Assignment. 3

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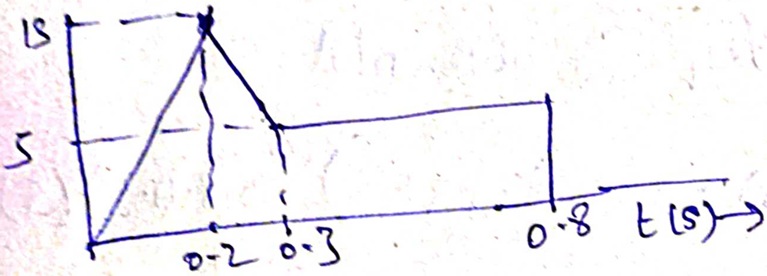
1) Given,

$m = 60g = 0.06\,kg$

weight $= mg = (0.06)(9.81) = 0.5886\,N$

At the interval $0 < t < 0.2s$

$P = \frac{13}{0.2} t = 65t$



Before the rocket lifts off

$S = W - P = 0.5886 - 65t$

let at $t = t_1$, $S = 0$ then

$0 = 0.5866 - 65t_1$

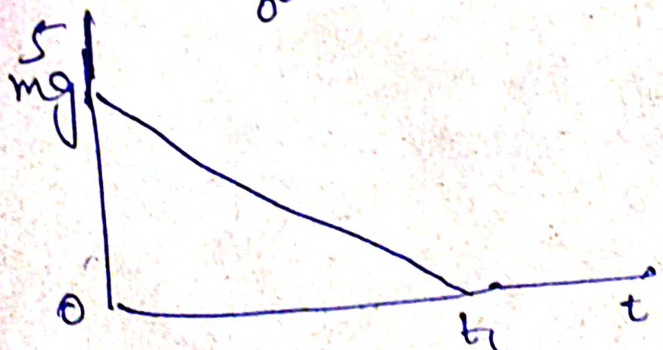
$\Rightarrow \boxed{t_1 = 0.009\,s}$

Impulse due to S; $(t \to t_1)$

$\int_0^t S\,dt = \int_0^{t_1} S\,dt = \frac{1}{2} mg\,t_1$

$= \frac{1}{2}(0.5)(0.5886)(0.009)$

$= 0.0026\,Ns$



the maximum speed occurs when $\frac{dv}{dt} = a = 0$

At this time $w - P = 0$ which occurs at $t_2 = 0.8$

a) Maximum speed

from principle of impulse and momentum

$$\int_0^{0.8} P\,dt = \text{area under the given plot}$$

$$= \frac{1}{2}(0.2)(13) + \frac{1}{2}(0.1)(13+5)(0.8-0.3)(5)$$

$$= 4.7\,NS$$

$$\int_0^{0.8} w\,dt = (0.5886)(0.8) = 0.47088\,NS$$

$$m_1 v_1 + \int_0^{0.8} P\,dt + \int_0^{0.8} S\,dt - \int_0^{0.8} w\,dt = m v_2$$

