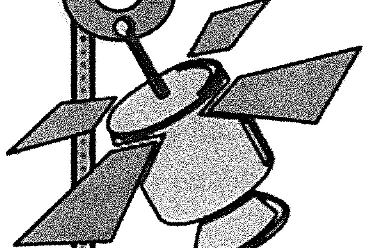
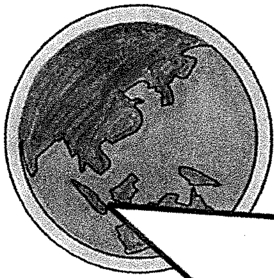
Newton's 3rd Law

For every action force there exists an equal and opposite reaction force.



Identify the action and reaction forces involved when the Earth pulls a satellite towards it. ↑ even at-a-distance forces like gravity

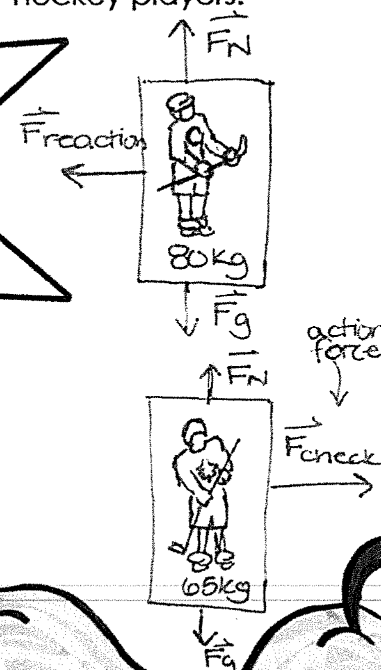


action: Earth pulls on the satellite

reaction: The satellite pulls on Earth. * Earth does not accelerate as much due to its large mass.

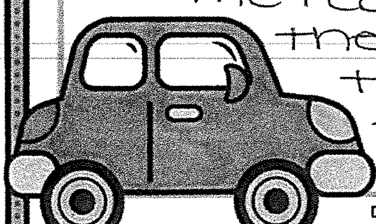
Forces ALWAYS come in pairs!

An 80-kg hockey player checks a 65-kg hockey player on frictionless ice. Draw the FBD for both hockey players.



Use The Law of Force Pairs to explain how a car accelerates.

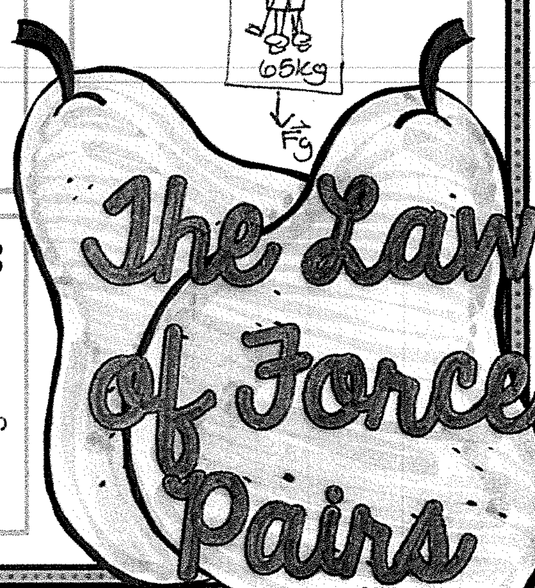
The car's tires grip the road and push the road backwards. The reaction force moves the car forward; the road pushes the car forward.



TRUE OR FALSE:

When a bug hits a car's windshield it splats because the force of the car on the bug is greater than the force of the bug hitting the car.

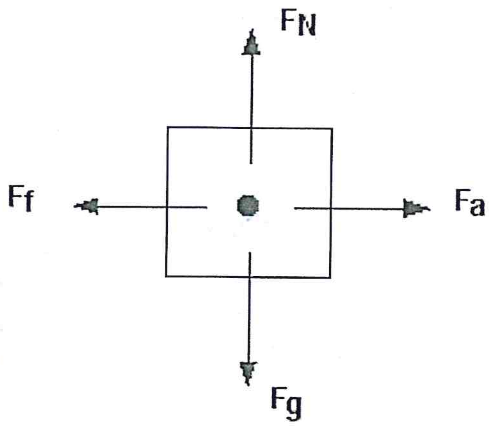
False - the forces are equal, but the bug's tiny mass results in a huge deceleration.



