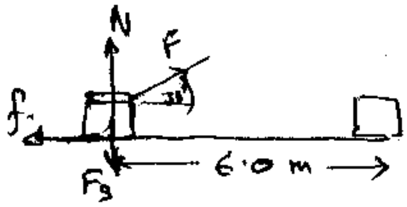
Exam 2022

Q1



$$W_{net} = \Delta K$$

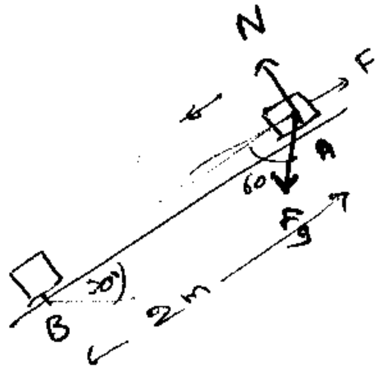
$$\underbrace{W_N}_{0} + \underbrace{W_g}_{0} + W_f + W_F = 0 \quad (\Delta K = 0 \text{ constant speed})$$

$$W_f = -W_F = -\left(F \cos 30\,(6)\right)$$

$$= -\left((15)\cos 30\,(6)\right)$$

$$= \underline{\underline{-78\ J}}$$

Q2



$$W_{net} = \Delta K$$

$$W_F + W_g + \underbrace{W_N}_{0} = K_B - K_A$$

$$-(3)(2) + (2)(9.8)\cdot(2)\cos 60 = K_B - 10$$

$$-6 + 19.6 = K_B - 10$$

$$\underline{\underline{K_B = 24\ J}}$$

OR using

$$W_{ex} = \Delta K + \Delta U + \cancel{\Delta E_{th}}^{\,0}$$

$$-(3)(2) = (K_B - 10) + 2(9.8)(-1)$$

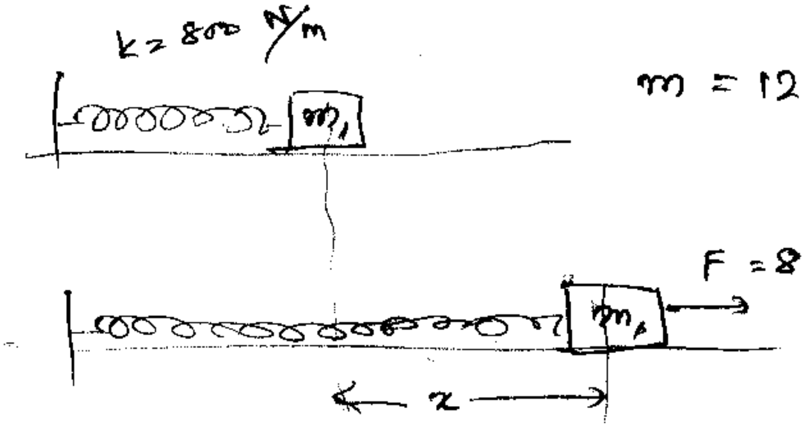
$$\boxed{K_B = 24\ J}$$

Q3

$$P = \vec{F}\cdot\vec{v} = (3\hat{i} + 4\hat{j})\cdot 5\hat{i}$$

$$= \underline{\underline{15\ W}}$$

Q4



$m = 12$ kg

system = spring + block + earth + floor

13 cm

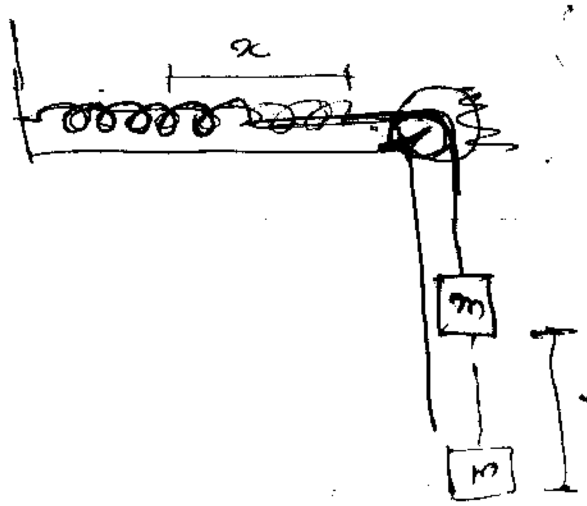
$$\Delta K + \Delta U_s + \Delta E_{int} = W_{ext} \qquad (\Delta U_g = 0)$$

$$\tfrac{1}{2} m (v^2 - 0^2) + \tfrac{1}{2} k (x^2 - 0^2) = (80)(x)$$

$$\tfrac{1}{2} m v^2 = (80)(0.13) - \tfrac{1}{2}(800)(0.13)^2$$
$$= 10.4 - 6.76$$
$$= 3.64$$