$$0 + 4.7 + 0.002 - 0.47088 = 0.06\,(v_2)$$

$$\boxed{v_2 = 70.5\,m/s}$$

the maximum speed occurs when $\frac{dv}{dt} = a = 0$

At this time $W - P = 0$ which occurs at $t_2 = 0.8s$

a) Maximum speed

from principle of impulse and momentum

$\int_0^{0.8} P\,dt$ = area under the given plot

$= \frac{1}{2}(0.2)(13) + \frac{1}{2}(0.1)(13+5)(0.8-0.3)(5)$

$= 4.7\,NS$

$\int_0^{0.8} W\,dt = (0.5886)(0.8) = 0.47088\,NS$

$mV_1 + \int_0^{0.8} P\,dt + \int_0^{0.8} S\,dt - \int_0^{0.8} W\,dt = mV_2$

$0 + 4.7 + 0.002 - 0.47088 = 0.06(V_2)$

$$\boxed{V_2 = 70.5\,m/s}$$

b) Time to reach maximum height

$$m_1 v_1 + \int_0^{t_3} P\,dt + \int_0^{t_3} S\,dt - W t_3 = m v_3$$

$$0 + 4.7 + 0.00266 - 0.5886(t_3) = 0$$

$$\boxed{t_3 = 7.99\,s}$$

2) given, $m = 200g$

$f_{avg} = 2KN = 2000N$

$\Delta t = 2ms = 0.002s$

a) Velocity imediately after impact

from principal of impulse & momentum

$$m v_1 + f_{avg}(\Delta t) = m v_2$$

$$0 + f_{avg}(\Delta t) = m v_2$$

$$v_2 = \frac{2000(0.002)}{0.2} = 20\,m/s$$

b) Average resistance to penetration

$\Delta x = 1mm = 0.001m$

$v_2 = 20m/s \quad v_3 = 0$

from principle of work & Energy

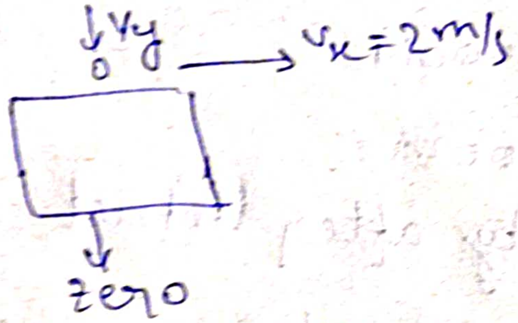
$$T_2 + U_{2\to 3} = T_3$$

$\frac{1}{2}mv^2 - R_{ave}(\Delta x) = 0$

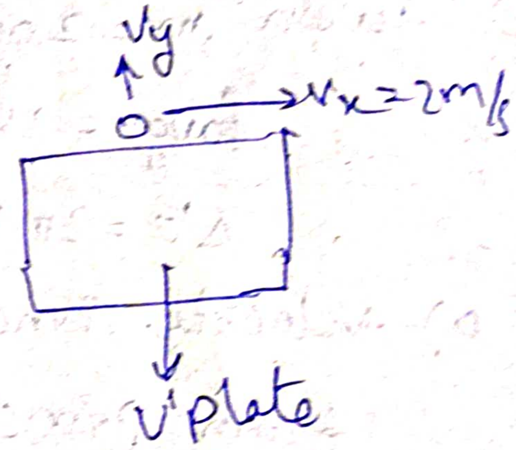
$R_{ave} = \frac{mv^2}{2(\Delta x)} = \frac{0.2\,(20)^2}{2\,(0.001)} = 40\times10^3\,N$

$\boxed{R_{ave} = 40\,KN}$

3) FBD Before impact



FBD just after impact



$V_y = \sqrt{2gh}$
$= \sqrt{2(9.81)(1.6)}$

$\boxed{V_y = 5.603\,m/s}$

$V_y' = \sqrt{2(9.81)(0.6)}$

$\boxed{V_y = 3.43\,m/s}$

a) from conservation of momentum

$m_B V_y + 0 = -m_B V_y' + m_p V_p'$

$(0.075)(5.603) = 0.075(3.431) + (0.4)V_p'$

$\boxed{V_p' = 1.694\,m/s}$

b) initial energy: $(T+V)_1 = \frac{1}{2}(0.075)(2)^2 + (0.075)(9)(1.6)$

final energy:

$$(T+V)_2 = \frac{1}{2}(0.075)(2)^2 + 0.075(g)(0.6) + \frac{1}{2}(0.4)(1.699)^2$$

energy lost = $(1.3272 - 1.1653)$ J

$$\boxed{\text{energy lost} = 0.1619\ J}$$

4) from conservation of angular momentum

$$(H_O)_1 = (H_O)_2$$

$$r_1 m v_1 = r_2 m v_2$$

$$v_2 = \frac{r_1 v_1}{r_2} = \frac{15(30)}{10} = 45\ ft/s$$

$$v_2 = \sqrt{(v_2)_r^2 + (v_2)_\theta^2} = \sqrt{3^2 + (45)^2} = 45.10\ ft/s$$

from principle of work & Energy

$$T_1 + \Sigma U_{1\to 2} = T_2$$

$$\frac{1}{2} m v_1^2 + U_F = \frac{1}{2} m v_2^2$$

$$\frac{1}{2}\left(\frac{150}{32.2}\right)(30)^2 + U_F = \frac{1}{2}\left(\frac{150}{32.2}\right)(45.1$$

