Dynamics Notes

1 – Newton's Laws

Newton's 1st Law:
An object...in motion will stay in motion
and an object...at rest will stay at rest
unless...an outside force is applied

aka. Law of Inertia

Newton's 2nd Law:
The acceleration of a body is proportional to the force and inversely proportional to the mass...
As a formula:

$$F_{net} = ma$$

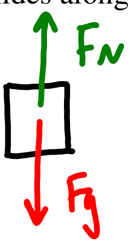
Newton's 3rd Law:
For every...action force there is an equal and opposite reaction force
As a formula:

$$F_{action} = -F_{reaction}$$

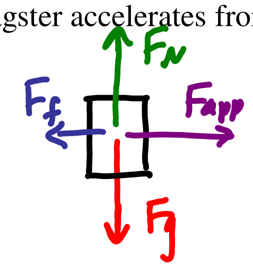
Free Body Diagrams: (Draw one for **EVERY** force question)

1) Represent the object as a box and,
2) Represent all forces as arrows
   - The arrows are vectors so their direction is critical
   - Start in the center and draw outwards
   - The size of the arrow represents the magnitude of the force

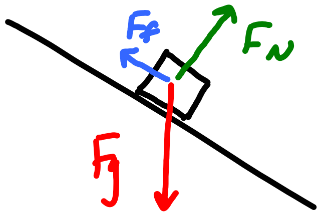
1. A puck slides along frictionless ice.



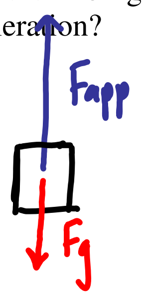
2. A dragster accelerates from rest.



3. A block of wood slides down an incline



Ex. A student pulls straight upwards with a force of 650 N on their 15 kg backpack. What is the backpack's acceleration?



$F_{net} = F_{app} - F_g = ma$

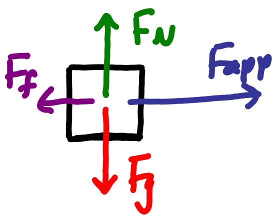
$a = \frac{F_{app} - F_g}{m}$

$= \frac{650N - 147N}{15\ kg}$

$= \boxed{34\ m/s^2}$

$F_g = mg$
$= (15kg)(9.8 m/s^2)$
$= 147 N$

Ex. A 1200kg car accelerates at 5.85 m/s². If the coefficient of friction acting on the car is roughly 0.24, how much force does the engine exert?



$F_f = \mu F_N$ (only true on level surface)
$= \mu F_g$
$= \mu mg$
$= (0.24)(1200 kg)(9.8 m/s^2)$
$= 2822 N$

$F_{net} = F_{app} - F_f = ma$

$F_{app} = ma + F_f$
$= (1200)(5.85) + 2822$
$= \boxed{9800 N}$

$$F_g = mg$$

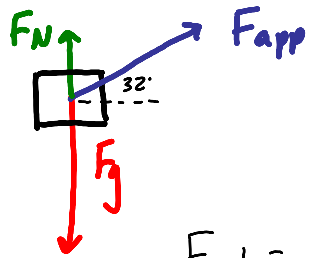
g: on Earth's surface $\simeq 9.8 m/s^2$

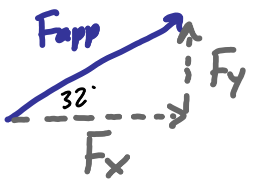
$$F_f = \mu F_N$$

F_N: Normal Force supports ⊥ to surface

μ: coefficient of friction

Ex: A boy pulls his 8.0 kg toboggan by a rope that angles 32° above the horizontal. If his 36.0 kg sister sits on the toboggan, how much force does he need to exert to accelerate them at 2.25 m/s^2? Assume $\mu = 0$





$F_{net} = F_x = ma$

$= (36.0 + 8.0)(2.25)$

$= 99\ N$

$\cos 32° = \frac{F_x}{F_{app}}$

$F_{app} = \frac{F_x}{\cos 32°} = \boxed{120\ N}$

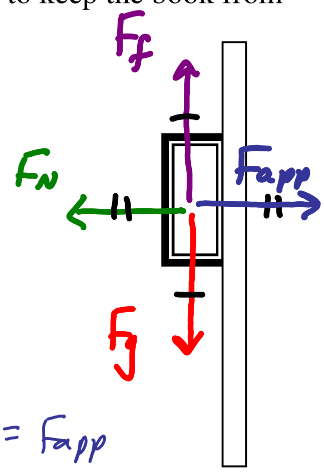
Ex: A 1.12 kg textbook is pushed horizontally against a wall with a coefficient of friction of 0.465. What is the least amount of force required to keep the book from slipping?

$F_f = F_g$

$= mg$

$= (1.12 kg)(9.8 m/s^2)$

$= 10.976 N$



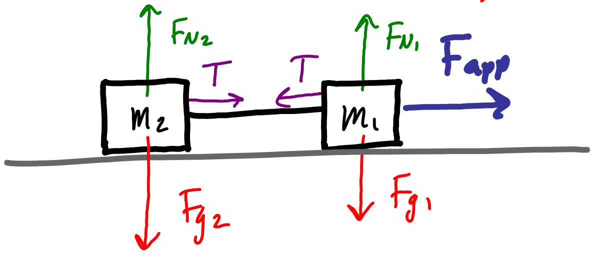
$F_f = \mu F_N \qquad F_N = F_{app}$

$F_f = \mu F_{app}$

$F_{app} = \frac{F_f}{\mu} = \frac{10.976 N}{0.465}$

$= \boxed{23.6\ N}$

Ex: Two blocks (m1 = 2.0 kg and m2 = 3.0 kg) are connected by a rope as shown. m1 is pulled to the right with a force of 18 N. What is the tension in the rope connecting the two masses? Assume $\mu = 0$



To find $\vec{a}$ look at the entire system:

$F_{net} = F_{app} = m_{total}\, a$

$a = \frac{F_{app}}{m_{total}} = \frac{18 N}{(2.0 + 3.0)} = 3.6\ m/s^2$

To find tension look at only 1 mass:

m1

$F_{net} = F_{app} - T = m_1 a$

$T = F_{app} - m_1 a$

$= 18 - (2.0)(3.6)$

$= 10.8$

$= \boxed{11\ N}$

m2

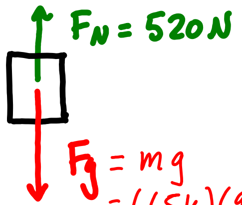
$F_{net} = T = m_2 a$

$T = (3.0)(3.6)$

$= 10.8$

$= \boxed{11\ N}$

Ex: A 65 kg student stands on a bathroom scale in an elevator and notices that it reads 520 N. Determine the magnitude and direction of the acceleration of the elevator.



apparent weight, how heavy you feel $= F_N$

$F_g = mg$

$= (65 kg)(9.8 m/s^2)$

$= 637 N$

since $F_g > F_N$ it must be winning, so...

$F_{net} = F_g - F_N = ma$

$a = \frac{F_g - F_N}{m} = \frac{637 - 520}{65}$

$= \boxed{1.8\ m/s^2\ \text{down}}$