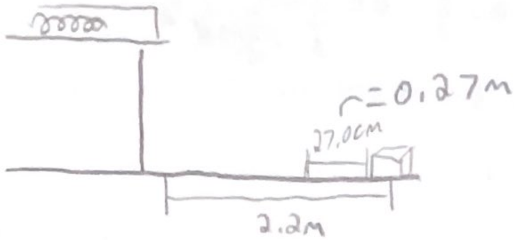
9.)

Frank Ceraolo



$g = 10\,m/s^2$

$\Delta x_B = 1.1\,cm = 0.011\,m$

From spring compressed → leaving

$0 = KE + PE \qquad 0 = \left(\frac{1}{2}mv_f^2 - \cancel{\frac{1}{2}mv_i^2}\right) + \left(\cancel{\frac{1}{2}k\Delta x_f^2} - \frac{1}{2}k\Delta x_B^2\right)$

$\Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}k\Delta x_B^2$

Bobby $\frac{1}{2}k\Delta x_B^2 + \cancel{mgh} = \frac{1}{2}mv^2$

Rhoda $\frac{1}{2}k\Delta x_R^2 + \cancel{mgh} = \frac{1}{2}mv^2$

Say this happens in 1 second (time same because freefall)

Bobby $\frac{1}{2}k\Delta x_B^2 = \frac{1}{2}m\cdot(2.2-0.27)^2$

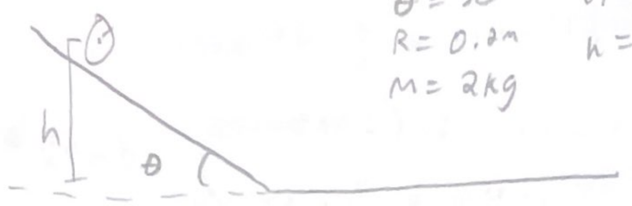
Rhoda $\frac{1}{2}k\Delta x_R^2 = \frac{1}{2}m(2.2)^2$

$$\frac{B}{R} = \frac{\cancel{\frac{1}{2}k}\Delta x_B^2}{\cancel{\frac{1}{2}k}\Delta x_R^2} = \frac{\cancel{\frac{1}{2}m}(1.93)^2}{\cancel{\frac{1}{2}m}(2.2)^2}$$

$$= \frac{0.011^2}{\Delta x_R^2} = \frac{1.93^2}{2.2^2}$$

$$\Delta x_R = \sqrt{\frac{0.011^2}{\left(\frac{1.93^2}{2.2^2}\right)}} = 0.0125389\,m \cdot \frac{100\,cm}{1\,m} = \boxed{1.25389\,cm}$$

10.)

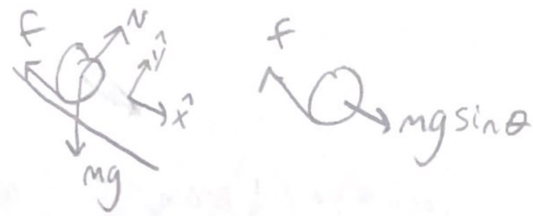


$\theta = 30^\circ$ $\quad V_i = 0\ m/s$ $\quad g = 10\ m/s^2$

$R = 0.2m$ $\quad h = 3m$ $\quad I = \frac{1}{2}MR^2$

$M = 2kg$

(a.)



$$ma = Mg\sin\theta - f$$

$$f \cdot R \cdot \sin 90^\circ = I\alpha = I\frac{a}{R}$$

$$\Rightarrow f = I\frac{a}{R^2}$$

$$M \cdot a = mg\sin\theta - I\frac{a}{R^2}$$

$$ma = mg\sin\theta - \frac{\frac{1}{2}MR^2 a}{R^2}$$

$$\cancel{M}a = \cancel{M}g\sin\theta - \frac{1}{2}\cancel{M}a$$

$$a + \frac{1}{2}a = g\sin\theta$$

$$a = \frac{g\sin\theta}{\frac{3}{2}} = \frac{10 \cdot \sin(30)}{\frac{3}{2}} = 3.33\ m/s^2$$

(b.) $\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

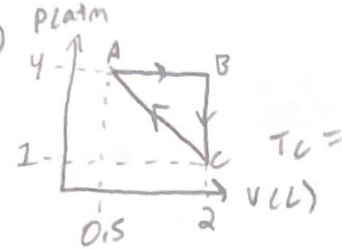
$$V = \sqrt{2gh} = \sqrt{2 \cdot 10 \cdot 3} = 7.74597\ m/s$$

$$V = rw \qquad \frac{V}{r} = w = \frac{7.74597}{0.2} = 38.7298\ rad/s$$

$$KE_{rot} = \frac{1}{2}Iw^2 = \frac{1}{2}\left(\frac{1}{2}MR^2\right) \cdot w^2 = \frac{1}{2}\left(\frac{1}{2} \cdot 2 \cdot 0.2^2\right) \cdot 38.7298^2$$

$$= 30\ J$$

11.)



