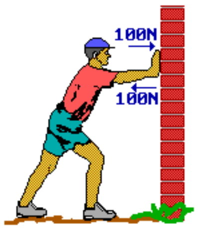
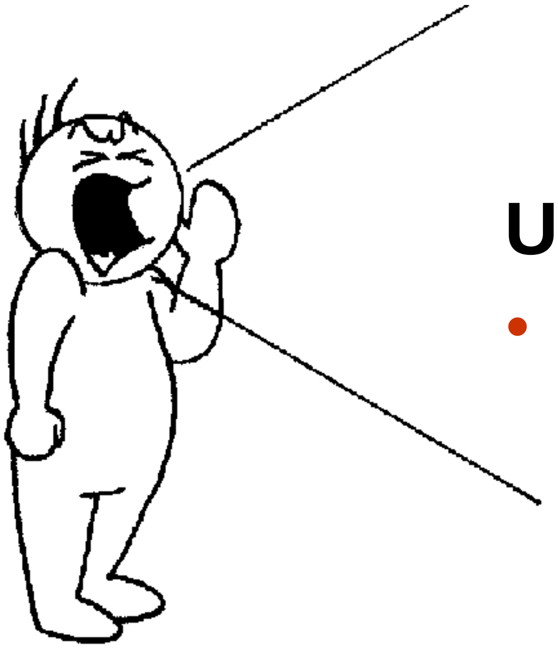
Physics 2204: Unit 2

'Dynamics'

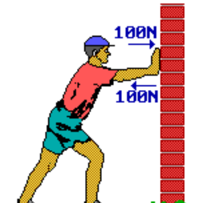




Unit 2 Topic 1

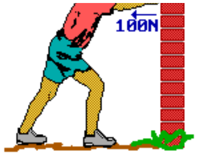
- Introduction of Force

Text: 5.1 - 5.3



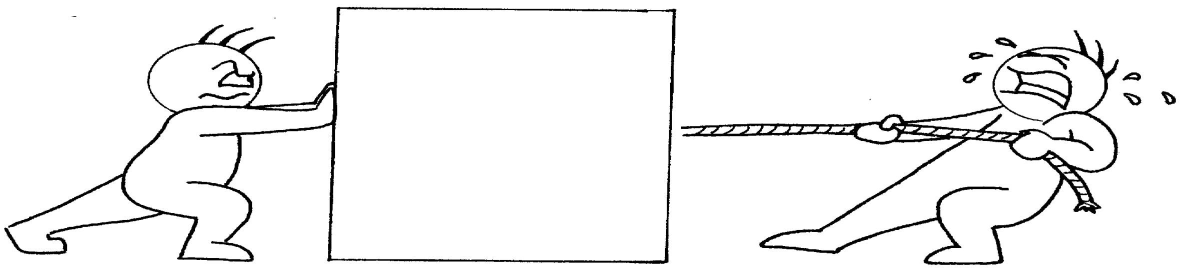
WHAT IS DYNAMICS?

Dynamics is the study of the factors that cause change in motion. It is concerned with the forces that change or produce motion within objects



WHAT IS A FORCE?

Force is a push or a pull exerted on an object

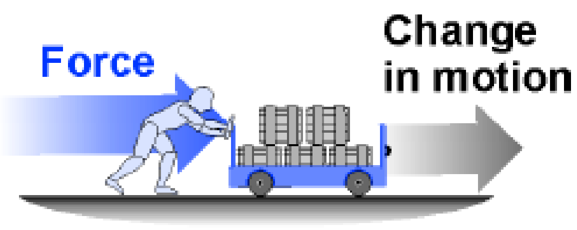


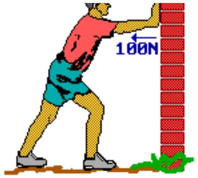
A force can affect an object in 3 ways:

1) make an object speed up;

2) make an object slow down;

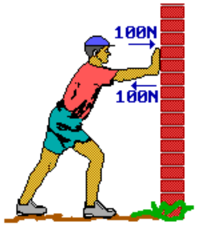
3)make an object change shape.





