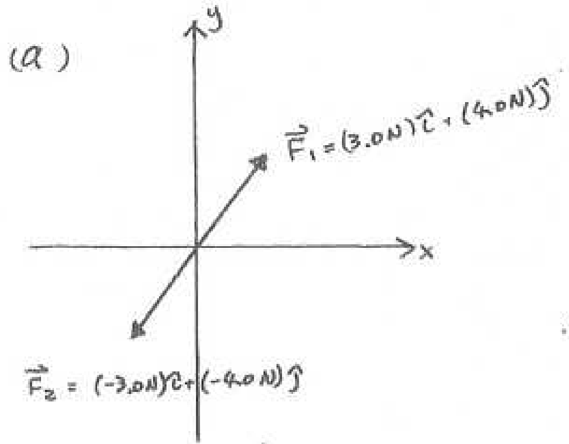
Ch 5. #3, #8, #42, #51, #72, #82, #83

#3. Warning: You still are a beginner. You can't be lazy yet.
Try to draw an accurate diagram & write equations step by step.

(a)




$m = 2.0\ kg$

$\Sigma \vec{F} = \vec{F}_1 + \vec{F}_2$

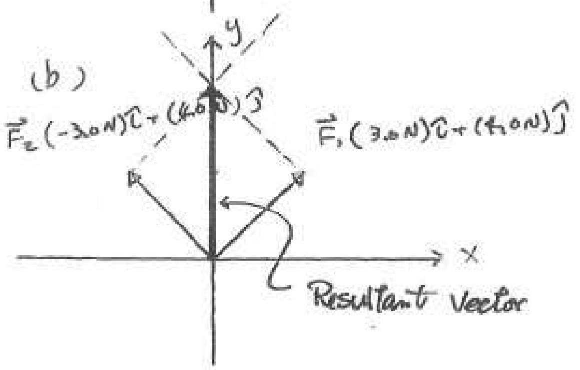
$= (3.0N)\hat{i} + (4.0N)\hat{j} + (-3.0N)\hat{i} + (-4.0N)\hat{j}$

$= (3.0 - 3.0)N\hat{i} + (4.0 - 4.0)N\hat{j}$

$= 0N\hat{i} + 0N\hat{j}$ (Equilibrium)

$\therefore \vec{a} = \frac{\vec{F}}{m} = \frac{0N}{2.0kg}\hat{i} + \frac{0N}{2.0kg}\hat{j} = \underline{\underline{0\ m/sec^2\ \hat{i} + 0\ m/sec^2\ \hat{j}}}$

(b)




$\Sigma \vec{F} = \vec{F}_1 + \vec{F}_2$

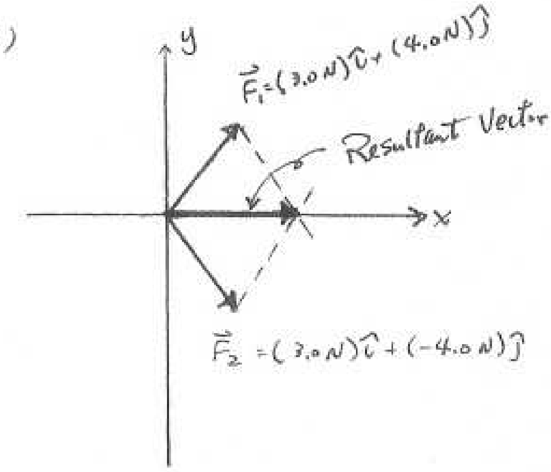
$= (3.0N)\hat{i} + (4.0N)\hat{j} + (-3.0N)\hat{i} + (4.0N)\hat{j}$

$= (3.0 - 3.0)N\hat{i} + (4.0 + 4.0)N\hat{j}$

$= 0N\hat{i} + 8.0N\hat{j}$

$\therefore \vec{a} = \frac{\vec{F}}{m} = \frac{0N}{2.0kg}\hat{i} + \frac{8.0N}{2.0kg}\hat{j} = \underline{\underline{0\ m/sec^2\ \hat{i} + 4\ m/sec^2\ \hat{j}}}$

