Home Work 3 Solutions

1) A person of $m = 60\ kg$ is riding an elevator. We want a force diagram for each cash showing the magnitude of the forces acting on the person.

(a) Elevator at rest.

$$\sum F = N - mg = 0$$

$$\Rightarrow N = mg$$

(b) Elevator accelerating up at $a = 5\,m/s^2$.

$$\sum F = N - mg = m a_b$$

$$\Rightarrow N = m(g + a_b) = m\,(14.8\,m/s^2)$$

Notice that $N > mg$.

(c) Elevator accelerating down at $a = -5\,m/s^2$.

$$\sum F = N - mg = m a_c$$

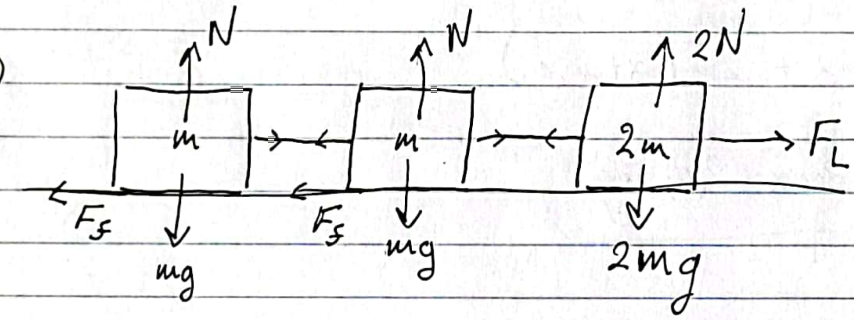
$$\Rightarrow N = m(g + a_c) = m\,(4.8\,m/s^2)$$

Notice that $N < mg$.

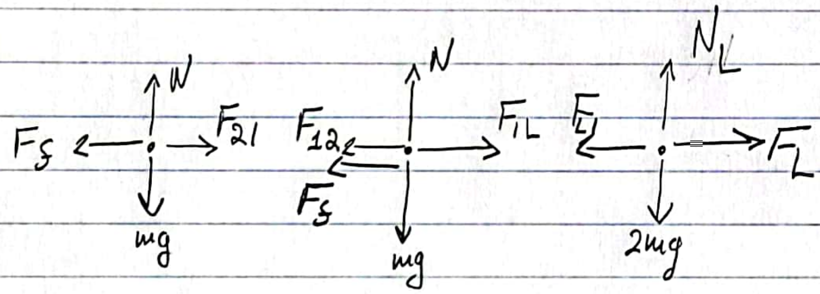
2) When the Elevator is accelerating upwards, you will feel heavier. While the Elevator is accelerating downwards, you will feel lighter.

Based on our solution to question (1), this is clearly related to the Normal Force. When the Elevator had a positive acceleration we found that $N > mg$. In the case when acceleration was negative, we noticed that $N < mg$. The force of gravity never changes because it doesn't depend upon the motion of the system. However, the Normal force will change depending upon the acceleration of the system, cause you to feel as though your weight is changing.

3) (a)



(b)



(c) L :
$$\sum F_x = F_L - F_{L1} = ma_x$$
$$\sum F_y = N_L - 2mg = 0$$

1 :
$$\sum F_x = F_{1L} - F_{12} - F_f = ma_x$$
$$\sum F_y = N - mg = 0$$

2 :
$$\sum F_x = F_{21} - F_f = ma_x$$
$$\sum F_y = N - mg = 0$$

$F_{L1} = F_{1L}$, $F_{12} = F_{21}$, $F_f = \mu_k N$, $a_x = \alpha$

$N_L = 2mg$, $N = mg$

(d)
$$F_L - F_{1L} = m\alpha$$
$$F_{1L} - F_{12} - \mu_k N = m\alpha$$
$$F_{12} - \mu_k N = m\alpha$$

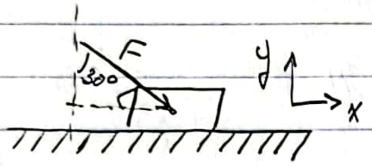
$$F_{1L} - (m\alpha + \mu_k N) - \mu_k N = m\alpha$$
$$F_{1L} = 2m\alpha + 2\mu_k N$$
$$F_{1L} = 2m\alpha + 2\mu_k mg$$
$$\boxed{F_{1L} = 2m(\alpha + \mu_k g)}$$

$$F_{12} = m\alpha + \mu_k N$$
$$\boxed{F_{12} = m(\alpha + \mu_k g)}$$

$F_L = m\alpha + 2m(\alpha + \mu_k g)$

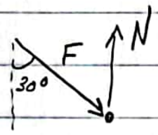
$\boxed{F_L = 3m\alpha + 2\mu_k m g}$

4)



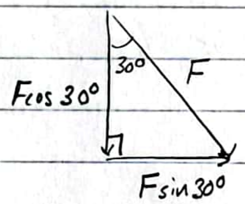
$m = 1\,kg$, $F = 9.8N$

(a)



In space, no gravity.