$T_C = 300K$ $\quad C_V = \frac{3}{2}R$

Frank Cera010

(a) From $B \to C$ Isovolumetric $\quad PV = nRT$ (V constant) $\Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\frac{P_C}{T_C} = \frac{P_B}{T_B}$ $\quad 1atm = 10^5 Pa$ $\quad \frac{10^5}{300K} = \frac{4 \cdot 10^5}{T_B}$

$T_B = \frac{4 \cdot 10^5}{\left(\frac{10^5}{300K}\right)} = 1200\ K$

From $A \to B$ Iso Baric $\quad PV = nRT$ (P constant) $\Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{V_B}{T_B} = \frac{V_A}{T_A}$ $\quad 1L = 10^{-3} m^3$ $\quad \frac{2 \cdot 10^{-3}}{1200K} = \frac{0.5 \cdot 10^{-3}}{T_A}$ $\quad T_A = \frac{0.5 \times 10^{-3}}{\left(\frac{2 \cdot 10^{-3}}{1200}\right)} = 300K$

(b) $A \to B$ (isobaric) $\quad W = -P\Delta V$

$W = -(4 \cdot 10^5) \cdot ((2 \cdot 10^{-3}) - (0.5 \cdot 10^{-3})) = -600\ J$

$B \to C$ (isovolumetric) $\quad W = -P\underbrace{\Delta V}_{=0} \quad W = 0$

$C \to A \quad \Delta E_{int} = nC_V\Delta T = 0$ $\quad W = -P\Delta V$

P over the process $= \frac{4 \cdot 10^5 + 1 \cdot 10^5}{2} = \frac{5}{2} 10^5$ $\quad W = -\frac{5}{2} \cdot 10^5 \cdot ((0.5 \cdot 10^{-3}) - (2 \cdot 10^{-3}))$

$W = 375\ J$

(c.) $\Delta E_{int} = nC_V\Delta T$ for all processes

At Point C: $PV = nRT \quad (1 \cdot 10^5) \cdot (2 \cdot 10^{-3}) = n \cdot 8.314 \cdot 300$

$\Rightarrow n = 0.080186$ moles

$A \to B \quad \Delta E_{int} = nC_V\Delta T = 0.080186 \cdot \frac{3}{2} \cdot 8.314 \cdot (\overset{T_B}{1200} - \overset{T_A}{300}) = 900 J$

$B \to C \quad \Delta E_{int} = nC_V\Delta T = 0.080186 \cdot \frac{3}{2} \cdot 8.314 \cdot (\overset{T_C}{300} - \overset{T_B}{1200}) = -900 J$

$C \to A \quad \Delta E_{int} = nC_V\Delta T = 0.080186 \cdot \frac{3}{2} \cdot 8.314 \cdot (\overset{T_A}{300} - \overset{T_C}{300}) = 0\ J$

(d.) $A \to B$ (isobaric) $Q = n C_p \Delta T$

$$Q = 0.080186 \cdot \frac{5}{2} \cdot 8.314 \cdot (\overset{T_B}{1200} - \overset{T_A}{300}) = 1500\ J$$

$B \to C$ (isovolumetric) $Q = n C_v \Delta T$

$$Q = 0.080186 \cdot \frac{3}{2} \cdot 8.314 \cdot (\overset{T_C}{300} - \overset{T_B}{1200}) = -900\ J$$

$C \to A$ since $\Delta E_{int} = 0$ $Q = -W$

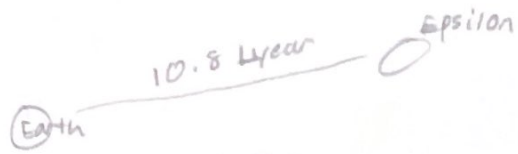
$Q = -375\ J$

(e.) $e = \frac{W_s}{Q_H}$ $\to$ (works w/ positive sign) $\to$ (Q's w/ positive sign)

$$e = \frac{375}{1500} = 0.25 = 25\%$$

12.)

From Ceraolo



$V_p = 0.3c$

(a.) $T = \frac{L}{V}$ $\quad \frac{10.8}{0.3} = 36$ lightyears

(b.) $T = \frac{L}{V}$ $\quad \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{1}{\sqrt{1 - \frac{(0.3c)^2}{c^2}}} = 1.04826$

$L = \frac{L_p}{\gamma}$ $\quad \frac{10.8 \text{ lyr}}{1.04828} = 10.3025$ lightyears

$T = \frac{10.3025}{0.3} = 34.3418$ lightyears

(c.) $u' = \frac{u - v}{1 - \frac{uv}{c^2}}$

S frame = Epsilon plant
S' frame = Probe
Object = interceptor

$$u' = \frac{-0.7c - 0.3c}{1 - \frac{-0.7c \cdot 0.3c}{c^2}} = -2.47934 \times 10^8$$

$$\frac{u'}{c} = -0.826446c$$