IS FORCE A SCALAR OR VECTOR

Forces are vector. Therefore it must have a direction and magnitude!

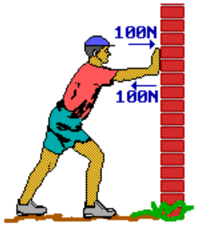


MEASURING FORCE

Newton (N) is the standard unit of force. Named after Isaac Newton

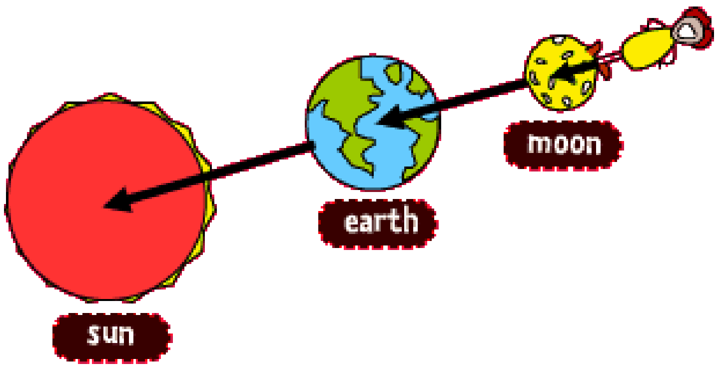
1 N is approximately the same as the amount of gravitational force the Earth exerts on an object with a mass of 100 grams.

This is about the same as the force required to lift an apple

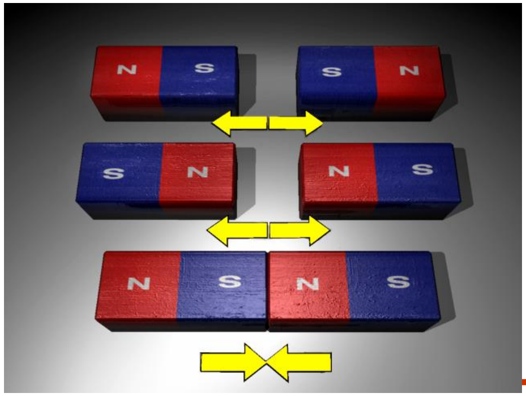


THE FOUR MAJOR FORCES IN NATURE :

1. Gravitational Force: the forces that keep objects "stuck" to the earth. Significant only when masses are very large (such as planets), otherwise is very weak for "normal" objects. Acts over very large distances.

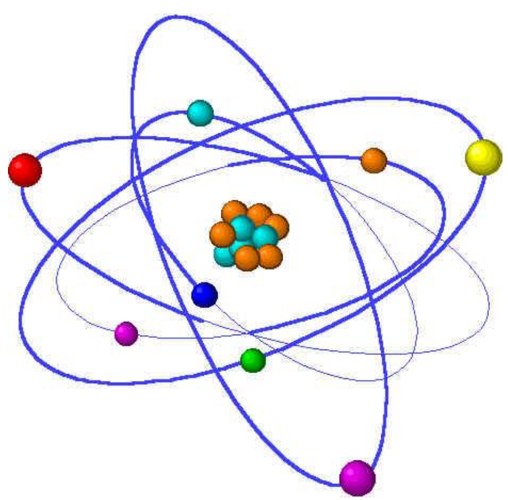


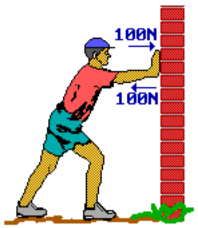
2.Electrical and Magnetic Forces – static electricity, magnetism etc.



