1 a) $v_0 = 7.5\,m/s$ [N] $t = 3.0\,s$
$v_f = 10.0\,m/s$ [E 40° N]

Step 1: Horizontal | Vertical

$v_{0E} = 0\,m/s$ | $v_{0N} = 7.5\,m/s$

$v_{fE} = 10\cos 40° = 7.66\,m/s$ | $v_{fN} = 10\sin 40° = 6.43\,m/s$

Step 2:
$$\vec{a}_E = \frac{v_{fE} - v_{0E}}{t} = \frac{7.66 - 0}{3.0} = 2.55\,m/s^2$$
$$\vec{a}_N = \frac{v_{fN} - v_{fE}}{t} = \frac{6.43 - 7.5}{3.0} = -0.357\,m/s^2$$

Step 3:
$$\vec{a} = \sqrt{(\vec{a}_E)^2 + (\vec{a}_N)^2}$$
$$\vec{a} = \sqrt{(2.55)^2 + (-0.357)^2}$$
$$\vec{a} = 2.57\,m/s^2$$
$$\phi = \tan^{-1}\left(\frac{0.357}{2.55}\right)$$
$$\phi = 8°$$
$$\boxed{\vec{a} = 2.57\,m/s^2\ [E\ 8°\ S]}$$

1 b) $v_f$ after 6.0 s
$$v_f = v_0 + at$$

Step 1:
$$v_{fE} = v_{0E} + \vec{a}_E t$$
$$= 0\,m/s + (2.55\,m/s^2)(6.0\,s)$$
$$= 15.3\,m/s$$
$$v_{fN} = v_{0N} + \vec{a}_N t$$
$$= 7.5\,m/s + (-0.357)(6)$$
$$= 5.358\,m/s$$

Step 2:
$$\vec{v}_f = \sqrt{(\vec{v}_{fE})^2 + (\vec{v}_{fN})^2}$$
$$= \sqrt{(15.3)^2 + (5.358)^2}$$
$$= 16.2\,m/s$$
$$\phi = \tan^{-1}\left(\frac{5.358}{15.3}\right)$$
$$= 19°$$
$$\boxed{v_f = 16.2\,m/s\ [E\ 19°\ N]}$$

② $\vec{V}_0 = 6.5\,m/s$ [E20°S]

$\vec{a} = 2.1\,m/s^2$ [E60°N]

$t = 18\,s$

Step 1: a) $\vec{V}_f = ?$ $\quad \vec{V}_f = \vec{V}_0 + \vec{a}t$

Horizontal:

$\vec{V}_{0E} = 6.5\cos 20° = 6.11\,m/s$

$\vec{a}_E = 2.1\cos 60° = 1.05\,m/s^2$

Vertical:

$\vec{V}_{0N} = -6.5\sin 20° = -2.22\,m/s$

$\vec{a}_N = 2.1\sin 60° = 1.82\,m/s^2$

Step 2: $\vec{V}_{fE} = \vec{V}_{0E} + \vec{a}_E t = 6.11 + (1.05)(18) = \underline{25.01\,m/s}$

$\vec{V}_{fN} = \vec{V}_{0N} + \vec{a}_N t = -2.22 + (1.82)(18) = \underline{30.54\,m/s}$

Step 3: $\vec{V}_f = \sqrt{(25.01)^2 + (30.54)^2} = \underline{39.5\,m/s}$ $\quad \phi = \tan^{-1}\left(\frac{30.54}{25.01}\right) = 51°$

$$\boxed{\vec{V}_f = 39.5\,m/s\ [E51°N]}$$

② b) $\vec{d} = ?$ $\quad \vec{d} = \vec{V}_0 t + \frac{1}{2}\vec{a}t^2$

Step 1: $\vec{d}_E = \vec{V}_{0E}t + \frac{1}{2}\vec{a}_E t^2$

Found in part a

$= (6.11)(18) + \frac{1}{2}(1.05)(18)^2$

$= 109.98 + 170.1$

$= \underline{280.1\,m}$

$\vec{d}_N = \vec{V}_{0N}t + \frac{1}{2}\vec{a}_N t^2$

Found in part a

$= (-2.22)(18) + \frac{1}{2}(1.82)(18)^2$

$= -39.96 + 294.84$

$= \underline{254.9\,m}$

$\vec{d} = \sqrt{(280.1)^2 + (254.9)^2} = 378.7\,m$ $\quad \phi = \tan^{-1}\left(\frac{254.9}{280.1}\right) = 42°$