(c)




$\Sigma \vec{F} = \vec{F}_1 + \vec{F}_2$

$= (3.0N)\hat{i} + (4.0N)\hat{j} + (3.0N)\hat{i} + (-4.0N)\hat{j}$

$= (3.0 + 3.0)N\hat{i} + (4.0 - 4.0)N\hat{j}$

$= 6.0N\hat{i} + 0N\hat{j}$

$\therefore \vec{a} = \frac{\vec{F}}{m} = \frac{6.0N}{2.0kg}\hat{i} + \frac{0N}{2.0kg}\hat{j} = \underline{\underline{3\ m/sec^2\ \hat{i} + 0\ m/sec^2\ \hat{j}}}$

\# 8 From the given diagram, we can calculate $a_x$, and hence we can calculate $F_x$ as well.

Notice that the line passes (0 sec, $-4$ m/sec) & (2 sec, 2 m/sec)

$$\therefore\ a_x = \frac{\Delta V_x}{\Delta t} = \frac{2\,\text{m/sec} - (-4\,\text{m/sec})}{2\,\text{sec} - 0\,\text{sec}} = \underline{\underline{3\,\text{m/sec}^2}}$$

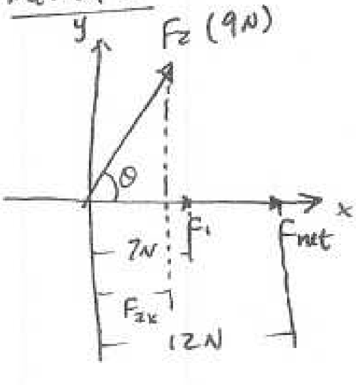
$$\therefore\ \Sigma F_x = m a_x = 4.0\,\text{kg} \cdot 3.0\,\text{m/sec}^2 = 12\,\text{N}$$

Since the two forces ($\vec{F}_1$ & $\vec{F}_2$) are acting on the 4.0 kg and the net force is 12 N & $\vec{F}_1 = 7.0\,\text{N}\,\hat{i} + 0.0\,\text{N}\,\hat{j}$,

Method 1

$$\Sigma F_x = 12\,\text{N} = F_{1x} + F_{2x}$$
$$= 7.0\,\text{N} + |\vec{F}_2| \cos\theta$$
$$\therefore\ 7.0\,\text{N} + 9.0\,\text{N} \cos\theta = 12\,\text{N}$$
$$\therefore\ \cos\theta = \frac{5}{9}$$
$$\therefore\ \theta = \cos^{-1}\frac{5}{9} = 56.^\circ 2510114 \sim \underline{\underline{56.^\circ 3}}$$

Method 2



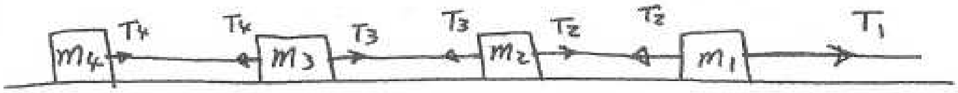

$$\vec{F}_1 = 7.0\,\text{N}\,\hat{i} + 0\,\text{N}\,\hat{j}$$
$$\vec{F}_2 = F_{2x}\,\hat{i} + F_{2y}\,\hat{j} \quad \& \quad |\vec{F}_2| = 9\,\text{N}$$

$$\Sigma F_x = 12\,\text{N} = F_{1x} + F_{2x}$$
$$= 7.0\,\text{N} + F_{2x} \qquad \therefore\ \underline{\underline{F_{2x} = 5.0\,\text{N}}}$$

Also

$$|\vec{F}_2| = 9.0\,\text{N} = \sqrt{F_{2x}^2 + F_{2y}^2}$$
$$= \sqrt{(5\,\text{N})^2 + (F_{2y})^2}$$
$$\therefore\ F_{2y} = \sqrt{(9.0\,\text{N})^2 - (5.0\,\text{N})^2} = \sqrt{56}\,\text{N}$$

$$\therefore\ \theta = \tan^{-1}\frac{F_{2y}}{F_{2x}} = \tan^{-1}\frac{\sqrt{56}}{5} = 56.^\circ 2510114 \sim \underline{\underline{56.^\circ 3}}$$




$T_1 = 222\,N$
$T_3 = 111\,N$

Method 1 (pick a point)

At $m_1$ $\quad T_1 - T_2 = m_1 a$ (Tension difference between $T_1$ & $T_2$ causes $m_1$ to acc.)