$$v = \sqrt{\frac{2(3.64)}{12}} = \underline{\underline{0.78}} \text{ m/s}$$

Q5



$m = 10$ kg

$k = 400$ N/m

released from rest with spring at rest

syst

$$\cancelto{0}{\Delta K} + \Delta U_s + \Delta U_g + \cancelto{0}{\Delta E_{th}} = \cancelto{0}{W_{ex}}$$

system = spring + block + earth

$\Delta K = 0$ because $K_i = 0$

& $K_f = 0$ at maximum compression (momentarily)

$$\Rightarrow \quad \Delta U_s + \Delta U_g = 0$$

$$\tfrac{1}{2} k (x^2 - 0^2) + mg(-x) = 0$$

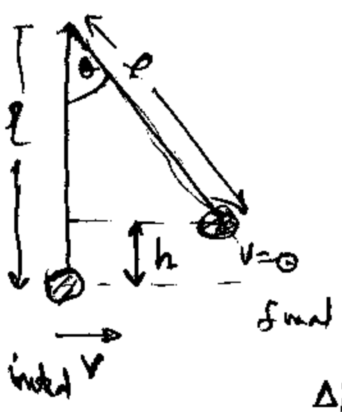
[$\because \Delta y = -x$ going down]

$$\tfrac{1}{2} k x^{\cancel{2}} = mg \cancel{x}$$

$$x = \frac{2mg}{k} = \frac{(2)(10)(9.80)}{400}$$

$$= \underline{\underline{0.49\ m}} = \underline{\underline{49\ cm}}$$

(26)



$m = 0.6$ kg

$l = 2.0$ m

$v_0 = 4.0$ m/s

$v = 0$ at maximum angle

$$\Delta K + \Delta U = 0$$

$$\tfrac{1}{2} \cancel{m}(0^2 - v_0^2) + \cancel{m} g h = 0$$

$$h = \frac{v_0^2}{2g} = \frac{4^2}{2(9.8)} = 0.816\ m$$

$$\cos\theta = \frac{l-h}{l} = 1 - \frac{h}{l}$$

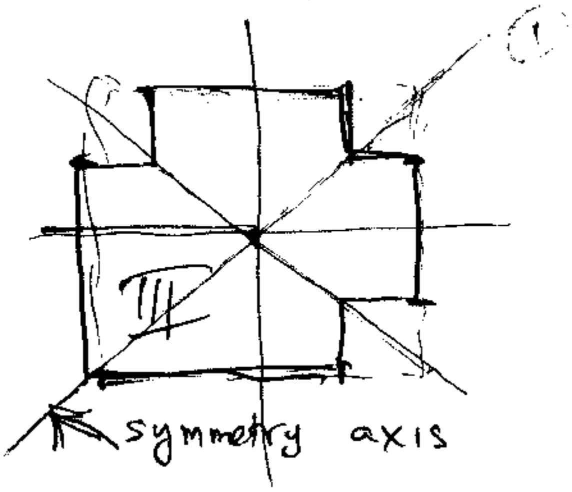
$$\cos\theta = 1 - \frac{0.816}{2}$$

$$\underline{\underline{\theta = 54^\circ}}$$

Q7 A force is conservative if

A. its work done for closed paths is equal to zero

Q8



By symmetry the center of mass should lie in the symmetry axis. And since more mass is on the negative side of this symmetry line, the COM is located definitely in the III rd quadrant.

(9)

$$\vec{V}_{com} = \frac{\sum m_i v_i}{\sum m_i}$$

$$\left\{\sum m_i\right\} \vec{V}_{com} = \sum m_i \vec{v}_i$$

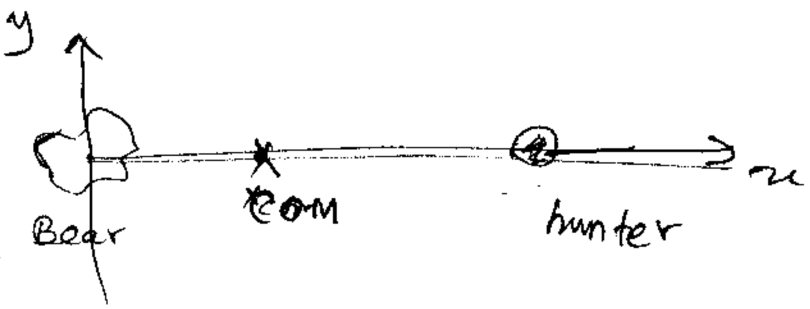
$$(1000 + 1500)\, 24 \hat{j} = (1000)\, 80 \hat{i} + 1500\, \vec{v}$$

$$(25\cancel{00})(24)\hat{j} - (10\cancel{00})(80)\hat{i} = 15\cancel{00}\, \vec{v}$$

$$\vec{v} = -\frac{800}{15}\hat{i} + \frac{(25)(24)}{15}\hat{j} \quad \frac{km}{h}$$

$$\vec{v} = \underline{\underline{-53\hat{i} + 40\hat{j}}} \left(\frac{km}{h}\right)$$