3. STRONG Nuclear Force: The force that holds the nucleus of an atom together.

4. WEAK Nuclear Force:– The force associated with the behavior o subatomic particles.

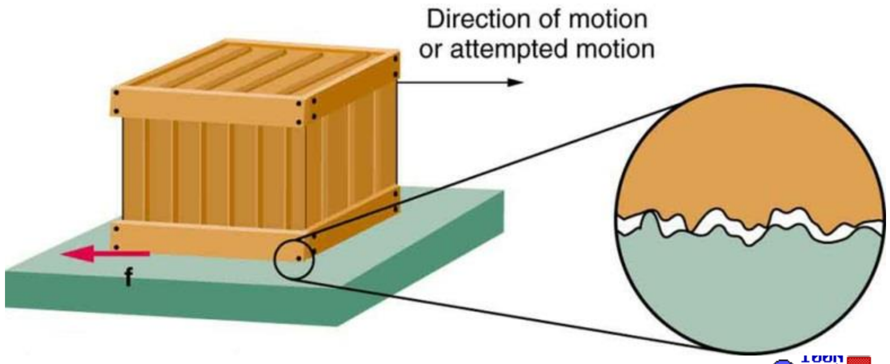




WHAT ARE MECHANICAL FORCES?

Mechanical forces involve contact with an object. Include such things as:

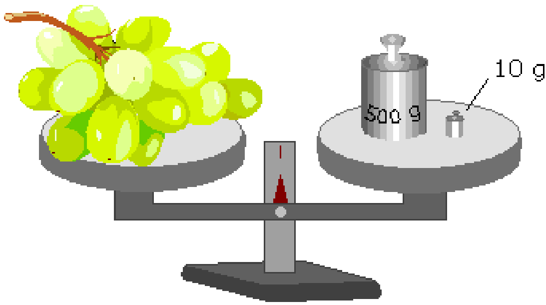
1. Ordinary push and pull forces.
2. Frictional forces.
3. Elastic forces
4. Compression (squeezing) forces
5. Torsional (twisting) forces.



WHAT IS MASS?

Mass is a measurement of the amount of matter something contains

Mass is measured by using a balance scale

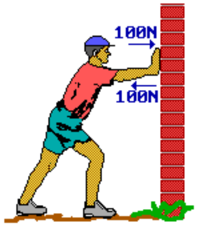


Measuring Mass is a "Balancing Act"

Mass is measured in kilograms or grams

Mass of an object doesn't change when an object's location changes.

Mass is a scalar quantity



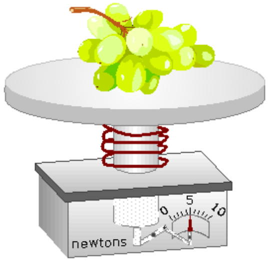
WHAT IS WEIGHT?

Weight is the measurement of the pull of gravity on an object.

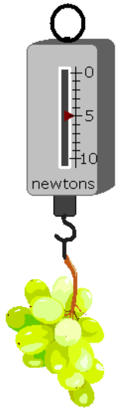
Weight is measured on a spring scale.

Weight is a force gravity

Weight is measured in Newtons(N)

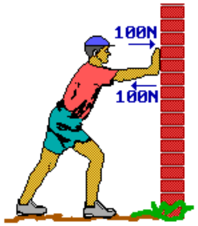


Measuring Weight is a "Springy Affair"



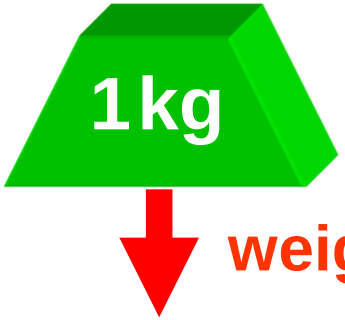
Weight is a vector quantity

Weight does change with location



Summary

mass = 1kg



weight = 10 N

Mass is the amount of matter that makes up an object.

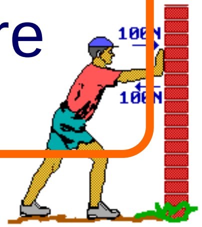
The mass of an object is always the same, wherever it is in the Universe.

The units of mass are **kilograms (kg)**.

Weight is a force due to the pull of gravity on an object.

The weight of an object will vary depending on where it is in the Universe.

