Q12

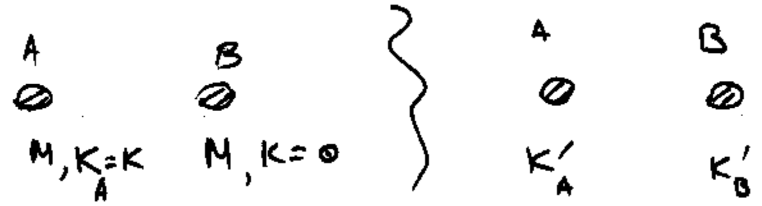
$\vec{J} = \int \vec{F} \cdot dt = F_{avg} \Delta t$ definition of J, impulse

but this doesn't help as we don't know $\int F \cdot dt$ or $F_{avg} \Delta t$, So use

$\vec{J} = \Delta \vec{p}$ impulse momentum theory

$$\Rightarrow \vec{J} = m(\vec{v}_f - \vec{v}_i)$$
$$= (3.0)\{(-3\hat{i} + 2\hat{j}) - (3\hat{i} + 2\hat{j})\}$$
$$= (3.0)\{-6\hat{i} + 0\hat{j}\}$$
$$\vec{J} = -18\,\hat{i} \ (N.s)$$

Q13



Conservation of momentum

$$Mv_A + 0 = Mv'_A + Mv'_B$$
$$v_A = v'_A + v'_B \quad \text{—— (1)}$$

Conservation of K

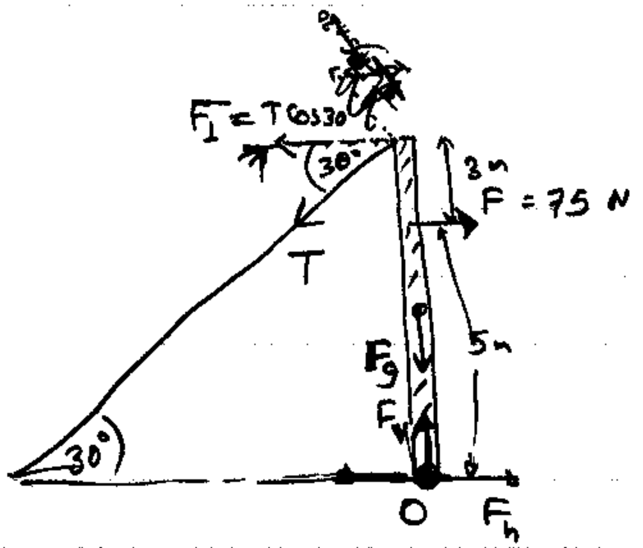
$$\Rightarrow \tfrac{1}{2}Mv_A^2 + 0 = \tfrac{1}{2}Mv_A'^2 + \tfrac{1}{2}Mv_B'^2$$
$$v_A^2 = v_A'^2 + v_B'^2 \quad \text{—— (2)}$$

Solving for (1) & (2)

$$\Rightarrow \quad v'_A = 0 \quad \& \quad v'_B = v_A$$

$$\therefore \quad \underline{\underline{K'_A = 0}}$$

(Q14)



The beam is acted upon by 5 forces T, F, F_g, F_v & F_h.

However we can ~~efficiently~~ quickly solve the problem by taking net torque about point O (the pin) and equating it to zero (rotational equilibrium).

$$\sum \tau_O = 0$$

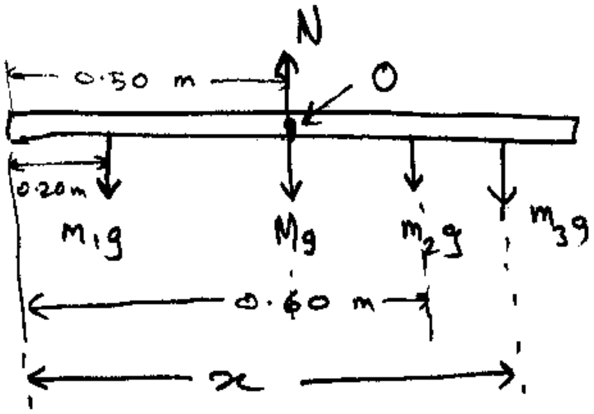
$$\vec{\tau}_T + \vec{\tau}_F + \cancel{\vec{\tau}_{F_g}}^{0} + \cancel{\vec{\tau}_{F_v}}^{0} + \cancel{\vec{\tau}_{F_h}}^{0} = 0$$

$$\vec{\tau}_T + \vec{\tau}_F = 0$$

$$+(T \cancel{\cos} 30)(8) - (75)5 = 0$$

$$T = \frac{(75)(5)}{8 \cancel{\cos} 30} = \underline{\underline{54\ N}}$$

Q15



$m_1 = 0.5$ kg
$m_2 = 0.3$ kg
M = mass of the meter stick? (not given)

m_3 is the third mass hung at position 'x' to keep the balance. Take the torque about the center of the meter stick. (point O).