Name: Solutions

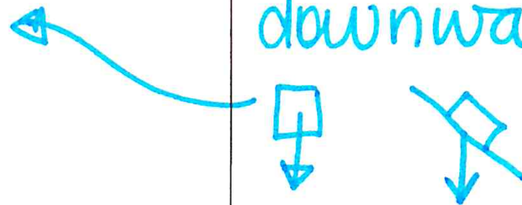
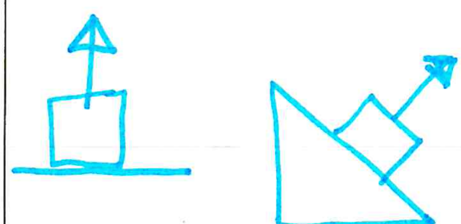
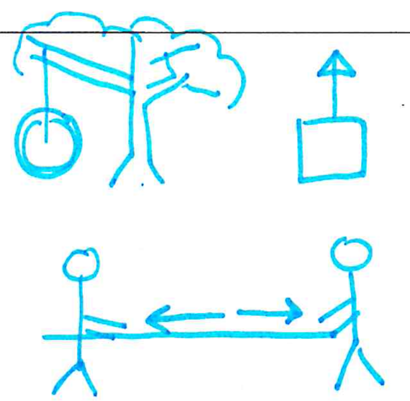
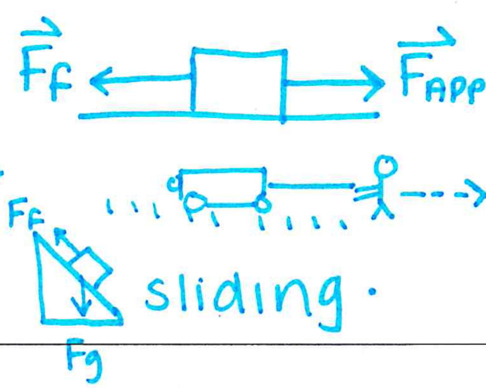
NAME:______________________________

FREE BODY DIAGRAMS (FBD)



a FBD is a diagram that shows all forces acting on an object
Objects are represented as a Box.
We think of all the mass as concentrated in the center, therefore all forces act from the center of the box.
The direction of the arrow represents the direction of the force vector
The size of the arrow represents the magnitude of the force vector

HOW TO DRAW DIFFERENT FORCES ON FBDs

FORCE:	DRAW IT:	THE RULE:
$\vec{F}_g$ FORCE of GRAVITY		pointing downward 
$\vec{F}_N$ NORMAL FORCE		perpendicular to surface
($\vec{F}_T$ & Tension) $\vec{F}_{APP}$ Applied Force (push or pull)		drawn along direction of force
$\vec{F}_f$ FRICTIONAL FORCE		parallel to surface of contact & opposes direction of motion

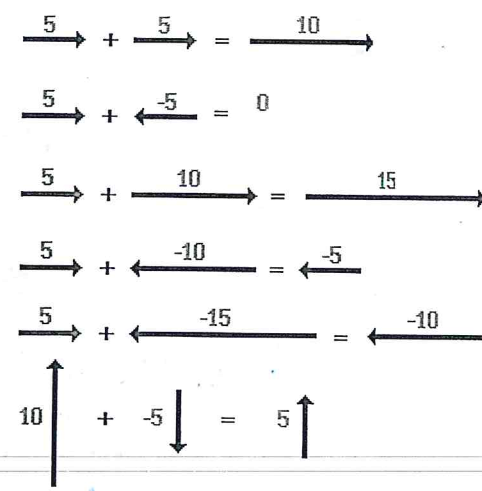
NET FORCE

F_{net}	$\Sigma\vec{F}$
"the combination *of all* Forces *acting on an object"*	

Net force can be calculated by finding the sum of all forces acting on an object:

$$\Sigma\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 \ldots$$

The net force is the vector sum of all the forces that act upon an object. Force is a vector and two forces of equal magnitude and opposite direction will cancel each other out.



