Homework (Week-10) Solutions!

Ch 7:

Problem 48:

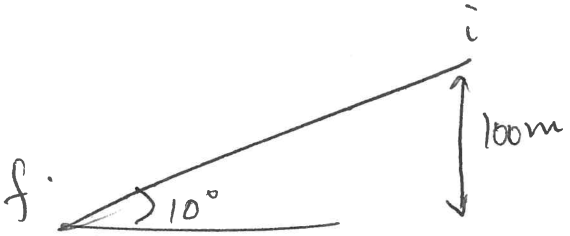
$m_1 = 5.0\text{ kg}$ $\qquad m_2 = 8.0\text{ kg}$.

$$\frac{1}{2} m_1 v_1^2 = 3\left(\frac{1}{2} m_2 v_2^2\right).$$

$$\frac{v_1^2}{v_2^2} = \frac{3m_2}{m_1}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{3m_2}{m_1}} = \sqrt{\frac{3(8)}{5}} = \sqrt{4.8}$$

Problem 58:



$$E_i = \frac{1}{2} m v_i^2 + mgh_i$$

$$E_f = \frac{1}{2} m v_f^2 + mgh_f$$

$U = mgh$ (Gravitational potential energy)

E = total mechanical energy.

$$\frac{1}{2} m v_f^2 = mgh_i$$

$$v_f = \sqrt{2g(100)}$$

$$= \sqrt{2(9.81)(100)}$$

$$=$$

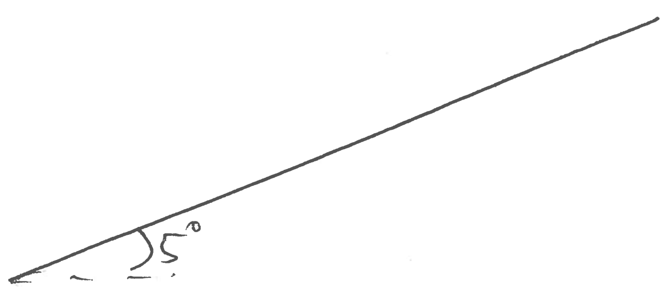
Problem 74:

$$P = \frac{W}{\Delta t} = \frac{(2500)(10)(35) + \frac{1}{2}(2500)(4)^2}{12}$$

W = Increase in potential energy + increase in kinetic energy.

(b) Cost in dollars = Power in (kWh) × \$0.090.

Problem 98:



If he has to move-up at constant speed.

$\Delta(K.E) = 0$.

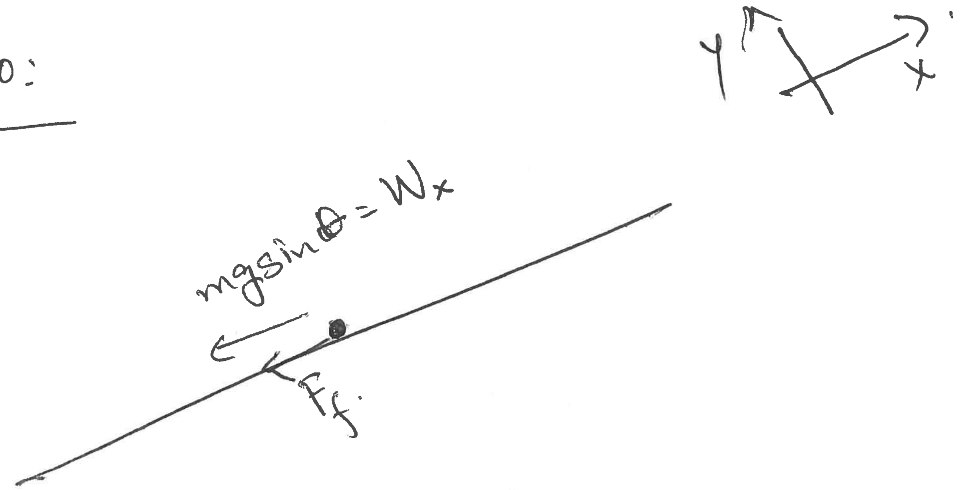
Work done by biker is against gravity.

$$P = \vec{F}.\vec{v} = (mg\sin\theta)(8)$$

$$= (80)(10)\sin 15^\circ)(8)$$

Ch: 8

Problem 40:



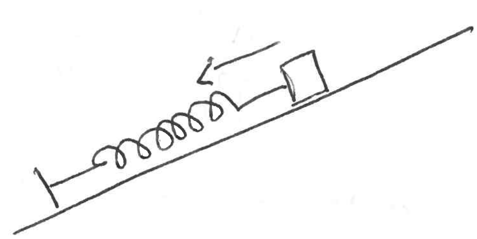
Using Energy Conservation.

