v_0^2 + 2as$ $\therefore v = 0$, $a = -g$, $S = 50$ ft $\therefore 0 = v_0^2 - 2*32*50$

$\therefore$ (a) $v_0 = \sqrt{32*10^2} = 56.6$ ft/s

(b) $v = v_0 + at$ $\therefore 0 = 56.6 - 32t \Rightarrow t = 1.77$ sec to reach max hight

$\therefore$ It will be on air for 3.54 sec.

39/40

$v^2 = v_0^2 + 2as$, $v_0 = 0$, $a = +32$ ft/s^2 , $S = 4$ ft

$\therefore v^2 = 0 + 2*32*4$ $\therefore v = 16$ ft/sec downwards speed before contact

$v'^2 = v_0'^2 + 2a's'$, $v' = 0$, $a' = -32$ ft/s^2 , $s' = 3$ ft

$\therefore 0 = v_0'^2 - 32*2*3$ $\therefore v_0' = 13.9$ ft/s up, speed after contact

$\therefore$ average acceleration during contact $= \frac{\text{speed after} - \text{speed before}}{\text{contact time}} =$

$= \frac{13.9\text{ up} - 16\text{ down}}{.01} = \frac{13.9 + 16}{.01}$ up $= 2986$ ft/sec^2 up

$\therefore$ Average acceleration is about 3000 ft/sec^2 upwards.

4

$\frac{43}{40}$

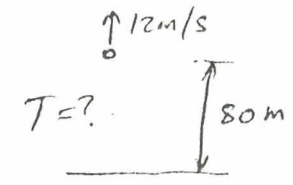
$S = v_i t + \frac{1}{2} g t^2$

$\therefore 80 = -12\,t + \frac{1}{2} \times 9.81 \times t^2$

$\therefore \frac{9.81}{2} t^2 - 12t - 80 = 0$

$\therefore t = \frac{12 \pm \sqrt{12^2 - 4 \times \frac{9.81}{2} \times (-80)}}{9.81} = \frac{12 \pm 41.4}{9.81}$

$= 5.443$ sec (reject $-$)



$\frac{50\ a,b}{41}$

$\frac{h}{2} = \frac{v_1^2 - 0^2}{2g}$ $\therefore h = v_1^2/g$ (1)

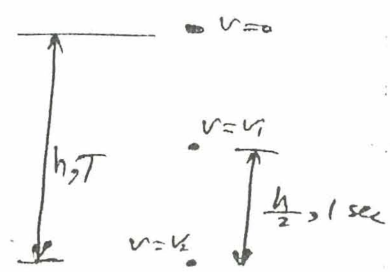
& $h = \frac{v_2^2 - 0^2}{2g}$ $\therefore h = v_2^2/2g$ (2)

& $1 \times g = v_2 - v_1$ (3)

$\therefore$ (1) & (2) in (3) $\Rightarrow g = \sqrt{2hg} - \sqrt{hg} = (\sqrt{2} - 1)\sqrt{hg}$

$\therefore \sqrt{hg} = \frac{g}{(\sqrt{2}-1)}$ $\therefore h = \frac{g}{(\sqrt{2}-1)^2} = 57.2$ m

$\therefore h = 0 + \frac{1}{2} g T^2$ $\therefore T = \sqrt{\frac{2h}{g}} = 3.41$ sec



$\frac{53}{41}$

Assume the elevator to have a motion of S feet up during the fall of the bolt

$\therefore$ The distance traveled by bolt is, $S' = 9 - S$ (1)

Now, for the elevator, $S = v_0 t + \frac{1}{2} a t^2$ with:

$v_0 = 8$ ft/s, $a = 4$ ft/s^2 $\therefore S = 8t + 2t^2$ (2)

& For the bolt, $-S' = v_0' t + \frac{1}{2} a' t^2$ with $v_0' = 8$ ft/s, $a' = -32$ ft/s^2

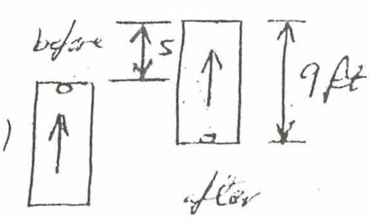
$\therefore -S' = 8t - 16t^2$ (3)

Substituting (2) & (3) in (1):

$\therefore -8t + 16t^2 = 9 - 8t - 2t^2$ $\therefore 18t^2 = 9$ $\therefore t = \sqrt{\frac{1}{2}} = .71$ s

$\therefore$ (a) The flight time is 0.71 sec.

& (b) $S' =$ (from (3)) $-8t + 16t^2 = -8 \times \sqrt{\frac{1}{2}} + 16 \times \frac{1}{2} = 2.3$ ft.



$\frac{2}{53}$

$a = \frac{V - V_0}{t} = \frac{\langle 100, -75\rangle - \langle 125, 25\rangle}{3} = \frac{\langle -25, -100\rangle}{3}$

$\therefore a = \langle -8.3, -33.3\rangle$ ft/s^2.

$\frac{7}{53}$

$S_A = S_B \times \sin\theta$ (1) & $S_A = v\,t$ (2) & $S_B = \frac{1}{2} a t^2$ & (3)

$d = S_B \times \cos\theta$ (4). Dividing (1) by (4) $\therefore \tan\theta = \frac{S_A}{d} =$ (from (2))

$= \frac{v\,t}{d} =$ (from (3)) $\frac{v \times \sqrt{2 \times S_B / a}}{d} =$ (from (4)) $\frac{v}{d} \cdot \sqrt{\frac{2}{a} \cdot \frac{d}{\cos\theta}} = \sqrt{\frac{2v^2}{a\,d\cos\theta}} = \tan\theta$

Squaring both sides:

$\therefore \tan^2\theta = 2v^2/(a d \cos\theta)$ or $\sec^2\theta - 1 = \frac{2v^2}{ad} \cdot \sec\theta$

$\therefore ad \cdot \sec^2\theta - 2v^2 \cdot \sec\theta - ad = 0$ $\therefore \sec\theta = \frac{2v^2 \pm \sqrt{4v^4 + 4a^2d^2}}{2ad} =$

$= \frac{2 \times 3^2 \pm \sqrt{4 \times 3^4 + 4 \times 4^2 \times 30^2}}{2 \times 4 \times 30} = \frac{18 \pm 30}{24} = \left\langle \begin{matrix} -.5 \\ +2 \end{matrix} \right.$ $\therefore \cos\theta = \left\langle \begin{matrix} -2 \times \\ \frac{1}{2} \end{matrix} \right.$ $\therefore \theta = \cos^{-1}\frac{1}{2} = 60°$.

12/54

$V_{oy} = 0$, $V_y = \sqrt{(3V_o)^2 - V_o^2} = \sqrt{8}\, V_o$

$\therefore V_y^2 = V_{oy}^2 + 2g \cdot S$, $S = 20\ m$

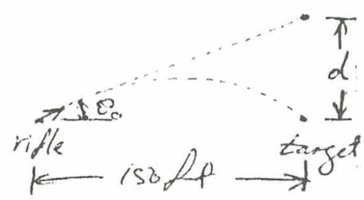
$\therefore 8V_o^2 = 0 + 2 * 9.81 * 20$ $\therefore V_o = 7.0\ m/s$

13/54

$V_o = 1500\ ft/s$, range $= 150\ ft$

$R = \frac{V_o^2 \sin 2\theta_o}{g}$

$\therefore 150 = \frac{1500^2 \sin 2\theta_o}{32} \Rightarrow \sin 2\theta_o = 2.13 * 10^{-3}$



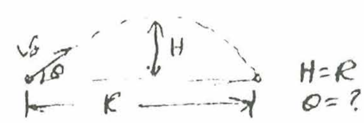
$\therefore 2\theta_o = 0.122^\circ$ $\therefore \theta_o = 0.06112^\circ$

$\therefore \tan\theta_o = \frac{d}{150}$ $\therefore d = 150 * \tan .06112^\circ = .160\ ft = 1.92\ in$

$\therefore$ He should point the rifle 1.92 in above target.

16/54

$R = \frac{V_o^2 \sin 2\theta}{g}$, $H = \frac{(V_o \sin\theta)^2}{2g}$ $\because R = H$



$\therefore V_o^2 \sin 2\theta / g = V_o^2 \sin^2\theta / 2g$ $\therefore \sin 2\theta = \frac{\sin^2\theta}{2}$

$\therefore 2\sin\theta \cos\theta = \frac{\sin^2\theta}{2}$ $\therefore 2\cos\theta = \frac{\sin\theta}{2}$

$\therefore \tan\theta = 4$ $\therefore \theta = 76.0^\circ$.

or,

$T = \frac{R}{V_o \cos\theta}$ (1) , $H = V_o \sin\theta \cdot \frac{T}{2} - \frac{1}{2} g \left(\frac{T}{2}\right)^2 = 0 + \frac{1}{2} g \left(\frac{T}{2}\right)^2$ (2) $\therefore g\left(\frac{T}{2}\right) = \frac{V_o \sin\theta\, T}{T}$

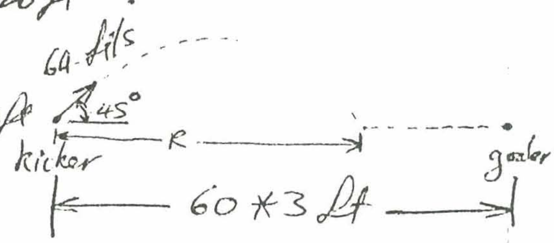
نصف الزمن الى القمة   من القمة الى الأرض

or $T = \frac{2V_o \sin\theta}{g}$ (3) from (1) & (2) $\therefore R = 2V_o^2 \sin\theta \cos\theta / g = H$ (from (2) & (3)) $= V_o^2 \sin^2\theta / 2g$

$\therefore$ dividing by $V_o^2 \sin\theta / g$ $\therefore 2\cos\theta = \sin\theta / 2$ $\therefore \tan\theta = 4$ $\therefore \theta = 76.0^\circ$

23/54

$R = \frac{V_o^2}{g} \cdot \sin 2\theta_o = \frac{64^2}{32} \cdot \sin(2*45^\circ) = 128\ ft$.



$\therefore$ The distance the goaler run $= 180 - 128 = 52\ ft$

$\because$ Time of run = time of flight $= \frac{R}{V_o \cos\theta}$

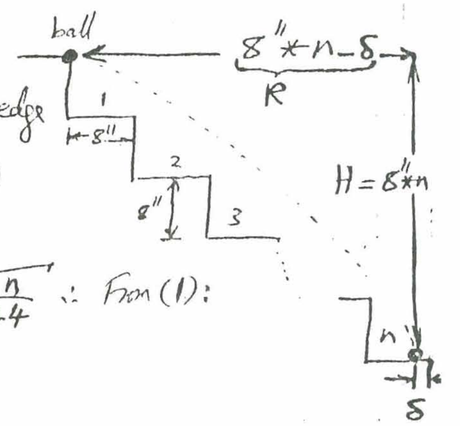
$= \frac{128}{64 \cos 45} = 2.83$ sec.

$\therefore$ The speed of goaler must be $\frac{52}{2.83} = 18.4\ ft/s$.

31/55

$V_o = 5$ ft/s

Let the ball hit the nth step δ ft before edge



$\therefore R = 8''*n - \delta = \frac{8}{12} ft * n - \delta = \frac{8n}{12} - \delta = V_o t$ (1)

& $H = 8''*n = \frac{8n}{12} = \frac{1}{2}*g*t^2$ (2)

$\therefore$ From (2) $\because t = \sqrt{\frac{2}{g}\cdot\frac{8n}{12}} = \sqrt{\frac{16n}{32*12}} = \sqrt{\frac{n}{24}}$ $\therefore$ From (1):

$\therefore \delta = \frac{8n}{12} - V_o t = \frac{8n}{12} - 5*\sqrt{\frac{n}{24}}$

But $\because \delta \in [0, \frac{8}{12})$ ft, $\therefore$ try various values of $n \in \{1, 2, 3, ..\}$ and check for δ,

$\therefore n = 1 \quad \therefore \delta = \frac{8}{12}*1 - 5\sqrt{\frac{1}{24}} = -.354$ ft (out of interval)

& $n = 2 \quad \therefore \delta = \frac{8*2}{12} - 5\sqrt{\frac{2}{24}} = -.110$ ft (")

& $n = 3 \quad \therefore \delta = \frac{8*3}{12} - 5\sqrt{\frac{3}{24}} = 0.23$ ft $\in [0, \frac{8}{12})$ ft

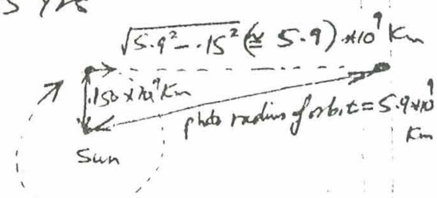
$\therefore$ The ball will hit the third step $.23 ft = .23*12 = 2.8''$ from its edge

—

1/75

If gravity is turned off the earth would move with a linear speed of $\frac{\text{Circumference of orbit}}{\text{Period of one cycle}} = \frac{2\pi * 150*10^6 \text{ Km}}{1 \text{ Yr}} = 3\pi*10^8$ Km/Yr

$\therefore$ Time for travel $= \frac{\sqrt{(5.9)^2-(.15)^2}*10^9 \text{ Km}}{3\pi*10^8 \text{ Km/Yr}} = 6.3$ Yrs



—

3/75

$F = ma = m\cdot\frac{v - v_o}{t} =$
$= 500\cdot\frac{(1600/3.6) - 0}{1.8} = 1.23*10^5$ N

—

7/75

$t_{field} = \frac{30*10^{-3}}{1.2*10^7} = 2.5*10^{-9}$ s

$F_{field} = m_e a_{field} \quad \therefore a_{field} = \frac{F_{field}}{m_e} = \frac{4.5*10^{-16}}{9.1*10^{-31}} = 4.95*10^{14}$ m/s²

$\therefore$ Vertical deflection $= V_o^{\,0} t + \frac{1}{2} a_{field} t_{field}^2 = \frac{1}{2}*4.95*10^{14}*(2.5*10^{-9})^2 = 1.55*10^{-3}$ m

$\therefore$ The vertical deflection is 1.55 mm

—

$\frac{13}{76}$ (a) $a = \frac{F}{m} = \frac{3}{2+1} = 1\ m/s^2$

$\therefore$ The force of contact is causing m_2 to accelerate at $1 m/s^2$ $\therefore$ This force $= m_2 a = 1 * 1 = 1N$

(b) $a = \frac{3}{2+1} = 1\ m/s^2$

The force of contact is now causing m_1 to accelerate at $1 m/s^2$ $\therefore$ this force will now be $m_1 * a = 2 * 1 = 2N$, the reason being that it is now accelerating a bigger mass.

$\frac{19}{76}$ (a) $a = \frac{v - v_0}{t} = \frac{(50-0) * \frac{1760 * 3}{3600}}{60} = 1.22\ ft/s^2$

$\therefore$ $F = ma = \frac{400}{32} * 1.22 = 15.3\ lb$

(b) The engine provides force through wheels through contact with road.

$\frac{27}{77}$ $mg - T = ma$ $\therefore$ $a = \frac{mg - T}{m} = g - \frac{T}{m} = 9.81 - \frac{425}{50}$
$= 1.31\ m/s^2$

$\frac{30}{77}$ $mg - F = ma$ $\therefore$ $F = mg - ma = m(g-a)$

$\therefore$ $F = 0.25 * (9.81 - 9.2) = 0.153\ N$, friction force.

$\frac{33}{77}$ T_3 is pulling all of m_1, m_2, m_3 $\therefore$ They will all accelerate with

$a = \frac{T_3}{m_1 + m_2 + m_3} = \frac{60}{10 + 20 + 30} = 1\ m/s^2$

T_2 is only pulling m_1 & m_2 and their acceleration is $1\ m/s^2$

$\therefore$ $T_2 = (m_1 + m_2)\, a = (10 + 20) * 1 = 30\ N$

Similarly $T_1 = m_1 a = 10 * 1 = 10\ N$

Therefore the more masses are dragged the bigger the force is.

$\frac{39}{77}$ Assume m_2 to fall with acceleration a, let the tension of rope be T.

$\therefore$ $m_2 g - T = m_2 a$ (1)

& $T - m_1 g \sin 30 = m_1 a$ (2)

(a) (1) + (2) $\therefore$ $m_2 g - m_1 g \sin 30 = (m_1 + m_2)\, a$ $\therefore$ $a = \frac{m_2 - m_1 \sin 30}{m_2 + m_1} g$

$= \frac{2 - 3 \sin 30}{2 + 3} * 32 = 3.2\ ft/s^2$

(b) from (2) $\therefore$ $T = m_1 (g \sin 30 + a) = 3 * (32 * \sin 30 + 3.2) = 57.6\ lb$

8

$\frac{4\text{-}3}{78}$

from (1) $\therefore$ $F_{air} - (80+5)*9.81 = -2.5*(80+5)$

$\therefore$ $F_{air} = 85*(9.81-2.5) = 621.4\ N$

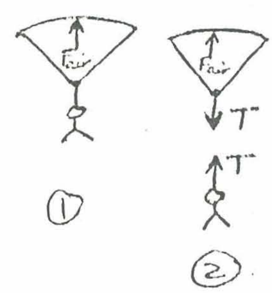
$\therefore$ (a) Force of air on parachute is $621\ N$

from (2)

$\therefore$ $80*9.81 - T = 80*2.5$

$\therefore$ $T = 80*(9.81-2.5) = 584.8\ N$

$\therefore$ (b) The man is pulling the parachute with $585\ N$.