$$\boxed{\vec{d} = 378.7\,m\ [E42°N]}$$

## Applications of Vectors

③ $\vec{v}_o = 9.2\,m/s$ [E 25° N]

$\vec{v}_f = 11\,m/s$ [E 14° S]

$t = 7.9\,s$

Step 1: a) $\vec{a} = ?$

| Horizontal | Vertical |
|---|---|
| $\vec{v}_{oE} = 9.2\cos 25° = 8.34\,m/s$ | $\vec{v}_{oN} = 9.2\sin 25° = 3.89\,m/s$ |
| $\vec{v}_{fE} = 11\cos 14° = 10.67\,m/s$ | $\vec{v}_{fN} = -11\sin 14° = -2.66\,m/s$ |

Step 2: $\vec{a}_E = \dfrac{\vec{v}_{fE} - \vec{v}_{oE}}{t} = \dfrac{10.67 - 8.34}{7.9} = \underline{0.29\,m/s^2}$

$\vec{a}_N = \dfrac{\vec{v}_{fN} - \vec{v}_{oN}}{t} = \dfrac{-2.66 - 3.89}{7.9} = \underline{-0.83\,m/s^2}$

Step 3: $\vec{a} = \sqrt{(\vec{a}_E)^2 + (\vec{a}_N)^2} = \sqrt{(0.29)^2 + (-0.83)^2} = 0.88\,m/s^2$

$\phi = \tan^{-1}\left(\dfrac{0.83}{0.29}\right) = 71°$

$$\boxed{\vec{a} = 0.88\,m/s^2 \text{ [E 71° S]}}$$

③ b) $\vec{d} = ?$

use values from part (a)

$\vec{d}_E = \vec{v}_{oE}t + \frac{1}{2}\vec{a}_E t^2$

$= (8.34)(7.9) + \frac{1}{2}(0.29)(7.9)^2$

$= 65.89 + 9.05$

$= \underline{74.9\,m}$

$\vec{d}_N = \vec{v}_{oN}t + \frac{1}{2}\vec{a}_N t^2$

$= (3.89)(7.9) + \frac{1}{2}(-0.83)(7.9)^2$

$= 30.73 + (-25.9)$

$= \underline{4.83\,m}$

$\vec{d} = \sqrt{(\vec{d}_E)^2 + (\vec{d}_N)^2} = \sqrt{(74.9)^2 + (4.83)^2} = 75.1\,m$

$\phi = \tan^{-1}\left(\dfrac{4.83}{74.9}\right) = 3.7°$

$$\boxed{\vec{d} = 75.1\,m \text{ [E 3.7° N]}}$$

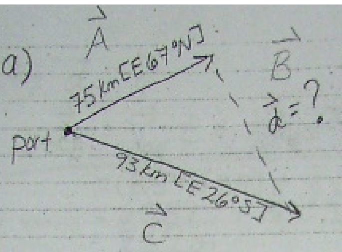
c) mass = 55 kg $\qquad \vec{F}_{avg} = ?$

$\vec{F} = m\vec{a}$

$= (55\,kg)(0.88\,m/s^2$ [E 71° S]$)$

$\boxed{= 48.4\,N \text{ [E 71° S]}}$

(4) a)




$\vec{C} = \vec{A} + \vec{B}$

$\vec{B} = \vec{C} - \vec{A}$
$(\vec{d})$

Step 1: *Horizontal* / *Vertical*

$\vec{d}_{AE} = 75\cos 67° = 29.3\,km$ $\quad\quad$ $\vec{d}_{AN} = 75\sin 67° = 69.0\,km$