$$+m_1 \cancel{g}(0.3) - m_2 \cancel{g}(0.1) - m_3 \cancel{g}(x - 0.5) = 0$$

$$(0.5)(0.3) - (0.3)(0.1) = (0.6)(x - 0.5)$$

$$0.15 - 0.03 = 0.6x - 0.3$$

$$0.6x = 0.42$$

$$x = 0.70\ m$$

$$x = \underline{\underline{70\ cm}}$$

Q16

$$\frac{F}{A} = E\,\frac{\Delta l}{l}$$ tensile stress (stretching)

$$\Delta l = \frac{F l}{E A} = \frac{(25000)(20)}{(2.0\times10^{11})(1.0\times10^{-4})}$$

Note $A = 1.0\ cm^2 = \underline{\underline{1.0\times10^{-4}}}\ m^2$

$\Delta l = 0.025\ m$

$= \underline{\underline{2.5}}\ cm$

Q17

$$T^2 = \frac{4\pi^2}{GM} r^3$$

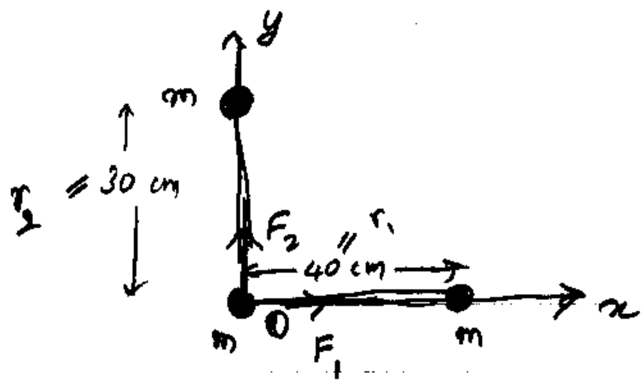
$$r^3 = \frac{GMT^2}{4\pi^2} = \frac{(6.67\times10^{-11})(5.0\times10^{24})(98\times60)^2}{4\pi^2}$$

Note $T = 98$ min $= \underline{\underline{(98\times60)\ s}}$

$r^3 = 2.92\times10^{20}\ m^3$

$\Rightarrow r = \underline{\underline{6.6\times10^{6}\ m}}$

Q18.



$m = 5$ kg

$r_1 = 40$ cm

$r_2 = 30$ cm

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2$$

$$= \frac{G m^2}{r_1^2}\hat{i} + \frac{G m^2}{r_2^2}\hat{j}$$

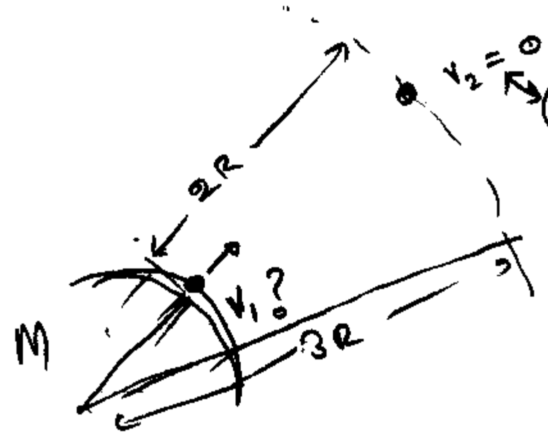
$$= G m^2 \left\{ \frac{1}{(0.4)^2}\hat{i} + \frac{1}{(0.3)^2}\hat{j} \right\}$$

$$\vec{F}_{net} = (6.67 \times 10^{-11})(5)^2 \left\{ 6.25\,\hat{i} + 11.1\,\hat{j} \right\}$$

$$|\vec{F}_{net}| = (6.67 \times 10^{-11})(25)\sqrt{(6.25)^2 + (11.1)^2}$$

$$= \underline{\underline{2.1 \times 10^{-8}}}\ N$$

Q19



$v_2 = 0$ (at max height $v=0$)

$K_1 + U_1 = K_2 + U_2$

(~~Note you can't say K + U = E = -GMm/2r~~)

$$\frac{1}{2}\cancel{m}v_1^2 + \left(-\frac{GM\cancel{m}}{R}\right) = 0 + \left(-\frac{GM\cancel{m}}{3R}\right)$$