$\frac{45}{78}$

(a) $T_1 - 1100*9.81 = 1100*2$

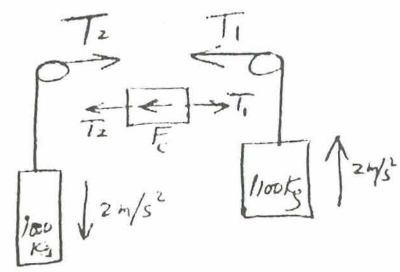
$\therefore$ $T_1 = 1100(9.81+2) = 13000\ N = 13\ KN$

(b) $1000*9.81 - T_2 = 1000*2$

$\therefore$ $T_2 = 1000(9.81-2) = 7810\ N = 7.8\ KN$

(c) $\therefore$ $T_1 = T_2 + F_c$ $\therefore$ $F_c = T_1 - T_2 = 13 - 7.8 = 5.2\ KN$

$\therefore$ The mechanism C is exerting $5.2\ KN$ from elevator to counterweight.



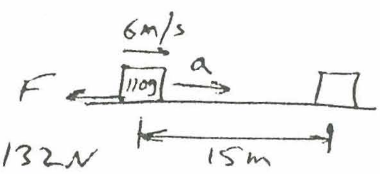
$\frac{7}{88}$

$$a = \frac{V^2 - V_0^2}{2S} = \frac{0 - 6^2}{2*15} = -1.2\ m/s^2$$

$\therefore$ $-F = ma = +110*10^{-3}*(-1.2) = -.132\ N$

$\therefore$ F (force of friction) $= 0.132\ N$

But $F = \mu mg$ $\therefore$ $\mu = \frac{F}{mg} = \frac{0.132}{.11*9.81} = 0.122$



$\frac{5}{88}$

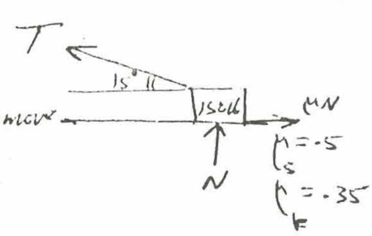
(a) The reaction of the floor $N = 150 - T\sin 15$

$\therefore$ $T\cos 15$ must be $> \mu_s N$ to start the block to move.

$\therefore$ $T\cos 15 > .5\ (150 - T\sin 15)$

$\therefore$ $T\cos 15 + .5\ T\sin 15 > .5 * 150$

$\therefore$ $T > \frac{.5*150}{\cos 15 + .5\sin 15} = 68.5\ lb$, the required tension to move it.



(b) Now the block is pulled with $68.5\ lb$ and moved $\therefore$ μ_s changes to μ_k

$\therefore$ friction is less $\therefore$ net force $= T\cos 15 - \mu_k * N = ma$ $\therefore$ $a = (T\cos 15 - \mu_k N)/m$

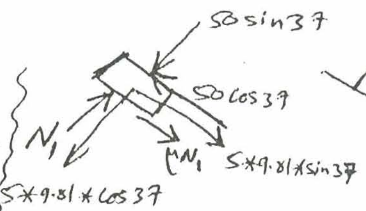
$$= \frac{68.5\cos 15 - .35*(150 - 68.5\sin 15)}{150/32} = 4.24\ ft/s^2.$$

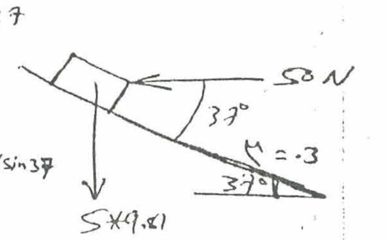
$\frac{9}{88}$ ⓐ $N_1 = 50 \sin 37 + 5 * 9.81 * \cos 37$

$= 69.3$ Newtons

$\therefore$ $50 \cos 37 - 5 * 9.81 * \sin 37 - \mu N_1 = ma$

$\therefore$ $a = \dfrac{10.41 - .3 * 69.3}{5} = -2.1 \, m/s^2$





$\therefore$ The block although it is moving up but it will decelerate at $2.1 \frac{m}{s^2}$

ⓑ $v^2 = v_0^2 + 2as$, $v = 0$, $v_0 = 4$ m/s , $a = -2.1$

$\therefore$ $s = \dfrac{v^2 - v_0^2}{2a} = \dfrac{0 - 4^2}{2 * (-2.1)} = 3.8$ m

ⓒ When the block reaches the highest point it will try to go down the incline and reverse its motion, hence μN_1 of the frictional force will also reverse; hence, the net force will now be $5 * 9.81 * \sin 37 - 50 \cos 37 - \mu N_1 = -10.41 - .3 * 69.3$ $= -31.2$ N down the incline $= 31.2$ N up the incline.

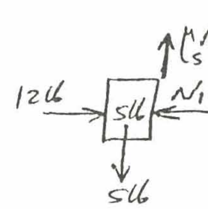
$\therefore$ It can't go down because the net force is holding it up, so it will stick where it stops.

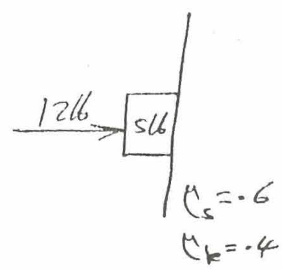
$\frac{13}{89}$ ⓐ $N_1 = 12$ lb

The block will move down if there is a net downward force,

$\therefore$ net downward force $= 5 - \mu_s N_1 =$

$= 5 - .6 * 12 = -2.2$ lb down $= 2.2$ lb up





$\therefore$ It will not move down because the net force is holding it up.

ⓑ Since it is not moving, the the force of the wall is not $\mu_s N_1$ but it is rather $\overset{\text{less}=}{\wedge}$ the weight of the block $= 5$ lb

$\therefore$ reaction of wall is 12 lb ← & 5 lb ↑.

$\frac{15}{89}$ $\therefore$ From fig. ① $\therefore$ $T_B = T_c \cos 45$ & $T_A = T_c \sin 45$

$\therefore$ $\dfrac{T_B}{T_A} = \dfrac{T_c \cos 45}{T_c \sin 45} = \cot 45 = 1$

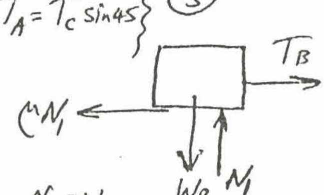
$\therefore$ $T_A = T_B$, but from fig. ② $T_A = W_A$

$\therefore$ $W_A = T_B$, but from fig ③ $T_B = \mu N_1$, $N_1 = W_B$

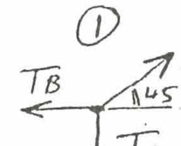
$\therefore$ $W_A = T_B = \mu N_1 = \mu W_B$ $\therefore$ $W_A = \mu W_B = .25 * 160 = 40$ lb

$\therefore$ maximum possible weight for $\underline{W_A}$ is 40 lb.

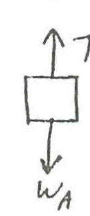
③



①

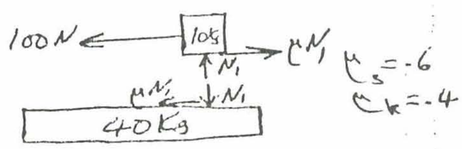


②



10

19/89 (a) $N_1 = 10 * 9.81 = 98.1\ N$



$\therefore\ \mu_s * N_1 = .6 * 98.1 = 58.9\ N < 100\ N$

$\therefore$ The block will move and the net force will be $100 - \mu_k N_1 = 100 - .4 * 98.1$
$= 60.8\ N$

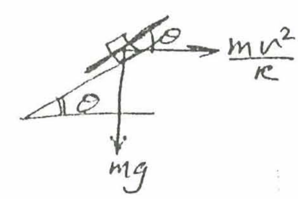
$\therefore$ The acceleration of the block $a_b = \dfrac{60.8}{10} = 6.1\ m/s^2$

(b) Now the force on the slab is $\mu_k N_1 = .4 * 98.1$ (equal and opposite to the frictional force on the 10 Kg block) $= 39.2$

$\therefore$ The acceleration of the slab $a_s = \dfrac{39.2}{40} = 0.98\ m/s^2$.

27/90 Tension in the cord $= Mg = m\dfrac{v^2}{R}$ $\quad\therefore\ \dfrac{v^2}{R} = \dfrac{Mg}{m}$.

31/90 (a) To prevent skidding θ must be satisfying:



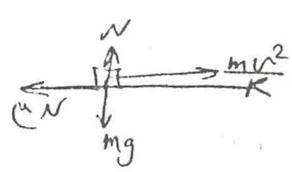
$mg\sin\theta = \dfrac{mv^2}{R}\cos\theta$

or $\tan\theta = \dfrac{\sin\theta}{\cos\theta} = \dfrac{v^2}{Rg} = \dfrac{\left(\frac{60 * 1000}{3600}\right)^2}{150 * 9.81} = .1888$

$\therefore\ \theta = \tan^{-1} .1888 = 10.7°$

$\therefore$ The angle of banking the road $= \theta = 10.7°$

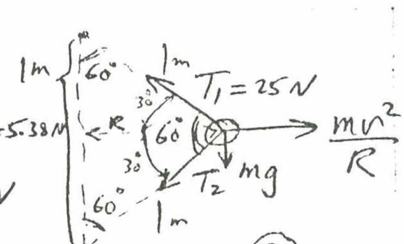
(b) $N = mg$



$\therefore\ \dfrac{mv^2}{R} = \mu N = \mu mg \quad \therefore\ \mu = \dfrac{mv^2}{Rmg} = \dfrac{v^2}{Rg}$
$= .1888$

$\therefore$ The coeffecient of friction must then be 0.19

40/91 $R = 1\cos\left(\frac{60}{2}\right) = 1\cos 30 = 0.866\ m$



$\therefore\ T_1\sin 30 = T_2\sin 30 + mg \quad \therefore\ T_2 = T_1 - \dfrac{mg}{\sin 30} = 25 - \dfrac{1 * 9.81}{1/2} = 5.38N$

@ tension — & /— string $= T_2 = 5.38N$

Net force $= T_1\cos 30 + T_2\cos 30$
$= (T_1 + T_2)\cos 30 = (25 + 5.38)\cos 30 = 26.3\ N$

$\therefore$ The net force is 26.3N inwords. (balanced by centrifugal force)

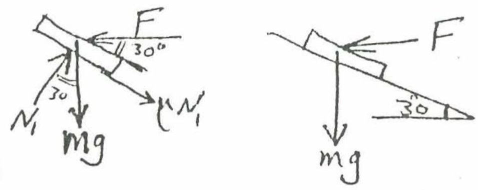
(d) $26.3 = \dfrac{mv^2}{R} \quad \therefore\ v^2 = \dfrac{26.3 * 0.866}{1} = 22.77 \quad \therefore\ v = 4.77\dfrac{m}{s}$

$\therefore$ The speed of the ball is 4.77 m/s

3/104

$N_1 = mg\cos 30 + F\sin 30 \quad (1)$

& $F\cos 30 = mg\sin 30 + \mu N_1 \quad (2)$



∴ (1) in (2)

∴ $F\cos 30 = mg\sin 30 + \mu(mg\cos 30 + F\sin 30)$

$F(\cos 30 - \mu\sin 30) = mg(\sin 30 + \mu\cos 30)$

∴ $F = mg\,\dfrac{\sin 30 + \mu\cos 30}{\cos 30 - \mu\sin 30} = 50 * 9.81 * \dfrac{\sin 30 + .2\cos 30}{\cos 30 - .2\sin 30} = 431\,N$

ⓐ Work done by force $= 431 * 6 * \cos 30 = 2240\,J = 2.24\,KJ$

ⓑ work done by friction $= N_1 * 6 * \cos 180 = .2 * (50 * 9.81 * \cos 30 + 431 * \sin 30) * 6 * (-1) = -768\,J$

ⓒ work done by gravity $= mg * 6 * \cos(90+30) = 50 * 9.81 * 6\cos 120 = -1472\,J = -1.47\,KJ$

9/104

$W = \int_0^8 F\,dx =$ (area below F from $x=0$ to $x = \ldots$) —

$=$ no. of squares * area of a square $= (2+1+0-0.5)*(5*2)$

$= 2.5 * 10 = 25\,N.m = 25\,J.$

12/105

$K = \frac{1}{2}mv^2 = \frac{1}{2}m * \left(\frac{55 * 1760 * 3}{3600}\right)^2 = 3254\,m$

$U = mgh = m * 32 * h = 32\,mh$

∴ $K = U$ ∴ $32mh = 3254m$ ∴ $h = \frac{3254}{32} = 102\,ft$

∴ The height is $102\,ft = 33.9\,Yd$

14/105

energy after penetration $= 0$

energy before $= \frac{1}{2}*30*10^{-3}*(500)^2 = 3750$ Joul

∴ $Energy_{after} - energy_{before} =$ work done by wood on bullet

∴ $0 - 3750 = F_{wood\ on\ bullet} * 12*10^{-2} * \cos 180 = -.12\,F_{wood\ on\ bullet}$

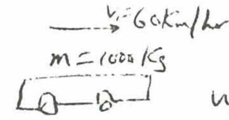
∴ $F_{wood\ on\ bullet} = 31250\,N = 31.3\,KN$

∴ The bullet pushes (due to Newton third law) the wood by a force of 31.3 KN

$\boxed{\frac{17a}{105}}$

$E_2 - E_1 = W \quad \therefore \frac{1}{2}mV_2^2 - \frac{1}{2}mV_1^2 = W$

$\therefore \frac{1}{2}m\left(V_2^2 - V_1^2\right) = W \quad \therefore \frac{1}{2} * 1000\left(V_2^2 - 60^2\right)\left(\frac{1000}{3600}\right)^2 = -5*10^4$



$W_{1\to2} = 5*10^4 J$

$V_2 = ?$

$\therefore V_2 = 48 \ km/hr$, final speed.

$\boxed{\frac{19}{105}}$

$F = ma = m\frac{dv}{dt} = m\frac{d^2x}{dt^2} = 3*(3t - 4t^2 + t^3)'' =$

$= 3*(3 - 8t + 3t^2)' = 3*(-8 + 6t) = -24 + 18t \quad N$

$\therefore W = \int_{t=0}^{t=4} F\,dx$

$= \int (-24 + 18t)\,\frac{dx}{dt}\,.\,dt = \int_0^4 (-24 + 18t).(3 - 8t + 3t^2)\,dt$

$= 3\int_0^4 (-8 + 6t)(3 - 8t + 3t^2)\,dt = 3.\frac{\left[3 - 8t + 3t^2\right]^2}{2}\Big|_0^4$

$= \frac{3}{2}\left[(3 - 32 + 48)^2 - (3)^2\right] = 528 \ J.$

$\boxed{\frac{23}{105}}$

$V_0 = \langle 3, 5\rangle m/s, \ V = \langle 0, 7\rangle m/s \quad \therefore |V_0| = \sqrt{9+25} = \sqrt{34}, |V| = 7$

$\therefore Work = E - E_0 = \frac{1}{2}mV^2 - \frac{1}{2}mV_0^2 = \frac{1}{2}m(49 - 34) = \frac{1}{2}*.5*15 = 3.75 J$

$\therefore$ Work done on body $= 3.75$ J

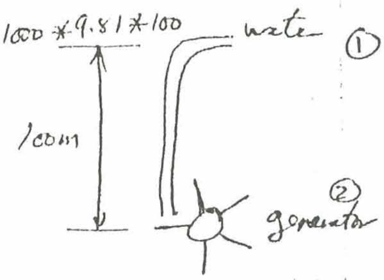
Av. power $= \frac{Work}{Time} = \frac{3.75}{3} = 1.25$ Watts.

$\boxed{\frac{25}{105}}$

The energy at level ① $E_1 = 0$ (Kinetic) $+ 1200*1000*9.81*100$

$= 1.1772 * 10^9$ J

This energy is converted to $E_2 = 0$ (potential) $+ K$ at level ②



$\therefore E_1 = E_2 \quad \therefore K = 1.1772 * 10^9 J$

$\therefore$ The electrical energy $= \frac{3}{4}K = .8829 * 10^9 J$

This energy is produced by the generator in each second

$\therefore$ power output $= \frac{\text{electrical energy}}{\text{time}} = \frac{.8829 * 10^9 J}{1s} = .883 * 10^9 W$

$= 883 \ MW$

$\boxed{\frac{31}{105}}$

(a) $K = \frac{1}{2}mv^2 = \frac{1}{2} * \frac{3200}{32} * \left(\frac{45 * 1760 * 3}{3600}\right)^2 = 217,800$ lb.ft

(b) Power $= \frac{K}{t} = \frac{217,800}{30} = 7260$ lb.ft/s $= 7260 * \frac{1}{550}$ hp $= 13.2$hp

(c) instantaneous power $= F.V = ma*v$

$= \frac{3200}{32} * \frac{V - 0}{30} * V = \frac{10}{3}V^2 = \frac{10}{3} * \left(\frac{45 * 1760 * 3}{3600}\right)^2 =$

$= 14,520$ lb ft/s $= \frac{14520}{550}$ hp $= 26.4$ hp

$\boxed{\frac{33}{106}}$

$F \propto V \quad \therefore F_1/F_2 = V_1/V_2$

$\because P = Fv \quad \therefore P_1/P_2 = F_1V_1/(F_2V_2) = \frac{F_1}{F_2}.\frac{V_1}{V_2} = \frac{V_1}{V_2}.\frac{V_1}{V_2} = \left(\frac{V_1}{V_2}\right)^2$

$\because P_1 = 10 hp, \ V_1 = 2.5, \ V_2 = 7.5 \quad \therefore \frac{10}{P_2} = \left(\frac{2.5}{7.5}\right)^2 = \frac{1}{9} \quad \therefore P_2 = 90hp$

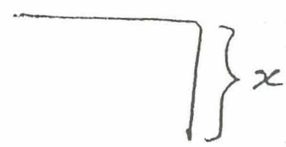
$\therefore P_2 = 90$ hp.

