3-85

FOR THIS PROBLEM IT IS EASIER TO THINK ABOUT THINGS FROM THE POINT OF VIEW OF THE CAR (ITS REST FRAME).

IN THIS FRAME THE HELICOPTER (AND A DROPPED PACKAGE) APPEAR TO HAVE A HORIZONTAL VELOCITY EQUAL TO THE ~~OPPOSITE~~ DIFFERENCE IN THE VEHICLES' VELOCITIES

$$v' = 208\,\text{km/h} - 156\,\text{km/h} = (52\,\text{km/h})\left(\frac{1000\,\text{m}}{1\,\text{km}}\right)\left(\frac{1\,\text{h}}{3600\,\text{s}}\right)$$

$$\boxed{v' = 14.4\,\text{m/s}}$$

WE ~~HAVE~~ CAN FIND THE TIME FOR THE PACKAGE TO FALL FROM 78 m

$$y = y_0 + v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad \left\{\begin{array}{l} y = 0\,\text{m} \\ y_0 = 78\,\text{m} \\ v_{0y} = 0\,\text{m/s} \\ a_y = -9.8\,\text{m/s}^2 \end{array}\right.$$

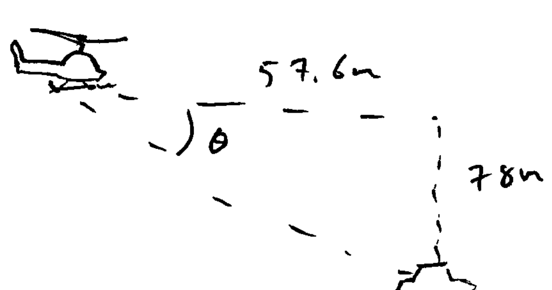
$$-78\,\text{m} = -\tfrac{1}{2}(9.8\,\text{m/s}^2)\,t^2$$

$$t = \sqrt{\frac{2 \cdot 78\,\text{m}}{9.8\,\text{m/s}^2}} \qquad \boxed{t = 4\,\text{s}}$$

NOW WE CAN FIGURE OUT HOW FAR BEHIND THE CAR THE CHOPPER MUST BE SO THAT THE CONTRABAND LANDS IN THE CAR

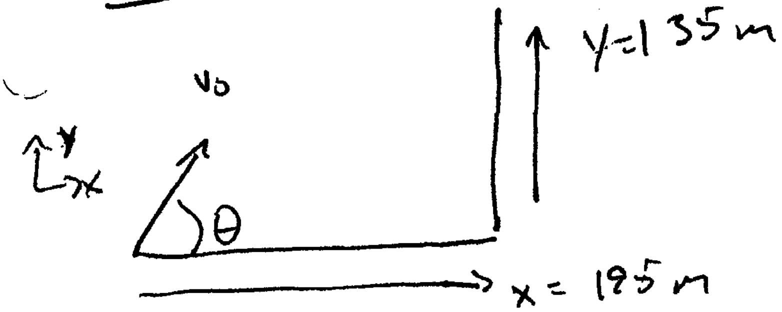
$$d = (14.4\,\text{m/s})(4\,\text{s}) = 57.6\,\text{m}$$

NOW WE CAN USE TRIG TO GET THE ANGLE



$$\boxed{\theta = \arctan\left(\frac{78}{57.6}\right) = 54^\circ}$$

3.88)



$y_0 = 0 \qquad t = 6.6\,s$

$x_0 = 0$

$\vec{a} = -g\hat{j}$

FIND v_0, θ

v_{0x} | $x = x_0 + v_{0x}t \rightarrow v_{0x} = \dfrac{x - x_0}{t} = \dfrac{x}{t}$

$v_{0x} = v_0 \cos\theta = \dfrac{x}{t}$ ①

FOR y $\quad y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$

$\rightarrow y = v_0 \sin\theta\, t - \frac{1}{2}gt^2 \rightarrow v_0 \sin\theta = \dfrac{y + \frac{1}{2}gt^2}{t}$ ②