(10)



Since there is no ~~exter~~ net external force acting on the system (man + bear) the COM does not change. So the hunter & the bear should end up at the <u>COM</u> point.

$$x_{com} = \frac{m_b(0) + m_h(10)}{m_b + m_h} = \frac{(80)(10)}{120 + 80} = \underline{\underline{4.0\ m}}$$

Q11) $\vec{J} = \Delta\vec{p}$

$\uparrow \vec{v}_i = 3\ m/s$, $\longrightarrow$ $F = 4N$, for $\Delta t = 1.5\ s$, $m = 2\ kg$

$$(4)(1.5)\,\hat{i} = m\left(\vec{v}_f - \underbrace{v\,\hat{j}}_{=\vec{v}_i}\right)$$

$$6\hat{i} = 2\left(\vec{v}_f - 3\hat{j}\right)$$

$$6\hat{i} + 6\hat{j} = 2\vec{v}_f \implies \vec{v}_f = \underline{3\hat{i} + 3\hat{j}}\ m/s$$

Q12) In any collision $\vec{P}_i = \vec{P}_f$

$\implies$ $\vec{V}_{com}$ remains the same.

$$\cancel{K = \tfrac{1}{2} M v_{com}^2 = \tfrac{1}{2}(2+3)(2)^2}$$

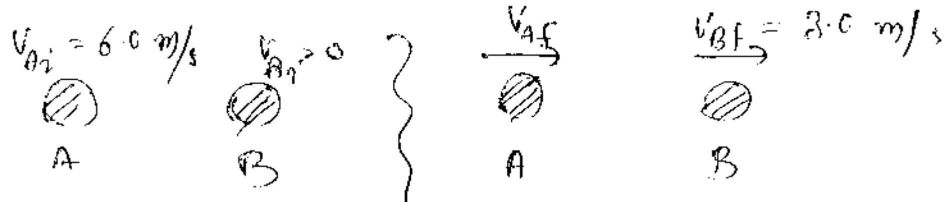
$$\cancel{= 10\ J}$$

~~Q13~~ In a completely INELASTIC collision $\vec{v}_{com}$ is the velocity of the combined mass also!

$$\therefore\ K_f = \tfrac{1}{2} M v_{com}^2$$

$$= \tfrac{1}{2}(2+3)(2)^2 = \underline{10\ J}$$

8B



$$\vec{P}_i = \vec{P}_f$$

$$(0.200)(6.0) + 0 = \cancel{(0.200)}\ \vec{V}_{Af} + \cancel{(0.400)}^{2}(3.0)$$

$$6.0 = \vec{V}_{Af} + 6.0$$

$$\vec{V}_{Af} = \underline{\underline{0}}$$

Q14

$$\omega = \cancel{\frac{2\pi}{3600\,s}} = \frac{2\pi}{1(h)} \cdot \frac{2\pi}{3600\,s} = \underline{\underline{\frac{\pi}{1800}\ \frac{rad}{s}}}$$

Q15

$$W1 = \tau\ \Delta\theta \qquad \text{constant torque}$$

$$= \tau \left\{ \underbrace{\omega_0 t}_{0} + \frac{1}{2}\alpha t^2 \right\}$$

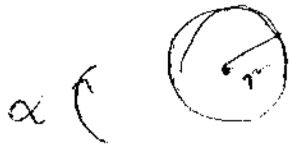
$$= \qquad \text{start from rest}$$

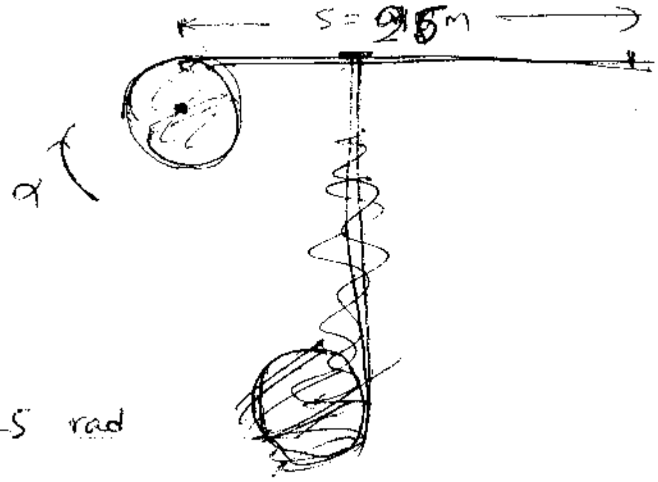
$$W1 = \tau \frac{1}{2}\alpha t_1^2 \qquad t_1 = 3\,s$$

