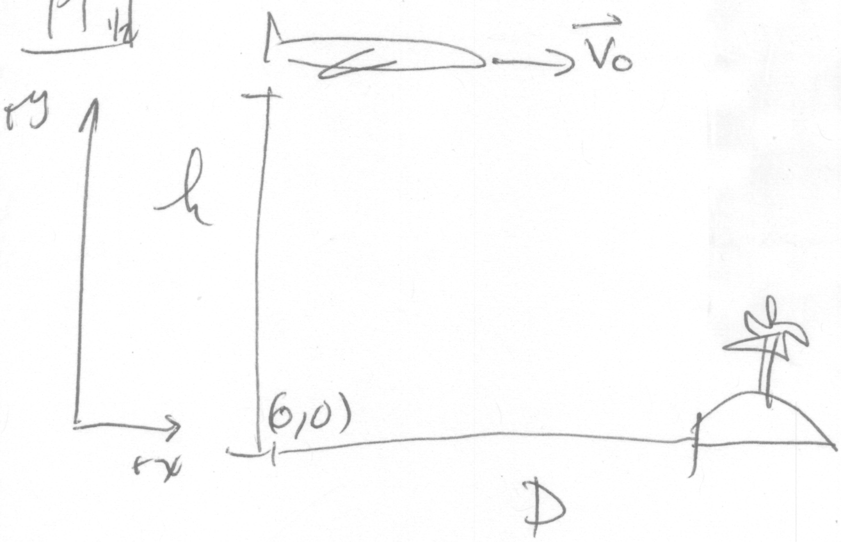
P1



Given: V_0, h

(a) how long to reach sea level?
(b) to land on island, what should D be?
(c) what is V_f?

$x(t) = 0 + V_0 t$ $\qquad$ $y(t) = h - \frac{1}{2}gt^2$

$v(t) = V_0$ $\qquad$ $V_y(t) = -gt$

$V_{x,i} = V_0$ $\qquad$ $V_{y,i} = 0$

(a) to get to sea level, $y(t_{hit}) = 0$

$$0 = h - \frac{1}{2}gt_{hit}^2$$

$$t_{hit}^2 = \frac{2h}{g} \quad ; \quad \boxed{t_{hit} = \sqrt{\frac{2h}{g}}}$$

(b) to land on island: $x(t_{hit}) = D$

$$D = V_0 t_{hit} = V_0\sqrt{\frac{2h}{g}}$$

(c) $|V_f| = \sqrt{V_{fx}^2 + V_{fy}^2}$

P1 pg 2

$V_{x,f} = V_0$

$V_y(t_{hit}) = -g t_{hit}$
$= -g\sqrt{\frac{2h}{g}}$
$= \boxed{140\ m/s}$

(a) $t_{hit} = \sqrt{\frac{2 \cdot 1000}{9.8\ m/s^2}}$
$= \boxed{14.29\ s}$

(b) $D = V_0\sqrt{\frac{2h}{g}} = (200\ m/s)(14.29\ s)$
$= \boxed{2858\ m}$

(c) $V_f = \sqrt{V_{ox}^2 + V_{y,f}^2}$
$= \sqrt{(200\ m/s)^2 + (140\ m/s)^2}$
$= \boxed{244.1\ m/s}$

2
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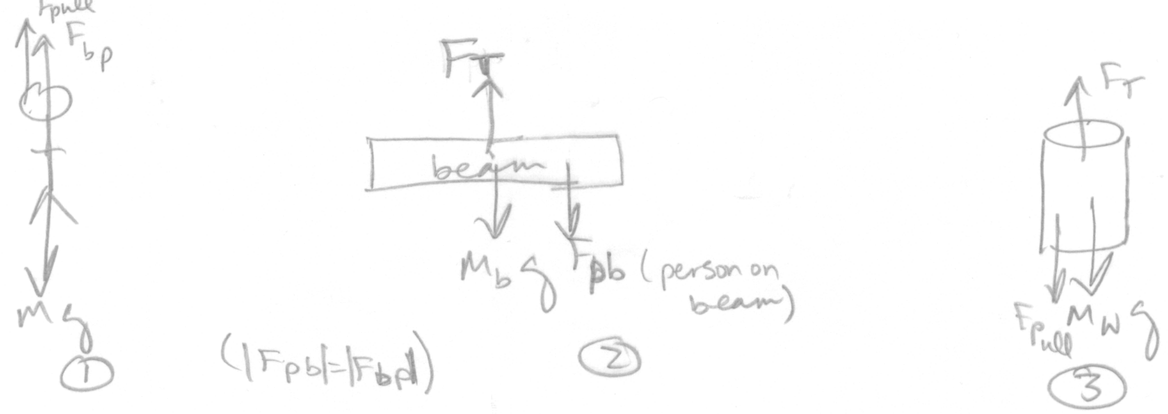

$(|F_{pb}| = |F_{bp}|)$

a) $\underline{a=0}$

① $F_p + F_{bp} - mg = 0$

② $F_T - M_b g - F_{pb} = 0$

③ $F_T - F_p - M_W g = 0.$

$\Rightarrow \overset{③}{(F_T - F_p - M_W g)} - \overset{②}{(F_T - M_b g - F_N)} = 0$