DIVIDE ② BY ①

$$\frac{v_0 \sin\theta}{v_0 \cos\theta} = \frac{\left(\frac{y + \frac{1}{2}gt^2}{t}\right)}{\left(\frac{x}{t}\right)} = \frac{y + \frac{1}{2}gt^2}{x}$$

$$\rightarrow \tan\theta = \frac{y + \frac{1}{2}gt^2}{x}$$

PLUGGING IN #'s

$$\theta = \arctan\left(\frac{135 + \frac{1}{2}(10)(6.6)^2}{195}\right)$$

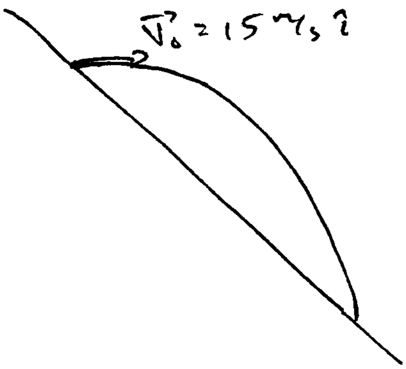
$$\boxed{\theta = 61^\circ}$$

NOW, SINCE

$$v_0 \cos\theta = \frac{x}{t} \Rightarrow v_0 = \frac{x}{t\cos\theta} = \frac{195\,m}{(6.6s)\cos(61^\circ)}$$

$$\boxed{v_0 = 61\ m/s}$$

3-95



THE POSITION OF THE ROCK WILL BE DESCRIBED AT ANY TIME BY

$$x = x_0 + v_{ox} t + \tfrac{1}{2} a_x t^2 = (15\ m/s)\, t$$

AND

$$y = y_0 + v_{oy} t + \tfrac{1}{2} a_y t^2 = (-4.9\ m/s^2)\, t^2$$

SINCE THE ANGLE OF THE HILL IS 45° WE KNOW THAT $x_f = -y_f$

SO

$$(15)t = 4.9 t^2$$

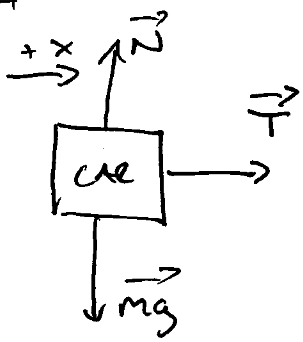
$$\boxed{t = \frac{15}{4.9} \approx 3\,s}$$

NOTE THAT IN GIANCOLI SOLUTION MANUAL HE PLUGS IN THE WRONG VALUE FOR V_0 IN THE LAST STEP ($25\ m/s$ INSTEAD OF $15\ m/s$) AND THUS GETS THE WRONG ANSWER.

$\boxed{t = 3\,s \text{ IS CORRECT.}}$

ALSO, GIANCOLI'S SOLUTION IS JUST WEIRD.

4-4/ DRAW A FREE BODY DIAGRAM



NOW SUM THE FORCES ACTING IN EACH DIRECTION

$$\sum F_x = T = ma_x \qquad \sum F_y = N - mg = 0$$

$$\cancel{\sum F_y = 0 = ma_y}$$

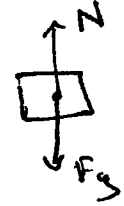
$$\left\{ \begin{array}{l} N = mg \\ T = ma_x \end{array} \right\}$$

$$T = ma_x = (1210\ \text{kg})(1.20\ \text{m/s}^2)$$

$$\boxed{T = 1452\ \text{N}}$$

4-10

y, x



(a)

$$\text{WEIGHT} = |\vec{F}_g| = mg = (20\,kg)(10\,m/s^2)$$

$$\boxed{\text{WEIGHT} = 200\,N}$$

SINCE BOX IS AT REST, $a = 0$

THUS $\Sigma F = N - mg = 0$

$$\rightarrow \boxed{\vec{N} = mg\hat{\imath}} = 200N$$

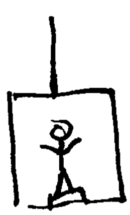
(b) FOR TABLE/BOTTOM BOX, TREAT BOTH BOXES AS A SINGLE MASS ($m = 30\,kg$)

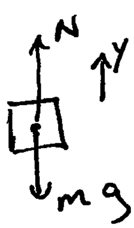
THEN $\vec{N} = (30\,kg)(10\,m/s^2)\hat{\jmath} = (300N)\hat{\jmath}$