$$W2 = \tau \frac{1}{2}\alpha t_2^2 \qquad t_2 = 6\,s$$

$$\frac{W1}{W2} = \frac{t_1^2}{t_2^2} = \frac{3^2}{6^2} = \underline{\underline{\frac{1}{4}}}\ \#$$

(Q25)





✓ $\alpha = 2.0 \text{ rad/s}^2$

$s = 2.5 \text{ m}$

✓ $\Delta\theta = \frac{s}{r} = \frac{2.5}{0.1} = 25 \text{ rad}$

✓ $\omega_0 = 0$

$t = ?$

$\cancel{\omega = ?}$ missing

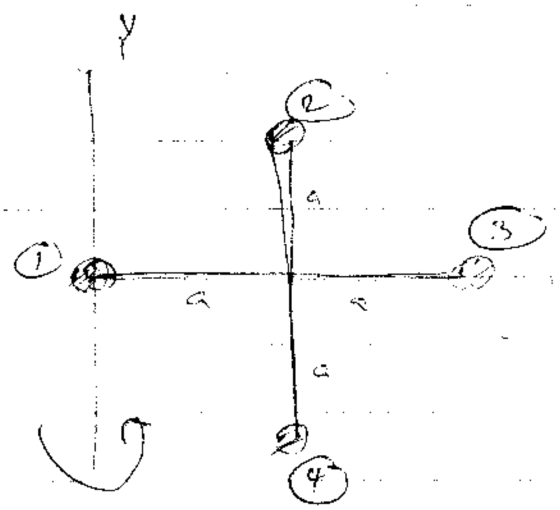
so use $\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$25 = 0 + \frac{1}{2}(2.0)\, t^2$

$t^2 = 25$

$t = 5.0 \text{ s}$

(Q27)



$I = 0 + ma^2 + m(2a)^2 + ma^2$

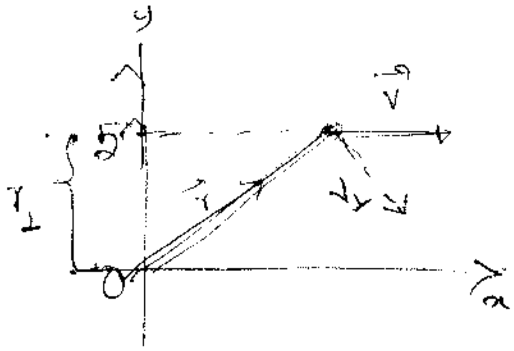
$= 2ma^2 + 4ma^2$

$= 6ma^2$

$= (6)(2)(1)^2$

$= 12 \text{ kg}\cdot\text{m}^2$

Q18



$\vec{l} = \vec{r} \wedge \vec{p}$

$\vec{l} = m\, \vec{r} \wedge \vec{v}$

$l = m r v \sin\phi$ — (1)

OR $= m r_\perp v$ — (2)

OR $= m r v_\perp$ — (3)

to find l (magnitude) we use eqn (2)

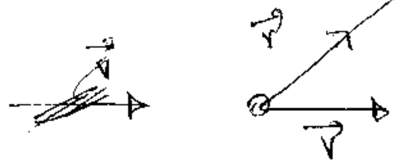
because $\sin\phi$ — not given

$v_\perp$ — cannot find

but $r_\perp = 5\ (m)$ is only given

$\Rightarrow \quad l = m r_\perp v = (2)(5)(3) = 30 \ \mathrm{kg \cdot m^2/s}$

direction: $\Rightarrow$



applying RHR $\rightarrow$ into the plane

or

$-$ve. z-axis

$\vec{l} = -30\,\hat{k}$

Q19

$K_t = \frac{1}{2} M v_{cm}^2 \ ; \quad K_r = \frac{1}{2} I_{com} \omega^2 = \frac{1}{\cancel{2}}\left(\frac{2}{5} M \cancel{R^2}\right) \frac{v_{cm}^2}{\cancel{R^2}}$

$= \frac{1}{5} M v_{com}^2$

$\frac{K_t}{K_r} = \frac{5}{2}$

Q20

L is const, because no net external torque about axis of rotation.