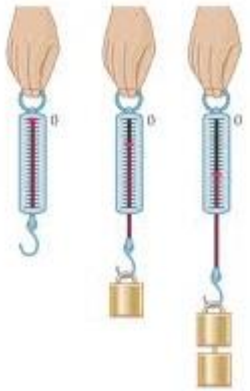
The units of weight are **newtons (N)**.

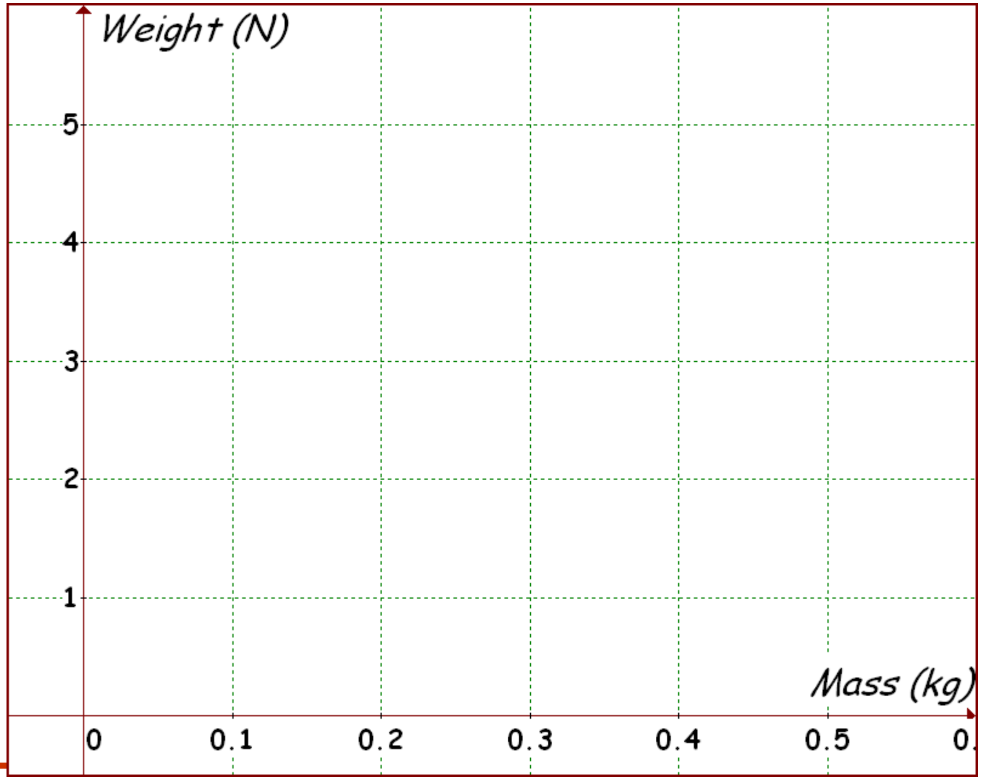


Example 1:

Consider small masses being attached to a spring scale (force meter):

Mass (kg)	Force (N)
0	0
0.200	1.96
0.300	2.94
0.400	3.92
0.500	4.90

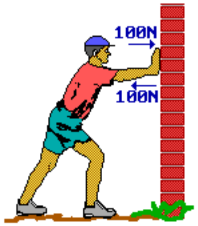




(A) Find slope.

(B) What are the slope units?

(C) What does the slope represent?



HOW TO CALCULATE WEIGHT?

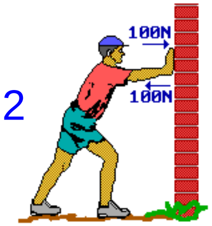
Force (ie. Weight) of an object due to gravity near the surface of the earth is;

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

Force (F) of Gravity is measured in newtons (N)

Mass(m) is measured in kilograms

Acceleration Due To Gravity () has a value of -9.81 m/s^2



Example 2

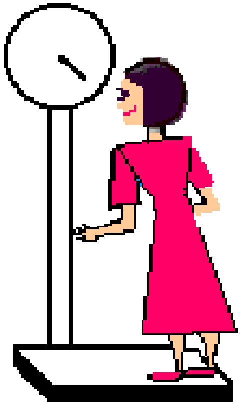
What is the weight of a 72 kg person who is standing in Blaketown?