13

$\frac{1}{127}$

Mass per unit length of chain = m/ℓ

Assume the hanging part to be x



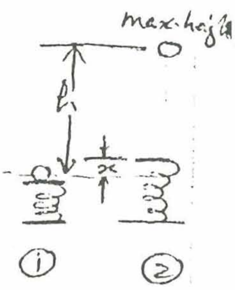
$\therefore$ weight of hanging part = $\frac{m}{\ell} * x * g$

$\therefore$ $dW = \frac{m}{\ell} * x * g * dx * \cos 180 = -\frac{mg}{\ell}\, x\,dx$

$\therefore$ $W = -\int_{\ell/5}^{0} \frac{mg}{\ell}\, x\,dx = -\frac{mg}{\ell} \cdot \frac{x^2}{2}\Big]_{\ell/5}^{0} = -\frac{mg}{2\ell}\left[0^2 - \left(\frac{\ell}{5}\right)^2\right] = \frac{mg}{2\ell} \cdot \frac{\ell^2}{25} = \frac{mg\ell}{50}$

$\frac{4}{127}$

Consider energy in case (1)



$\therefore$ $E_1 = 0$ (potential of gravity) $+ 0$ (kinetic) $+ \frac{1}{2} k x^2$ (potential of spring)

consider energy in case (2)

$\therefore$ $E_2 = mgh$ (potential of gravity) $+ 0$ (kinetic) $+ 0$ (potential of spring)

$\therefore$ $E_1 = E_2$ $\quad\therefore \frac{1}{2} k x^2 = mgh \quad \therefore k = \frac{2mgh}{x^2} =$

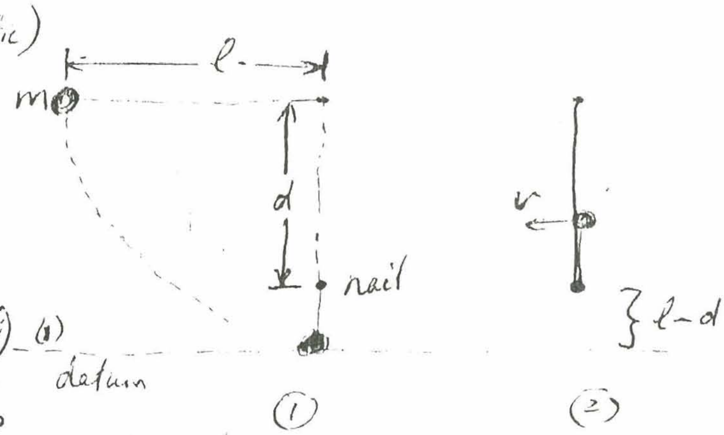
$= \frac{2 * 5 * 10^{-3} * 9.81 * 20}{(10 * 10^{-2})^2} = 196.2\ \frac{N}{M} = 1.96\ N/Cm.$

$\therefore$ The force constant of the spring is 1.96 N/Cm.

$\frac{19}{128}$

$E_1 = mg\ell$ (potential) $+ 0$ (kinetic)

$E_2 = mg(2(\ell-d)) + \frac{1}{2} m v^2$



$\therefore$ $E_1 = E_2$

$\therefore$ $mg\ell = 2mg(\ell-d) + \frac{1}{2} m v^2$

$\therefore$ $g\ell = 2g\ell - 2gd + \frac{1}{2} v^2$

$\therefore$ $v^2 = 2(2gd - g\ell) = 2g(2d-\ell)$ — (1)

$\therefore$ For the ball not to fall, the weight must equal to centripetal force.

$\therefore$ $mg = m \cdot \frac{v^2}{(\ell-d)}$ $\quad\therefore$ v^2 must equal to $g(\ell-d)$ (2)

from equations (1) & (2) $\quad\therefore v^2 = g(\ell-d) = 2g(2d-\ell)$

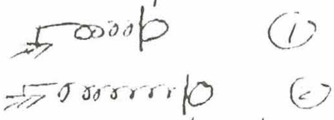
$\therefore$ $\ell - d = 2(2d-\ell) = 4d - 2\ell$

$\therefore$ $\ell + 2\ell = 4d + d$ $\quad\therefore 3\ell = 5d$ $\quad\therefore d = \frac{3}{5}\ell = .6\ell$

21/128

Compressed

$E_1 = \frac{1}{2} k x^2$ (spring potential) $+ 0$ (kinetic)



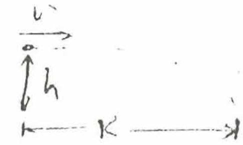
$E_2 = 0$ (spring potential) $+ \frac{1}{2} m v^2$ (kinetic)

released

$\therefore E_1 = E_2 \quad \therefore \cancel{\frac{1}{2}} k x^2 = \cancel{\frac{1}{2}} m v^2$

$\therefore k x^2 = m v^2 \qquad (1)$

Consider a projectile as shown besides:



$h = \frac{1}{2} g t^2$ where $t = \frac{R}{v}$

$\therefore h = \frac{1}{2} g \cdot \frac{R^2}{v^2} \qquad (2)$

from (1) + (2)

$\therefore h = \frac{1}{2} g \frac{R^2}{k x^2 / m} = \frac{m g R^2}{2 k x^2}$ OR $\frac{2 k h}{m g} = \frac{R^2}{x^2}$

Now, the left hand side is constant for both boys : $\frac{R_1^2}{x_1^2} = \frac{R_2^2}{x_2^2}$

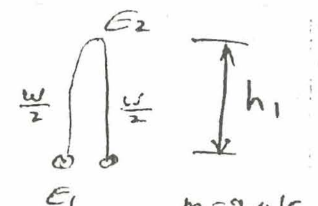
$\therefore \frac{R_1}{x_1} = \frac{R_2}{x_2}$, $R_1 = 2 - 20 \times 10^{-2} = 1.8$ m, $x_1 = 1$ Cm

$R_2 = 2.0$ m $\quad \therefore x_2 = \frac{R_2}{R_1} \cdot x_1 = \frac{2}{1.8} * 1 = 1.11$ Cm

$\therefore$ The second boy must compress the spring 1.11 Cm

34/129

$E_2 - E_1 = \frac{W}{2} = -\frac{6.8 * 10^5}{2}$



$\therefore m g h_1 - \frac{1}{2} m v_1^2 = -\frac{6.8 * 10^5}{2} \qquad (1)$

$\therefore 9.4 * 9.81 * h_1 - \frac{1}{2} * 9.4 * 470^2 = -\frac{6.8 * 10^5}{2}$

$m = 9.4$ kg

$v_1 = 470$ m/s

$\therefore h_1 = 7.572 * 10^3$ m $= 7.572$ Km

If no air is there $\therefore$ RHS of (1) $= 0$

$\therefore 9.4 * 9.81 * h_2 - \frac{1}{2} * 9.4 * 470^2 = 0 \quad \therefore h_2 = 11.26 * 10^3$ m $= 11.26$ Km

$\therefore \Delta h = h_2 - h_1 = 11.26 - 7.572 = 3.69$ Km, higher it would go.

36/129

$m = 1$ Kg, $k = 2$ N/m, $x = 4$ m, $\mu = .25$, $v = ?$

Energy before $= \frac{1}{2} m v^2 = \frac{1}{2} * 1 * v^2 = \frac{v^2}{2}$

Energy after $= \frac{1}{2} k x^2 = \frac{1}{2} * 2 * 4^2 = 16$ Joul

$\therefore$ Work done $= E_{after} - E_{before} = 16 - \frac{v^2}{2}$

but work done $=$ Frictionforce $*$ distance $* \cos 180 = (\mu m g * x * (-1))$

$= .25 * 1 * 9.81 * 4 * (-1) = -9.81$

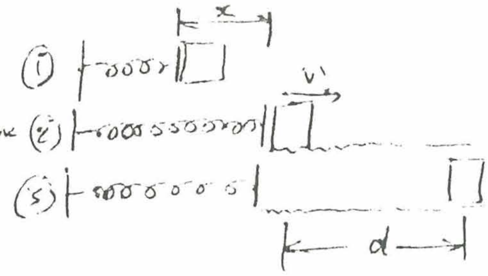
$\therefore -9.81 = 16 - \frac{v^2}{2} \qquad \therefore \frac{v^2}{2} = 16 + 9.81 = 25.81$

$\therefore v = \sqrt{2 * 25.81} = 7.185$ m/s

15

$\frac{37}{130}$

$E_1 = \frac{1}{2} k x^2$, $E_2 = \frac{1}{2} m v^2$ $\therefore E_1 = E_2$



$\therefore k x^2 = m v^2$ (1) . $E_3 = 0$ $\therefore E_3 - E_2 =$ Work done

$\therefore 0 - \frac{1}{2} m v^2 = \mu m g * d * \cos 180 = -\mu m g d$

$\therefore v^2 = 2 \mu g d \therefore v = \sqrt{2 * .2 * 9.81 * 8} = 5.6$ m/s

(a) $\therefore$ maximum kinetic energy $= E_2 = \frac{1}{2} m v^2 = \frac{1}{2} * 3 * 5.6^2 = 47.1$ J

(b) $\therefore$ from (1) $\therefore x = \sqrt{\frac{m}{k}} \cdot v = \sqrt{\frac{3}{120}} * 5.6 = 0.885$ m $= 88.5$ Cm

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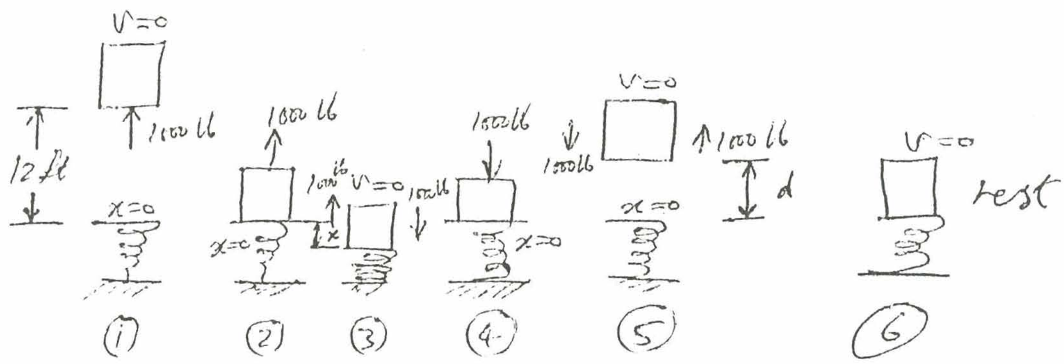
$\frac{43}{130}$



$E_1 = \underbrace{\frac{4000}{32} * 32 * 12}_{\text{potential of gravity}} + \underbrace{0}_{\text{kinetic}} + \underbrace{0}_{\text{spring potential}} = 48000$ lb ft

$\therefore E_2 - E_1 =$ Work , $E_2 = \underbrace{0}_{\text{pot. of g}} + \underbrace{\frac{1}{2} * \frac{4000}{32} * v^2}_{\text{kinetic}} + \underbrace{0}_{\text{spring}} = 62.5 v^2$

$\therefore 62.5 v^2 - 48000 = \underbrace{1000 * 12}_{\text{friction force distance}} * \cos 180 = -12000$ lb.ft

(a) $\therefore v = \sqrt{\frac{48000 - 12000}{62.5}} = \sqrt{\frac{36000}{62.5}} = 24$ ft/sec.

$\therefore E_2 = 62.5 v^2 = 36000$ lb.ft.

$E_3 - E_2 =$ Work , $E_3 = \underbrace{-\frac{4000}{32} * 32 * x}_{\text{gravity potential}} + \underbrace{0}_{\text{kinetic}} + \underbrace{\frac{1}{2} * 10{,}000 * x^2}_{\text{spring potential}}$

$\therefore -4000 x + 5000 x^2 - 36000 = 1000 * x * \cos 180 = -1000 x$

$\therefore 5000 x^2 - 3000 x - 36000 = 0$ $\therefore 5 x^2 - 3 x - 36 = 0$ $\therefore x = \frac{3 \pm \sqrt{9 + 4 * 5 * 36}}{10}$

(b) $\therefore x = \frac{3 \pm 27}{10} = \begin{cases} + & 3 \\ - & -2.4 \times \end{cases} = 3$ ft. $\therefore E_3 = -4000 * 3 + \frac{1}{2} * 10^4 * 3^2 = 33000$ lb.ft

$E_5 - E_3 =$ Work , $E_5 = \frac{4000}{32} * 32 * d + 0 + 0 = 4000 d$

$\therefore 4000 d - 33000 = 1000 * (3 + d) * \cos 180 = -1000 (3 + d)$

(c) $\therefore 5000 d = 33000 - 3000 = 30000$ $\therefore d = \frac{30000}{5000} = 6$ ft $\therefore E_5 = 24000$ lb/ft

$\therefore$ The bouncing distance $= x + d = 3 + 6 = 9$ ft.

(d) Assuming now that the spring is infinitely stiff (no deflection occurs)

$\therefore E_6 - E_5 =$ work , $E_6 = 0 + 0 + 0 = 0$

$\therefore 0 - 24000 = 1000 * \text{distance}_{5 \to 6} * \cos 180 = -1000 * \text{distance}_{5 \to 6}$

$\therefore \text{distance}_{5 \to 6} = 24$ ft

$\therefore$ Total distance $= \text{distance}_{1 \to 2} + \text{distance}_{2 \to 3} + \text{distance}_{3 \to 4} + \text{distance}_{4 \to 5} + \text{distance}_{5 \to 6}$

$= 12 + 3 + 3 + 6 + 24 = 48$ ft

The answer is not accurate because the spring action is ignored whereas in reality it shouldn't be ignored since its stiffness is finite.

16

47/131 $1eV = 1 * 1.6*10^{-19} C * 1V = 1.6*10^{-19}$ Joul

∴ energy of moving electron $= K = (m - m_0) * c^2$

$$= \left[\frac{m_0}{\sqrt{1-(\frac{v}{c})^2}} - m_0\right] c^2 = m_0 c^2 * \left[\frac{1}{\sqrt{1-(\frac{v}{c})^2}} - 1\right] \therefore v = c\left[1 - \frac{1}{(\frac{K}{m_0 c^2}+1)^2}\right]^{1/2}$$

∴ (a) $K = 1.0*10^5 eV = 1.0*10^5 * 1.6*10^{-19} = 1.6*10^{-14}$ J.

$$\therefore v = 3.0*10^8 * \left[1 - \frac{1}{\left(\frac{1.6*10^{-14}}{9.1*10^{-31}*(3.0*10^8)^2} + 1\right)^2}\right]^{1/2} = 1.64*10^8 \text{ m/s.}$$

∴ (b) $K = 1.0*10^6 eV = 1.0*10^6 * 1.6*10^{-19} = 1.6*10^{-13}$ J.

$$\therefore v = 3.0*10^8 * \left[1 - \frac{1}{\left(\frac{1.6*10^{-13}}{9.1*10^{-31}*(3.0*10^8)^2} + 1\right)^2}\right]^{1/2} = 2.82*10^8 \text{ m/s.}$$

4/146 $M_x = 3*0 + 8*2 + 5*1 = 16+5 = 21 = (3+8+5)*\bar{y}$

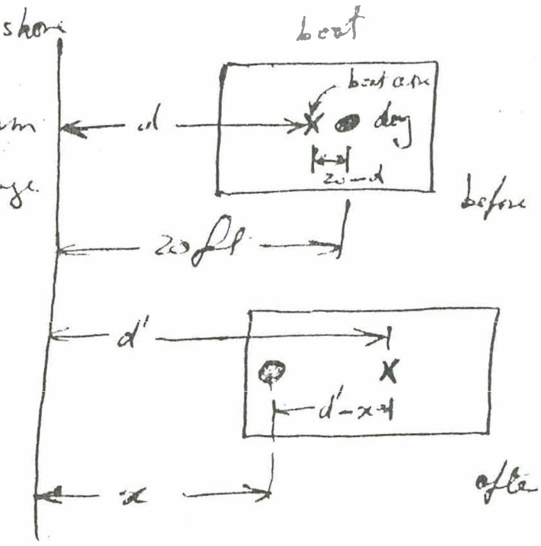
∴ $\bar{y} = \frac{21}{16} = 1.325$ m

$M_y = 3*0 + 8*1 + 5*2 = 8+10 = 18 = (3+8+5)*\bar{x}$

∴ $\bar{x} = \frac{18}{16} = 1.125$ m

∴ The centre of mass is at $(1.125, 1.325)$ m

11/147 The centre of mass of boat-dog is not changing because, before motion, momentum = 0, ∴ speed of centre of mass = 0 ∴ no change.
take moments about shore line:



∴ $10 * 20 + 40 * d = 10x + 40d'$

∴ $200 + 40(d - d') - 10x = 0$ (1)

The distance he walked on boat = 8 =

$= (20 - d) + (d' - x) = 20 - d + d' - x$

∴ $d - d' = 20 - 8 - x = 12 - x$ (2)

from (1) & (2) ∴ $200 + 40*(12 - x) - 10x = 0$

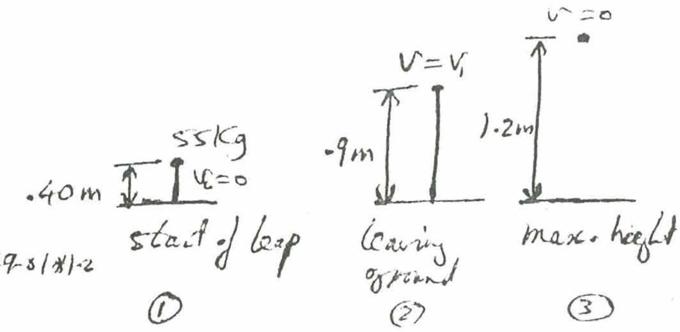
∴ $200 + 480 - 40x - 10x = 0$ ∴ $680 = 50x$ ∴ $x = 13.6$ ft

∴ He is 13.6 ft away from shore.