Once you add the forces acting on an object, you will see either...

- the forces will be unbalanced, and the object will accelerate according to the net force.
- the forces will be balanced, the net force will be zero, and the object will not change motion

$\vec{v} = 0\,m/s$ OR constant $\vec{v}$

so $\vec{a} = 0\,m/s^2$

* next page

FORCES

UNBALANCED → Acceleration

Net Force Exists

BALANCED → $\vec{a} = 0 m/s^2$; $\Sigma\vec{F} = 0N$

The forces on the person are balanced.

Let's say Lil Jimmy here has a mass of 68 kgs…

What is the NET FORCE?

$\Sigma\vec{F} = 0N$

not moving ↕

If there is no motion there is a $\Sigma\vec{F}$ of 0N.

…forces are balanced

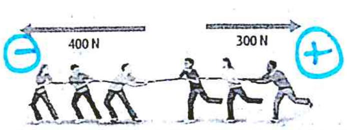
…this is called a state of EQUILIBRIUM.

An object is also in equilibrium if it is in motion and continuing in motion with the same $\vec{v}$ (no acceleration AKA constant $\vec{v}$.)

What is the net force?

$\Sigma\vec{F} = 0N$

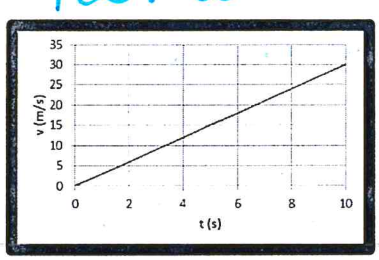
$\Sigma\vec{F} =$ ⊖



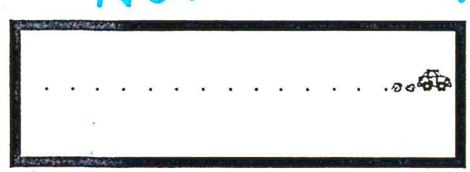
⊕

↳ $-400N + 300N = -100N$

yes! $\vec{a}$ exists

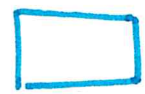
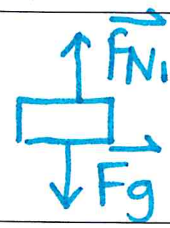
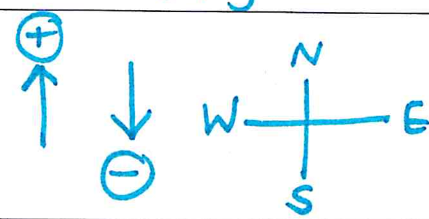