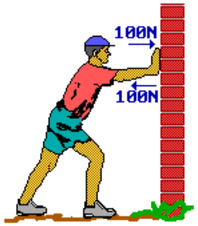
Given:

m = 72 kg

g = 9.8 N/kg

F_g = ?





Example 3

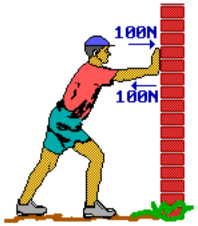
The lighthouse keeper at Cape Bonavista weighs 804 N. What would be his mass if he flew to the moon?

Given:

g on earth = 9.81 N/kg

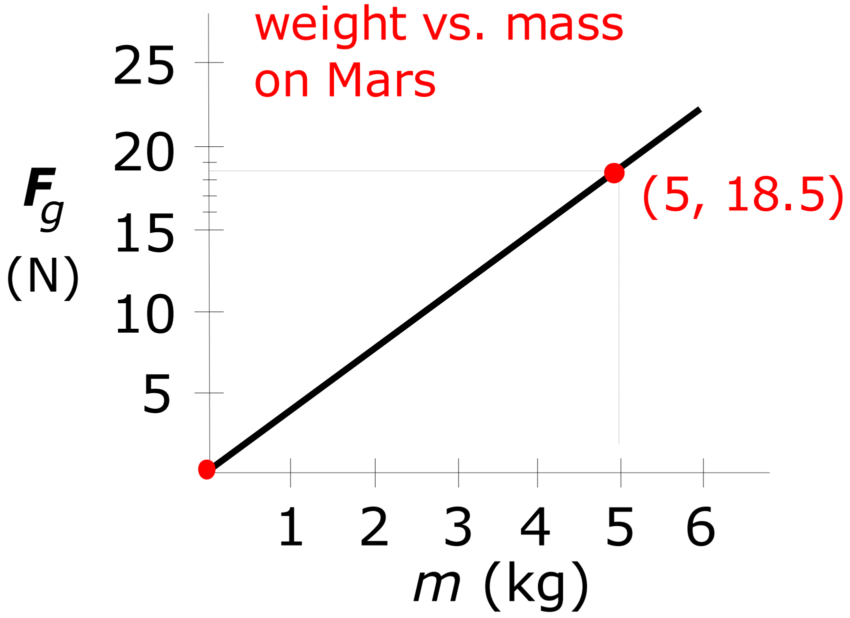
$\boldsymbol{F}_g$ on earth = $(\boldsymbol{F}_g)_e$ = 804 N

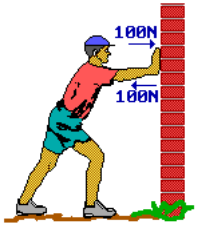
m on moon = m_m = ?



Example 4

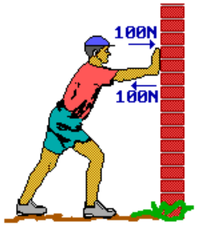
The graph shows the relation-ship between mass and weight on Mars. Use it to determine the weight of a 85 kg astronaut on Mars.





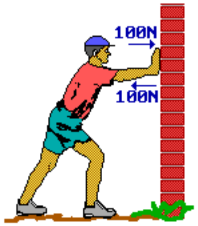
Example 5:

A 8.10 kg object is placed on a spring scale. If the spring scale reads 79.2 N. What is the acceleration due to gravity at that location?