16/148

$E_2 = 55*9.81*.9 + \frac{1}{2} m v_1^2$

$E_3 = 55*9.81*1.2$



∴ $E_2 = E_3$

∴ $\cancel{55}*9.81*.9 + \frac{1}{2}*\cancel{55}*v_1^2 = \cancel{55}*9.81*1.2$

∴ $9.81*(1.2-.9) = \frac{1}{2} v_1^2$

∴ $v_1 = \sqrt{2*9.81*0.3} = 2.43$ m/s

Since the ground exerts force at hor between ① & ②

∴ $F_{12} - mg = ma$, F_{12} is constant ∴ a is constant

∴ $a = \frac{v_1^2 - v_2^2}{2s} = \frac{2.43^2 - 0}{2*(.9-.4)} = 5.90$ m/s^2

(a) ∴ $F_{12} = mg + ma = m(g+a) = 55*(9.81+5.90) = 864$ N

(b) max. speed is at the instant of leaving ground $= v_1 = 2.43$ m/s

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21/148

$P_{before} = 5*30 = 150$ kg m/s at angle $-45°$

$P_{after} = 5*30 = 150$ kg m/s at angle $+45$

∴ $P_{after} - P_{before} = 150\angle{+45} - 150\angle{-45} =$

$= 150[\langle\cos 45, \sin 45\rangle - \langle\cos(-45), \sin(-45)\rangle]$

$= 150[\langle\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\rangle - \langle\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}\rangle] = 150\langle 0, \frac{2}{\sqrt{2}}\rangle$

$= 150\langle 0, \sqrt{2}\rangle = \langle 0, 150\sqrt{2}\rangle$

∴ The change of momentum is $150\sqrt{2}$ ↑ kg m/s = 212 kg m/s ↑.

25/148

Assume the maximum no. of bullets he can fire to be n per minute, consider 1 minute of time:

∴ momentum before firing = 0

& momentum after firing $= n*50*10^{-3}*1000 = 50n$ kg m/s

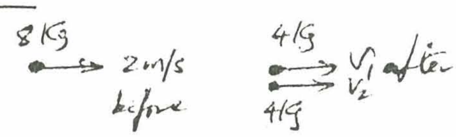
∴ force $= \frac{\text{momentum after} - \text{momentum before}}{\text{time}} = \frac{50n - 0}{60\text{ sec}} = \frac{5}{6} n$ Newt.

∴ $180 = \frac{5}{6} n$

∴ $n = \frac{6*180}{5} = 216$ bullets.

27/148

$P_{before} = P_{after}$ ∴ $8*2 = 4V_1 + 4V_2$



∴ $V_1 + V_2 = 4$ (1)

$Energy_{after} - Energy_{before} = 16$ ∴ $\frac{1}{2}*4*v_1^2 + \frac{1}{2}*4*v_2^2 - \frac{1}{2}*8*2^2 = 16$

∴ $v_1^2 + v_2^2 = 16$ (2)   solving (1) & (2) ∴ $v_1^2 + (4-v_1)^2 = 16$ ∴ $2v_1^2 - 8v_1 = 0$

∴ $v_1 = 0$ or 4 m/s ∴ $v_2 = 4$ or 0 m/s respectively ∴ The two velocities are 0, 4 m/s

29/148

mass of bullet, m = 40 g = .04 Kg , its speed = 1000 m/s
mass of wood, M = 10 Kg , u = 0 , no. of bullets, n = 15

∴ momentum before = momentum after , momentum = mV

∴ $.04 * 1000 * 15 = (10 + .04 * 15) *$ speed of wood after absorbing, V

∴ $600 = 10.6\, V$

∴ $V = 56.6$ m/s speed of wood after absorbing 15 bullets.

43/149

Thrust $= V_{rel} \dfrac{dm}{dt}$

$V_{rel} = 490$ m/s $- 180 = 310$ m/s

$\dfrac{dm}{dt} = 70 \underset{\text{air}}{\text{Kg}}\ \underset{\text{sec}}{} + 2.9 \underset{\text{fuel}}{\text{Kg}}\ \underset{\text{sec}}{} = 72.9$ Kg/s

(a) ∴ Thrust $= 310 * 72.9 = 2.26 * 10^4$ N $= 22.6$ kN

(b) power = thrust force * speed $= 22.6 * 10^3 * 180 =$
$= 4.07 * 10^6$ watt $= 4.07$ MW.

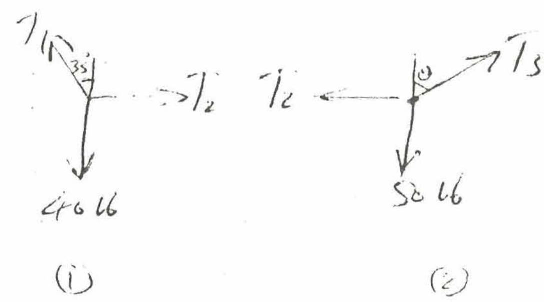
5/214

from (1) $\Sigma F_y = 0$

∴ $T_1 \cos 35 = 40$ lb ∴ $T_1 = 48.83$ lb

from (1) $\Sigma F_x = 0$

∴ $T_1 \sin 35 = T_2$ ∴ $T_2 = 28.01$ lb



from (2) $\Sigma F_y = 0$

∴ $T_3 \cos \theta = 50$ (1)

& from (2) $\Sigma F_x = 0$

$T_3 \sin \theta = T_2 = 28.01$ (2)

$\frac{(1)}{(2)} \Rightarrow \cot \theta = \frac{50}{28.01}$ ∴ $\theta = 29.26°$

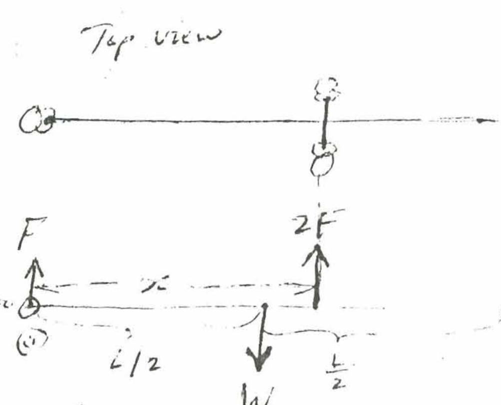
∴ from (1) ∴ $T_3 = \frac{50}{\cos 29.26} = 57.31$ lb

∴ (a) $\theta = 29.3°$

& (b) $T_1 = 48.8$ lb , $T_2 = 28.0$ lb , $T_3 = 57.3$ lb

72/214

Let the weight of the beam be W, & its length be L & let the cross piece be placed x from the end with man, and let each one exert a force F. Since $\Sigma F_y = 0$



∴ $3F = W$ ∴ $F = \frac{W}{3}$

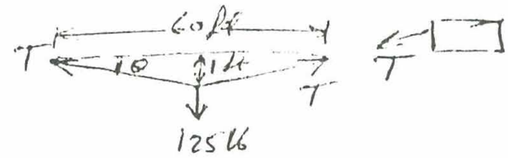
+ ∴ $\Sigma M_o = 0$ ∴ $F * 0 + 2F * x = W * \frac{L}{2}$

or $2Fx = \frac{WL}{2}$ ∴ $x = \frac{WL}{4F} = \frac{WL}{4\left(\frac{W}{3}\right)} = \frac{3}{4} L$.

∴ The cross piece should be three quarters of beam length away from end man

15/215

$\tan\theta = \frac{1}{60/2} = \frac{1}{30}$



$\therefore\ \theta = 1.91^\circ$

$\therefore\ \Sigma F_y = 0$

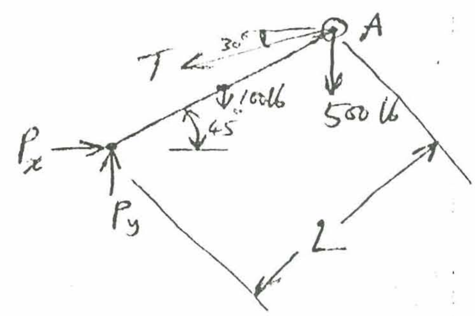
$\therefore\ T\sin\theta + T\sin\theta = 125$

$\therefore\ 2T\sin\theta = 125 \qquad \therefore\ T = \frac{125}{2\sin 1.91} = 1876.0\ lb$

$\therefore$ The rope-tension is 1876 lb and this is the force exerted by rope on car.

25/216

$\Sigma F_x = 0 \qquad \therefore\ P_x = T\cos 30 \qquad (1)$



$\Sigma F_y = 0 \qquad \therefore\ P_y = 500 + 100 + T\sin 30 \quad (2)$

$\Sigma M_A = 0 \qquad \therefore\ 0 + 0 + 100 * \frac{L}{2}\cos 45 +$

$P_x * L\sin 45 = P_y * L\cos 45$

$\therefore\ 50\cancel{L}*\cancel{\frac{1}{\sqrt2}} + P_x*\cancel{L}*\cancel{\frac{1}{\sqrt2}} = P_y*\cancel{L}*\cancel{\frac{1}{\sqrt2}}$

$\therefore\ 50 + P_x = P_y \qquad (3)$

(1) & (2) in (3) $\quad \therefore\ 50 + T\cos 30 = 600 + T\sin 30$

$\therefore\ 600 - 50 = T(\cos 30 - \sin 30) \qquad \therefore\ T = \frac{550}{\cos 30 - \sin 30} = 1502.6\ lb$

$\therefore$ (a) The tension T in the cable is 1503 lb.

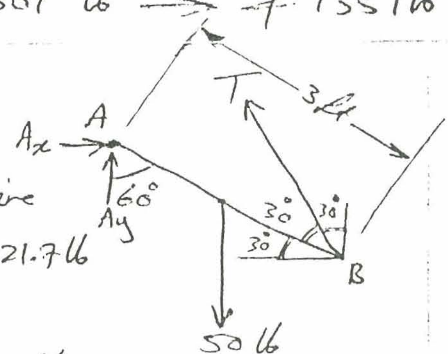
$\therefore$ from (1) $\quad P_x = 1503 * \cos 30 = 1301.3\ lb$

& from (2) $\quad P_y = 600 + 1503 * \sin 30 = 1351.3\ lb$

(b) $\therefore$ The force exerted on S by P is 1301 lb $\rightarrow$ & 1351 lb $\uparrow$

28/216

$\Sigma M_A = 0$



$\therefore\ 50 * \frac{\cancel{3}\cos 30}{2} = T\sin 30 * \cancel{3}$

$\therefore$ (a) $T = 25\cot 30 = 43.3\ lb$, tension in wire

(b) $\Sigma F_x = 0 \qquad \therefore\ A_x = T\sin 30 = 43.3*\frac{1}{2} = 21.7\ lb$

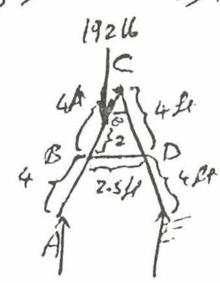
& $\Sigma F_y = 0 \qquad \therefore\ A_y + T\cos 30 = 50$

$\therefore\ A_y = 50 - 43.3 * \frac{\sqrt3}{2} = 50 - 37.5 = 12.5\ lb$

$\therefore$ Reaction at hinge A is $\langle A_x, A_y\rangle = \langle 21.7, 12.5\rangle$ lb $= 25.0\ lb \angle 30^\circ$

31/217

$A + E = 192 \qquad (1) \quad (\Sigma F_y = 0)$



$\Sigma M_A = 0 \quad \therefore\ 0 + E*2*8*\cancel{\sin\frac{\theta}{2}} =$

$= 192 * 6 * \cancel{\sin\frac{\theta}{2}}$

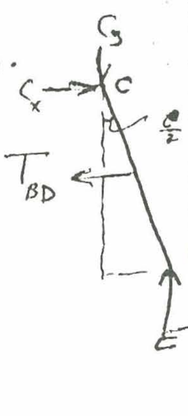
$\sin\frac{\theta}{2} = \frac{2.5/2}{4}$

$\therefore\ \frac{\theta}{2} = 18.21^\circ$

$\therefore\ 16E = 192 * 6 \qquad \therefore\ E = 72.0\ lb$

$\therefore$ from (1) $\quad A = 192 - 72.0 = 120.0\ lb$

now cut joint C & bar BD and consider the right portion.



$\therefore\ \Sigma M_C = 0 \qquad \therefore\ T_{BD} * 4\cos\frac{\theta}{2} = E * 8\sin\frac{\theta}{2}$

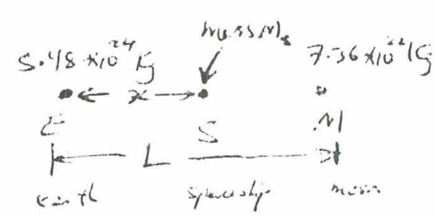
$\therefore\ T_{BD} = 2E\tan\frac{\theta}{2} = 2 * 72.0 * \tan 18.21 = 47.4\ lb$

$\therefore$ (a) Tension in BD $= T_{BD} = 47.4\ lb$

& (b) Reaction at $A = 120\ lb \uparrow$ & at $E = 72\ lb \uparrow$

2/265

$F_{SM} = F_{SE}$ $\therefore \dfrac{G \times 7.36 \times 10^{22} \times M_s}{(L-x)^2} = \dfrac{G \times 5.98 \times 10^{24} M_s}{x^2}$



$\therefore 7.36\, x^2 = 598\,(L-x)^2 = 598\,(L^2 - 2xL + x^2)$

$\therefore (598 - 7.36)x^2 - 598 \times 2L \times x + 598 L^2 = 0$

$\therefore 590.64\left(\dfrac{x}{L}\right)^2 - 1196\left(\dfrac{x}{L}\right) + 598 = 0$ $\left(\dfrac{x}{L}\right)^2 - 2.025\left(\dfrac{x}{L}\right) + 1.0125 = 0$

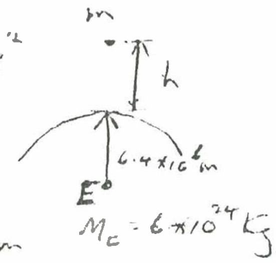
$\therefore \dfrac{x}{L} = \dfrac{2.025 \pm \sqrt{2.025^2 - 4 \times 1 \times 1.0125}}{2} = 2.25 L \;\; .225$ $\times 1.125$ -?or

$\therefore \dfrac{x}{L} = .900$ $\therefore x = .7 L$

$\therefore$ The spaceship should be away from earth by 90% of distance between earth & moon.

11/266

$mg = \dfrac{G m M}{R^2}$ $g = 5.67 \times 10^{-11} \times 6 \times 10^{24} / R^2$



$R^2 = 8.17 \times 10^{13}$ $\therefore R = 9.04 \times 10^6$ m

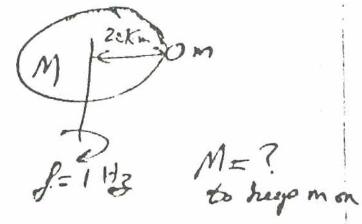
$\therefore 9.04 \times 10^6 \text{ m} = 6.4 \times 10^6 + h$ $\therefore h = 2.64 \times 10^6$ m

$\therefore$ The altitude $= 2.64 \times 10^6$ m

13/266

$F_{centrifugal} = \dfrac{V^2}{R} m = (V = 2\pi f r)\ \dfrac{(2\pi f R)^2 m}{R} = (2\pi f)^2 R m$

$F_{gravitational} = \dfrac{G m M}{R^2}$ $\therefore F_{centrifugal} = F_{gravitational}$



$\therefore (2\pi f)^2 R \cdot m = \dfrac{G m M}{R^2}$

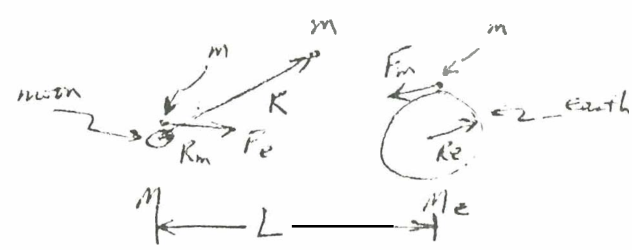
$\therefore M = (2\pi f)^2 R^3 / G = (2\pi \times 1)^2 \times (20 \times 10^3)^3 / (6.67 \times 10^{-11})$ $M = ?$ to keep m on

$= 4.74 \times 10^{24}$ Kg

$\therefore$ Mass of star must be 4.74×10^{24} Kg or more.

18/266

$g_{earth} = 9.8\ m/s^2$



$m g_{earth} = \dfrac{G m M_e}{R_e^2}$ (1)

& $m g_{moon} = \dfrac{G m M_m}{R_m^2}$ (2)

(a) $\dfrac{(2)}{(1)}$, $\therefore \dfrac{g_{moon}}{g_{earth}} = \dfrac{M_m}{M_e} \cdot \left(\dfrac{R_e}{R_m}\right)^2 = .012 \times \left(\dfrac{1}{.27}\right)^2 = .165$ $\therefore g_{moon} = 1.615 m/s^2$.

(b) $m g_{moon} = \dfrac{1.615}{9.8} \times 1.615 = 16.5$ N $\therefore$ The weight will be 16.5 N

(c) Assume the distance to be $R = n R_e$ $\therefore m g_{moon} = \dfrac{G m M_m}{R_m^2} = \dfrac{G m M_e}{R^2}$

$\therefore \left(\dfrac{R}{R_m}\right)^2 = \dfrac{M_e}{M_m}$ $\therefore \dfrac{n R_e}{R_m} = \sqrt{\dfrac{M_e}{M_m}}$ $\therefore n = \dfrac{R_m}{R_e}\sqrt{\dfrac{M_e}{M_m}} = .27 \times \sqrt{\dfrac{1}{.012}} = 2.465$

$\therefore$ The object must be 2.465 Re off earth centre to have g_{moon}.

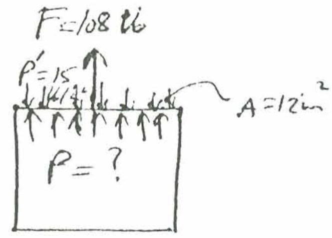
(d) $L >> R_e$ & R_m $\therefore F_m = (\text{of moon on earth}) = \dfrac{G m M_m}{L^2}$ & $F_e = (\text{of earth on moon}) = \dfrac{G m M_e}{L^2}$

$\therefore \dfrac{F_m}{F_e} = \dfrac{M_m}{M_e} = .012$ $\therefore F_e > F_m$, i.e gravitational force of earth on moon is greater than gravitational force of moon on earth.