FOR THE TOP BOX, IT IS THE SAME AS PART (a), BUT WITH $m = 10\,kg$

$$\vec{N} = (10\,kg)(10\,m/s^2)\hat{\jmath} = (100\,N)\hat{\jmath}$$

4-18





APPLY THE SECOND LAW.

$$\Sigma F_y = N - mg = ma_y$$

$$a_y = \frac{N - mg}{m}$$

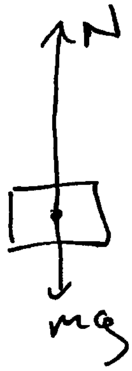
BUT $N = (0.75)mg$ SO

$$a_y = \frac{0.75mg - mg}{m}$$

$$a_y = -0.25g = \boxed{-2.5\,m/s^2 = a_y}$$

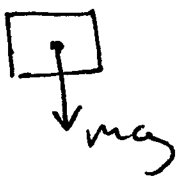
4-28

(a)



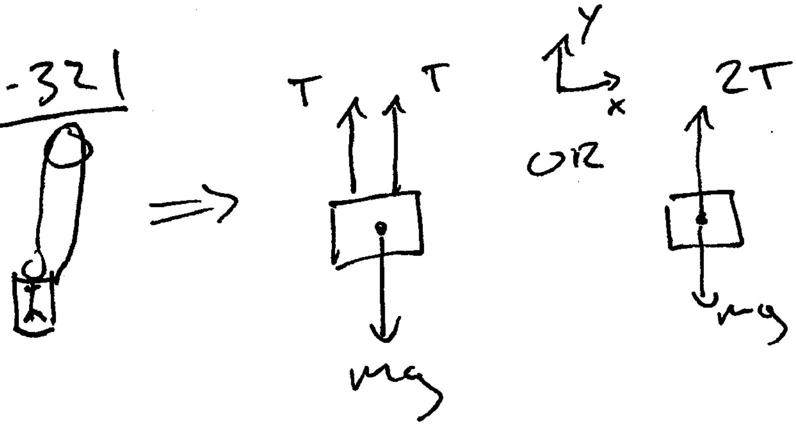
$N > mg$ (OTHERWISE HE CAN'T LEAVE THE GROUND)

(b)



THERE AREN'T ANY MORE FORCES (ASSUMING HE ISN'T FOULED BY BIG BEN WALLACE)

4-321



APPLY SECOND LAW

$$\sum_i F_y = 2T - mg = ma_y$$

(a) IF SHE WANTS TO MOVE AT A CONSTANT SPEED, $a_y = 0$ SO

$$2T - mg = ma_y \rightarrow 2T = mg$$

$$T = \frac{mg}{2}$$

$$m = 72\,\text{kg} \rightarrow T = \frac{(72\,\text{kg})(10\,\text{m/s}^2)}{2} = \boxed{360\,\text{N}}$$

(b) IF $T^* = 1.15\,T = 414\,\text{N}$

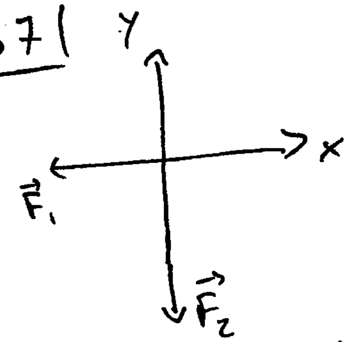
THEN

$$\sum_i F_y = 2T^* - mg = ma_y \rightarrow a_y = \frac{2T^* - mg}{m}$$

$$a_y = \frac{2(414\,\text{N}) - 720\,\text{N}}{72\,\text{kg}} = \boxed{1.5\,\text{m/s}^2}$$

4-37

(a)



$\vec{F}_1 = -(10.2\text{ N})\hat{i}$

$\vec{F}_2 = -(16\text{ N})\hat{j}$

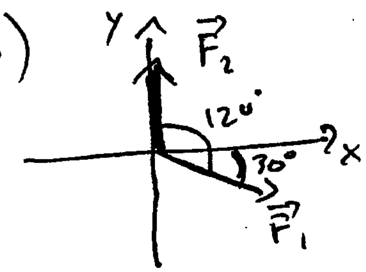
$$\boxed{\vec{F}_{NET} = \vec{F}_1 + \vec{F}_2 = (-10.2\text{ N})\hat{i} + (-16\text{ N})\hat{j}}$$

$$\vec{a} = \frac{\vec{F}_{NET}}{m}$$

$$\vec{a} = \left(-\frac{10.2\text{N}}{18.5\text{kg}}\right)\hat{i} + \left(-\frac{16\text{N}}{18.5\text{kg}}\right)\hat{j}$$

$$\boxed{\vec{a} = (-0.6\text{ m/s}^2)\hat{i} + (-0.9\text{ m/s}^2)\hat{j}}$$

(b)



