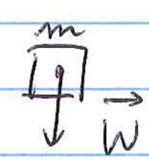
PHYS 107 - Week 04 - Monday

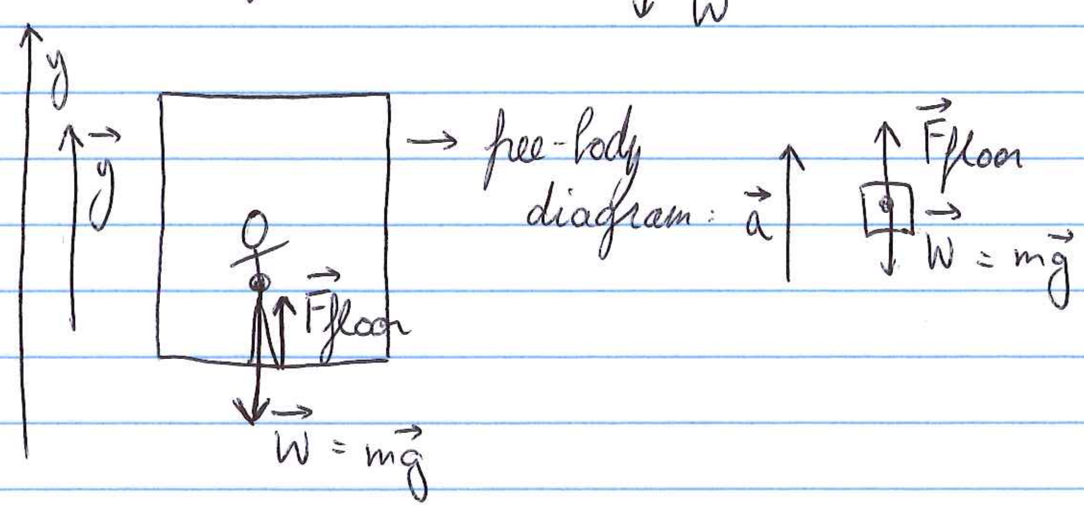
* Dynamics of { moving / accelerating } elevator: force = weight

Newton's first law: $\vec{a} = 0$ unless $\vec{F}_{net} \neq 0$
Newton's second law: $\vec{a} = \frac{\vec{F}_{net}}{m}$ or $\vec{F}_{net} = m\vec{a}$
Newton's Third law: $\vec{F}_{BA} = -\vec{F}_{AB}$

weight = force due to gravity by a mass m

↳ $\vec{W} = m\vec{g}$, $\vec{g} = -9.80 \, m/s^2$, downwards
$g = |\vec{g}| = 9.80 \, m/s^2$

free-body diagram: 



→ $\vec{F}_{floor} + \vec{W} = m\vec{a}$

↳ $F_{floor} - mg = ma$

↳ $F_{floor} = m(g + a)$

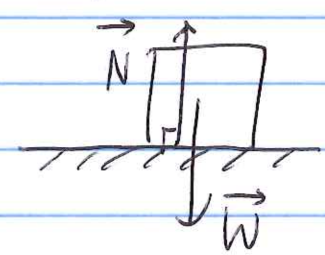
1) $\vec{a} = 0 \rightarrow$ elevator not accelerating, $F_{floor} = mg$

2) $\vec{a} > 0 \rightarrow$ elevator accelerating up, $F_{floor} = m(g+a) > mg$
(upwards) ↳ heavier

3) $\vec{a} < 0 \rightarrow$ elevator accelerating down, $F_{floor} = m(g-a) < mg$
(downwards) ↳ lighter

* Contact forces: forces between macroscopic objects in contact with each other (microscopically these are electrical, chemical forces)

example: $\vec{F}_{floor}$, more generally $\vec{N}$



1) normal forces $\vec{N}$: perpendicular to the surface of an object

$$\vec{F}_{net} = \vec{N} + \vec{W} = m\vec{a} = 0 \rightarrow N = W = mg$$

- normal forces are "as large as the need to be" to result in the zero acceleration perpendicular to the surface
- normall forces can "push but not pull"

Question Forces 5-a

2) tension $\vec{T}$: parallel to the length of rope or chain or muscle, tendon

- tension can "pull but not push"