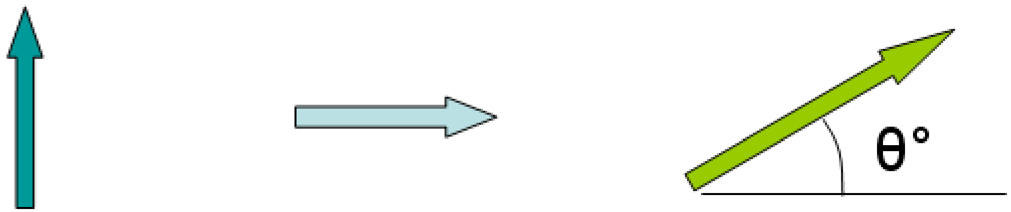
Topic 2

- Net Force – One Dimension



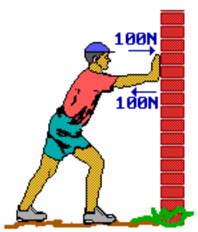
Remembering Vectors

Vector quantity has **direction** and **magnitude**



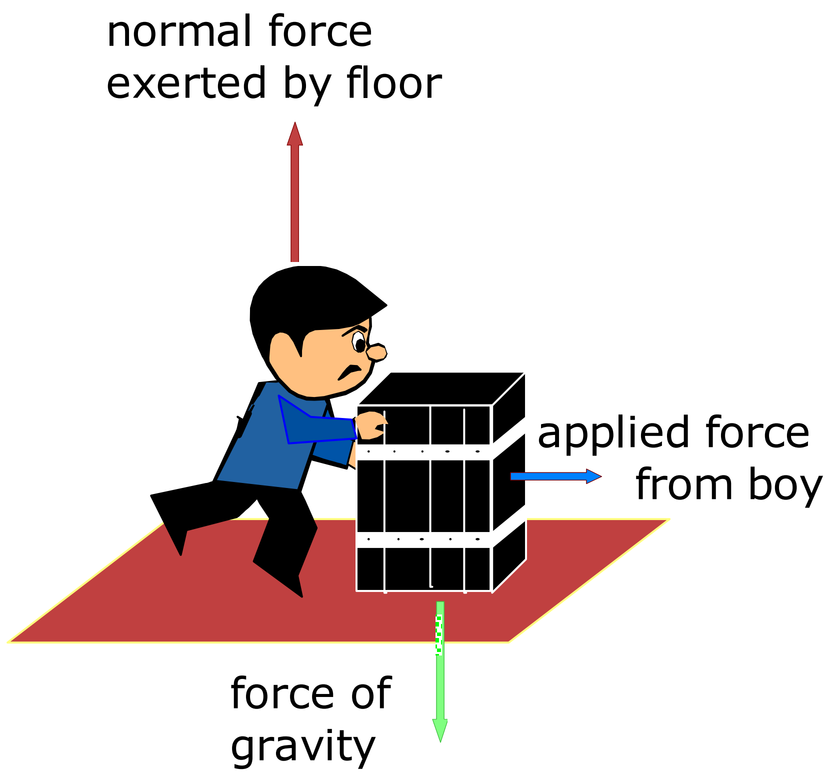
Direction is illustrated by **arrowhead**

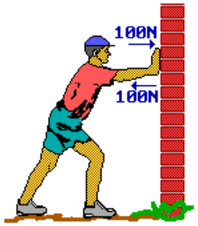
Magnitude is illustrated by **length** of line segment and is the amount of push or pull