$\frac{2}{286}$

$P \cdot A + F = P' A$

$\therefore P = P' - \frac{F}{A} = 15 - \frac{108}{12} = 6 \ lb/in^2$



$\frac{7}{287}$

$\Delta P = \rho g h = 1.06 * 10^3 * 9.81 * 1.83 = 1.9 * 10^4 \ Pa$

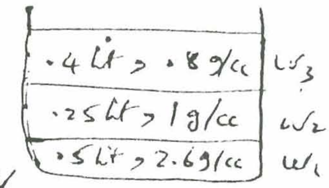
$\frac{9}{287}$

Force acting on bottom of container is equal to total weights $= W_1 + W_2 + W_3$

$= (.5 * \frac{2.6 * 10^{-3}}{10^{-3}} + .25 * 1 * \frac{10^{-3}}{10^{-3}} + .4 * .8) g =$

$= (1.3 + .25 + .32) g = 1.87 \ Kg * 9.81 \frac{m}{s^2} = 18.3 N$

$\therefore$ Total force $= 18.3 N$

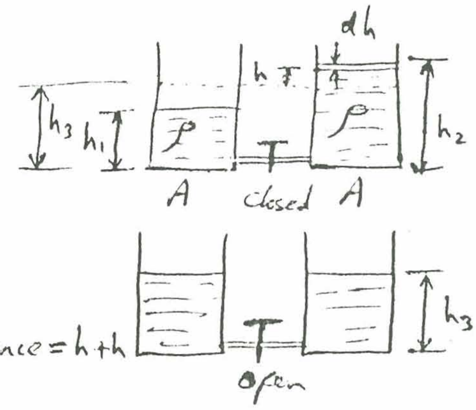


$\frac{13}{289}$

$h_1 A + h_2 A = h_3 A + h_3 A$

$\therefore h_1 + h_2 = 2 h_3 \quad \therefore h_3 = \frac{h_1 + h_2}{2}$

To move a layer from one vessle to the other gravity will exert $dW =$ $\rho g A dh *$ distance. And since the topmost layer will go bottommost $\therefore$ distance $= h + h = 2h$



$\therefore dW = \rho g A dh (2h) \quad \therefore W = \int_0^{h_2 - h_3} 2 \rho g A h \, dh = \rho g A h^2 \Big]_0^{h_2 - h_3} =$

$= \rho g A (h_2 - h_3)^2$

$= \rho g A \left(h_2 - \frac{h_1 + h_2}{2}\right)^2 = \rho g A \left(\frac{h_2 - h_1}{2}\right)^2 = \frac{\rho g A}{4} (h_2 - h_1)^2 =$ Work of gravity

---

$\frac{17}{288}$

(a) $F_{down} = \left(\frac{L}{2}\right) * L^2 * \rho * g + P_o \cdot A = L^2 \left(\rho g \frac{L}{2} + P_o\right) = 4 \left(2 * 32 * \frac{2}{2} + \frac{14.7}{(\frac{1}{12})^2}\right)$

$= 8723.2 \ lb$

(b) $F_{up} = A\left(\rho g \left(L + \frac{L}{2}\right) + P_o\right) = L^2 \left(\rho g \cdot \frac{3L}{2} + P_o\right) = 4\left(2 * 32 * \frac{3 * 2}{2} + \frac{14.7}{(\frac{1}{12})^2}\right) = 9235.2 \ lb$

(c) $\therefore$ Tension $= W + F_{down} - F_{up} = 1000 + 8723.2 - 9235.2 = 488 \ lb$

$\frac{29}{288}$

$Av = A'v' \quad \therefore \frac{\pi}{4} (.75)^2 * 3 = \frac{\pi}{4} (.05)^2 * 24 * v' \quad \therefore v' = 28.1 \ ft/s.$

$\frac{37}{289}$

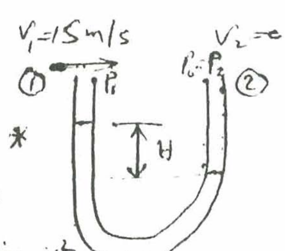
$P_1 + \frac{1}{2} \rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho V_2^2 + \rho g h_2, \quad \because h_1 = h_2, V_2 = 0$

$\therefore P_1 + \frac{1}{2} \rho_{air} V_1^2 = P_2 = P_o \quad \therefore P_1 = P_o - \frac{1}{2} \rho_{air} V_1^2 \quad \therefore P_o - P_1 = \frac{1}{2} \rho_{air} V_1^2 \quad *$

but $P_o = P_1 + \rho_{water} g H \quad \therefore P_o - P_1 = \rho_{water} g H \quad **$

Comparing $*$ & $** \quad \therefore \frac{1}{2} \rho_{air} V_1^2 = \rho_{water} g H \quad \therefore H = \frac{1}{2} \frac{\rho_{air}}{\rho_{water}} \cdot \frac{V_1^2}{g} =$

$= \frac{1}{2} * \frac{1.3}{1.0 * 10^3} \cdot \frac{15^2}{9.81} = .015 m = 1.5 \ Cm$



$\frac{44}{290}$

Flux volume, $R = V \cdot A$

$A = \left(\frac{10}{2}\right)^2 \pi = 78.54 \text{ in}^2$, $P = 8 \text{ lb/in}^2$

$a = \left(\frac{5}{2}\right)^2 \pi = 19.63 \text{ in}^2$, $P' = 6 \text{ lb/in}^2$

$\therefore \; v' = \frac{A}{a} v = 4v$

$\therefore \; 8 + \frac{1}{2} * \rho \cdot v^2 = 6 + \frac{1}{2} * \rho * 16 v^2$

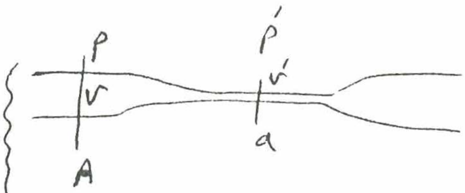
$\therefore \; \frac{1}{2}\rho v^2 (1 - 16) = -2 \quad \therefore \; v = \sqrt{\frac{2}{\rho} \cdot \left(\frac{-2}{-15}\right)} =$

$= \sqrt{\frac{.2667 \text{ lb/in}^2}{1.12 * 10^{-3} \text{ slug/in}^3}} =$

$= \sqrt{237.8 \frac{\text{slugs ft/s}^2}{\text{in}^2} \cdot \frac{\text{in}^3}{\text{slug}}} = \sqrt{237.8 \text{ ft in/s}^2}$

$= \sqrt{237.8 * 12 \text{ in}^2/\text{s}^2} = 53.4 \text{ in/s} = 4.45 \text{ ft/s}$

$\therefore \; R = V \cdot A = 4.45 \frac{\text{ft}}{\text{s}} * 78.54 \left(\frac{1}{12} \text{ft}\right)^2 = 2.43 \text{ ft}^3/\text{s}.$



$P + \frac{1}{2}\rho v^2 = P' + \frac{1}{2}\rho v'^2$

$vA = v'a$

$\rho_{water}\, g = 62.4 \text{ lb/ft}^3$

$\therefore \; \rho_{water} = \frac{62.4}{32.2} * \frac{1}{12^3} \cdot \frac{\text{slug}}{\text{in}^3}$

$= 1.12 * 10^{-3} \text{ slug/in}^3$

$\frac{46}{290}$

$V_{air/plane} = \sqrt{\frac{2ghp'}{\rho}}$ $\quad \rho' = .81 * 10^3 \text{ Kg/m}^3$ (calculated) $\quad$, $\rho_{air \; 0°C} = 1.3 \text{ Kg/m}^3$

$\therefore \; V_{air/plane} = \sqrt{\frac{2 * 9.81 * .26 * .81 * 10^3}{1.3}} = 56.4 \text{ m/s}$

$\therefore$ Speed of plane relative to air = speed of air relative to plane = $56.4 \frac{m}{s}$

$\frac{1}{312}$

$\lambda f = v = 3 * 10^8 \text{ m/s}$

(a) $\lambda = 4 * 10^{-7} \text{ m} \quad \therefore \; f = \frac{3 * 10^8}{4 * 10^{-7}} = \frac{3}{4} * 10^{15} = 7.5 * 10^{14} \text{ Hz} = 750 \text{ THz}$

$\lambda = 7 * 10^{-7} \text{ m} \quad \therefore \; f = \frac{3 * 10^8}{7 * 10^{-7}} = .43 * 10^{15} \text{ Hz} = 430 \text{ THz}$

$\therefore$ Range of frequency of light waves is 430 THz to 750 THz

(b) $f = 1.5 \text{ MHz} = 1.5 * 10^6 \text{ Hz} \quad \therefore \; \lambda = \frac{3 * 10^8}{1.5 * 10^6} = 200 \text{ m}$

$f = 300 \text{ MHz} = 3 * 10^8 \text{ Hz} \quad \therefore \; \lambda = \frac{3 * 10^8}{3 * 10^8} = 1 \text{ m}$

$\therefore$ Wavelength range of radio frequencies is 1m to 200m.

(c) $\lambda = 5 \text{ nm} = 5 * 10^{-9} \text{ m} \quad \therefore \; f = \frac{3 * 10^8}{5 * 10^{-9}} = .6 * 10^{17} \text{ Hz} = 6 * 10^4 \text{ THz}$

$\lambda = 1 * 10^{-2} \text{ nm} = 1 * 10^{-11} \text{ m} \quad \therefore \; f = \frac{3 * 10^8}{1 * 10^{-11}} = 3 * 10^{19} \text{ Hz} = 3 * 10^7 \text{ THz}.$

$\therefore$ frequency range for x-ray is $6 * 10^4$ THz to $3 * 10^7$ THz

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$\frac{4}{313}$

$y = 2\,mm \sin(20\,mm^{-1}x - 600\,s^{-1}t)$

(a) Amplitude $= 2.00$ mm

$k(x - vt) = 20\,mm^{-1}x - 600\,s^{-1}t = 20\,mm^{-1}\left(x - \frac{600\,s^{-1}}{20\,mm^{-1}}t\right)$

$= 20\,mm^{-1}(x - 30\,mm/s \cdot t)$

$\therefore k = \frac{2\pi}{\lambda} = 20\,mm^{-1} \quad \therefore \lambda = \frac{2\pi}{20} = \frac{\pi}{10}$ mm

& $v = 30$ mm/s

$\therefore v = f\lambda \quad \therefore f = \frac{v}{\lambda} = \frac{30}{\pi/10} = \frac{300}{\pi} = 95.5$ Hz

$\therefore$ frequency $= 95.5$ Hz

& velocity $= v = 30$ mm/s

& wavelength $= \lambda = \frac{\pi}{10}$ mm $= 0.314$ mm

(b) transverse speed $= \frac{dy}{dt} = 2\,mm * \cos(20\,mm^{-1}x - 600\,s^{-1}t) * (-600\,s^{-1})$

$= -1200\,\frac{mm}{s} \cos(20\,mm^{-1}x - 600\,s^{-1}t)$

$\therefore$ max transverse speed is 1200 mm/s $= 1.2$ m/s

$\frac{5}{313}$ (a) $\frac{T}{4} = .17$ sec $\quad \therefore T = 4 * .17 = .68$ sec $\quad \therefore$ period is $.68$ sec.

(b) frequency, $f = \frac{1}{T} = \frac{1}{.68} = 1.47$ Hz.

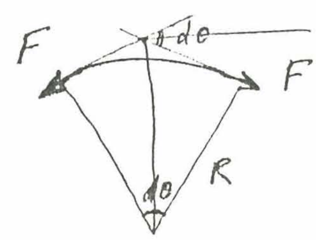
(c) $v = f\lambda = 1.47 * 1.4 = 2.1$ m/s, speed of wave.

$\frac{13}{313}$ $\mu = 1.3 * 10^{-4}$ Kg/m, $y = (.021\,m)\sin[(1.0\,m^{-1})x + (30\,s^{-1})t]$

$\therefore k(x - vt) = x + 30t \quad \therefore v = -30$ m/s

but $v = \sqrt{\frac{F}{\mu}} \Rightarrow \therefore F = \mu v^2 = 1.3 * 10^{-4} * (-30)^2 = 0.117$ N

$\frac{18}{313}$ Consider a section of the loop and assume a linear density μ $\therefore$ mass of section is $\mu R\,d\theta$ $\therefore 2F\sin\left(\frac{d\theta}{2}\right) = \mu R\,d\theta \cdot \frac{V_0^2}{R}$



$\therefore F = \mu V_0^2\,d\theta / (2\sin\frac{d\theta}{2})$

$\because \sin\alpha = \alpha$ for small α

$\therefore F = \mu V_0^2\,d\theta / (2\,\frac{d\theta}{2}) = \mu V_0^2$

$\therefore$ speed of travelling waves $= \sqrt{\frac{F}{\mu}} = \sqrt{\frac{\mu V_0^2}{\mu}} = V_0$

i.e the waves travel at the same speed that the string rotates at.

$\boxed{\frac{21}{314}}$

$P = 1\,W, \quad A = 4\pi(1)^2 = 4\pi\, m^2$

$\therefore I = \frac{P}{A} = \frac{1}{4\pi} = .0796\ W/m^2$

$\boxed{\frac{27}{314}}$

(a) $k_1(x - v_1 t) = \frac{\pi}{2}(2x + 8t) = \pi(x + 4t)$

$\therefore V_1 = -4\ m/s, \quad k_1 = \pi = \frac{2\pi}{\lambda_1} \quad \therefore \lambda_1 = 2m \quad \therefore f_1 = \frac{V_1}{\lambda_1} = \frac{4}{2} = 2\,Hz$

$\therefore$ frequency of first source $= f_1 = 2\,Hz$, with wavelength $= \lambda_1 = 2m$ & speed $= 4\,m/s$

& $k_2(x - V_2 t) = \frac{\pi}{2}(2x - 8t) = \pi(x - 4t)$

$\therefore V_2 = 4\ m/s, \quad k_2 = \pi = \frac{2\pi}{\lambda_2} \Rightarrow \lambda_2 = 2m, \quad f_2 = \frac{V_2}{\lambda_2} = \frac{4}{2} = 2\,Hz$

$\therefore$ frequency of second source $= f_2 = 2\,Hz$, with $\lambda_2 = 2m$ & speed $= 4\,m/s$

(b) $y = y_1 + y_2$

$= 6\cos\frac{\pi}{2}(2x + 8t) + 6\cos\frac{\pi}{2}(2x - 8t) = 6\left[\cos(\pi x + 4\pi t) + \cos(\pi x - 4\pi t)\right]$

$= 6 * 2 * \cos \pi x \cos 4\pi t = 12 * \cos \pi x * \cos 4\pi t$

$\therefore y = 0$ for all t when $\cos \pi x = 0 \quad \therefore \pi x = (2k-1)\frac{\pi}{2}, \quad k = 1, 2, 3, \ldots$

or $x = \frac{2k-1}{2}$ i.e at $\frac{1}{2}m, \frac{3}{2}m, \frac{5}{2}m$

$\therefore$ Nodes are at $x = .5m, 1.5m, 2.5m, \ldots$

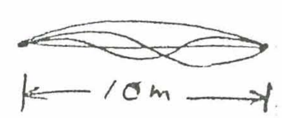
(c) The motion will be max. when $\cos \pi x$ is max., i.e $\pi x = k\pi$, $k = 0, 1, 2$.

$\therefore x = k$ or, Antinodes are at $x = 0, 1m, 2m, 3m \ldots$

$\boxed{\frac{36}{315}}$

$\mu = \frac{.1}{10} = .01\ Kg/m, \quad F = 250 \quad \therefore v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{250}{.01}} = 158\,\frac{m}{s}$

Lowest frequencies are:



(1) $\frac{\lambda}{2} = 10 \quad \therefore \lambda = 20 \quad \therefore f = \frac{v}{\lambda} = \frac{158}{20} = 7.9\,Hz$

(2) $\lambda = 10 \quad \therefore f = \frac{v}{\lambda} = \frac{158}{10} = 15.8\,Hz$

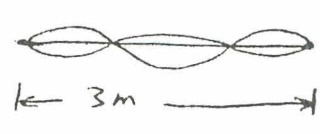
(3) $\frac{3\lambda}{2} = 10 \quad \therefore \lambda = \frac{20}{3} \quad \therefore f = \frac{158}{20/3} = 23.7\,Hz$

$\therefore$ Lowest three frequencies are $7.9\,Hz$, $15.8\,Hz$ & $23.7\,Hz$.

$\boxed{\frac{43}{315}}$

$v = 100\ m/s, \quad \frac{3\lambda}{2} = 3 \quad \therefore \lambda = 2m$

$\therefore$ (a) $f = \frac{v}{\lambda} = \frac{100}{2} = 50\,Hz$



(b) $y = y_1 + y_2$

$y_1 = 0.5\,Cm\ \sin k(x + vt)$ $\quad , k = \frac{2\pi}{\lambda} = \frac{2\pi}{2} = \pi$

$y_2 = 0.5\,Cm\ \sin k(x - vt)$ $\quad , v = 100$

$\therefore y_1 = .5\,Cm\ \sin(\pi x + 100\pi t), \quad y_2 = .5\,Cm\ \sin(\pi x - 100\pi t)$

Check: $y_1 + y_2 = .5\left[2 \sin \pi x \cos 100\pi t\right] = 1 \sin \pi x \cos 100\pi t$

which is of magnitude 1 cm and has nodes at $x = 0, 1, 2, 3\ m$

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$\lambda = \frac{v}{f}$ $\qquad v = 343\ m/s$

$\therefore$ (a) if $f = 20\ Hz$ $\therefore \lambda = \frac{343}{20} = 17.15\ m.$

(b) if $f = 20\ KHz$ $\therefore \lambda = \frac{343}{20 * 10^3} = 17.15 * 10^{-3} m = 17.15\ mm$

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shortest $\lambda = 3.3 * 10^{-3}\ m$, speed of sound $= 343\ m/s$

$\therefore v = \lambda f \quad \therefore f = \frac{v}{\lambda}$

$\therefore$ max. $f = \frac{v}{\text{shortest } \lambda} = \frac{343}{3.3 * 10^{-3}} = 1.04 * 10^5\ Hz = 104\ KHz.$

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assume the number of seconds since seeing the flash till hearing the thunder is n, then it take the sound of thunder n seconds to travel from the lightning to me

$\therefore$ distance $= v * t = 343\ \frac{m}{s} * n$ seconds $= 343\ n$ meters

$= 331\ n * \frac{100}{2.54 * 12 * 3 * 1760}$ miles $= 0.206\ n = \frac{n}{4.862}$

$\therefore$ To divide the number of seconds by 5 gives the approximate distance in miles. The error is $\frac{\left(\frac{n}{5} - \frac{n}{4.862}\right) * 100}{\frac{n}{4.862}} = \left(\frac{1}{5} - \frac{1}{4.862}\right) * 4.862 * 100 = -2.8\%$

$\therefore$ The error in this approximation is about -3%.