$\Rightarrow -F_p - M_W g + M_b g + F_N = 0.$

$(-F_p - M_W g + M_b g + F_N) - \overset{①}{(F_p + F_{bp} - mg)} = 0$

$\Rightarrow +2F_p = -M_W g + M_b g + mg$

$\Rightarrow F_{pull} = \frac{1}{2}(-M_W + M_b + m)g$

Recall $M_W = M_b = 100\,kg$

$\Rightarrow F_{pull} = \frac{mg}{2}$ // $(= 343 \quad N)$

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b) Now, person $(\downarrow a)$ beam $(\downarrow a)$ bucket $(\uparrow a)$

so: ①' $F_N + F_p - mg = -ma$

②' $F_T - M_b g - F_N = -M_b a$

③' $F_T - M_W g - F_p = M_W a$

$\Rightarrow \overset{②}{\cancel{F_T} - M_b g - F_N} - \overset{③}{(\cancel{F_T} - M_W g - F_p)} = -M_W a - M_b a$

$\boxed{-M_b g - F_N + M_W g + F_p = -a(M_W + M_b).}$

$\Rightarrow (-M_b g - \cancel{F_N} + M_W g + F_p) + \overset{①}{(\cancel{F_N} + F_p - mg)}$

$= -a(M_W + M_b) + (-ma)$

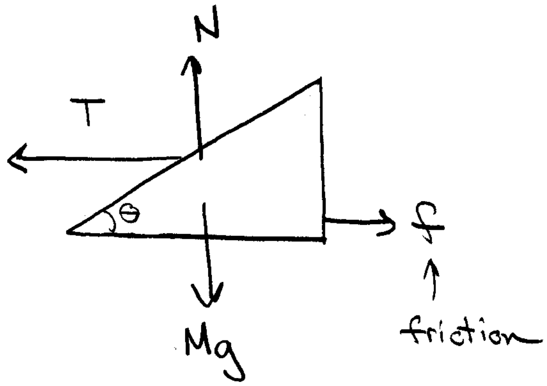
$\Rightarrow -M_b g + M_W g + F_p + F_p - mg = -a(M_b + M_W + m)$

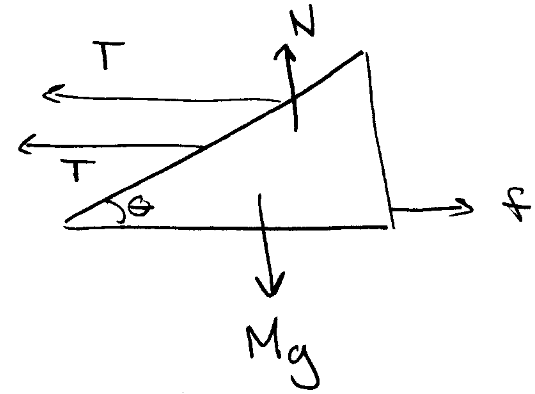
$\Rightarrow 2F_p = -a(M_b + M_W + m) - (\cancel{M_W} - \cancel{M_b} - m)g$

Recall $v_0 = 3\,m/s$, $V = 0\,m/s$, $d = 5\,m$, $\Rightarrow V^2 = v_0^2 + 2(-a)d \Rightarrow a = \frac{V_0^2}{2d}$.

$\Rightarrow F_p = \left[\left(\frac{-V_0^2}{2d}\right)(M_b + M_W + m) + mg\right](1/2) = 221.5\ N$

3a) Panel (b) will require the smallest tension to move the wedge.



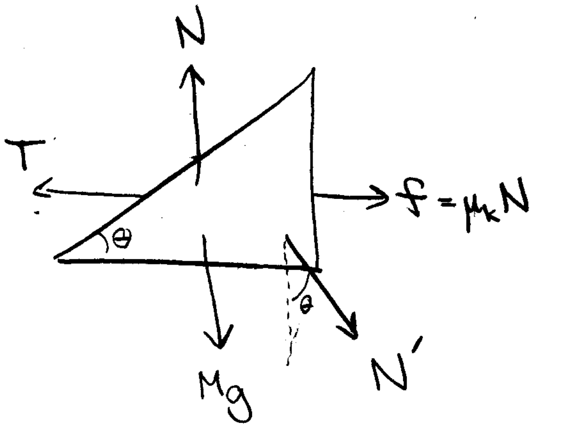


You can tell this because in order to move the wedge the net horizontal force must be greater than zero.

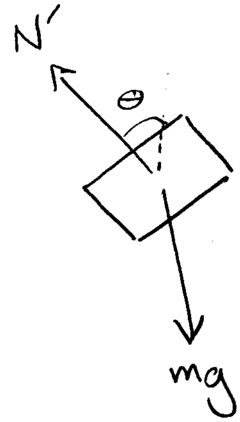
Panel a: $T - f > 0 \Rightarrow \boxed{T > f}$

Panel b: $2T - f > 0 \Rightarrow \boxed{T > f/2}$

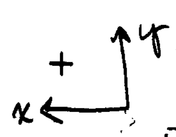
(b) Wedge



Block → (4 pts)



(c) Axes:



For the block:

$$N' \cos\theta - mg = 0 \quad \text{(No motion up or down)}$$
$$N' \sin\theta = ma$$

For the Wedge:

$$N = Mg + N' \cos\theta$$
$$T - \mu_k N - N' \sin\theta = Ma$$

4 equations.

