SOLUTIONS – 5

FORMULAE

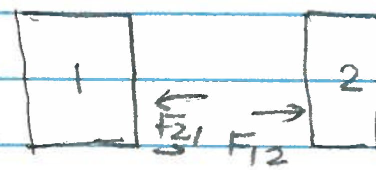
Newton's LAWS:

Second. $M\underset{\rightarrow}{a} = \sum \underset{\rightarrow}{F_i}$ at that point at that time.

If $\equiv m$, $\underset{\rightarrow}{a} = 0$

$$\sum \underset{\rightarrow}{F_i} = 0.$$

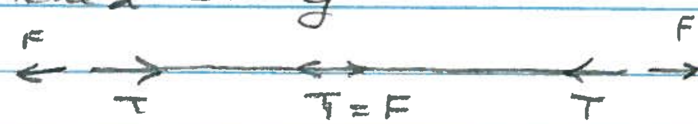
Third $\underset{\rightarrow}{F_{12}} + \underset{\rightarrow}{F_{21}} = 0$



FORCES Weight $\underset{\rightarrow}{W} = -Mg\hat{y}$ or $-Mg\hat{z}$.

Normal force (perpendicular to solid surface) $\uparrow \underset{\rightarrow}{n}$

Tension in stretched string

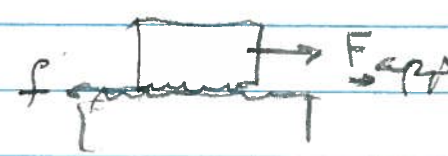


spring force $\underset{\rightarrow}{F} = -k\Delta x\,\hat{x}$.

Friction (between two solid surfaces)

static $f_s \leq \mu_s N$

kinetic $f_k = \mu_k N$



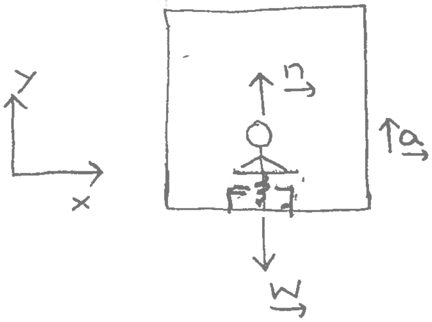
SOLUTIONS To

CHAPTER 5 — PROBLEMS

20.

Forces on you are $n\hat{y} + -Mg\hat{y}$

a. Before the elevator starts moving,



$\vec{a} = 0$, you are in $\equiv$ m

So, net force $= M\vec{a} = n\hat{y} - Mg\hat{y}$

$\therefore$ Apparent weight (force on machine)

$= n = w = mg = (60\ kg)(9.8\ m/s^2) = 590N$

b. To find the acceleration of the elevator, we use the equation

$(v_y)_f = (v_y)_i + a_y\Delta t$

Here, $(v_y)_f = 10\ m/s$, $(v_y)_i = 0$, $\Delta t = 4.0\ s$

$\therefore 10 = a_y \times 4 \Rightarrow a_y = 2.5\ m/s^2$ or, $\vec{a} = 2.5\ m/s^2\ \hat{y}$

So $M\vec{a} = (n - Mg)\hat{y}$

$\vec{n} = M(g+a)\hat{y} = M(9.8 + 2.5)\hat{y}$

and machine measures

$n = 590N + 150\ N$

$= 740\ N$

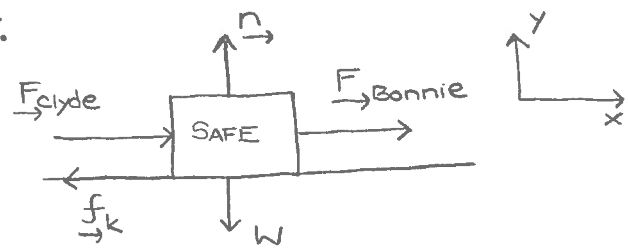
$\therefore$ Apparent weight $= 740N$

c. After the elevator reaches its cruising speed, it keeps moving at constant speed. In other words, its acceleration is zero. So, just as in part a. of this problem, the apparent weight is equal to the actual weight, that is 590 N.

