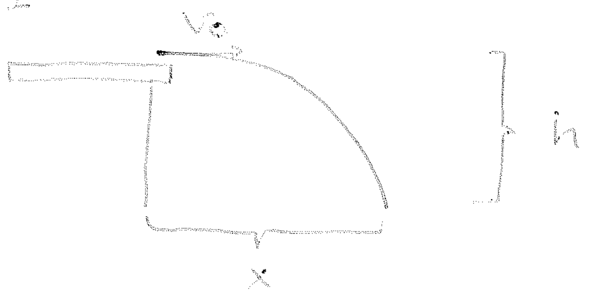
Assignment 6 Solutions

Q1



We will find v_0 using our knowledge of projectile motion

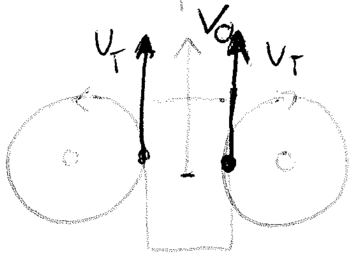
<u>in this situation:</u>

(1) $x = v_0 t$ $\Rightarrow$ $v_0 = \frac{x}{t}$

(2) $h = \frac{1}{2} g t^2$ $\Rightarrow$ $t = \sqrt{\frac{2h}{g}}$

$$\underline{v_0 = x\sqrt{\frac{g}{2h}}}$$

v_0 is speed of the car when it leaves the booster



$v_0 = v_t$ – tangential velocity of the point on the rim of the wheel

$$v_T = \frac{2\pi R}{T}$$

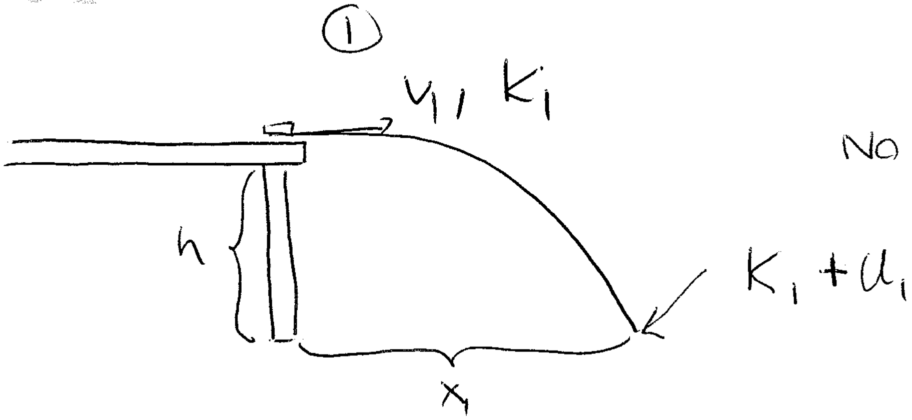
$$T = \frac{2\pi R}{v_T}$$

$$\omega = \frac{2\pi}{T} = \frac{v_T}{R} = x\sqrt{\frac{g}{2h}}\,\frac{1}{R} = \frac{x}{R}\sqrt{\frac{g}{2h}} \quad \left(\frac{rad}{s}\right)$$

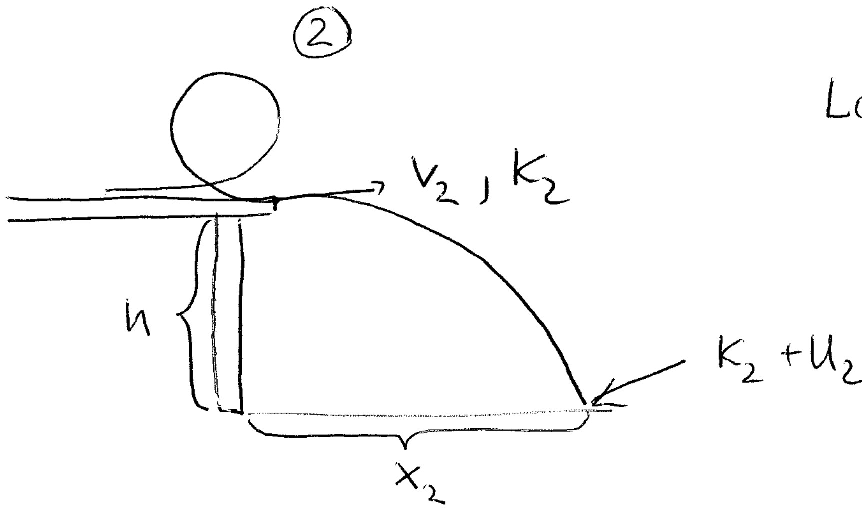
In this question we are asked to find ω in rpm (revolutions per minute)

$$\underline{\omega\,(rpm) = \frac{x}{R}\sqrt{\frac{g}{2h}}\left(\frac{60}{2\pi}\right) \; rpm}$$