At $m_2$ $\quad T_2 - T_3 = m_2 a$ ( " $T_2$ & $T_3$ " $m_2$ " )

At $m_3$ $\quad T_3 - T_4 = m_3 a$ ( " $T_3$ & $T_4$ " $m_3$ " )

At $m_4$ $\quad T_4 = m_4 a$ ( Tension 4 causes $m_4$ to acc.)

$$\begin{cases} 222 - T_2 = 20a & \text{——— ①} \\ T_2 - 111 = 15a & \text{——— ②} \\ 111 - T_4 = m_3 a & \text{——— ③} \\ T_4 = 12a & \text{——— ④} \end{cases}$$

Eqn. ①. solve for $T_2$

$$T_2 = -20a + 222 \quad \text{——— ①'}$$

② ⟵ ①' solve for $a$

$$(222 - 20a) - 111 = 15a \Rightarrow a = \frac{111}{35} \quad \text{——— ②'}$$

③ ⟵ ②' & ④

$$111 - 12a = m_3 \frac{111}{35}$$

$$111 - 12 \cdot \frac{111}{35} = m_3 \frac{111}{35} \Rightarrow m_3 = \frac{\left(111 - 12 \cdot \frac{111}{35}\right)}{\frac{111}{35}} = \underline{\underline{23\,kg}}$$

Method 2.

$T_1$, 222N of force caused 4 penguin to accelerate.

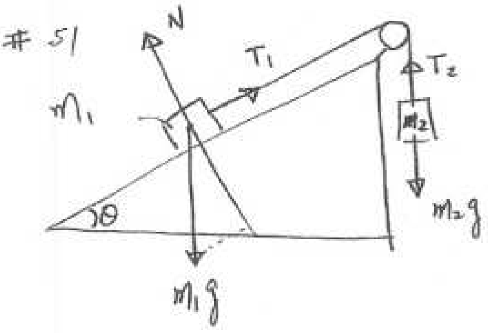
$$222N = (20kg + 15kg + m_3 + 12kg)\,a \quad \text{——— ①}$$

$T_3$, 111N of force caused $m_3$ & $m_4$ to accelerate

$$111\,N = (m_3 + 12kg)\,a \quad \text{——— ②}$$

After playing with these eqns., you will get the same result.

#51




$m_1 = 3.70\,kg$
$m_2 = 2.30\,kg$
$\theta = 30°$

Initial Test :
$m_1 g \sin\theta \overset{?}{\lesseqgtr} m_2 g$
$1.85\,kg < 2.3\,kg$

the initial test indicates that $m_1$ will slide up

(a) $m_1$

x (along the slope)
$$-m_1 g \sin\theta + T_1 = m_1 a \quad \text{—} ①$$

y (extra for this problem)
$$-m_1 g \cos\theta + N = 0$$

$m_2$

x
None

y
$$-m_2 g + T_2 = -m_2 a \quad \text{—} ②$$

Since $T_1 = T_2$, from eqn. ②
$$T_2 = T_1 = -m_2 a + m_2 g \quad \text{—} ②'$$

① ← ②'
$$-m_1 g \sin\theta + (-m_2 a + m_2 g) = m_1 a$$
$$-m_1 g \sin\theta + m_2 g = m_1 a + m_2 a$$
$$\therefore a = \frac{(-m_1 \sin\theta + m_2) g}{(m_1 + m_2)} = \frac{(-3.7 \sin 30° + 2.3)\,9.81}{(3.7 + 2.3)}$$
$$= 0.73575\ m/sec^2 \quad (\text{upward})$$

(b) The initial test is very important & helpfull & saves your time. Make sure you do the test → upward

(c) eqn ①
$$T_1 = m_1 a + m_1 g \sin\theta = m_1 (a + g \sin\theta)$$
$$= 3.70\,(0.73575 + 9.81 \sin 30°)$$
$$= 20.870775\,N$$

\#57 This is not our 230 Level problem, but I just wanted to stress the importance of indicating "units".