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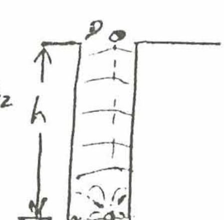
Let the time taken to reach water be t_1 and the time taken by sound of splash to reach up be t_2



$\therefore t_1 + t_2 = 3\ sec \quad (1)$

but $h = \cancel{v_0 t} + \frac{1}{2} g t^2 = \frac{1}{2} * 32 * t_1^2 = 16\, t_1^2 \quad (2)$

& $h = V_{sound} \cdot t_2 = 1130 * t_2 \quad (3)$

$\therefore$ (2) & (3) in (1)

$\therefore \sqrt{\frac{h}{16}} + \frac{h}{1130} = 3$, Let $\sqrt{h} = x$

$\therefore \frac{x^2}{1130} + \frac{x}{4} = 3 \qquad \therefore x = \frac{-\frac{1}{4} \pm \sqrt{(\frac{1}{4})^2 - 4\left(\frac{1}{1130}\right)(-3)}}{2\left(\frac{1}{1130}\right)} = 11.53 = \sqrt{h}$

Not possible

$\therefore$ Depth of well is $h = 133$ feet.

11/335

(a) pressure amplitude $= 1.5\ Pa$

(b) $k(x - vt) = \pi\,(x - 330\,t) \qquad \therefore k = \pi,\ v = 330\ m/s$

$\therefore k = \frac{2\pi}{\lambda} = \pi \quad \therefore \lambda = 2\ m \qquad \therefore f = \frac{v}{\lambda} = \frac{330}{2} = 165\ Hz$

(c) $\lambda = 2\ m$

(d) $v = 330\ m/s$

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Sources are in phase $\therefore S = P_m \sin k(x - vt) = P_m \sin \frac{2\pi}{\lambda}(x - vt)$

$= P_m \sin \frac{2\pi}{v/f}(x - vt) = P_m \sin \frac{2\pi f}{v}(x - vt) = P_m \sin \frac{2\pi * 540}{330}(x - 330t)$

$= P_m \sin 2\pi\,(1.64\,x - 540\,t) \quad \therefore \phi_1 = 2\pi(1.64\,x_1 - 540\,t),\ \phi_2 = 2\pi(1.64\,x_2 - 540\,t)$

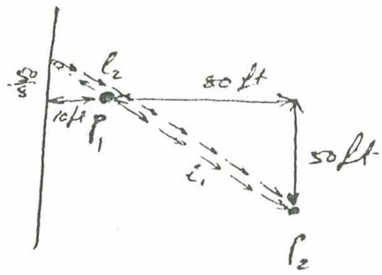
$\therefore \phi_1 - \phi_2 = 2\pi\,(1.64\,(x_1 - x_2) - 0) = 2\pi * 1.64 * (4.4 - 4.0) = 4.12\ rad = 236.2°$

19
336

Let the source at P_1 be

$P = P_m \sin k(x - vt)$

$\therefore$ It will reach at point P_2 through two routs l_1 & l_2



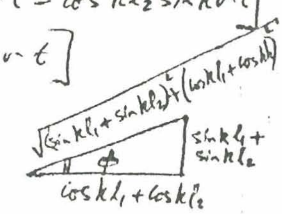
Let the sound pressure at P_2 be P'

$\therefore$ $P' = P_m \sin k(l_1 - vt) + P_m \sin k(l_2 - vt)$

$= P_m \left[\sin(kl_1 - kvt) + \sin(kl_2 - kvt)\right]$

$= P_m \left[\sin kl_1 \cos kvt - \cos kl_1 \sin kvt + \sin kl_2 \cos kvt - \cos kl_2 \sin kvt\right]$

$= P_m \left[(\sin kl_1 + \sin kl_2)\cos kvt - (\cos kl_1 + \cos kl_2)\sin kvt\right]$



$= P_m \sqrt{\sin^2 kl_1 + 2\sin kl_1 \sin kl_2 + \sin^2 kl_2 + \cos^2 kl_1 + 2\cos kl_1 \cos kl_2 + \cos^2 kl_2} \cdot$

$(\sin\phi \cos kvt - \cos\phi \sin kvt)$

$= P_m \sqrt{2 + 2\cos k(l_2 - l_1)} \cdot \sin(\phi - kvt)$

$= P_m \sqrt{2\left(1 + \cos 2\frac{k(l_2 - l_1)}{2}\right)} \quad \sin(\phi - kvt)$

$= P_m \sqrt{2\left(2\cos^2 \frac{k(l_2 - l_1)}{2}\right)} \quad \sin(\phi - kvt) = 2P_m \cos k\left(\frac{l_2 - l_1}{2}\right) \cdot \sin(\phi - kvt)$

$\therefore$ The intensity will be maximum when $k\left(\frac{l_2 - l_1}{2}\right) = n\pi \quad n = 0, 1, 2, \ldots$

$\therefore$ $k = \frac{2n\pi}{l_2 - l_1}$ but $k = \frac{2\pi}{\lambda}$

$\therefore$ $\frac{2\pi}{\lambda} = \frac{2n\pi}{l_2 - l_1} \Rightarrow \frac{1}{\lambda} = \frac{n}{l_2 - l_1}$ but $\frac{1}{\lambda} = \frac{f}{v}$

$\therefore$ $f = \frac{nv}{l_2 - l_1}$. $v = 330$ m/s , $l_1 = \sqrt{80^2 + 50^2} = 94.34$ ft

$l_2 = 2\sqrt{10^2 + \left(\frac{50}{8}\right)^2} + l_1 = 23.58 + 94.34 = 117.9$ ft

$\therefore$ $l_2 - l_1 = 23.58$ ft $= 7.19$ m

$\therefore$ $f = \frac{n * 330}{7.19} = 45.9\, n$ Hz $\therefore$ Two frequencies are 46 Hz & 92 Hz

OR P and its reflection at point P_1 should be in phase for maximum sound intensity

$\therefore$ $P_m \sin k(0 - vt)$ should be in phase with $P_m \sin k(l_2 - l_1 - vt)$

$\therefore$ $2n\pi - kvt = k(l_2 - l_1) - \cancel{kvt}$, $\therefore$ $k = \frac{2n\pi}{l_2 - l_1}$ $\therefore$ $\frac{2\pi}{\lambda} = \frac{2n\pi}{l_2 - l_1}$ $\therefore$ $\lambda = \frac{l_2 - l_1}{n}$

$\therefore$ $f = \frac{v}{\lambda} = \frac{nv}{l_2 - l_1}$.

ايضاً انك تستطيع حسابها بمقارنة الطور الصادر للمصدر اعتبارية

$\boxed{\frac{21}{336}}$ $I = \frac{P_m^2}{2V\rho_0}$

$\therefore \frac{I_1}{I_2} = \frac{P_{m1}^2}{P_{m2}^2}\cdot\frac{V_2\rho_{02}}{V_1\rho_{01}}$

ⓐ $\underset{(water)}{I_1} = \underset{(air)}{I_2}$ $\therefore \left(\frac{P_{m1}}{P_{m2}}\right)^2 = \frac{V_1}{V_2}\cdot\frac{\rho_{01}}{\rho_{02}} = \frac{1486}{343}\cdot\frac{1000}{1.3} = 3333$

$\therefore \frac{P_{m\,water}}{P_{m\,air}} = \sqrt{3333} = 58$

ⓑ $\underset{water}{P_{m_1}} = \underset{air}{P_{m_2}}$ $\therefore \frac{I_1}{I_2} = \frac{V_2\rho_{02}}{V_1\rho_{01}} = \frac{343*1.3}{1486*1000} = 3*10^{-4}$

$\therefore \frac{I_{wat}}{I_{air}} = 3*10^{-4}$

$\boxed{\frac{27}{337}}$ Barely audible (100Hz) $\Longrightarrow I = 10^{-9}\ W/m^2$ distance = 1 Km

Painfull (at 100 Hz) $\Longrightarrow I = 1.5\ W/m^2$ distance = x Km

$\therefore$ Power of Source $= I * 4\pi * \text{distance}^2$

$\therefore P = 10^{-9} * 4\pi * 1^2 = 1.5 * 4\pi * x^2$ $\therefore x^2 = \frac{10^{-9}}{1.5}$ $\therefore x = 2.6\times10^{-5}$ Km

$\therefore$ Distance from source $= 2.6*10^{-2}$ m $= 2.6$ Cm

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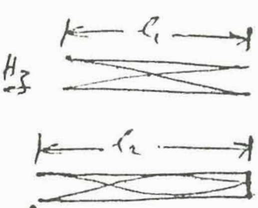
$\boxed{\frac{33}{337}}$ $f_1 = \frac{nV}{2l_1}$ $\therefore$ fundamental $= \frac{V}{2l_1} = 300$ ① $f_1 = 300$ Hz



$\therefore l_1 = \frac{V}{600} = \frac{343}{600} = .57\,m = 57$ Cm

$f_{1_2} = \frac{2V}{2l_1} = \frac{V}{l_1} = \frac{343}{.57} = 600$ Hz

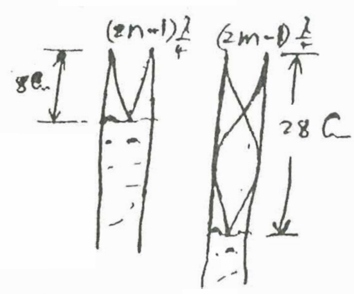
$f_{2_2} = f_{1_2}$

$\therefore f_{2_2} = f_{1_2} = 600$ Hz but $f_2 = \frac{V}{4l_2}(2n-1)$

$\therefore f_{2_2} = 600 = \frac{V}{4l_2}(3)$ $\therefore l_2 = \frac{3V}{2400} = \frac{3*343}{2400} = .43\,m = 43$ Cm

$\therefore$ The first is 57 Cm long, the second 43 Cm long.

$\boxed{\frac{37}{337}}$ "Same fork causes the two resonances



$\therefore 8 = \frac{(2n-1)\lambda_{fork}}{4}$ & $28 = \frac{(2m-1)\lambda_{fork}}{4}$, The difference

dbt — the two a— is half ~~wave~~length,

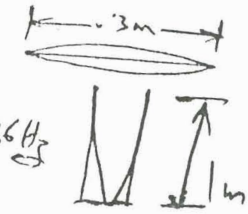
$\therefore 28 - 8 = 1\frac{\lambda_{fork}}{2}$ $\therefore \lambda_{fork} = 2 * 20 = 40$ Cm

$\therefore f = \frac{V}{\lambda} = \frac{330}{40*10^{-2}} = 825$ Hz

$\therefore$ The fork frequency is 825 Hz

43/337

$\mu = \frac{.01}{.3} = .0333 \ Kg/m$



$\therefore \frac{\lambda}{4} = 1m \quad \therefore \lambda = 4m \quad \therefore f = \frac{v}{\lambda} = \frac{343}{4} = 86 Hz$

∴ (a) frequency of oscilation is 86 Hz

(b) $\frac{\lambda'}{2} = .3 \quad \therefore \lambda' = 2 * .3 = .6 m \quad , f' = f = 86 Hz$

$\therefore v = \lambda' f' = .6 * 86 = 51.6 \ m/s = \sqrt{\frac{F}{\mu}} \quad \therefore F = 51.6^2 * .033 = 88.7 N$

∴ Tension in wire is 89 N.

3/352

Let the difference in the manometer be h

$\therefore P_A - P_B = \rho_{mercury} * g * h \qquad$ but $P_A = k . T_A \ , P_B = k . T_B$

$\therefore k (T_A - T_B) = \rho_{Hg} * g * h \qquad \therefore T_A = T_B + \frac{\rho_{Hg} * g * h}{k} = T_B + k' h$

$T_A = 100 + 273 = 373 °K \ , T_B = 0 + 273 = 273 °K$

$\therefore 373 = 273 + k' * 120 \qquad \therefore k' = \frac{100}{120} \ \frac{°K}{mm}$

$\therefore T_A = 273 + k' * 90 = 273 + \frac{100}{120} * 90 = 348 °K = 75 °c$

∴ The unknown temperature is 348 °K.

9/352

(a) $\frac{F - 32}{180} = \frac{c}{100} \qquad F = C \quad \therefore \frac{C - 32}{180} = \frac{c}{100}$

$\therefore (C - 32) \frac{100}{180} = c$

$\therefore c \left(\frac{100}{180} - 1\right) = \frac{32 * 100}{180} \qquad \therefore C = -40 °c$

(b) $K = 273 + C = 273 + \frac{100}{180} (F - 32) \qquad \therefore F = K$

$\therefore K = 273 + \frac{100}{180} (K - 32) \qquad \therefore K \left(1 - \frac{100}{180}\right) = 273 - \frac{100 * 32}{180}$

$\therefore K = 574.3 °K$

(c) $K = 273 + C \qquad \therefore K = c$

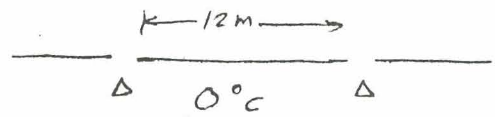
$\therefore \cancel{K} = 273 + \cancel{K} \qquad \therefore 0 = 273$ Canot be.

13/353

$\Delta D = D \alpha \Delta T = 200 * 3.2 * 10^{-6} (50 - (-10)) = .0384 \ in$

∴ Max. change is 0.0384 in

15/353 each rail track will expand at either end by $\frac{\Delta}{2}$



$\alpha_{steel} = 11 * 10^{-6}/°C$

$T = 42°C$

∴ total expansion $= 2 * \frac{\Delta}{2} = \Delta$ at $T = 42°C$

but $\Delta = l \alpha \Delta T = 12 * 11 * 10^{-6} * (42 - 0) = .0055\ m$

$= 5.5\ mm$

∴ The gap Δ should be 5.5 mm to prevent buckling at 42°C

19/353 $\alpha = \frac{\Delta l}{l \Delta T} = \frac{10.015 - 10.000}{10.000\,(100 - 20)} = 1.875 * 10^{-5}/°C$

∴ ⓐ $\Delta l = l_{20} - l_0 = l_0 \cdot \alpha \cdot (20 - 0) = l_0 * 1.875 * 10^{-5} * 20 = 3.75 * 10^{-4}\, l_0$

∴ $l_{20} - l_0 = 3.75 * 10^{-4} \cdot l_0$

∴ $l_{20} = (1 + 3.75 * 10^{-4})\, l_0$ but $l_{20} = 10.000$ ∴ $l_0 = 9.9963\ cm$

ⓑ $l_T - l_{20} = l_{20}\, \alpha\, \Delta T$

∴ $10.009 - 10.000 = 10.000 * 1.875 * 10^{-5}\,(T - 20)$

∴ $T = 68\ °C$

25/353 $\alpha_{Al} = 23 * 10^{-6}/°C$ ∴ $\gamma_{Al} = 3 * 23 * 10^{-6} = 69 * 10^{-6}/°C$

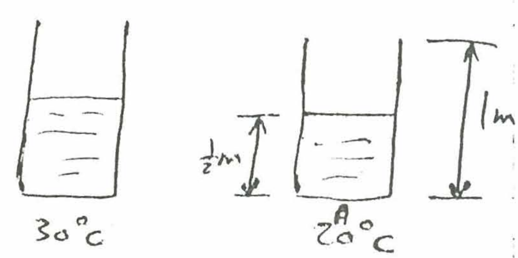
∴ $\Delta V = V \gamma \Delta T = \frac{4}{3}\pi (10)^3 * 69 * 10^{-6} * (100 - 0) = 28.9\ cm^3$

∴ Change in volume $= 29\ cm^3$.

33/354 Let A be the tube area,

∴ $V_{20°C} = \frac{1}{2} * A = \frac{A}{2}$

where V is the volume of liquid.