FORCE DIAGRAM

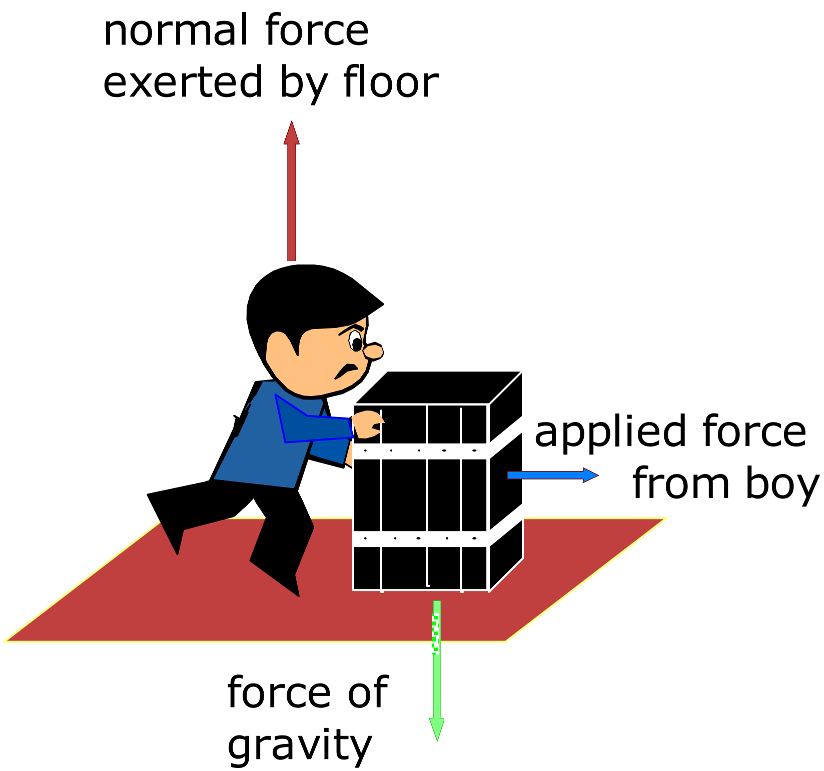
Force diagram shows all the force acting on an object.

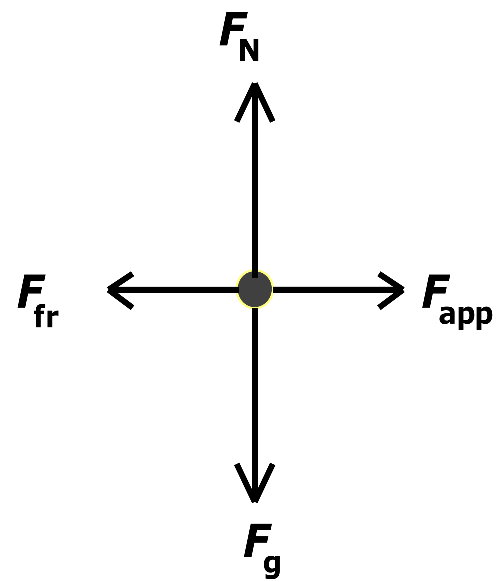




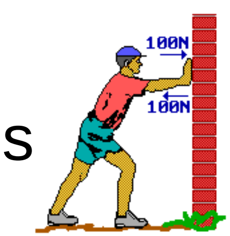
Free Body Diagram (FBD)

Free Body Diagram (FBD) shows all the forces acting on an object.





Objects are isolated from their environment and indicates all forces acting upon it.



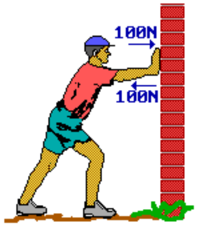
How To Draw Free Body Diagrams?

To draw a proper free body diagram, you must follow these steps:

1. Draw a quick sketch of the object. Often a simple dot will do. We basically treat this as the spot that all the forces are thought to act upon.

2. For every force acting on that object (we don't care about forces acting on any other objects), draw a vector that shows the size and direction of the force. Each vector must start from the dot and point outwards.