$\vec{d}_{CE} = 93\cos 26° = 83.6\,km$ $\quad\quad$ $\vec{d}_{CN} = -93\sin 26° = -40.8\,km$

Step 2: $\vec{d}_{BE} = \vec{d}_{CE} - \vec{d}_{AE} = 83.6 - 29.3 = 54.3\,m$ $\quad\quad$ $\vec{d}_{BN} = \vec{d}_{CN} - \vec{d}_{AN} = -40.8 - 69.0 = -109.8$

Step 3: $\vec{d} = \sqrt{(54.3)^2 + (-109.8)^2} = 122.4\,km$ $\quad\quad$ $\phi = \tan^{-1}\left(\frac{109.8}{54.3}\right) = 64°$

$$\boxed{\vec{d} = 122.4\,km\ [E\,64°\,S]}$$

b) $\vec{v}_{mh} = ?$ $\quad$ $\vec{v} = \frac{\Delta\vec{d}}{t} = \frac{122.4\,km}{0.5\,h} = 244.8\,km/h$ [E 64° S]

(5) *Horizontal*

$\vec{v}_x = 5.0\,m/s$

$\vec{d}_{ox} = 0\,m$

$\vec{d}_{fx} = ?$

*Vertical*

$\vec{v}_{oy} = 0$

$\vec{v}_{fy} = ?$

$\vec{d}_{oy} = 78.4\,m$

$\vec{d}_{fy} = 0\,m$

$\vec{a} = -9.81\,m/s^2$

a) $\vec{d}_{fy} = \vec{d}_{oy} + \vec{v}_{oy}t + \frac{1}{2}at^2$

$0 = 78.4 + (0)(t) + \frac{1}{2}(-9.81)t^2$

$0 = 78.4 + (-4.9)t^2$

$\frac{-78.4}{-4.9} = \frac{-4.9t^2}{-4.9}$

$16 = t^2$

$4\,sec = t$

b) $\vec{v}_x = \frac{\vec{d}_{fx} - \vec{d}_{ox}}{t}$

$5.0\,m/s = \frac{\vec{d}_{fx} - 0}{4\,s}$

$20.0\,m = \vec{d}_{fx}$

c) $\vec{v}_{fy} = \vec{v}_{oy} + \vec{a}t$

$\vec{v}_{fy} = 0 + (-9.81)(4)$

$\vec{v}_{fy} = -39.24\,m/s$

$\vec{v}_f = \sqrt{(\vec{v}_x)^2 + (\vec{v}_{fy})^2} = \sqrt{(5.0)^2 + (-39.24)^2} = 39.6\,m/s$

$\phi = \tan^{-1}\left(\frac{\vec{v}_{fy}}{\vec{v}_x}\right)$

$\phi = \tan^{-1}\left(\frac{39.24}{5.0}\right)$

$\phi = 82.7°$

(6) Horizontal

$\vec{V}_x = 24\,m/s$

$\vec{d}_{ox} = 0\,m$

$\vec{d}_{fx} = ?$

Vertical

$\vec{V}_{oy} = 0\,m/s$

$\vec{d}_{oy} = 15\,m$

$\vec{d}_{fy} = 0\,m$

a) i) $\vec{d}_{fy} = \vec{d}_{oy} + \vec{V}_{oy}t + \frac{1}{2}\vec{a}t^2$

$0 = 15 + (0)t + \frac{1}{2}(-9.81)t^2$

$0 = 15 + (-4.9)t^2$

$\frac{-15}{-4.9} = \frac{-4.9t^2}{-4.9}$

$3.061 = t^2$

$\underline{1.75\,s = t}$

ii) $\vec{V}_x = \frac{\vec{d}_{fx} - \vec{d}_{ox}}{t}$

$24 = \frac{\vec{d}_{fx} - 0}{1.7\,s}$

$\underline{42.0\,m = \vec{d}_{fx}}$

b) $\vec{V}_{fy} = \vec{V}_{oy} + \vec{a}t$

$= 0 + (-9.81)(1.75)$

$= \underline{-17.17\,m/s}$

c) $\vec{V}_f = \sqrt{(\vec{V}_x)^2 + (\vec{V}_{fy})^2}$

$= \sqrt{(24)^2 + (-17.17)^2}$

$= 29.5\,m/s$

$\theta = \tan^{-1}\left(\frac{\vec{V}_{fy}}{\vec{V}_x}\right)$

$= \tan^{-1}\left(\frac{17.17}{24}\right)$

$= 35.6°$

29.5 m/s, 35.6° to the horizontal

(E 35.6° S)