(a) $7682\,L \times \frac{1.77\,kg}{1\,L} = \underline{\underline{13597.14\,kg}}$

(b) $(22300\,kg - 13597.14\,kg) \times \frac{1\,L}{1.77\,kg} = \underline{\underline{4916.870056\,L}}$

(c) $7682\,L \times \frac{1.77\,lb}{1\,L} \times \frac{1\,kg}{2.205\,lb} = \underline{\underline{6166.503401\,kg}}$ $\left(\begin{array}{l} 1\,kg = 2.205\,lb \\ \text{from Appendix A-6} \end{array}\right)$

(d) $(22300\,kg - 6166.503401\,kg) \times \frac{2.205\,lb}{1\,kg} \cdot \frac{1\,L}{1.77\,lb} = \underline{\underline{20098.50847\,L}}$

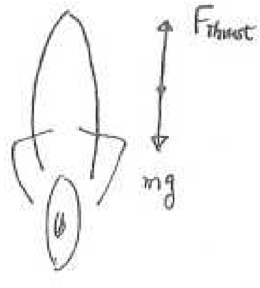
(e) $$\frac{7682\,L + 4916.870056\,L \text{ (asked to add)}}{22300\,kg \times \frac{2.205\,lb}{1\,kg} \cdot \frac{1\,L}{1.77\,lb} \text{ (Total needed)}} \times 100$$

$= \underline{\underline{45.35\,\%\text{ of the Max. fuel capacity}}}$

( they were Lucky this time, but usually things are not this Lucky. )

\#72 Even though the things are not on the earth, physics is physics. start w/ diagrams, pick a pt. or pts., draw forces, and write an eqn or eqns.

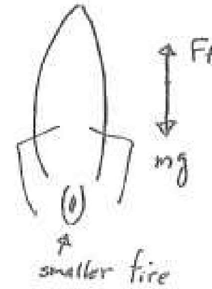
Case 1



$3260\,N - mg = m\cancel{a}^{0}$ — ①

(Because it descends at const. speed $\Rightarrow a = 0$)

Case 2



smaller fire

$2200\,N - mg = m\cancel{a}^{-0.39\,m/sec^2}$ — ②

(a) Eqn ①

$3260\,N - mg = 0$

$\therefore \underline{\underline{mg = 3260\,N}} = \text{weight}$ —— ①'

(b) ② ← ①'

$2200\,N - mg = -0.39\,m$

$\therefore \underline{\underline{m = 2717.948718\,kg}}$ —— ②'

(c) ①' ← ②'

$g = \frac{3260\,N}{m} = \underline{\underline{1.199433962\,m/sec^2}}$

#82

(a) $a = \text{const.}$ ——— ①

$V = \int a \cdot dt = at + \cancel{V_0}^0$ ——— ②  $m_s = 1.20 \times 10^6 kg$

$x = \int v \cdot dt = \frac{1}{2}at^2 + \cancel{x_0}^0$ — ③

Eqn. ② $V = 0.1C = 3\times10^8 m/sec \times 0.1 = 3\times10^7 m/sec$

$t = 3 \text{ days} = 3 \text{ days} \times \frac{24 hrs}{1 day} \times \frac{60 min}{1 hr} \times \frac{60 sec}{1 min}$

$\therefore a = \frac{v}{t} = \frac{3\times10^7 m/sec}{3\times24\times60\times60 sec} = \underline{\underline{1.1574\times10^2 m/sec^2}}$ —— ②'

(b) $1.1574\times10^2 m/sec^2 \times \frac{1g}{9.81 m/sec^2} = \underline{\underline{11.80 \text{ g's}}}$ ( Wait! Normal people die under this acc. )

(c) 1 light sec = $3\times10^8 m$

$\Rightarrow$ 5 light months = $3.888\times10^{15} m$

Dist. the ship travels in 1st 3days (during the acc.)