No! constant $\vec{v}$



example
- binder on desk

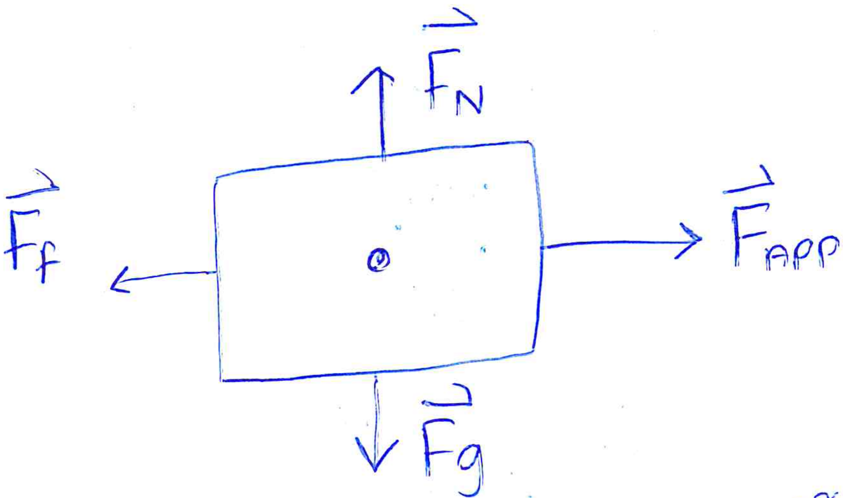
STEPS TO DRAWING and SOLVING FBDS

Draw a BOX (NO shapes)!	
Draw + Label Forces	
Choose coordinate system	
Find $\Sigma \vec{F}$	$\Sigma \vec{F} = \vec{F_g} + \vec{F_N}$
Substitute Known Values and Newton's 2nd	$\Sigma \vec{F} = \vec{F_g} + \vec{F_N}$ $\Sigma \vec{F} = mg + \vec{F_N}$
Plug + Chug and Solve	let's say binder = 2kgs $\Sigma \vec{F} = mg + \vec{F_N}$ $0N = 2kg(9.8 m/s^2) + \vec{F_N}$

$\boxed{\vec{F_N} = -19.6N}$

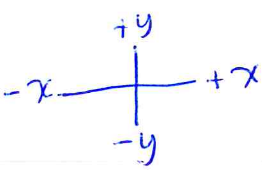
X and Y components of net force

1) Object being pulled on a horizontal surface:



$$\Sigma \vec{F} = \vec{F_N} + \vec{F_g} + \vec{F_{app}} + \vec{F_f}$$

Or... if we consider direction right away...

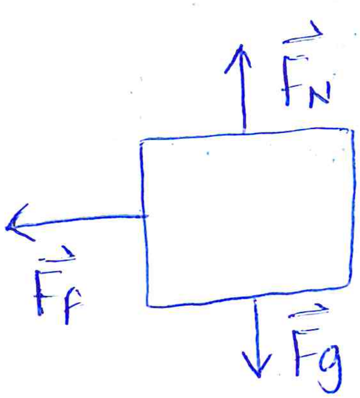


x	y
$+\vec{F_{APP}}$	$+\vec{F_N}$
$-\vec{F_f}$	$-\vec{F_g}$

$$\Sigma \vec{F_x} = \vec{F_{APP}} - \vec{F_f}$$

$$\Sigma \vec{F_y} = \vec{F_N} - \vec{F_g}$$

2) Object coming to rest because of friction after being pushed:



$$\Sigma \vec{F_y} = \vec{F_N} - \vec{F_g}$$

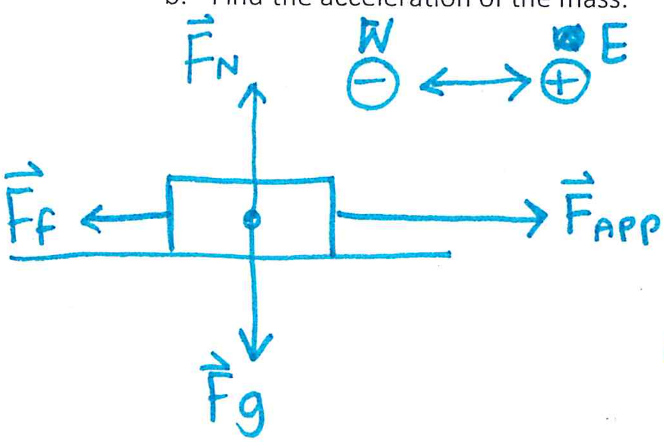
$$\Sigma \vec{F_x} = -\vec{F_f}$$

Net Force Examples

1) An 8.0 kg mass is at rest on a level surface, An applied force of 30.0N [E] is applied to the mass against 12.0 N of friction.

   a. Draw a FBD.

   b. Find the acceleration of the mass.