Now when we heat the glass to 30°C

∴ $\Delta V = V_{20°C} * \beta_{liquid} * (30 - 20) = V_{20°C} * 4 * 10^{-5} * 10 = 4 * 10^{-4}\, V_{20°C} = V_{30°C} - V_{20°C}$

∴ $V_{30°C} = (1 + 4 * 10^{-4})\, V_{20°C} = 1.0004 * \frac{A}{2} = .5002\ A$

And since the glass is expanding ∴ The tube area will increase

∴ $\Delta A = A * 2\alpha * \Delta T = A * 2 * 1 * 10^{-5} * (30 - 20) = 2 * 10^{-4} A$

∴ $A_{30} = (1 + 2 * 10^{-4}) A = 1.0002\ A$

∴ hight of liquid will be $\frac{.5002\ A}{1.0002\ A} = 0.5001\ m$

∴ Change in hight $= 0.5001 - 0.5 = .0001\ m = .01\ cm = .1\ mm$

∴ The hight of liquid will change by 0.1 mm

4/370

Heat lost = Heat gained . Let the final temperature be $T > 0°c$

$\therefore 200(25-T) = .5*2*50*(0-(-15)) + 2*50*80 + 2*50*(T-0)$

ice to come to 0°c — ice at 0°c → water at 0°c — water from 0 → T

$\therefore T = \frac{200*25 - .5*2*50*15 - 2*50*80}{200+2*50} = -12.5°C$ (below 0°C)

$\therefore$ Recalculate for $T \leq 0$

$\therefore 200(25-T) = .5*2*50*(T-(-15))$

$\therefore T = \frac{200*25 - .5*2*50*15}{.5*2*50+200} = 17$ (above 0°c)

$\therefore$ T is not negative & not positive $\therefore T = 0°C$

7/370

Let mass of sphere be m_s and of ring be m_r and let the equilibrium temperature be T

$\therefore$ Heat lost = Heat gained

$\therefore C_{Al} * m_s * (100-T) = C_{Copper} * m_r * (T-0)$

$\therefore .215 * m_s * (100-T) = .0923 * m_r * T$ (1)

but both diameters are equal at T

$\therefore 1.00000 * (1+\alpha_{Cu}(T-0)) = 1.00200 * (1-\alpha_{Al}(100-T))$

$\therefore T = \frac{1.00200 - 1.00000 - \alpha_{Al} * 100.2}{1.00000 * \alpha_{Cu} - 1.00200 * \alpha_{Al}} = \frac{.002 - 100.2*23*10^{-6}}{17*10^{-6} - 1.002*23*10^{-6}} = 50.4°c$

$\therefore$ from (1)

$.215 * m_s * (100-50.4) = .0923 * m_r * 50.4 \quad \therefore \frac{m_s}{m_r} = 0.436$

$\therefore$ ratio is 0.436

17/371

Temp. of water is 0°c (because of existance of ice)

$\therefore H = kA\frac{\Delta T}{L} \quad k = .004\ cal/(s.Cm.°c),\ L = 5.0Cm$

$\Delta T = 0-(-10) = 10°c \quad \therefore H = .004*A*\frac{10}{5} = .008A\ \frac{Cal}{Cm^2.s}$

This heat is absorbed from water at 0°c to make it ice at 0°c

$\therefore$ assuming rate of formation of ice is r Cm/hr

$\therefore$ heat rate lost by water $= \frac{r}{3600} * A * \rho *$ heat of fusion of ice $= .008A$

$\therefore \frac{r}{3600} * .92 * 80 = .008 \Rightarrow r = .39$ Cm/hr.

$\frac{21}{371}$ power $= \frac{4000 \text{ Kcal}}{\text{day}} = \frac{4000 * 4187 \text{ J}}{24 * 3600 \text{ sec}} = 193.8 \text{ Watt} = 1.938 * 100 \text{ Watt}$

$\therefore$ his power is 1.938 times more than the 100 Watt bulb power.

$\frac{28}{372}$ $m = \frac{1}{2} * 10^{-3} * 10^{3} = \frac{1}{2}$ Kg , $h = 1 ft = 12 * 2.54 * 10^{-2} m$
$= .305 m$

$T_0 = 59°F = \frac{59-32}{180} * 100 = 15°C$

$T_{final} = 100°c$, $f = 30$ shakes/min

$\therefore$ energy required to boil water $= \frac{1}{2} Kg * \frac{1 \text{ Cal}}{gr.°c} * (100-15)°c =$
$= 42.5 * Kg * \frac{1000 gr}{1 Kg} * \frac{1 Cal}{gr} * \frac{4.187 J}{1 Cal} = 1.78 * 10^5$ J

energy delievered each shake $= mgh = \frac{1}{2} * 9.81 * .305 = 1.495$ J

$\therefore$ no of shakes required $= \frac{1.78 * 10^5}{1.495} = 1.19 * 10^5 = ft = 30t$

$\therefore$ $t = \frac{1.19 * 10^5}{30}$ min $= 3965$ min $= 66.1$ hrs $= 2.75$ days

$\therefore$ It needs 2.75 days to boil.

$\frac{29}{372}$ $W_{BC} = \int_{along B}^{2} p dV + \int_{along^2 C}^{1} p dV =$ area under B + area under C
$= \frac{40+10}{2} * (4-1) + 10 * (1-4) = 45$ J/cycle

$W_{BA} =$ area under B + area under A $= \frac{40+10}{2} * (4-1) + 40 \times (1-4) = -45$ J/cycle

$\frac{33}{372}$ $\Delta U = U_A - U_A = 0$

$W = W_{AB} + W_{BCA} =$ area under P between A & B $+ 15 = 0 + 15 = 15$ J

$Q = Q_{AB} + Q_{BC} + Q_{CA} = (4.77 + 0 + Q_{CA})$ Cal $= (4.77 + Q_{CA}) * 4.187$J

$\therefore$ $\Delta U = Q - W$ $\therefore$ $0 = Q - W$ $\therefore$ $Q = W$

$\therefore$ $15 = 4.187 (4.77 + Q_{CA})$ $\therefore$ $Q_{CA} = -1.19$ Cal

$\frac{35}{373}$ $\Delta U = U_1 - U_1 = 0$ $\because$ $\Delta U = Q - W$

$\therefore$ $0 = Q - W$ $\therefore$ $Q = W$

Q (heat added to system) = heat lost by water ice mixture
$= -$ heat gained by ice to become water $= -100 *$ heat of fusion of ice
$= -100 * 80 = -8000$ Cal

$\therefore$ $W = Q = -8000$ Cal $= -8.0$ Kcal

$\therefore$ Work done by system is -8.0 Kcal

$\therefore$ Work done on system is 8.0 Kcal.

$\frac{4}{395}$

$P = \rho g h + P_{atm} = 1*10^3*9.81*40+1.01*10^5$
$= 4.93*10^5$ Pa

$P' = 1 atm = 1.01*10^5$ Pa
$T' = 20°C = 293°K$
$V' = ?$
40m
$\rho_{water} = 1$ Kg/liter
$T = 4°C = 277°K$
$V = 20$ Cm^3

$\therefore \frac{PV}{T} = \frac{P'V'}{T'}$ $\therefore \frac{4.93*10^5*20}{277} = \frac{1.01*10^5*V'}{293}$

$\therefore V' = 103.3$ Cm^3

$\frac{5}{395}$ (a) $PV = nRT$ $\therefore (76*10^{-2}*13.6*10^3*9.81)(1*10^{-3}) = n(8.314)(40+273)$

$\therefore n = 0.039$ mole is the amount of O_2 is the system.

(b) $\frac{PV}{T} = \frac{P'V'}{T'}$ $\therefore \frac{76*1}{40+273} = \frac{80*1.5}{T'}$ $\therefore T' = 494.2°K = 221.2°c$

$\therefore$ The final temperature is $221.2°C$

$\frac{7}{395}$ $PV = nRT$ $\therefore n = \frac{PV}{RT} = \frac{(1.00*10^{-3}*1.014*10^5)(1*10^{-6})}{(8.314)(?)} = 6.1$ mole

but 1 mole $6.023*10^{23}$ nu-lecules

$\therefore$ no. of molecules in the gas $= 6.1*6.023*10^{23} = 3.673*10^{16}$ molecules

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$\frac{4}{429}$ $F = \frac{1}{4\pi\epsilon_0}\cdot\frac{q_1 q_2}{r^2} = 9*10^9*\frac{1*1}{r^2} = \frac{9\times10^9}{r^2}$

(a) $r = 1$ mile $= 1.6$ Km $= 1600$ m $\Rightarrow$ $\therefore F = \frac{9*10^9}{1600^2} = 3516N$

(b) $r = 1m$ $\Rightarrow \therefore F = \frac{9*10^9}{1^2} = 9*10^9 N$

$\frac{5}{429}$ $F = \frac{1}{4\pi\epsilon_0}\cdot\frac{q_1 q_2}{r^2}$

12Cm
+3μC   −1.5μC

$= 9*10^9 \cdot \frac{3*10^{-6}*1.5*10^{-6}}{(12*10^{-2})^2} = 2.813 N$

$\therefore$ The force is attractive of 2.8 N

$\frac{7}{429}$ $F = \frac{1}{4\pi\epsilon_0}\cdot\frac{q(Q-q)}{r^2}$

r
q $Q-q$

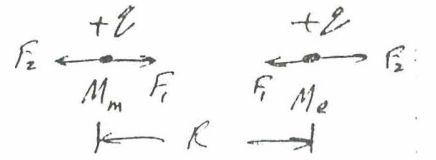
$\therefore F$ max $\therefore \frac{dF}{dq} = 0$

$\therefore \frac{1(Q-q)+q(-1)}{4\pi\epsilon_0 r^2} = 0$ $\therefore Q-q-q=0$ $\therefore Q = 2q$

$\therefore q = \frac{Q}{2}$ gives max. repulsive force.

15/429

$F_1 = \frac{G \cdot M_m \cdot M_e}{R^2}$, $F_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q \cdot q}{R^2}$



$\because F_1 = F_2$

$\therefore \frac{G \cdot M_m M_e}{R^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{R^2}$

(a) $\therefore q = \sqrt{4\pi\varepsilon_0 \cdot G \cdot M_m \cdot M_e} = \sqrt{\frac{1}{9 \times 10^9} \times 6.67 \times 10^{-11} \times 7.36 \times 10^{22} \times 6 \times 10^{24}} = 5.7 \times 10^{13} C$

(b) We don't need to know R because it cancels out.

(c) one ton of hydrogen gas has a charge of $\frac{1000 \text{ Kg} \times (6.023 \times 10^{23} \text{ molecule/mole})}{(2.02 \times 10^{-3} \text{ Kg/mole})}$ $\times 2 \frac{\text{atoms}}{\text{molecule}} \times \frac{1 \text{ electron}}{\text{atom}} \times \frac{1.6 \times 10^{-19} C}{\text{electron}} = 9.54 \times 10^{10} C$

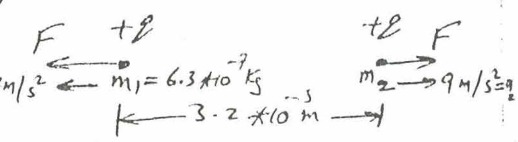
$\therefore$ No of tons of H_2 are $\frac{q}{9.54 \times 10^{10}} = \frac{5.7 \times 10^{13} \cancel{C}}{9.54 \times 10^{10} \cancel{C}} = 597$ tons

$\therefore$ About 600 Tons of hydrogen will be needed.

19/430

$F = m_1 a_1 = 6.3 \times 10^{-7} \times 7 = 4.41 \times 10^{-6} N$

$\therefore F = m_2 a_2 \Rightarrow 4.41 \times 10^{-6} = m_2 \times 9$



(a) $\therefore m_2 = 4.9 \times 10^{-7}$ Kg , mass of second particle.

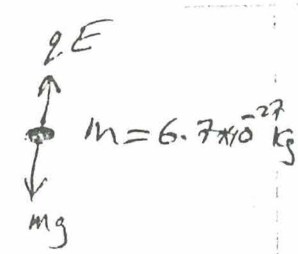
(b) $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{r^2}$ $\therefore 4.41 \times 10^{-6} = 9 \times 10^9 \cdot \frac{q^2}{(3.2 \times 10^{-3})^2}$

$\therefore q = 7.1 \times 10^{-11} C$, the common charge.

1/441

$mg = 6.7 \times 10^{-27} \times 9.81 = 6.57 \times 10^{-26} N = F$

$\therefore E = \frac{F}{q} = \frac{6.57 \times 10^{-26}}{2 \times 1.6 \times 10^{-19}} = 2.05 \times 10^{-7} \frac{N}{C}$



$\therefore$ magnitude of Electric Field is 2.1×10^{-7} N/C up and direction is up because q is positive

3/442 (a) $E = \frac{F}{q} = \frac{3 \times 10^{-6}}{2 \times 10^{-9}} = 1.5 \times 10^{3}$ N/C

(b) $F_1 = Eq = 1.5 \times 10^3 \times 1.6 \times 10^{-19} = 2.4 \times 10^{-16} N$ Upwards.

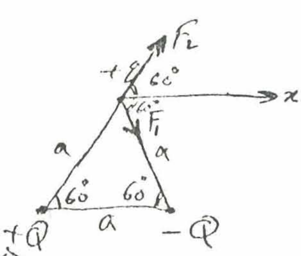
(c) $F_2 = mg = 1.67 \times 10^{-27} \times 9.81 = 1.64 \times 10^{-26} N$ down.

(d) $\frac{F_1}{F_2} = \frac{2.4 \times 10^{-16}}{1.64 \times 10^{-26}} = 1.46 \times 10^{10}$ ratio between Electric to Gravitational forces.

9/442

$F_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q Q}{a^2}$

$F_2 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q Q}{a^2}$ $\therefore F_1 = F_2$



$\therefore$ Resultant $= F_1 \langle \cos 60, -\sin 60 \rangle + F_2 \langle \cos 60, \sin 60 \rangle$

$= \langle \cos 60 \, (F_1 + F_2) , \sin 60 \, (\cancel{-F_1 + F_2}) \rangle$ $(F_1 = F_2)$

$= \langle 2\cos 60 \cdot F_1 , 0 \rangle$

$= 2\cos 60 \cdot F_1 \cdot \langle 1, 0 \rangle = F_1 \langle 1, 0 \rangle$

$\therefore$ Resultant is equal in magnitude to F_1 and direction is along + x-axis.

10/442 $E = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r^2}$ ∴ $2 = 9\times10^{9} \times \frac{q}{(.5)^2}$ ∴ $q = 5.56\times10^{-11}$ C

1/479 Energy = Work done by charge on crossing the potential difference $= qV$.
$= 30 \times 10^{9} = 3.0\times10^{10}$ Joul = mass of ice × heat of fusion
∴ $3.0\times10^{10} = m \times 3.3\times10^{5}$ ∴ $m = 9.1\times10^{4}$ Kg, mass of ice melt.

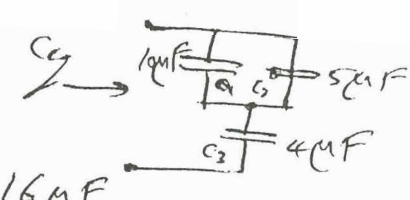
2/498 $C = \frac{\epsilon_0 A}{d} = \frac{8.85\times10^{-12}\times[\pi\times(8\times10^{-2})^2]}{1\times10^{-3}} = 1.78\times10^{-10}$ F

∴ $q = CV = (1.78\times10^{-10})\times(100) = 1.78\times10^{-8}$ C, charge that appears.

7/498 $C = \frac{q}{V} = \frac{1}{300} = 3.333\times10^{-3}$ F $= 3333\ \mu F$
n capacitors of $1\mu F$ each when connected in parallel will give $C = n\,\mu F$
∴ $3333\,\mu F = n\,\mu F$ ∴ $n = 3333$, no. of capacitors to be ∥ connected.

9/499 $C_{eq} = (C_1 \text{ series } C_2)\text{ parallel }(C_3) = \left(\frac{C_1C_2}{C_1+C_2}\right) + C_3 = \frac{10\times5}{10+5} + 4 =$
$= \frac{50}{15} + 4 = \frac{10}{3} + 4 = \frac{10+12}{3} = \frac{22}{3} = 7.33\ \mu F$, the equivalent capacitance.

10/499 $C_{eq} = (C_1 \parallel C_2)$ series C_3
$= (10+5)$ series (4)
$= 15$ series 4
$= \frac{15\times4}{15+4} = \frac{60}{19} = 3.16\,\mu F$
∴ $C_{eq} = 3.16\ \mu F$.



$\frac{18}{580}$

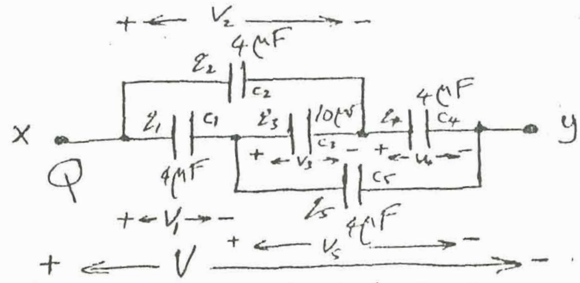
$q_1 = C_1V_1 \quad (1)$

$q_2 = C_2V_2 \quad (2)$

$q_3 = C_3V_3 \quad (3)$

$q_4 = C_4V_4 \quad (4)$

$q_5 = C_5V_5 \quad (5)$



$q_1 = q_3 + q_5 \quad (6)$ or: $q_1 - q_3 - q_5 = 0$ $\quad \therefore$ from (1), (3) & (5): $C_1V_1 - C_3V_3 - C_5V_5 = 0$

$Q = q_1 + q_2 \quad (7)$ or: $q_1 + q_2 - Q = 0$ $\quad \therefore$ from (1) & (2) : $C_1V_1 + C_2V_2 - Q = 0$

$q_4 = q_2 + q_3 \quad (8)$ or: $q_2 + q_3 - q_4 = 0$ $\quad \therefore$ from (2), (3) & (4) : $C_2V_2 + C_3V_3 - C_4V_4 = 0$

$V_3 = V_2 - V_1 \quad (9)$ or: $V_1 - V_2 + V_3 = 0$

$V_3 = V_5 - V_4 \quad (10)$ or: $V_3 + V_4 - V_5 = 0$

$V = V_1 + V_5 \quad (11)$ or: $V_1 + V_5 = V$

These are eleven equations in twelve unknowns and last 6 eqns. can be expressed interms of V, so becoming six equations in six unknowns.