$M\vec{a} = (n - Mg)\hat{y}$

$= 0.$

25.



Since the safe is sliding with constant speed, it has zero acceleration.

So, Net force in x-direction must be zero.

$$\vec{F} = F_{Clyde}\hat{x} + F_{Bonnie}\hat{x} + f_k(-\hat{x})$$
$$= ma_x\hat{x}$$
$$= 0$$

or, $f_k = F_{Clyde} + F_{Bonnie} = 735\text{N}$

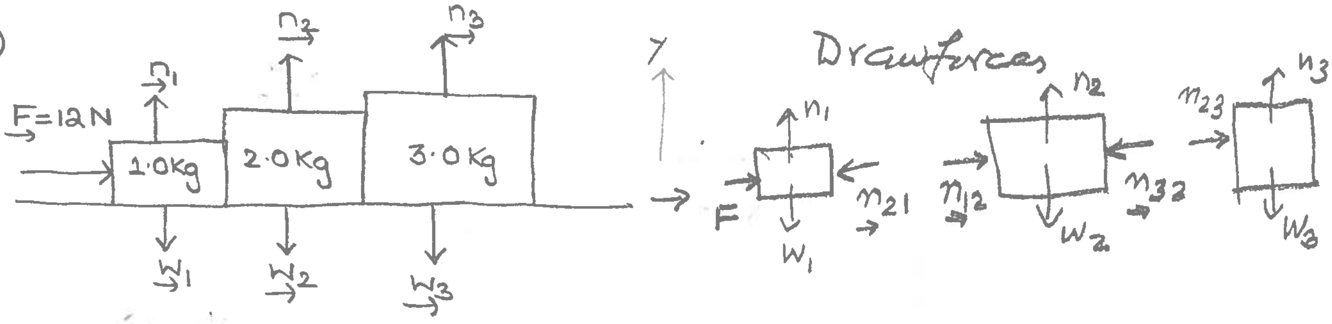
Net force in y-direction

$$= n\hat{y} + w(-\hat{y})$$
$$= ma_y\hat{y}$$
$$= 0$$

or, $n = w = mg = (300\text{Kg})(9.8\,\text{m/s}^2)$
$$= 2940\text{N}$$

$\therefore$ Co-efficient of kinetic friction $= \dfrac{f_k}{n}$
$$= \frac{735}{2940} = 0.25$$

35)



Assuming the blocks do not lose contact with each other, all three of them have the same acceleration and we can treat all 3 blocks together as 1 system (or, as one large block of mass $1+2+3 = 6\,kg$) [b/c when you add all the forces $\vec{n}_{12} + \vec{n}_{21} + \vec{n}_{23} + \vec{n}_{32} = 0$]

Since $\vec{F}$ is the only force in the horizontal direction

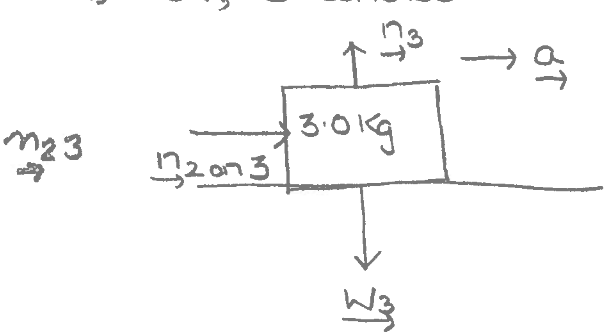
$$\vec{F} = m\vec{a}$$

where $\vec{a}$ is the common acceleration of the 3-blocks in the horizontal direction.

$$\text{or, } \vec{a} = \frac{1}{m}\vec{F} = \frac{1}{(6\,kg)}(12N\,\hat{x})$$

$$= 2\,m/s^2\,\hat{x}$$

a) Now, we consider the 3.0 kg block separately.