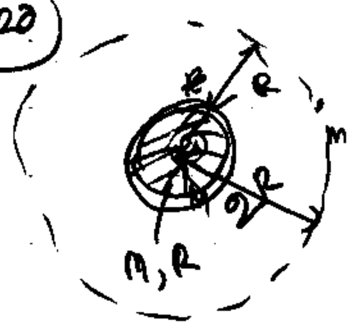
(m) is the mass of the rocket (say)

$$\frac{1}{2}v_1^2 = \frac{GM}{R} - \frac{GM}{3R} = \frac{GM}{R}\left\{1 - \frac{1}{3}\right\}$$

$$v_1^2 = \frac{2GM}{R}\left(\frac{2}{3}\right)$$

$$v_1 = \sqrt{\frac{4GM}{3R}}$$

Q20



~~$\frac{1}{2}mv_{esc}^2$~~

$K_1 + U_1 = K_\infty + U_\infty$

~~$\frac{1}{2}mv_{esc}^2 + \left(-\frac{GMm}{R}\right) = 0 + 0$~~

$K_{esc} + (-GM_1 R / R$

~~$v_{esc}^2 = \frac{2GM}{R}$~~ 2)

~~K_{esc}~~

This question is not clear whether the spaceship is at a distance R from the center of the planet OR a distance $(2R)$ from the center of the planet with R as the radius of the planet.

~~ASSUMING~~

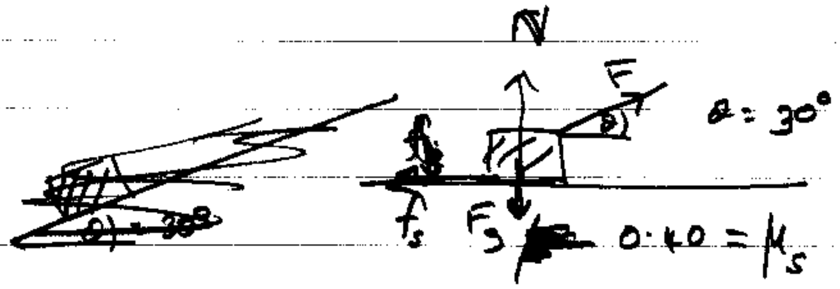
$$K_{esc} + U_1 = K_\infty + U_\infty$$

$$K_{esc} + \left(-\frac{GMm}{(2R)}\right) = 0 + 0$$

(assuming $r = 2R$)

$$K_{esc} = \frac{GMm}{2R}$$

(P21)



$\Sigma F_x = 0$ with max static friction force $f_s = f_{s,max}$

$$F\cos\theta - f_{s,max} = 0$$

$$F\cos\theta - \mu_s N = 0 \quad (1)$$

$\Sigma F_y = 0$

$N + F\sin\theta - F_g = 0$

$N = Mg - F\sin\theta \quad \text{—} (2)$

(2) in (1)

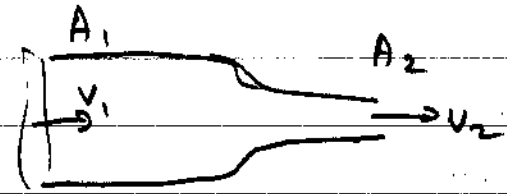
$F\cos\theta - \mu_s (Mg - F\sin\theta) = 0$

$F(\cos\theta + \mu_s \sin\theta) = \mu_s Mg$

$F = \dfrac{\mu_s Mg}{\cos\theta + \mu_s \sin\theta} = \dfrac{(0.4)(12)(9.8)}{(\cos 30 + (0.4)\sin 30)}$

$F = \underline{\underline{44}}\,(N)$

Q23

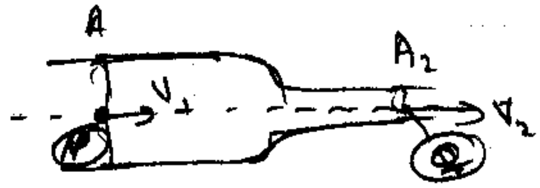


continuity equation $A_1 V_1 = A_2 V_2$

$$\boxed{\frac{V_2}{V_1} = \frac{A_1}{V_1}}$$

Q24 $P + \frac{1}{2}\rho v^2 + \rho g y = \text{const}$
is derived from law of conservation of Energy

Q25



$A_1 V_1 = A_2 V_2$ — (1)

Bernoulli's equ.: $P_1 + \frac{1}{2}\rho V_1^2 + \cancel{\rho g y_1} = P_2 + \frac{1}{2}\rho V_2^2 + \cancel{\rho g y_2}$