(7) $\vec{V} = 21\,m/s$ $\theta = 35°$

Horizontal

$\vec{V}_{ox} = 21\cos 35°$

$= 17.2\,m/s$

$\vec{d}_{ox} = 0\,m$

$\vec{d}_{fx} = ?$

Vertical

$\vec{V}_{oy} = 21\sin 35°$

$= 12.0\,m/s$

$\vec{d}_{oy} = 60.0\,m$

$\vec{d}_{fy} = 0\,m$

$\vec{d}_{fy} = \vec{d}_{fo} + \vec{V}_{oy}t + \frac{1}{2}\vec{a}t^2$

$-60 = 0 + (12.0)t - \frac{1}{2}(-9.81)t^2$

$-60 = 12.0t - 4.9t^2$

$4.9t^2 - 12.0t - 60 = 0$

$t = \frac{12 \pm \sqrt{(12)^2 - 4(4.9)(-60)}}{2(4.9)}$

$= \frac{12 \pm \sqrt{1320}}{9.81}$

$= \frac{12 \pm 36.33}{9.81}$

$\underline{t = 4.93\,s}$ or $t = \cancel{-2.48}\,s$

$\vec{V}_x = \frac{\vec{d}_{fx} - \vec{d}_{ox}}{t}$

$17.2 = \frac{\vec{d}_{fx} - 0}{4.93}$

$\boxed{\vec{d}_{fx} = 84.8\,m}$

Horizontal

$\vec{v}_{ox} = 15\cos 42^\circ$
$= 11.15\ m/s$

$\vec{d}_{ox} = ?$
$\vec{d}_{fx} = ?$

Vertical

$\vec{v}_{oy} = 15\sin 42^\circ$
$= 10.04\ m/s$

$\vec{d}_{oy} = 5.3\ m$
$\vec{d}_{fy} = 0\ m$

$\vec{d}_{fy} = \vec{d}_{oy} + \vec{v}_{oy}t + \frac{1}{2}\vec{a}t^2$
$-5.3 = 0 + (10.04)t + \frac{1}{2}(-9.81)(t^2)$
$-5.3 = 10.04t - 4.9t^2$
$4.9t^2 - 10.04t - 5.3 = 0$

$t = \dfrac{10.04 \pm \sqrt{(10.04)^2 - 4(4.9)(-5.3)}}{2(4.9)}$
$= \dfrac{10.04 \pm \sqrt{204.6816}}{9.81}$

$\underline{t = 2.48\,s}$ or $t = \cancel{-0.43}\,s$

$\vec{v}_{fy} = \vec{v}_{oy} + at$
$= (10.04) + (-9.81)(2.48)$
$= \underline{-14.3\ m/s}$

$\vec{v}_f = \sqrt{(\vec{v}_{fx})^2 + (\vec{v}_{fy})^2}$
$\vec{v}_f = \sqrt{(11.15)^2 + (-14.3)^2}$
$\underline{\vec{v}_f = 18.1\ m/s}$

$\phi = \tan^{-1}\left(\frac{\vec{v}_{fy}}{\vec{v}_{fx}}\right)$
$\phi = \tan^{-1}\left(\frac{-14.3}{11.15}\right)$
$\phi = 52^\circ$

$\vec{v}_f = 18.1\ m/s$ at $52^\circ$ below the horizontal.