$E_i = E_f$ + Work done against friction.

$\frac{1}{2}mv_i^2 = mgh + F_f(14.2)$.

$\frac{1}{2}m(10)^2 = mg(14.2\sin 20°) + F_f(14.2)$.

Problem 64:



(a) $U_i = \frac{1}{2}k(\Delta x)^2 = \frac{1}{2}(80)(0.1)^2 = 0.4\,J$.

(b) $U_i + mgh_i = mgh_f + \frac{1}{2}mv_f^2$

$$\frac{1}{2} m v_f^2 = U_i + mg(h_i - h_f).$$

where $(h_f - h_i) = 0.1\text{m}$.

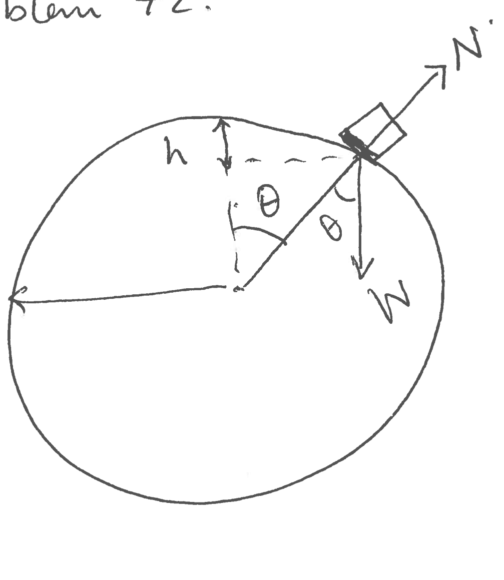
(c) $$U_i = mg(h_f - h_i).$$

$$\frac{1}{2} k(\Delta x)^2 = mg\,\Delta h.$$

$$\Delta h = \frac{\frac{1}{2} k(\Delta x)^2}{mg}.$$

Distance up the ramp is $\Delta s = \dfrac{\Delta h}{\sin(30^\circ)}$

Problem 72:



Using 2^{nd} Law

$$-N + W\cos\theta = \frac{mv^2}{R}.$$

$$N = -\frac{mv^2}{R} + mg\cos\theta$$

Using conservation of energy

$$h = R - R\cos\theta.$$

$$\frac{1}{2} mv^2 = mgh.$$
$$= mg(R - R\cos\theta)$$
$$v^2 = 2g(R - R\cos\theta)$$

$$N = -\frac{m\,2gR(1-\cos\theta)}{R} + mg\cos\theta.$$

$N \geq 0$ for the block to stay on the surface of the sphere.

$$-2(1-\cos\theta) + \cos\theta.$$

$$-2 + 3\cos\theta \geq 0.$$

$$\cos\theta \geq 2/3.$$

$$\theta_{min} = \cos^{-1}(2/3).$$

Problem 74:

(a) $\frac{1}{2}mv_f^2 = mgh - (F_f)(2.0/\sin 30^\circ).$

$F_f = \mu_k N.$; $v_f \equiv$ velocity at the bottom of incline

Since we don't know μ_k.

We use conversion of block's kinetic energy to spring's elastic potential energy.

$$\frac{1}{2}mv_f^2 = \frac{1}{2}k(\Delta x)^2$$

$$v_f^2 = \frac{k}{m}(\Delta x)^2$$

$$= \sqrt{\frac{500}{10}(0.75)^2}$$

$$v_f = \sqrt{50(0.75)^2}$$

Work done against friction is.

$$W_{friction} = mgh - \frac{1}{2}mv_f^2.$$

$$= (10)(10)(2) - \frac{1}{2}(10)\left(\sqrt{50(0.75)^2}\right)^2.$$

$$= 200 - (5)(50)(0.75)^2.$$

$$= 200 - 140.625 = \underline{59.375\ J}.$$

Use this to find μ_k.

(c) $v_i = \sqrt{\frac{k}{m}(\Delta x)^2}$

$v_i = v_f$. no loss of energy on recoiling back from spring until the block reaches bottom of incline

v_f from part (b).