③ ⟵ ②'

$x = \frac{1}{2}(1.1574\times10^2)(3\cdot24\cdot60\cdot60 \text{ sec})^2$

$= 3.888\times10^{12} m$

The rest $(3.888\times10^{15}m - 3.888\times10^{12}m)$ is traveled at $V = 0.1C$.

$t = \frac{D}{t} = \frac{(3.888\times10^{15}m - 3.888\times10^{12}m)}{3\times10^7 m/sec} = 1.2947\times10^8 sec$

$= 1.4985\times10^3$ days

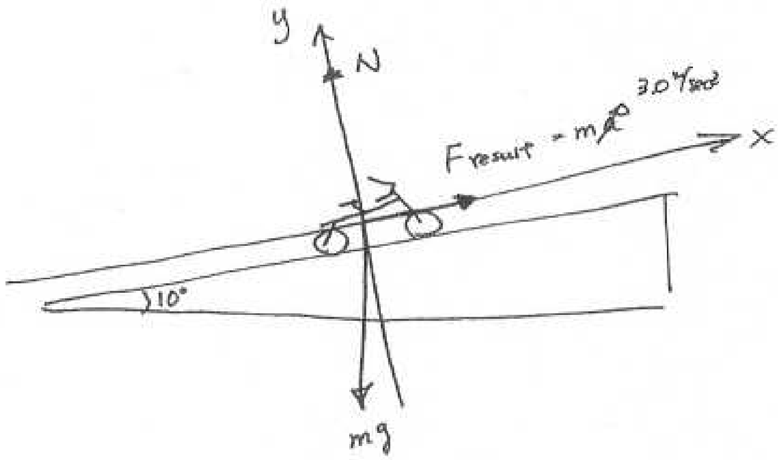
$= 4.105479452$ yrs

$= 4$ yrs $38.5$ days.

Total time = 3days + 4yrs. 38.5days

= $\underline{\underline{\text{4 yrs. 41.5 days}}}$

#83




X comp

$$-mg\sin\theta + F_{bike,x} = ma \quad \text{——— ①}$$

y comp.

$$-mg\cos\theta + N = 0 \quad \text{——— ②}$$

(a) Resultant Force ( along the inclined plane $- \Sigma F_y = 0$)

$$ma = 60.0\,kg \cdot 3.0\,m/sec^2 = \underline{\underline{180\,N}}$$

(b) Equ ①, solve for $F_{bike,x}$

x: $F_{bike,x} = ma + mg\sin\theta$

$= 60\,kg \cdot 3.0\,m/sec^2 + 60\,kg \cdot 9.81\,m/sec^2 \cdot \sin 10°$

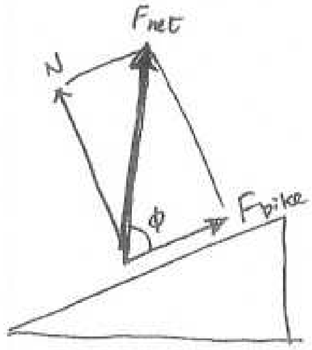
$= \underline{282.2093174\,N}$

y. Equ. ② . solve for N.

$N = mg\cos\theta$

$= 60\,kg \cdot 9.81\,m/sec^2 \cos 10°$

$= \underline{579.6578434\,N}$




$$|F_{net}| = \sqrt{(F_{bike,x})^2 + N^2}$$

$$= \underline{\underline{644.7\,N}} \quad (644.7056028\,N)$$

$$\phi = \tan^{-1}\frac{579.6\ldots}{282.2\ldots} = \underline{\underline{64.04° \text{ above the plane}}}$$