---

Horizontal
$\vec{d}_{ox} = 0m$
$\vec{d}_{fx} = 75cm = 0.75m$
$\vec{v}_x = \vec{v}\cos 55^\circ$

Vertical
$\vec{d}_{oy} = 0m$
$\vec{d}_{fy} = 0m$
} lands on the ground
$\vec{v}_{oy} = \vec{v}\sin 55^\circ$

① $\vec{v}_x = \dfrac{\vec{d}_{fx} - \vec{d}_{ox}}{t}$

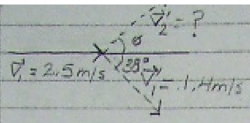
$\vec{v}_x = \dfrac{0.75 - 0}{t}$

$\therefore\ \vec{v}\cos 55^\circ = \dfrac{0.75}{t}$

Rearrange for t:
$t = \dfrac{0.75}{\vec{v}\cos 55^\circ}$

② $\vec{d}_{fy} = \vec{d}_{oy} + \vec{v}_{oy}t + \frac{1}{2}\vec{a}t^2$
$0 = 0 + (\vec{v}\sin 55^\circ)t + \frac{1}{2}(-9.81)t^2$
$0 = (\cancel{\vec{v}}\sin 55^\circ)\left(\dfrac{0.75}{\cancel{\vec{v}}\cos 55^\circ}\right) + \frac{1}{2}(-9.81)\left(\dfrac{0.75}{\vec{v}\cos 55^\circ}\right)^2$
$0 = 0.75\tan 55^\circ - 4.9\left[\dfrac{0.75^2}{\vec{v}^2\cos 55^{\circ 2}}\right]$
$0 = 1.0711 - 4.9\left[\dfrac{0.5625}{\vec{v}^2(0.3290)}\right]$
$-1.0711 = -4.9\left(\dfrac{1.7097}{\vec{v}^2}\right)$
$\dfrac{-1.0711\vec{v}^2}{-1.0711} = \dfrac{-8.37753}{-1.0711}$
$\vec{v}^2 = 7.8214$
$\vec{v} = 2.796$

$\boxed{\vec{v} = 2.8\ m/s}$




$m_1 = 0.155\,kg$ $\quad m_2 = 0.125\,kg$

$\vec{v}_1 = 2.5\,m/s$ $\quad \vec{v}_2 = 0\,m/s$

$\vec{v}_1' = 1.4\,m/s$ $\quad \vec{v}_2' =$

x-direction

$$m_1\vec{v}_{1x} + m_2\vec{v}_{2x} = m_1\vec{v}_{1x}' + m_2\vec{v}_{2x}'$$

$$\vec{v}_{2x}' = \frac{m_1\vec{v}_{1x} + m_2\vec{v}_{2x} - m_1\vec{v}_{1x}'}{m_2}$$

$$\vec{v}_{2x}' = \frac{(0.155)(2.5) + (0) - (0.155)(1.4\cos 38°)}{0.125}$$

$$\vec{v}_{2x}' = 1.73\,m/s$$

y-direction

$$m_1\vec{v}_{1y} + m_2\vec{v}_{2y} = m_1\vec{v}_{1y}' + m_2\vec{v}_{2y}'$$

$$\vec{v}_{2y}' = \frac{m_1\vec{v}_{1y} + m_2\vec{v}_{2y} - m_1\vec{v}_{2y}'}{m_2}$$

$$\vec{v}_{2y}' = \frac{(0) + (0) - (0.155)(-1.4\sin 38°)}{0.125}$$

$$\vec{v}_{2y}' = 1.07\,m/s$$

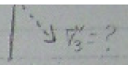
$$\vec{v}_2' = \sqrt{(\vec{v}_{2x}')^2 + (\vec{v}_{2y}')^2} \qquad \phi = \tan^{-1}\left(\frac{\vec{v}_{2y}'}{\vec{v}_{2x}'}\right)$$

$$\vec{v}_2' = \sqrt{(1.73)^2 + (1.07)^2} \qquad \phi = \tan^{-1}\left(\frac{1.07}{1.73}\right)$$