$$\boxed{U_F = 2641\ ft\ lb}$$

b) initial energy: $(T+V)_1 = \frac{1}{2}(0.075)(2)^2 + (0.075)(9)(1.6)$

final energy:

$$(T+V)_2 = \frac{1}{2}(0.075)(2)^2 + 0.075(g)(0.6) + \frac{1}{2}(0.4)(1.699)^2$$

energy lost $= (1.3272 - 1.1653)$ J

$$\boxed{\text{energy lost} = 0.1619\text{ J}}$$

4) from conservation of angular momentum

$$(H_O)_1 = (H_O)_2$$

$$r_1 m v_1 = r_2 m v_2$$

$$v_2 = \frac{r_1 v_1}{r_2} = \frac{15(30)}{10} = 45\text{ ft/s}$$

$$v_2 = \sqrt{(v_2)_r^2 + (v_2)_\theta^2} = \sqrt{3^2 + (45)^2} = 45.10\text{ ft/s}$$

from principle of work & Energy

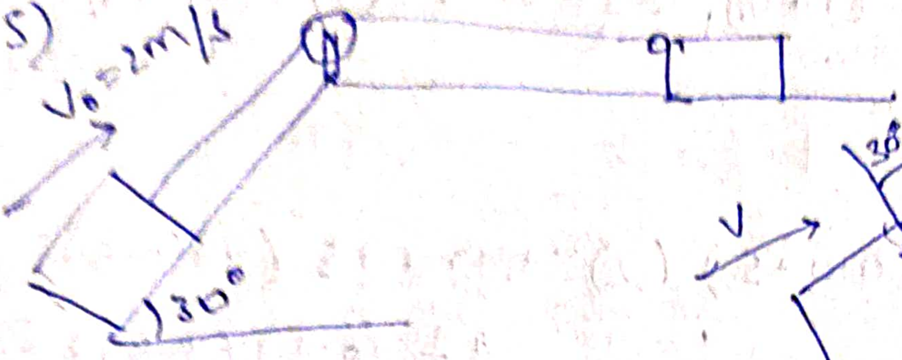
$$T_1 + \Sigma U_{1\to 2} = T_2$$

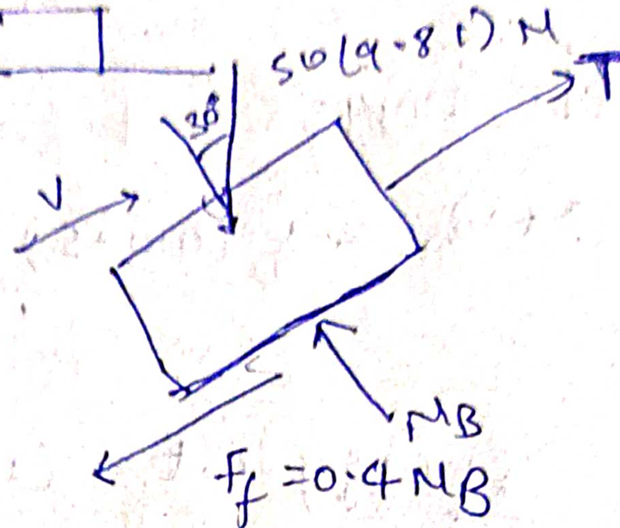
$$\frac{1}{2}mv_1^2 + U_F = \frac{1}{2}mv_2^2$$

$$\frac{1}{2}\left(\frac{150}{32.2}\right)(30)^2 + U_F = \frac{1}{2}\left(\frac{150}{32.2}\right)(45.10)^2$$

$$\boxed{U_F = 2641\text{ ft lb}}$$

5)