But we have $y_1 = y_2$ horizontal

$$P_1 + \frac{1}{2}\rho V_1^2 = P_2 + \frac{1}{2}\rho V_2^2$$

$$(P_1 - P_2) = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right)$$

$$= \frac{1}{2}\rho\left(\left[\frac{A_1 V_1}{A_2}\right]^2 - V_1^2\right)$$ from (1) $\Rightarrow V_2 = \frac{A_1 V_1}{A_2}$

but it is given that $\frac{A_1}{A_2} = 2$

$$\Rightarrow (P_1 - P_2) = \frac{1}{2}\rho\left(4V_1^2 - V_1^2\right) = \frac{1}{2}\rho\, 3V_1^2$$

$$V_1^2 = \frac{2(P_1 - P_2)}{\rho(3)} = \frac{2(4120)}{(791)(3)} =$$

$$V_1 = 1.86 \text{ m/s}$$

Q26

$x = 2\cos(50t)$ $k = ?$ $m = 3$ kg

$\Rightarrow x_m = 2$ (m) & $\omega = 50$ (rad/s)

$$k = m\omega^2 = (3)(50)^2 = 7500 \text{ N/m}$$

Q27 $V_m = \omega x_m = ?$

given $x_m = $ 'A', ~~mass = m~~, spring const = 'k' & mass = 'm'

$k = m\omega^2 \Rightarrow \omega = \sqrt{\frac{k}{m}} =$

$\Rightarrow V_m = \left(\sqrt{\frac{k}{m}}\right) A$

Q28 $m = 0.25\ kg,\quad k = 200\ N/m,$
$x(t=0) = 0.15\ (m)$
$v(t=0) = 3.0\ (m/s)$ } given

find $V_m = \omega x_m$

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{200}{0.25}} = 28.3\ rad/s$

$x = x_m \cos(\omega t + \phi)$

$\Rightarrow 0.15 = x_m \cos\phi$ — (1)

$v = -\omega x_m \sin(\omega t + \phi)$

~~$v = v_m \sin(\omega t + \phi)$~~

$\Rightarrow 3.0 = -28.3\, x_m \sin\phi$ — ~~(2)~~

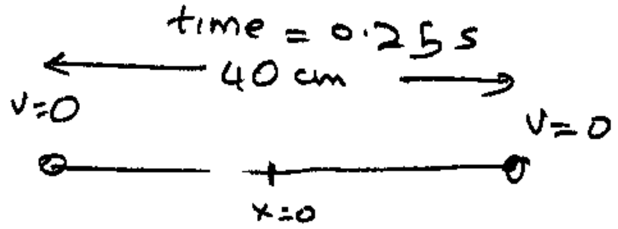
$-0.106 = x_m \sin\phi$ — (2)

$(1)^2 + (2)^2 \Rightarrow (0.15)^2 + (-0.106)^2 = x_m^2$

$x_m = 0.184\ (m)$

$V_m = \omega x_m = (28.3)(0.184) = 5.2\ m/s$

Q29



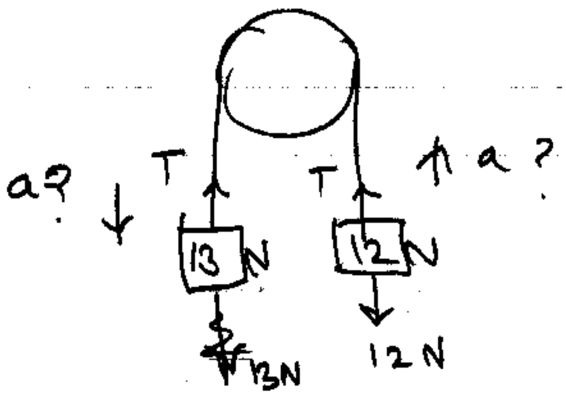
$$\Rightarrow \quad T/2 = 0.25\ (s) \quad \& \quad 2x_m = 40\ \text{cm}$$

$$x_m = \underline{\underline{20}}\ \text{cm} = \cancel{0.20\ \text{m}}$$

$$T = 0.50\ (s) \quad \Rightarrow \quad \cancel{\omega = \frac{2\pi}{T}}$$

$$f = \frac{1}{T} = \underline{\underline{2\ \text{Hz}}}$$

Q30



13N $\qquad 13 - T = \left(\frac{13}{g}\right) a \quad$ — (1)

12N $\qquad T - 12 = \left(\frac{12}{g}\right) a \quad$ — (2)

(1) + (2) $\qquad 1 = \left(\frac{13}{g} + \frac{12}{g}\right) a$

$$g = 25a$$

$$a = \underline{\underline{\frac{g}{25}}}$$