$$\vec{v}_2' = 2.03\,m/s \qquad \phi = 31.7°$$

$\vec{v}_2' = 2.0\,m/s$, $32°$ up from the positive x-axis

(11) $m_{total} = 3.5\,kg$




$m_1 = 1.3\,kg$ $\quad m_2 = 1.2\,kg$ $\quad m_3 = 3.5 - 1.3 - 1.2$

$\vec{v}_1' = 1.8\,m/s$ $\quad \vec{v}_2' = 2.5\,m/s$ $\quad = 1.0\,kg$

at $52°$ ccw from + x-axis $\quad$ at $61°$ cw from − x-axis $\quad \vec{v}_3' = ?$

x-direction

$$m_1\vec{v}_{1x}' + m_2\vec{v}_{2x}' + m_3\vec{v}_{3x}' = 0$$

$$\vec{v}_{3x}' = \frac{-m_1\vec{v}_{1x}' - m_2\vec{v}_{2x}'}{m_3}$$

$$\vec{v}_{3x}' = \frac{-(1.3)(1.8\cos 52°) - (1.2)(-2.5\cos 61°)}{1.0}$$

$$\vec{v}_{3x}' = 0.0138$$

y-direction

$$m_1\vec{v}_{1y}' + m_2\vec{v}_{2y}' + m_3\vec{v}_{3y}' = 0$$

$$\vec{v}_{3y}' = \frac{-m_1\vec{v}_{1y}' - m_2\vec{v}_{2y}'}{m_3}$$

$$\vec{v}_{3y}' = \frac{-(1.3)(+1.8\sin 52°) - (1.2)(+2.5\sin 61°)}{1.0}$$

$$\vec{v}_{3y}' = -4.47$$

$$\vec{v}_3' = \sqrt{(\vec{v}_{3x}')^2 + (\vec{v}_{3y}')^2} \qquad \phi = \tan^{-1}\left(\frac{\vec{v}_{3y}'}{\vec{v}_{3x}'}\right)$$

$$\vec{v}_3' = \sqrt{(0.0138)^2 + (4.47)^2} \qquad \phi = \tan^{-1}\left(\frac{4.47}{0.0138}\right)$$

$$\vec{v}_3' = 4.47 \qquad \phi = 89.8°$$

$\vec{v}_3' = 4.5\,m/s$, $89.8°$ down from the + x-axis

(12) $m = 75.0\ kg$ $F_a = 535\ N$

$\vec{F}_{net_x} = 15.0\ N$ $\phi = 28.0°$ to the horizontal

$\vec{F}_{ax} = 535 \cos 28°$
$= 472\ N$

$\vec{F}_{ay} = -535 \sin 28°$
$= -251\ N$

$\vec{F}_g = mg$
$= (75.0)(-9.81)$
$= -736\ N$

x-direction:

$\vec{F}_{net_x} = \Sigma$ forces in x-direction

$\vec{F}_{net_x} = \vec{F}_{ax} + \vec{F}_f$

$15.0 = 472 + \vec{F}_f$

$\vec{F}_f = -457\ N$

$|\vec{F}_f| = 457\ N$

y-direction:

$\vec{F}_{net_y} = \Sigma$ forces in y-direction

$\vec{F}_{net_y} = \vec{F}_{ay} + |\vec{F}_N| + \vec{F}_g$

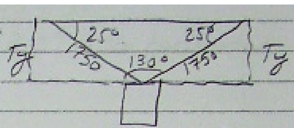
$\vec{F}_N = \vec{F}_{net_y} - \vec{F}_{ay} - \vec{F}_g$

$\vec{F}_N = 0 - (-251) - (-736)$

$\vec{F}_N = 987\ N$

$\mu = \frac{|\vec{F}_f|}{\vec{F}_n} = \frac{457\ N}{987\ N} = \boxed{0.46}$

(13) largest mass = ?