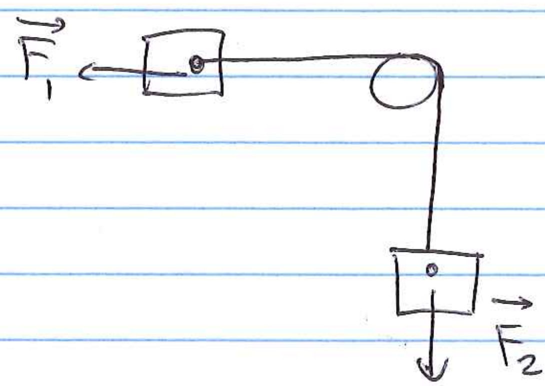
$\vec{a} = 0$

$\hookrightarrow \vec{F}_{net} = \vec{F}_1 + \vec{F}_2 = m\vec{a} = \vec{0}$

Even when $\vec{a} \neq 0$ and rope is light: $m = 0$

$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 = 0 \rightarrow |\vec{F}_1| = |\vec{F}_2| = T$

- tension can be used to change directions of forces:

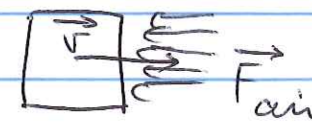


example: shoulder muscles

Q 4a-b

3) air resistance, drag → how much does the air affect the motion of an object

$\vec{F}_{air} \sim - f(\vec{v})$



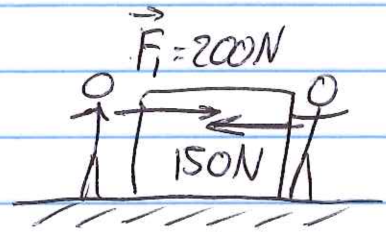
↑ always against direction of motion

4) friction $\vec{f}$

↳ see next chapter

* Examples of problems with forces:

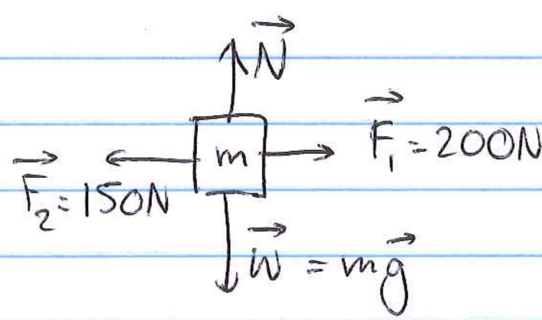
1) Moving:



* what is the acceleration of the object?

* what is the normal force from the ground on the object?

FBD:



m = 50kg

$\vec{F}_{net} = m\vec{a} \Rightarrow x: \quad F_1 - F_2 = ma_x$

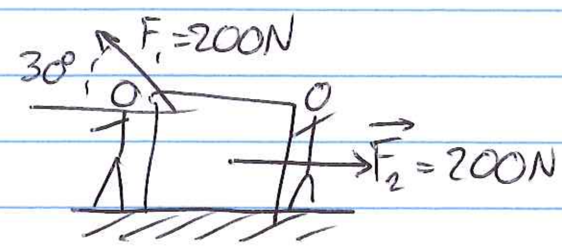
$y: \quad -mg + N = ma_y = 0$

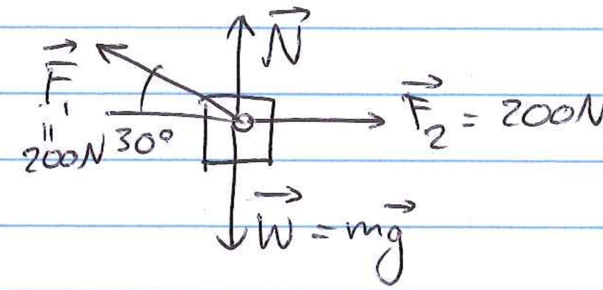
Q Moving 1

$\rightarrow \quad a_x = \frac{1}{m}(F_1 - F_2) = +1\ m/s^2$

$\rightarrow \quad N = mg = 500\ N$

2)





$\vec{F}_{net} = m\vec{a} \Rightarrow \quad x: \; -F_1 \cos\theta + F_2 = ma_x$

$\qquad\qquad\qquad\quad y: \; N - mg + F_1 \sin\theta = ma_y$

$\rightarrow \quad a_x = +0.54\ m/s^2$

what about a_y? could it be non-zero?

1) assume $a_y = 0 \rightarrow$ find N, must be positive

if $N > 0$, then $a_y = 0$ is ok

if $N < 0$, then $a_y \neq 0$, but $N = 0$

$\rightarrow \quad N = mg - F_1 \sin\theta = +390\ N \rightarrow$ OK

what if $F_1 = 1200N$? $\rightarrow N = -110N \rightarrow$ not OK

$ma_y = -mg + F_1 \sin\theta \rightarrow a_y = +2.2\ m/s$

$\rightarrow$ box lifts off the floor