correct answer is obtained by using this formula



No losses



Losses on the loop

$$K_1 - K_2 = W = \text{loss on the loop}$$

$$\frac{m v_1^2}{2} - \frac{m v_2^2}{2} = W$$

$$\frac{m}{2}\left(x_1^2 \frac{g}{2h} - x_2^2 \frac{g}{2h}\right) = W$$

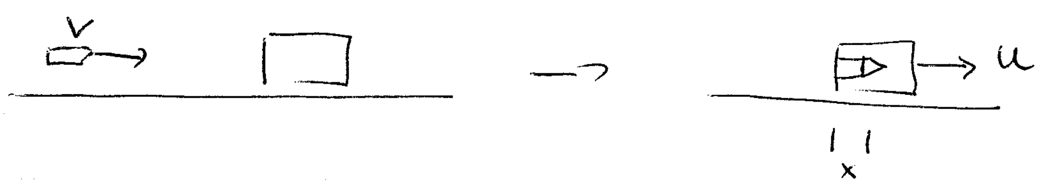
$$\frac{mg}{4h}\left(x_1^2 - x_2^2\right) = W$$

03

1) When block is in the vice all of its kinetic energy is lost due to "friction" inside the block that is being penetrated.

Ⓐ $K_i = Fd \rightarrow \frac{1}{2} m v^2 = Fd$

2) When the block is free to move



x - depth of the hole   u - velocity of block + bullet

For such inellastic collision we have:

Ⓑ $\frac{1}{2} m v^2 = \frac{1}{2} (M+m) u^2 + Fx$ F - force of friction is the same as before

Ⓒ $m v = (M+m) u$

From Ⓐ and Ⓑ we have:

$$Fd = \frac{1}{2}(M+m)u^2 + Fx$$

Using Ⓒ

$$Fd = \frac{1}{2}(M+m)\left(\frac{m}{M+m}\right)^2 v^2 + Fx$$

$$Fd = \left(\frac{m}{M+m}\right)\frac{1}{2} m v^2 + Fx$$

$$\cancel{F}d = \frac{m}{M+m}(\cancel{F}d) + \cancel{F}x$$

Q3 cont

$$d = \left(\frac{m}{M+m}\right) d + x$$

$$\underline{x = \left(1 - \frac{m}{M+m}\right) d}$$

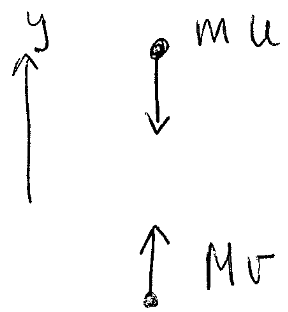
Q4

The first part of the problem - collision will yield the final velocity of the „vampire - werewolf" furry ball.

The second part is essentially a „free-fall" problem:

an object has certain velocity when it is shot up from a known height h. Using kinematic equations we can find t - time it will take for it to land.

1) Collision is inelastic (vampire connects with werewolf)



Conservation of linear mom.

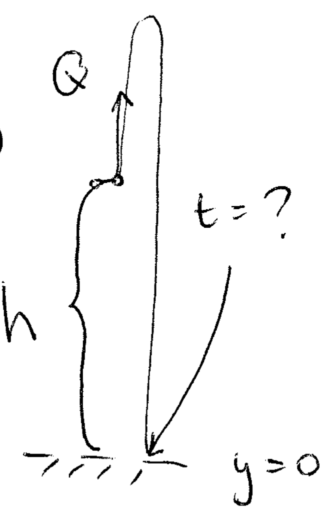
$$p_i = p_f$$

$$Mv - mu = (M+m)\,Q$$

↑ final velocity

$$Q = \left(\frac{Mv - mu}{M+m}\right)$$

2)



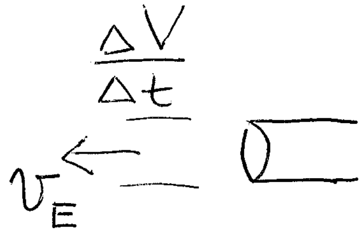
$$y_f = y_i + Q t - \frac{1}{2} g t^2$$

$$0 = h + Q t - \frac{1}{2} g t^2$$

positive solution:

$$\boxed{t = \frac{Q + (2hg + Q^2)^{1/2}}{g}}$$

Q7



$$\frac{\Delta m}{\Delta t} = \rho_{H_2O} \frac{\Delta V}{\Delta t} = \frac{\Delta V}{\Delta t} \quad [kg/s] \quad \rho_{H_2O} = 1 \frac{kg}{l}$$

$$F_{Thrust} = v_E \frac{\Delta m}{\Delta t} = v_E \left(\frac{\Delta V}{\Delta t} \right)$$