$\sin \phi = \frac{Ty}{T}$

$Ty = T \sin \phi$

$Ty = 1750 \sin 25°$

$\boxed{Ty = 740\ N}$ (max weight can be supported)

$F_{net_y} = \Sigma$ forces in y-direction

$0 = Fg + 2Ty$

$0 = Fg + 2(740)$

$-1480 = Fg$

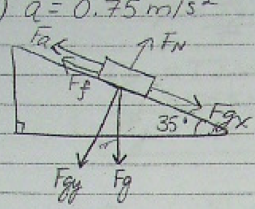
$Fg = mg$

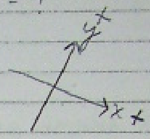
$\frac{-1480}{-9.81} = \frac{m(-9.81)}{-9.81}$

$\boxed{151\ kg = m}$

(14) $m = 33\ kg$ $\phi = 35°$ $\mu = 0.13$

a) $\vec{a} = 0.75\ m/s^2$ $\vec{F_a} = ?$




$F_{net\,x} = \Sigma$ forces in x-dir.

$F_{net\,x} = Fa + F_{gx} + F_f$

i) $\vec{F}_{net\,x} = m\vec{a}_x$
$= (33)(0.75)$
$= \underline{24.8\ N}$

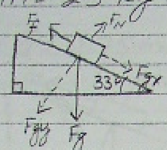
ii) $F_f = \mu F_N$
$= (0.13)(265\ N)$
$= \underline{\underline{34.5\ N}}$

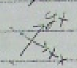
$F_N = F_{gy}$
$= mg\cos\phi$
$= (33)(9.81)\cos 35°$
$= 265\ N$

iii) $F_{gx} = F_g \sin\phi$
$= mg\sin\phi$
$= (33)(9.81)\sin 35°$
$= \underline{\underline{186\ N}}$

$F_{net\,x} = Fa + F_{gx} + F_f$
$24.8 = Fa + 186\ N - 34.5$
$24.8 = Fa + 151.5$

(15) $m = 25\ kg$ $\phi = 33°$ $\mu = 0.38$




$F_{gy} = -mg\cos 33°$
$= -(25)(9.81)\cos 33°$
$= -205.68$

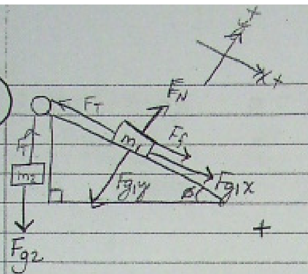
$F_y = ma_y$ $*a_y = 0$
$F_{gy} + F_N = ma_y$
$-205.68 + F_N = 0$
$F_N = \underline{\underline{205.68\ N}}$

$F_x = ma_x$
$F_{gx} + F_f = ma_x$
$133.57 - 78.158 = 25 \cdot \vec{a}_x$
$\frac{55.412}{25} = \frac{\cancel{25} \cdot \vec{a}_x}{\cancel{25}}$
$\boxed{2.2\ m/s^2 = \vec{a}}$

$F_{gx} = mg\sin 33°$
$= (25)(9.81)\sin 33°$
$= 133.57$

$F_f = -\mu F_N$
$= -(0.38)(205.68)$
$= \underline{\underline{-78.158\ N}}$

16




$\phi = 20°$ $\mu = 0.19$

$m_2 = 25\ kg$ $\vec{a} = ?$

$m_1 = 16\ kg$

$|F_N| = |F_{g1y}|$

$$\sum Forces = \sum m\vec{a}$$

$$-F_{g2} + F_{g1y} + F_f = (m_1 + m_2)\vec{a}$$

$$-m_2 g + m_1 g \sin\phi + \mu F_N = (m_1 + m_2)\vec{a}$$

$$-m_2 g + m_1 g \sin\phi + \mu m_1 g \cos\phi = (m_1 + m_2)\vec{a}$$

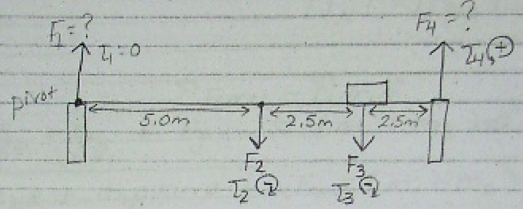
$$-(25)(9.81) + (16)(9.81)\sin 20° + (0.19)(16)(9.81)\cos 20° = (16+25)\vec{a}$$

$$-245.25 + 53.68 + 28.02 = 41\vec{a}$$

$$\frac{-163.55}{41} = \frac{41\vec{a}}{41}$$

$$\boxed{-4.0 m/s^2 = \vec{a}}$$

17 A uniform 150 kg beam, 10.0 m long, supports a 275 kg box that is 2.5 m from the right support column. Calculate the magnitude of the forces on the beam exerted by each of the vertical support columns.