(b)



$F\cos 30° \rightarrow \perp$ to surface
$F\sin 30° \rightarrow \parallel$ to surface

(c)

$$\sum F_x = F\sin 30° = ma_x$$
$$\sum F_y = N - F\cos 30° = ma_y$$

$\sum F_x \rightarrow$ component of the net force $\parallel$ to surface
$\sum F_y \rightarrow$ component of the net force $\perp$ to surface

(d) The book doesn't fall through the table, so $a_y = 0$.

$$N = F\cos 30°$$

$$N = (9.8N)\cos 30° = \boxed{8.487\,N}$$

(e) $a_x = \dfrac{F\sin 30°}{m}$

$$\boxed{a_x = 4.9\,m/s^2}$$

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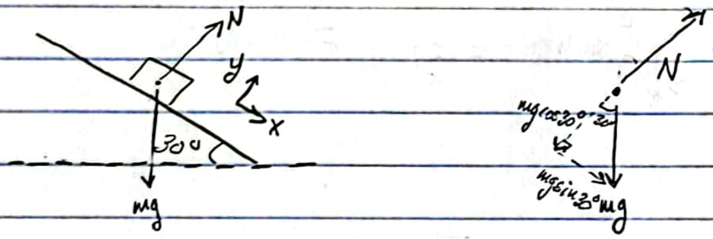
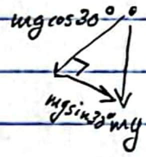
5) (a)



(b) $mg \sin 30^\circ \rightarrow$ force $\parallel$ to ramp
$mg \cos 30^\circ \rightarrow$ force $\perp$ to ramp



(c) Choose coordinate so that x is $\parallel$ to ramp.

$$\sum F_x = mg \sin 30^\circ = m a_x$$
$$\sum F_y = N - mg \cos 30^\circ = m a_y$$

$\sum F_x \rightarrow$ the component of the net force $\parallel$ to the surface
$\sum F_y \rightarrow$ the component of the net force $\perp$ to the surface

(d) $a_y = 0$

$\Rightarrow N = mg \cos 30^\circ$

$$\boxed{N = 8.487\, N}$$

$\Rightarrow a_x = g \sin 30^\circ$

$$\boxed{a_x = 4.9\, m/s^2}$$

6) $m = 1500\ kg$

$v_i = 20\ m/s$

Want to stop in distance $d = 30m$.

$$2xa = v_f^2 - v_i^2$$

Solve for a, then can find $F = ma$.

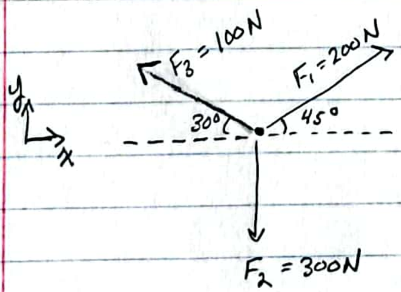
$v_f = 0$

$$\Rightarrow \quad a = \frac{-v_i^2}{2x} = -\frac{(20)^2}{2(30)} = -6.67\ m/s^2$$

$$\Rightarrow \quad F = (1500\ kg)(6.67\ m/s^2)$$

$$\boxed{F = 10{,}000\ N}$$

7)



$$\vec{F}_1 = (200N \cos 45^\circ,\ 200N \sin 45^\circ)$$

$$\vec{F}_2 = (0,\ -300N)$$

$$\vec{F}_3 = (-100N \cos 30^\circ,\ 100N \sin 30^\circ)$$

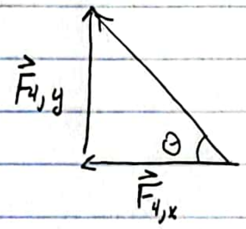
$$\Sigma F_x = 200N \cos 45^\circ - 100N \cos 30^\circ + F_{4,x} = 0$$

$$\Sigma F_y = 200N \sin 45^\circ - 300N + 100N \sin 30^\circ + F_{4,y} = 0$$

Solving for F_4's component yields

$$\boxed{\vec{F}_4 = (-54.819N,\ 108.579N)}$$

What direction should we apply this force?



$$\tan\theta = \frac{|\vec{F}_{4,y}|}{|\vec{F}_{4,x}|}$$

$$\theta = \text{Arctan}\left(\frac{|\vec{F}_{4,y}|}{|\vec{F}_{4,x}|}\right)$$

$$\theta = \text{Arctan}\left(\frac{108.58}{-54.83}\right)$$

$$\boxed{\theta \approx 63.2^\circ}$$

Net force of 121.63 N directed 63.2° North of West.

$$|\vec{F}_4| = \sqrt{F_x^2 + F_y^2}$$

$$= 121.63 \text{ N}$$

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