4 unknowns (N', F, a, N).

We're done (almost):

$$N' = \frac{mg}{\cos\theta}$$

$$\therefore \quad \cancel{m}g\tan\theta = \cancel{m}a$$

$$\therefore \quad T - \mu_k(Mg + mg) - mg\tan\theta = Mg\tan\theta$$

$$T = (M+m)g\tan\theta + \mu_k(M+m)g$$

$$\boxed{T = (M+m)g\,(\tan\theta + \mu_k)}$$

Rubric:

Part a)

2 pts → for being right

4 pts → Appealed to # of ropes or FBD.
Points also awarded for arguments that appeal to work, but force must be explicitly connected.

Part b)

½ point per correctly drawn force (3.5)

+ ½ point for 3rd Law pair of N'

Part c)

9 points → for consistent equations and axes (2 pts per eq.)

→ -2 pts for setting block equation to zero in x direction.

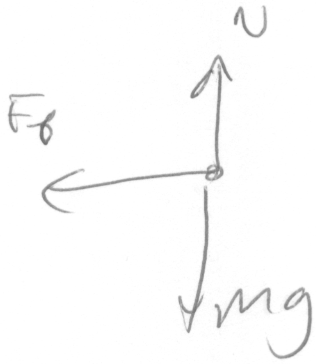
→ +2 pts if only 1 eq is right

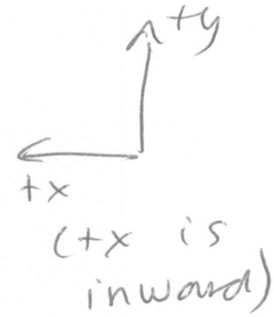
1 pts → for being right.

4| F08 MT 1 Lanzara

(a)

FBD:





$F_f \le N\mu$; for v_{max} need $\boxed{F_f = N\mu}$

2nd Law:

$\sum_x F = ma_x$

$F_f = ma_c$

$F_f = \frac{mv^2}{r}$

$\boxed{N\mu = \frac{m v_{max}^2}{r}}$

$mg\mu = \frac{m v_{max}^2}{r}$

$\boxed{v_{max} = \sqrt{g\mu r}}$

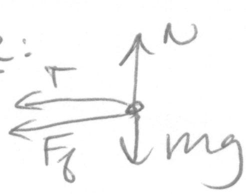
$\sum_y F = ma_y$

$N - mg = 0$

$\boxed{N = mg}$

(b) outside:

FBD:

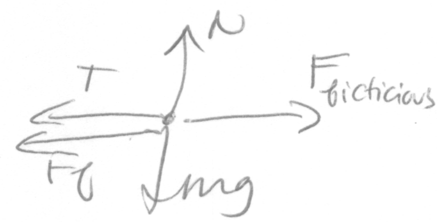


2nd Law: $T + F_f = \frac{mv^2}{r}$

$N - mg = 0$

on table:

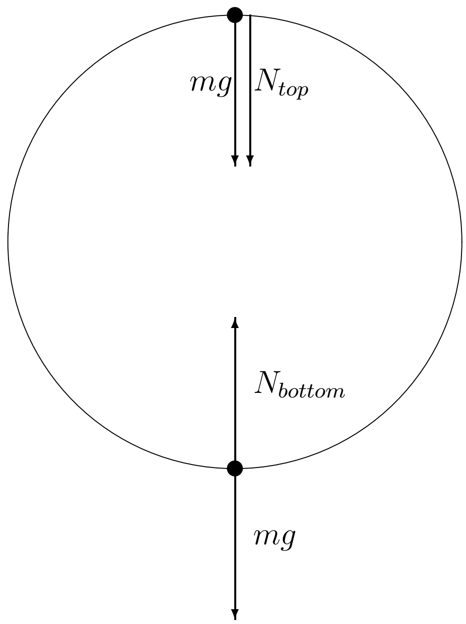
FBD:



2nd Law: $T + F_f - \frac{mv^2}{r} = 0$

$N - mg = 0$

5a)



$\Sigma F_{top} = mg + N_{top} = \frac{mv^2}{r} \quad \Rightarrow \quad N_{top} = \frac{mv^2}{r} - mg$

$\Sigma F_{bottom} = N_{bottom} - mg = \frac{mv^2}{r} \quad \Rightarrow \quad N_{bottom} = \frac{mv^2}{r} + mg$

$N_{top} < N_{bottom}$

5b)

$\Sigma F_{top} = mg + N_{top} = \frac{mv^2}{r}$

As the plane approaches its minimum velocity, the normal force goes to 0.

$v \rightarrow v_{min} \quad \Rightarrow \quad N_{top} \rightarrow 0$

$mg = \frac{mv_{min}^2}{r} \quad \Rightarrow \quad v_{min} = \sqrt{gr}$