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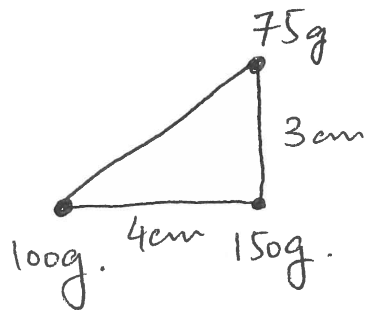
let's assume it gain vertical h.

(d) $\frac{1}{2}mv_i^2 = mgh + (\mu_k mg \cos\theta)\left(\frac{h}{\sin\theta}\right).$

$$h = \left(\frac{\frac{1}{2}mv_i^2}{mg + \mu_k mg \frac{\cos\theta}{\sin\theta}}\right).$$

Ch : 9

Problem 63 :



Let's choose co-ordinate system origin at the position of 100g mass.

$$X_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{(m_1 + m_2 + m_3)}$$

$$= \frac{(100)(0) + (150)(4) + (75)(4)}{325}$$

$$= \frac{900}{325}$$

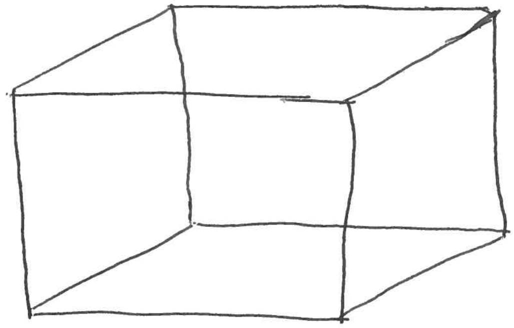
$$X_{cm} = 2.76 \text{cm}$$

$$Y_{cm} = \frac{(100)(0) + (150)(0) + (75)(3)}{325}$$

$$= 0.69 \text{ cm}.$$

$$(x_{cm}, y_{cm}) = (2.76, 0.69).$$

Problem 72:



Centre of mass of cube of side b

is $\left(\frac{b}{2}, \frac{b}{2}, \frac{b}{2}\right)$.

Similarly centre of mass of cube of side a

$\left(-\frac{a}{2}+r, \frac{a}{2}, \frac{a}{2}\right)$. $\left(r-\frac{a}{2}, \frac{a}{2}, \frac{a}{2}\right)$.

mass of cube with side b

is $6b^2$ assuming uniform mass density on each face and setting it to 1.

mass of cube with side a

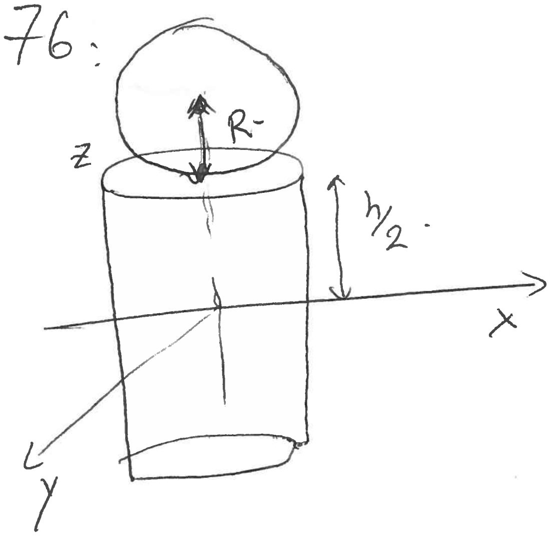
is $6a^2$.

$$X_{cm} = \frac{m_1 X_1 + m_2 X_2}{m_1 + m_2} = \frac{6b^2\left(\frac{b}{2}\right) - 6a^2\left(r-\frac{a}{2}\right)}{6b^2 - 6a^2}.$$

$$y_{cm} = \frac{1}{2}\frac{(b^3 - a^3)}{b^2 - a^2}. \qquad z_{cm} = \frac{1}{2}\frac{(b^3 - a^3)}{b^2 - a^2}.$$

Problem 76:

(a)



co-ordinate system with origin at the centre of cylinder.

$$z_{cm}^{sphere} = \frac{h}{2} + R.$$

$$z_{cm} = \frac{M\left(\frac{h}{2} + R\right)}{m + M}. \qquad x_{cm} = 0$$

$$y_{cm} = 0$$

(b).

$$z_{cm} = \frac{M(r + R)}{m + M}. \qquad x_{cm} = y_{cm} = 0.$$