Physics 1250 Final - Vibha Ramesh

9. Target box 2.2 m
Spring compressed 1.1 cm
Marble falls 27.0 cm short

Variables:

Bobby $v_1 \rightarrow v_{1B}$ Rhonda $v_2 \rightarrow v_{1R}$

$v_1 = v_{1B} = \frac{x_1}{t}$ x = distance covered $v_2 = v_{1R} = \frac{x_2}{t}$

Compression length:

$\frac{1}{2}kl_1^2 = \frac{1}{2}mv_1^2$ $\frac{1}{2}kl_2^2 = \frac{1}{2}mv_2^2$

Putting Equations together: (elimination)

$$\frac{\cancel{\frac{1}{2}}\cancel{k}l_1^2 = \cancel{\frac{1}{2}}\cancel{m}v_1^2}{\cancel{\frac{1}{2}}\cancel{k}l_2^2 = \cancel{\frac{1}{2}}\cancel{m}v_2^2}$$

$$\frac{l_1}{l_2} = \frac{v_1}{v_2} \longrightarrow \frac{l_1}{l_2} = \frac{\frac{x_1}{t}}{\frac{x_2}{t}} \rightarrow \frac{l_1}{l_2} = \frac{x_1}{x_2}$$

$l_2 = l_1\left(\frac{x_2}{x_1}\right)$ $l_1 = 0.011\text{ m}$ $x_1 = 2.2\text{ m} - 0.27\text{ m} = 1.93$
$x_2 = 2.2\text{ m}$

$$l_2 = (0.011\text{ m})\left(\frac{2.2}{1.93}\right) = 0.0125\text{ m}$$

$$\boxed{l_2 = 1.25\text{ cm}}$$

(10) $R = 0.2m$ $m = 2\,kg$ $h = 3\,m$ $g = 10\,m/s^2$ $I = \frac{1}{2}MR^2$

a) Find LINEAR acceleration

$a_T = r\alpha$

$I = \frac{1}{2}MR^2$

$= \frac{1}{2}(2)(.2)^2 = 0.04$

$\tau = Fr\sin\theta$ $\tau = I\alpha$

$Fr\sin\theta = I\alpha$

$\frac{Fr\sin\theta}{I} = \alpha \rightarrow \frac{mg\,r\sin\theta}{I} = \alpha = \frac{(2)(10)(.2)\sin(30)}{0.04} = \alpha$

$\alpha = 50$

$a_T = r\alpha \rightarrow a_T = 0.2(50) = \underline{10\,m/s^2}$

b) rotational KE

$\omega_f^2 = \omega_0^2 + 2\alpha\theta$

$KE_f = \frac{1}{2}I\omega_f^2$

$\omega_f^2 = (0)^2 + 2(50)\sin(30)$

$\omega_f = 7.071$

$KE_f = \frac{1}{2}(0.04)(7.071)^2$

$= 1\,J$

(11) Heat Engine $\quad PV = nRT$

	P	V	T
A	4 atm	0.5	300
B	4	2	1200
C	1	2	300

a) $\dfrac{P_B}{P_c} = \dfrac{T_B}{T_c} \rightarrow$

$\dfrac{4}{1} = \dfrac{T_B}{300K}$ $\quad \boxed{T = 1200K}$

$\dfrac{V_A}{V_B} = \dfrac{T_A}{T_B} \rightarrow \dfrac{0.5}{2} = \dfrac{T_A}{1200K}$ $\quad \boxed{T_A = 300K}$

e) efficiency
$= 1 -$

$C_v = \frac{3}{2}R$

b, c, d) work, IE change, heat transferred

$PV = nRT$ for C $\rightarrow$ find n

$(1\times10^5)(2\times10^{-3}) = n(8.314)(300k)$ $\quad n = 0.080$ mol

A → B

$W = -P\Delta V = (-4\times10^5)((2-0.5)\times10^{-3}) = -400$ J

$\Delta E_{int} = nC_v\Delta T = 0.080(\frac{3}{2}(8.314))(1200-300) = 897.912$ J

$Q = \Delta E_{int} - W = 897.912 - (-400) = 1297.912$

B → C

$W = -P\Delta V = 0$, $\quad \Delta V = 0$

$\Delta E_{int} = nC_v\Delta T = 0.080(\frac{3}{2}(8.314))(300-1200) = -897.912$

$Q = \Delta E_{int} - W = -897.912 - 0 = -897.912$

$W = \text{area under curve} = ((\frac{4+1}{2})(2-.5))\times100 = 375$ J

C → A

$\Delta E_{int} = 0 = nC_v\Delta T$, $\Delta T = 0$ $\quad Q = \Delta E_{int} - W = 0 - 375 = -375$ J

(12)

Distance → 10.8 LY $\xrightarrow{\text{launch at}}$ 0.3c

a) Earth's frame

$$\Delta t = L/v = \frac{L_p}{v} = \frac{10.8}{0.3c} = 1.2 \text{ ns}$$

b) Probe's frame

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1}{\sqrt{1-\frac{(0.3c)^2}{c^2}}} = 1.048$$

distance $= L_p/\gamma = 10.8/1.048 = 10.30$ Light years

$$\Delta t_p = L/v = \frac{10.3}{0.3c} = 1.14 \text{ ns}$$

vel of int as seen by probe

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

$u' = $ I seen by P

$u = $ speed I $= -0.7$

$v = $ speed P $= 0.3$

$$u' = \frac{-0.7 - 0.3}{1 - \frac{(-0.7)(0.3)}{c^2}} = -0.174c$$