$\vec{F}_1 = (10.2\text{N})\cos 30°\,\hat{i} - (10.2\text{N})\sin 30°\,\hat{j}$

$\vec{F}_2 = (16\text{N})\hat{j}$

$$\vec{F}_{NET} = (10.2\text{N})\cos 30°\,\hat{i} + (16\text{N} - 10.2\text{N}\sin 30°)\hat{j}$$

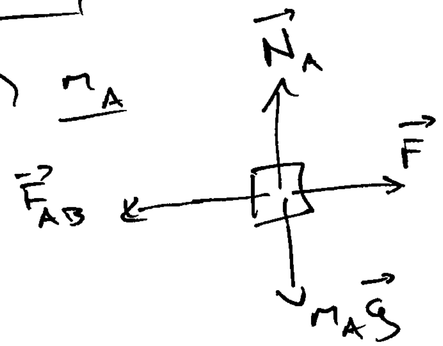
$$\boxed{\vec{F}_{NET} = (8.8\text{N})\hat{i} + (10.9\text{N})\hat{j}}$$

$$\vec{a} = \left(\frac{8.8\text{ N}}{18.5\text{ kg}}\right)\hat{i} + \left(\frac{10.9\text{ N}}{18.5\text{ kg}}\right)\hat{j}$$

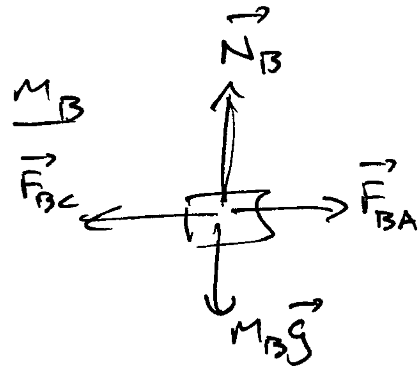
$$\boxed{\vec{a} \approx (0.5\text{ m/s}^2)\hat{i} + (0.6\text{ m/s}^2)\hat{j}}$$

4-46

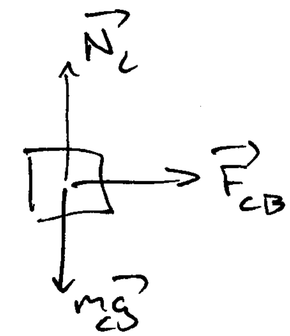
(a) m_A



m_B



m_C



(b) SINCE THE BLOCKS MOVE AS ONE TREAT THE WHOLE SYSTEM AS ONE BLOCK WITH $m = m_A + m_B + m_C$

THEN

$$\sum_i \vec{F} = \hat{i}\sum_i F_x = \hat{i}F = (m_A + m_B + m_C)\,a\,\hat{i}$$

$$\boxed{a = \frac{F}{(m_A + m_B + m_C)}}$$

(c) SINCE $a = \dfrac{F}{m_A + m_B + m_C}$ FOR EACH BLOCK AND $\vec{F} = m\vec{a}$ IN GENERAL,

$$\boxed{F_A = m_A a = \frac{F m_A}{m_A + m_B + m_C} \qquad F_B = m_B a = \frac{F m_B}{m_A + m_B + m_C} \qquad F_C = m_C a = \frac{F m_C}{m_A + m_B + m_C}}$$

4-46 (CONTINUED)

(d) FOR EACH BLOCK WE CAN SET THE NET FORCE EQUAL TO ma

→ BLOCK A: $F - F_{AB} = m_A a$

SO $F_{AB} = -m_A a + F$

$$F_{AB} = F - \frac{m_A F}{m_A + m_B + m_c} = F\left(1 - \frac{m_A}{m_A + m_B + m_c}\right)$$