Putting them in matrix form:

$$\therefore \begin{bmatrix} C_1 & 0 & -C_3 & 0 & -C_5 & 0 \\ C_1 & C_2 & 0 & 0 & 0 & -1 \\ 0 & C_2 & C_3 & -C_4 & 0 & 0 \\ 1 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & -1 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \\ V_5 \\ Q \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ V \end{bmatrix}$$

Putting the values of C's & Considering the augmented matrix for reduction:

$$\begin{bmatrix} 4 & 0 & -10 & 0 & -4 & 0 & 0 \\ 4 & 4 & 0 & 0 & 0 & -1 & 0 \\ 0 & 4 & 10 & -4 & 0 & 0 & 0 \\ 1 & -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & V \end{bmatrix} \begin{matrix} \Longrightarrow \\ R_2 - R_1 \\ \Longrightarrow \\ 4R_4 - R_1 \\ \Longrightarrow \\ R_6 - R_4 \end{matrix} \begin{bmatrix} 4 & 0 & -10 & 0 & -4 & 0 & 0 \\ 0 & 4 & 10 & 0 & 4 & -1 & 0 \\ 0 & 4 & 10 & -4 & 0 & 0 & 0 \\ 0 & -4 & 14 & 0 & 4 & 0 & 0 \\ 0 & 0 & 1 & 1 & -1 & 0 & 0 \\ 0 & 1 & -1 & 0 & 1 & 0 & V \end{bmatrix} \begin{matrix} \Longrightarrow \\ \Longrightarrow \\ R_3 - R_2 \\ R_4 + R_2 \\ \Longrightarrow \\ 4R_6 + R_4 \end{matrix}$$

$$\therefore \begin{bmatrix} 4 & 0 & -10 & 0 & -4 & 0 & 0 \\ 0 & 4 & 10 & 0 & 4 & -1 & 0 \\ 0 & 0 & 0 & -4 & -4 & 1 & 0 \\ 0 & 0 & 24 & 0 & 8 & -1 & 0 \\ 0 & 0 & 1 & 1 & -1 & 0 & 0 \\ 0 & 0 & 10 & 0 & 8 & 0 & 4V \end{bmatrix} \begin{matrix} \\ \\ R_5 \\ R_3 \\ 10R_5 - R_6 \\ 24R_5 - R_4 \end{matrix} \Longrightarrow \begin{bmatrix} - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ 0 & 0 & 1 & 1 & -1 & 0 & 0 \\ 0 & 0 & 0 & -4 & -4 & 1 & 0 \\ 0 & 0 & 0 & 10 & -18 & 0 & -4V \\ 0 & 0 & 0 & 24 & -32 & 1 & 0 \end{bmatrix} \begin{matrix} \Longrightarrow \\ \\ \\ \\ 2R_5 + 5R_4 \\ R_6 + 6R_4 \end{matrix}$$

$$\begin{bmatrix} - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ 0 & 0 & 0 & 0 & -56 & 5 & -8V \\ 0 & 0 & 0 & 0 & -56 & 7 & 0 \end{bmatrix} \begin{matrix} \Longrightarrow \\ \\ \\ \\ \Longrightarrow \\ R_6 - R_5 \end{matrix} \begin{bmatrix} - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ 0 & 0 & 0 & 0 & 0 & 2 & 8V \end{bmatrix}$$

$$\Longrightarrow \begin{bmatrix} - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ - & - & - & - & - & - & - \\ 0 & 0 & 0 & 0 & 0 & 1 & 4V \end{bmatrix} R_6/2$$

$\therefore \quad Q = 4V$

But $Q = C_{eq} \cdot V$

$\therefore C_{eq} = 4.0\,\mu F$, the equivalent capacitance between x & y.

11/515 $R = \rho \frac{l}{A} = (3.0 * 10^{-7}) * (10 * \frac{8}{5} * 1000) / (7.1 * (2.54 * 10^{-2})^2) = 1.05\,\Omega$

$\therefore$ Resistance of a single track is $1.05\,\Omega$

20/516 resistance of one wire $= \rho \frac{l}{\pi (\frac{d}{2})^2} = \frac{4\rho l}{\pi d^2}$

$\therefore$ resistance of 9 of them in parallel $= \frac{4\rho l}{9\pi d^2} = R$

But $R = \frac{\rho l}{\pi (\frac{D}{2})^2} = \frac{4\rho l}{\pi D^2}$

$\therefore \frac{4\rho l}{\pi D^2} = \frac{4\rho l}{9\pi d^2} \Longrightarrow D^2 = 9d^2 \quad \therefore D = 3d$

$\therefore$ The diameter of a single wire must be 3 times more.

21/516 $R_A = \frac{\rho l}{\pi (\frac{1}{2})^2} = \frac{4\rho l}{\pi}$

$R_B = \frac{\rho l}{\pi ((\frac{2}{2})^2 - (\frac{1}{2})^2)} = \frac{4\rho l}{3\pi}$

$\therefore R_A / R_B = \frac{4\rho l}{\pi} / \frac{4\rho l}{3\pi} = 1/\frac{1}{3} = 3$, the resistance ratio.

27/516 $R = R_0 (1 + \alpha \Delta T) \qquad \alpha_{copper} = 3.9 * 10^{-3} /°K$

$\therefore 58 = 50 (1 + 3.9 * 10^{-3} \Delta T)$

$\therefore \Delta T = 41.0\ °K = 41.0\ °C$

$\therefore T = 20 + \Delta T = 20 + 41 = 61\ °C$, temperature of winding.

35/517 (a) Power $= \frac{V^2}{R} = \frac{120^2}{14} = 1.03 * 10^3$ Watt $= 1.03$ KW, rate of Elect. Energy.

(b) Energy for 5 hrs $= 1.03 * 5 = 5.15$ KW.hr

$\therefore$ Cost $= 5.15 * 5¢ = 25.75\ ¢$, cost of operation for 5 hours.

41/517 (a) energy required to boil water $= 2 * 10^{-3}\,m^3 * \frac{10^3\,Kg}{m^3} * \frac{1\,Kcal}{Kg \cdot °C} * (100 - 20)°$

$= 160$ Kcal $= 160 * 4.187\,J = 670\,KJ$

$\therefore$ Elect. Energy $= \frac{670}{.8} = 837\,KJ =$ Power $*$ Time $= 400 * T \quad \therefore T = \frac{837K}{400} =$

$= 2.1$ K sec $= 2.1 * 10^3$ sec $= 35$ min, time required for boiling.

(b) energy required to evaporate $\frac{1}{2}$ the water $= \frac{1}{2} * 2 * 10^{-3} * 10^3 * 539 = 539$ Kcal

$= 539 * 4.187 = 2.26 * 10^6\,J \quad \therefore$ Elect Energy $= \frac{2.26 * 10^6}{.8} = 2.82 * 10^6\,J =$

$=$ Power $*$ time $= 400\,T \quad \therefore T = \frac{2.82 * 10^6}{400} = 7052$ sec $= 117.5$ min $= 1.96$ h

$\therefore$ It would take about 2 more hours to boil half the water away.

$\boxed{\frac{43}{517}}$ (a) $P = IV \quad \therefore \quad 1250 = I * 115 \quad \therefore I = \frac{1250}{115} = 10.9$ Amps

$\therefore$ Current in heater = 10.9 Amps.

(b) $R = \frac{V}{I} = \frac{115}{10.9} = 10.6\ \Omega$, resistance of heater.

(c) Energy = power * time = $1250 * 3600 = 4.5 * 10^6$ J = 4.5 MJ

$\therefore$ Elect. Energy converted to thermal Energy = 4.5 MJ.

$\boxed{\frac{2}{532}}$ Energy = $I * V * \text{Time} = Q * V = 12 * 120 * 3600 = 5.184 * 10^6$ J =

$= 100 * \text{time} \quad \therefore \text{Time} = \frac{5.184 * 10^6}{100} = 5.184 * 10^4$ sec =

= 864 min = 14.4 hr

OR:

Current required = $\frac{100}{12} = 8.33$ Amps

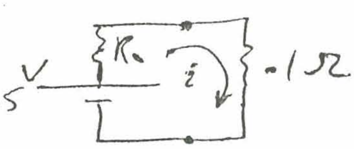
$\therefore$ time = $\frac{120\ \text{A.hr}}{8.33\ \text{A}} = 14.4$ hr.

$\boxed{\frac{3}{532}}$ Let the resistance of the original circuit be R

$\therefore V = IR = 5R = 4(R+2) \quad \therefore \quad 5R = 4R + 8 \quad \therefore R = 8\Omega$

$\boxed{\frac{5}{532}}$ (a) power = $\left(\frac{1.5}{.1 + R_o}\right)^2 * .1 = 10$ W

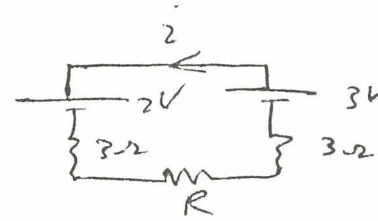
$\therefore R_o = 0.05\ \Omega$, internal resistance of battery



(b) $V = iR = \frac{1.5}{.1 + R_o} * .1 = \frac{1.5 * .1}{.1 + .05} = 1$ Volt

$\therefore$ Voltage accross resistor = 1 Volt.

$\boxed{\frac{8}{532}}$ $i = \frac{3 - 2}{3 + 3 + R} = 1 * 10^{-3}$



$\therefore \frac{1}{6 + R} = 10^{-3} \quad \therefore 6 + R = 1000$

(a) $\therefore R = 994\ \Omega$

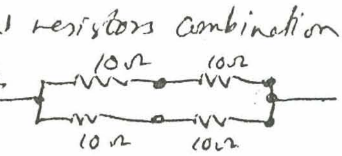
(b) $P_R = i^2 R = 994 * (10^{-3})^2 = 9.94 * 10^{-4}$ W = .994 mW ≃ 1mW

$\boxed{\frac{10}{533}}$ Current ability of one 10Ω resistor 1.0Watt = $\sqrt{\frac{1}{10}} = 0.316$A

" " " " " " 5W = $\sqrt{\frac{5}{10}} = .707$ Amp

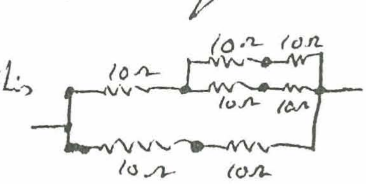
$\therefore$ No. of branches of 10Ω - 1W resistors combination = $\frac{.707}{.316} = 2.24$.

If you choose 2 then this



give $R_{eq} = 10$, P = 4.0W which is not enough

If you chose 3 for no. of branches then this



give $R_{eq} = 10\Omega$ & P = 7*1.0 = 7.0 Watt which is enough.

$\therefore$ min. no. of resistors to do the job is seven and connection is as shown above.

1/605 $N = 400$ Turns , $L = 8\,mh$, $I = 5\,mA$

$\therefore N\phi = LI$

$\therefore \phi = \frac{LI}{N} = \frac{8*10^{-3} * 5*10^{-3}}{400} = 0.1*10^{-6}\ Wb = 0.1\,\mu Wb.$

3/605 $L = 12\ H$ $I = 2.0A$, $V = 60\ V$

$V = L\frac{di}{dt}$

$\therefore 60 = 12\frac{di}{dt}$ $\therefore \frac{di}{\Delta t} = \frac{60}{12} = 5\ A/s$

$\therefore$ If we vary the current at the rate of 5 A/s , we get 60V.

1/621 ⓐ $\mu = NIA$, $\because \mu = 2*10^{-4}\ J/T$, $N = 5$ Turns , $I = ?$

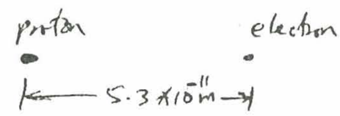
$A = \pi r^2 = \pi * (3*10^{-3})^2 = 2.83*10^{-5}\,m^2$

$\therefore 2*10^{-4} = 5 * I * 2.83*10^{-5} \Longrightarrow I = 1.415$ Amp.

ⓑ $B = \frac{\mu_0}{2\pi} \cdot \frac{\mu}{r^3} = \frac{4\pi*10^{-7}}{2\pi} * \frac{2*10^{-4}}{(.12)^3} = 2.315*10^{-8}\,T = 23.2\,nT.$

3/622 ⓐ $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{e}{r^2} = 9*10^9 * \frac{1.6*10^{-19}}{(5.3*10^{-11})^2}$

$= 5.13*10^{11}\ N/C = 5.13*10^{11}\ V/m$



$\therefore$ The electric field set by the proton is $5.13*10^{11}$ V/m

ⓑ $B = \frac{\mu_0}{2\pi} \cdot \frac{\mu}{r^3} = \frac{4\pi*10^{-7}}{2\pi} * \frac{1.4*10^{-26}}{(5.3*10^{-11})^3} = 1.88*10^{-2}\,T = 18.8*10^{-3}\,T$

$\therefore$ The magnetic field set by the proton is 18.8 mT

8/622 $\mu_{earth} = 8*10^{22}\ J/T = NIA$

$= 1 * I * \pi R_e^2 = \pi * (6.37*10^6)^2\, I$

$\therefore I = \frac{8*10^{22}}{\pi*(6.37*10^6)^2} = 6.3*10^8$ Amp

ⓐ $\therefore$ The required current is $6.3*10^8$ Amps.

ⓑ Yes. This arrangement can cancel earth magnetism well above earth surface

ⓒ No. " " can not " " " at earth surface due to unequal distribution of both fields.

1/647 $\therefore \omega = 2\pi f = 2\pi * 60 = 377$ rad/sec

The company establish this frequency through the rotational speed of the generating turbines.

3/683 ⓐ $f = \frac{c}{\lambda} = \frac{3*10^8}{.067*10^{-15}} = 4.48*10^{24}\ Hz$

ⓑ $\lambda = \frac{c}{f} = \frac{3*10^8}{30} = 1*10^7\,m = 10^4\ Km$

1/715 (a) $f = \frac{c}{\lambda} = \frac{3*10^{8}}{589*10^{-9}} = 5.1*10^{14}$ Hz

(b) $\frac{\lambda_{glass}}{\lambda_{air}} = \frac{n_{air}}{n_{glass}} = \frac{1.00029}{1.52}$ $\therefore \lambda_{glass} = \lambda_{air} * \frac{1.00029}{1.52} = \frac{589*1.00029}{1.52}$
$= 388$ nm

(c) speed in glass $= f * \lambda_{glass} = 5.1*10^{14} * 388*10^{-9} = 1.98*10^{8}$ m/s

5/715 $\frac{c}{v_{liquid}} = \frac{n_{liquid}}{n_{air}} \Rightarrow \frac{3*10^{8}}{1.92*10^{8}} = \frac{n_{liquid}}{1.00029} \Rightarrow n_{liquid} = 1.563$

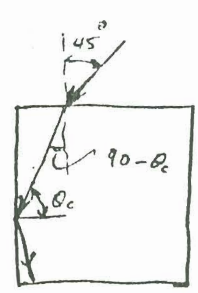
15/716 (a) $\frac{c}{v_{air}} = \frac{n_{air}}{n_{space}}$ $\therefore \frac{2.9979*10^{8}}{v_{air}} = \frac{1.00029}{1.00000}$ $\therefore V_{air} = 2.9971*10^{8}$ m/s

(b) $E = \Delta m\, c^2 = \left(\frac{m_0}{\sqrt{1-\left(\frac{v_0}{c}\right)^2}} - m_0\right) c^2 = \left(\frac{9.11*10^{-31}}{\sqrt{1-\left(\frac{1.00000}{1.00029}\right)^2}} - 9.11*10^{-31}\right)*(3*10^{8})^2$

$= 3.3232*10^{-12}\,J = \frac{3.3232*10^{-12}\,J}{1.602*10^{-19}\,J/eV} = 2.07*10^{7}\,eV$

$\therefore$ Required energy is 20.7 MeV.

17/716 For total internal reflection to occure at the vertical face, then:



$\sin\theta_c \geq \frac{n_{air}}{n_{glass}}$

but $\frac{\sin 45}{\sin(90-\theta_c)} = \frac{n_{glass}}{n_{air}}$

$\therefore \sin(90-\theta_c) = \cos\theta_c = \frac{n_{air}}{n_{glass}} \cdot \sin 45 = \frac{n_{air}}{\sqrt{2}\, n_{glass}}$

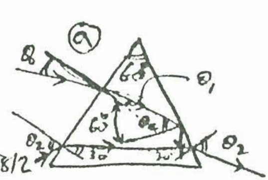
$\therefore \sin\theta_c = \sqrt{1-\cos^2\theta_c} = \sqrt{1-\frac{n^2_{air}}{2n^2_{glass}}} \geq \frac{n_{air}}{n_{glass}}$ let $r = \frac{n_{air}}{n_{glass}}$

$\therefore \sqrt{1-\frac{r^2}{2}} \geq r$ $\therefore 1-\frac{r^2}{2} \geq r^2$ $\therefore 1 \geq \frac{3}{2}r^2$

$\therefore r^2 \leq \frac{2}{3}$ $\therefore r \leq \sqrt{\frac{2}{3}}$ $\therefore \frac{n_{air}}{n_{glass}} \leq \sqrt{\frac{2}{3}}$ $\therefore n_{glass} \geq \sqrt{\frac{3}{2}}\, n_{air}$

$\therefore n_{glass} \geq \sqrt{\frac{3}{2}} * 1.00029$ $\therefore n_{glass} \geq 1.225$

19/717 (a) $\sin\theta_c = \frac{n_{air}}{n_{glass}} = \frac{1.00029}{1.60}$ $\therefore \theta_c = 38.7°$



$\therefore \theta_1 = 60 - \theta_c = 60 - 38.7 = 21.3°$

$\therefore \frac{\sin\theta_0}{\sin\theta_1} = \frac{n_{glass}}{n_{air}} = \frac{1.6}{1.00029}$ $\therefore \sin\theta_0 = \frac{1.6 * \sin 21.3}{1.00029} = .5812$

$\therefore \theta_0 = 35.5°$, smallest incidence angle for ray to emerge.

(b) For passing symmetrically $\therefore \frac{\sin\theta_2}{\sin 30} = \frac{n_{glass}}{n_{air}} = \frac{1.6}{1.00029}$

$\therefore \sin\theta_2 = .7998$ $\therefore \theta_2 = 53.1°$, incidence angle required for symmetry.