$\Sigma \vec{F}_x = \vec{F}_{app} + \vec{F}_f$

$\Sigma \vec{F}_x = 30.0\,N[E] + (-12.0\,N[W])$

$\Sigma \vec{F}_x = 18.0\,N[E]$

$\therefore \Sigma \vec{F}_x = ma$

$18.0\,N[E] = 8\,kg \cdot a$

$a = \frac{18}{8}$

$a = 2.25\,m/s^2\,[E]$

$\Sigma \vec{F}_y = \vec{F}_N + \vec{F}_g$

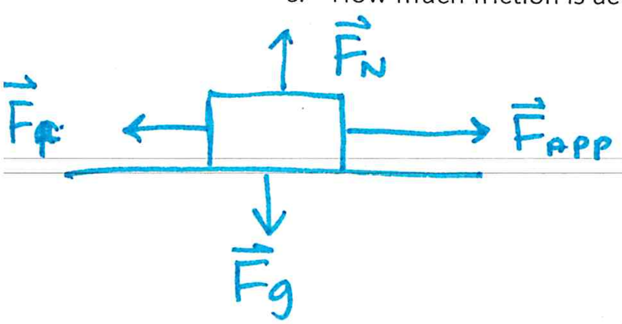
$\Sigma \vec{F}_y = 0N$

2) A 10.0 kg mass is at rest on a level surface. An applied force of 20.0 N acts on it for 4.0 s. The object reaches a speed of only 5.00 m/s because of friction.

   a. Draw a FBD.

   b. Find the actual acceleration of the mass.

   c. How much friction is acting on the object?



$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_0}{t_f - t_0}$

$\vec{a} = \frac{5\,m/s - 0\,m/s}{4s - 0s} = \frac{5}{4} = 1.25\,m/s^2$

$\Sigma \vec{F}_x = \vec{F}_{APP} + \vec{F}_f$

$\Sigma \vec{F}_x = m \cdot a = 10\,kg \cdot 1.25\,m/s^2$

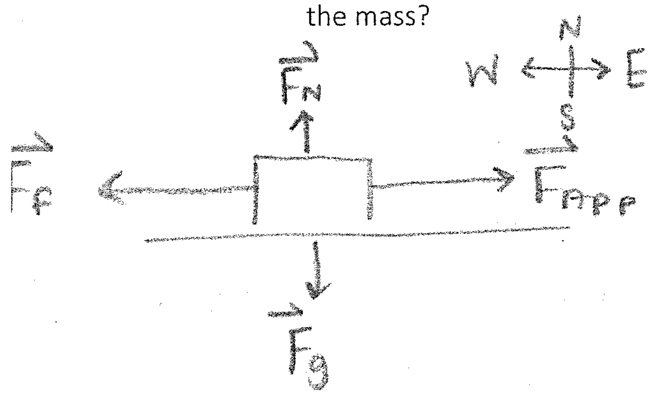
$\Sigma \vec{F}_x = 12.5\,N$

$\therefore \Sigma \vec{F}_x = \vec{F}_{APP} + \vec{F}_f$

$12.5N = 20\,N + \vec{F}_f$

$\vec{F}_f = -7.5\,N$

3) An applied force of 400.0 N [E] acts on a 1000.0 kg mass for 20.0 s against ~~4000~~ 40 N of friction. If the mass initially travels at a velocity of 2.0 m/s [E], what is the final velocity of the mass?



$$\Sigma\vec{F_x} = \vec{F_{app}} + \vec{F_f}$$

$$\Sigma\vec{F_x} = 400\,[E] + 40\text{ N }[W]$$

$$\Sigma\vec{F_x} = 400 - 40$$

$$\Sigma\vec{F_x} = 360\text{ N }[E]$$

$$\Sigma\vec{F_x} = m \cdot a$$

$$a = \frac{\Sigma\vec{F_x}}{m} = \frac{360\text{ N }[E]}{1000\text{ kg}}$$

$$a = 0.36\text{ m/s}^2$$

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v_f} - \vec{v_o}}{t_f - t_o}$$

$$0.36\text{ m/s}^2 = \frac{\vec{v_f} - 2.0\text{ m/s}}{20\text{ s}}$$

$$0.36\,(20) = \vec{v_f} - 2.0$$

$$7.2 = \vec{v_f} - 2$$

$$\boxed{9.2\text{ m/s} = \vec{v_f}}$$