WE CAN SUBSTITUTE

$$1 = \frac{m_A + m_B + m_c}{m_A + m_B + m_c}$$ ~~AND~~ TO GET

$$F_{AB} = F\left(\frac{m_A + m_B + m_c}{m_A + m_B + m_c} - \frac{m_A}{m_A + m_B + m_c}\right)$$

$$\boxed{F_{AB} = F\frac{m_B + m_c}{m_A + m_B + m_c} = -F_{BA}}$$

BLOCK C

$$F_{CB} = m_c a = \frac{F m_c}{m_A + m_B + m_c}$$

$$\boxed{F_{CB} = F\frac{m_c}{m_A + m_B + m_c} = -F_{BC}}$$

4-46 (CONTINUED)

(e) IF $F = 96\,N$, $m_A = m_B = m_c = 10\ kg$

(b_e) $$a = \frac{96\,N}{30\,kg} = \boxed{3.20\ m/s^2 = a}$$

(c_e) $$F_A = (10\,kg)(3.20\,m/s^2) = \boxed{32\,N = F_A}$$

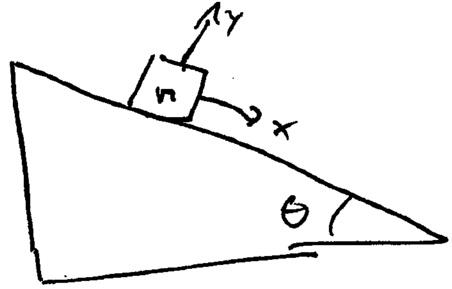
$$F_B = (10\,kg)(3.20\,m/s^2) = \boxed{32\,N = F_B}$$

$$F_C = (10\,kg)(3.20\,m/s^2) = \boxed{32\,N = F_C}$$

(d_e) $$F_{AB} = -F_{BA} = (96\,N)\left(\frac{20\,kg}{30\,kg}\right) \boxed{= 64\,N}$$

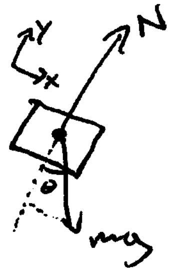
$$F_{CB} = -F_{BC} = (96\,N)\left(\frac{10\,kg}{30\,kg}\right) \boxed{= 32\,N}$$

4-48



$\theta = 22°$
$m = 7\ kg$

(a)



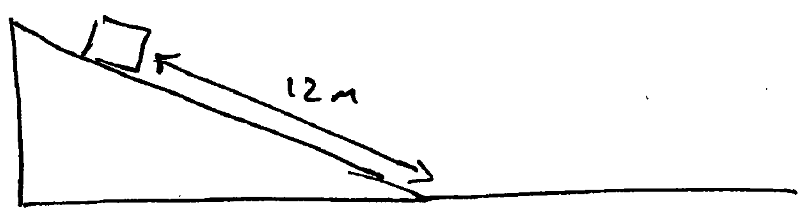
$\sum F_x = mg\sin\theta = ma_x$

$a_x = g\sin\theta$

$a_x = (10\ m/s^2)\sin 22°$

$\boxed{a_x = 3.7\ m/s^2}$

(b)



$(v_x^2 - v_{0x}^2) = 2a_x(x - x_0)$

$v_0 = 0$
$x_0 = 0$
$x = 12$
$a_x = 3.7\ m/s^2$
FIND v

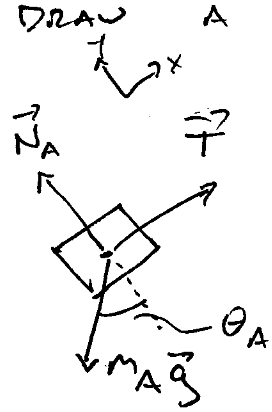
$v_x^2 = 2(3.7\ m/s^2)(12m - 0m) + (0\ m/s)^2$

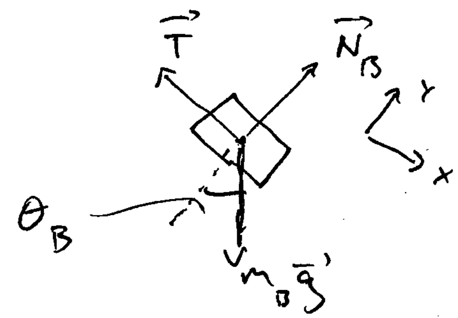
$v_x = \sqrt{2(3.7\ m/s^2)(12\ m)}$

$\boxed{v_x = 9.4\ m/s}$

4-69

DRAW A FREE-BODY-DIAGRAM FOR EACH BLOCK





(a)