i) $\tau_{net} = \tau_1 + \tau_2 + \tau_3 + \tau_4$

$0 = 0 - r_2 F_2 - r_3 F_3 + r_4 F_4$

$0 = -(5)(150)(9.81) - (7.5)(275)(9.81) + (10)F_4$

$0 = -7358 - 20233 + 10 F_4$

$\frac{27591}{10} = \frac{10 F_4}{10}$

$\boxed{2759N = F_4}$

ii) Move pivot point to $F_4$, and solve for $F_1$:

$\tau_{net} = \tau_1 + \tau_2 + \tau_3 + \tau_4$

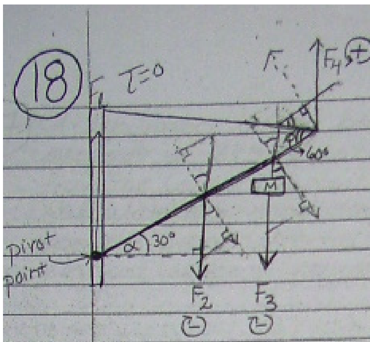
$0 = -10 F_1 + (5)(150)(9.81) + (2.5)(275)(9.81) + 0$

$0 = -10 F_1 + 7358 + 6744$

$\frac{-14102}{10} = \frac{-10 F_1}{10}$

$\boxed{1410N = F_1}$

18




max T in cable = 1800 N

beam = 15 m   $\phi = 60°$

$m_{beam} = 60\,kg$   $\alpha = 30°$

$m_{hanging\ mass} = ?$ , 10 m from hinge

a) $\tau_{net} = \tau_1 + \tau_2 + \tau_3 + \tau_4$

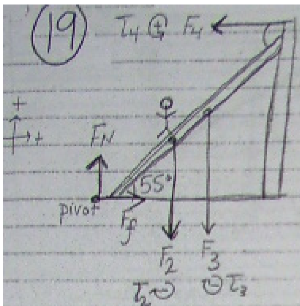
$0 = 0 - (7.5)(60)(9.81)\cos 30° - (10)(m)(9.81)\cos 30° + (15)(1800)\sin 60$

$0 = -3823 - 85m + 23383$

$-19560 = -85m$

$\boxed{230\,kg = m}$

19




$\sum torques = \tau_2 + \tau_3 + \tau_4$

$\tau_2 = -r_2 F_2 \cos\phi$
$= -(1.5)(75)(9.81)\cos 55°$
$= -633\ Nm$

$\tau_3 = -r_3 F_3 \cos\phi$
$= -(2.5)(25)(9.81)\cos 55°$
$= -351.7\ Nm$

$\tau_4 = +r_4 F_4 \sin\phi$
$= (5)F_4 \sin 55°$
$= 4.1 F_4$

$\tau_{net} = \tau_2 + \tau_3 + \tau_4$
$0 = -633 - 351.7 + 4.1 F_4$
$\frac{984.7}{4.1} = \frac{\cancel{4.1}}{\cancel{4.1}} F_4$
$\underline{240N = F_4}$

$F_{net\,x} = F_f + F_4$
$0 = F_f + (-240)$
$240N = F_f$

$F_{net\,y} = F_N + F_2 + F_3$
$0 = F_N - (75)(9.8) - (25)(9.8$
$0 = F_N - 735.75 - 245.2$
$0 = F_N - 981$
$981\,N = F_N$

$F_f = \mu F_N$
$\mu = \frac{F_f}{F_N}$
$\mu = \frac{240N}{981\,N}$