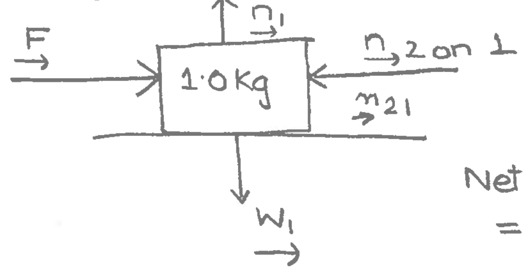
Again, in this case, $\vec{n}_{2\,on\,3}$ is the only horizontal force.

$$\therefore\; n_{2\,on\,3}\,\hat{x} = ma\,\hat{x}$$

$$= (3.0\,kg)(2\,m/s^2)\,\hat{x} = 6\,N\,\hat{x}$$

$$\text{or, } \vec{n}_{2\,on\,3} = 6\,N\,\hat{x}$$

b) Here, we consider the 1 kg block separately.



Again, using Newton's 2nd law in the horizontal direction,

Net force in horizontal direction

$$= F\hat{x} + n_{2\,on\,1}(-\hat{x}) = ma\,\hat{x}$$

$$\text{or, } n_{2\,on\,1}(-\hat{x}) = (ma - F)\,\hat{x}$$

$$= [(1.0\,kg)(2\,m/s^2) - 12N]\,\hat{x}$$

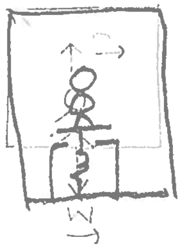
51. $g = 32.174\ \text{ft/s}^2$ (in the English system of units)

Case I : When the elevator is at rest,

Machine measures m!

$a = 0$

$n = W$



$\vec{a} = 0$

on you, $\vec{F}_{net} = n\hat{y} + w(-\hat{y}) = m\vec{a} = 0$

or, $n = w$

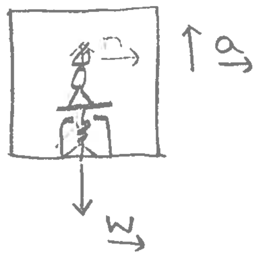
$= mg = (150\ \text{lb})(32.174\ \text{ft/s}^2)$

$= 4826\ \text{lb-ft/s}^2$

a) Case II : When elevator is accelerating upward,
(from figure, it is clear that normal force is greater than weight)
So, this corresponds to the 170 lb reading.

$n > W!$

$\vec{a} = +a\hat{y}$



$\vec{F}_{net} = n\hat{y} + w(-\hat{y})$

$= (170\ \text{lb})(32.174\ \text{ft/s}^2)\hat{y} - 4826\ \text{lb-ft/s}^2\ \hat{y}$

$= 5470.\ \text{lb-ft/s}^2\hat{y} - 4826\ \text{lb-ft/s}^2\ \hat{y}$

$= 644\ \text{lb-ft/s}^2\ \hat{y}$

$= m\vec{a}$

or, $\vec{a} = \frac{1}{m}\vec{F}_{net}$

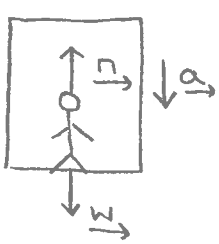
$= \frac{1}{(150\ \text{lb})}(644\ \text{lb-ft/s}^2)\hat{y}$

$= 4.3\ \text{ft/s}^2\ \hat{y}$

b) Case III : When elevator is braking to a stop (that is, having negative acceleration),

$n < W$

$\vec{a} = -a\hat{y}$



From figure, it is clear that weight is greater than normal force.
So, this corresponds to the 120 lb reading.

$\vec{F}_{net} = n\hat{y} + w(-\hat{y})$

$= (120\ \text{lb})(32.174\ \text{ft/s}^2)\hat{y} - 4826\ \text{lb-ft/s}^2\ \hat{y}$

$= -965.12\ \text{lb-ft/s}^2\ \hat{y} = m\vec{a}$

$\therefore\ \vec{a} = \frac{\vec{F}_{net}}{m} = \frac{-965.12\ \text{lb-ft/s}^2\ \hat{y}}{(150\ \text{lb})} = -6.4\ \text{ft/s}^2\ \hat{y}$