FBD of the block is

$+\uparrow \Sigma F_x = 0;$

$N_B - 50(9.81)\cos 30° = 0$

$\boxed{N_B = 424.79 N}$

$(+\nearrow)\ m(v_x)_1 + \Sigma \int F_x\,dt = m(v_x)_2$

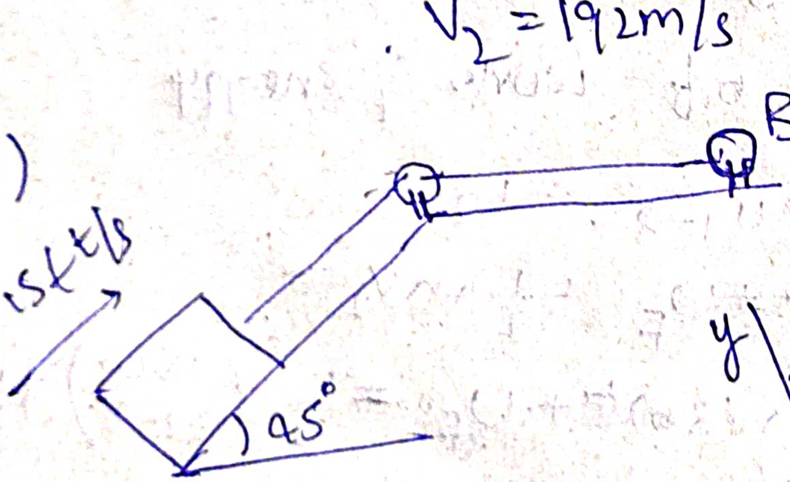
$50(2) + \int_0^2 (300 + 120\sqrt{t})\,dt - 0.4(424.79)(2)$

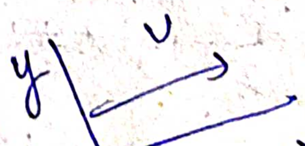
$- 50(9.81)(\sin 30)(2)$

$= 50 V_2$

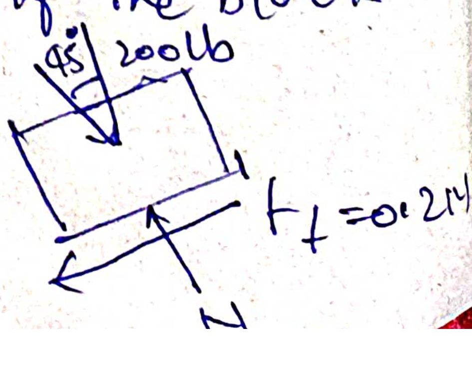
$\therefore V_2 = 192 m/s$

6)





FBD of the block



from principle of impulse and momentum

from fig (a)

$$+\uparrow (mv_1)_y + \Sigma \int_{t_1}^{t_2} F_y dt = m(v_2)_y$$

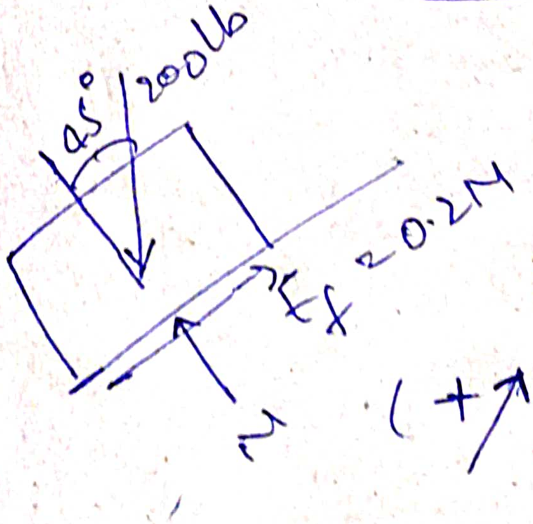
$$\frac{200}{32.2}(0) + N(t') - 200(\cos 45^\circ)(t') = \frac{200}{32.2}(0)$$

$$\boxed{N = 141.42 \text{ lb}}$$

$$+\nearrow m(v_1)_x + \Sigma \int_{t_1}^{t_2} F_x dt = m(v_2)_x$$

$$\frac{200}{32.2}(15) - 200(\sin 45^\circ)(t') - 0.2(141.42)t' = \frac{200}{32.2}(0)$$

$$\boxed{t' = 0.5490 s}$$



$t'' = 2 - 0.5490 = 1.451 s$

from fig b

$$(+\nearrow)\ m(v_1)_x + \Sigma \int_{t_1}^{t_2} F_x dt = m(v_2)_x$$

$$\frac{200}{32.2}(0) + 0.2(141.42)(1.451) - 200(\sin 45^\circ)(1.451) = \frac{200}{32.2}(-V)$$

$$\boxed{V = 26.9 \text{ ft/s}}$$