NOW USE NEWTON'S SECOND LAW

FOR BLOCK A

① $\sum_i F_x = T - m_A g \sin(\theta_A) = m_A a$

② $\sum_i F_y = N_A - m_A g \cos(\theta_A) = 0$

FOR BLOCK B

③ $\sum_i F_x = m_B g \sin(\theta_B) - T = m_B a$

④ $\sum_i F_y = N_B - m_B g \cos(\theta_B) = 0$

REARANGE ③ TO SOLVE FOR T

THEN PLUG IT INTO ①

$$T = m_B g \sin\theta_B - m_B a = m_B(g\sin\theta_B - a)$$

SO NOW ① BECOMS

$$m_B(g\sin\theta_B - a) - m_A g \sin\theta_A = m_A a$$

$$m_B g \sin\theta_B - m_B a - m_A g \sin\theta_A = m_A a$$

SO,
$$\boxed{a = \frac{m_B g \sin\theta_B - m_A g \sin\theta_A}{m_A + m_B}}$$

4-69 (CONTINUED)

(b) TO BE AT REST $a=0$ SO

$$a = 0 = g\left(\frac{m_B \sin\theta_B - m_A \sin\theta_A}{m_B + m_A}\right)$$

SOLVE FOR m_B

$$m_B \sin\theta_B - m_A \sin\theta_A = 0$$

$$m_B = \frac{m_A \sin\theta_A}{\sin\theta_B},$$ NOW PLUG IN $m_A = 5\,kg$, $\theta_A = 32°$, $\theta_B = 23°$

$$m_B = (5\,kg)\frac{\sin(32°)}{\sin(23°)} = \boxed{6.8\,kg = m_B}$$

TO GET ~~FORCE~~ TENSION PLUG THESE VALUES INTO EQUATION 3

$$m_B g \sin(\theta_B) - T = m_B a$$

$$\rightarrow T = m_B(g \sin\theta_B - a)$$

$$= (6.8\,kg)(9.8\,m/s^2 \cdot \sin(23°) - 0)$$

$$\boxed{T = 26\,N}$$

(c) CONSTANT SPEED $\rightarrow a = 0$ SO

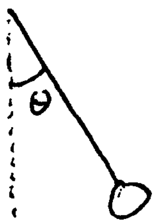
FROM PART (b) WE HAD

$$m_B \sin\theta_B - m_A \sin\theta_A = 0 \rightarrow \frac{m_A}{m_B} = \frac{\sin\theta_B}{\sin\theta_A}$$

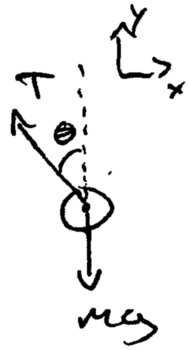
$$\cancel{\frac{m_B}{m_A} = \frac{\sin(32)}{\sin(23)}} = \frac{m_A}{m_B} = \frac{\sin(23)}{\sin(32)} = \boxed{0.74 = \frac{m_A}{m_B}}$$

4-74

$\theta = 25^\circ$



$\Rightarrow$



$$\sum F_x = -T\sin\theta = ma_x \quad (1)$$

$$\sum F_y = T\cos\theta - mg = ma_y \quad (2)$$

$a_y = 0$

FROM (1) $\quad a_x = \dfrac{-T\sin\theta}{m}$

FROM (2) $\quad T\cos\theta = mg \rightarrow T = \dfrac{mg}{\cos\theta}$

SUBSTITUTE T INTO a_x

$$a_x = -\left(\frac{mg}{m}\right)\left(\frac{\sin\theta}{\cos\theta}\right) \qquad a_x = -g\tan\theta$$

SO NOW WE NEED THE VELOCITY.

USE $\quad V = V_0 + at \qquad V_0 = 0,\ t = 16\,s$

$$V = -g\tan(25^\circ)(16\,s)$$

$$\boxed{V = -75\ m/s}$$