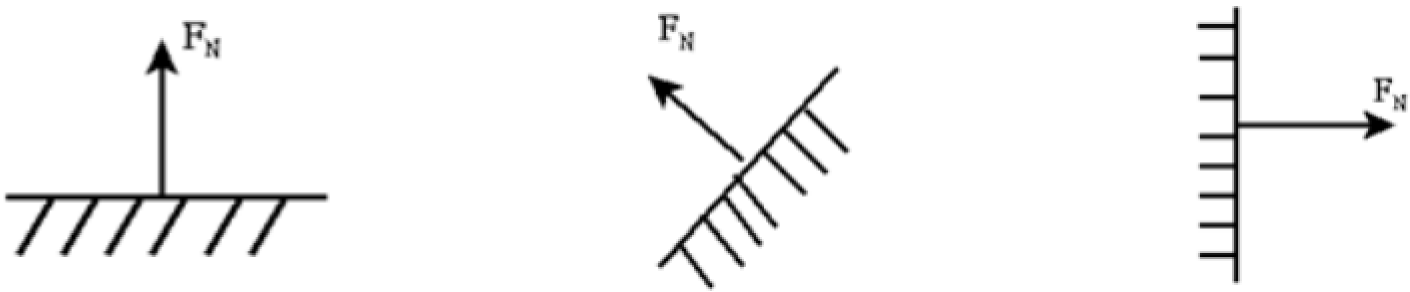
3.Label each vector based on the type of force it is. Do not include numbers or calculations!



What Is A Normal Force?

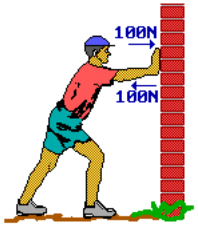
Normal Force is the force that surfaces exert to prevent solid objects from passing through each other.

The normal force is always perpendicular to the surface.

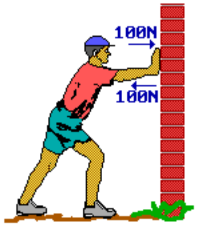


In many cases but not all, the normal forces is a reaction force for gravity!

In essence a normal force is the force applied /necessary so that the object dose not go through the surface!

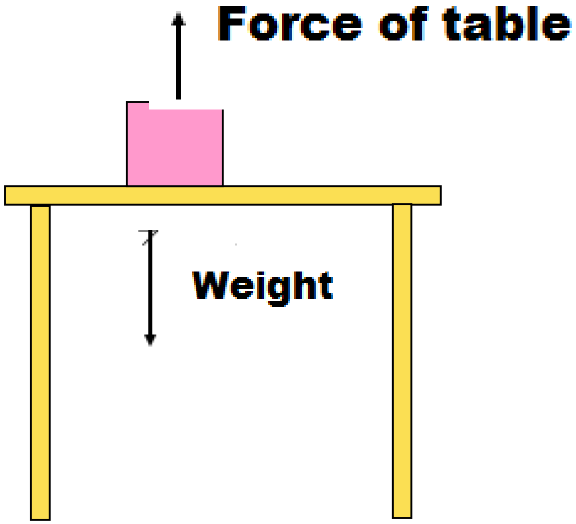


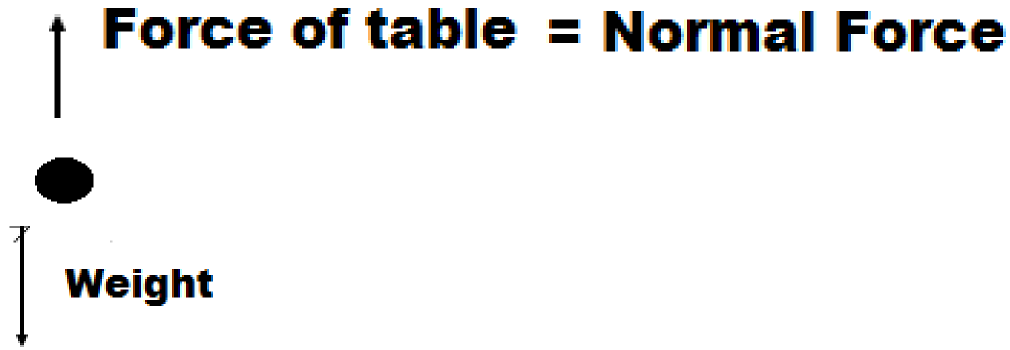
If the object is not on a surface there is no normal force!



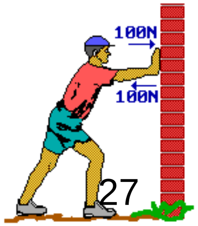
Example 1

Draw a Free Body Diagram for a box sitting on a table



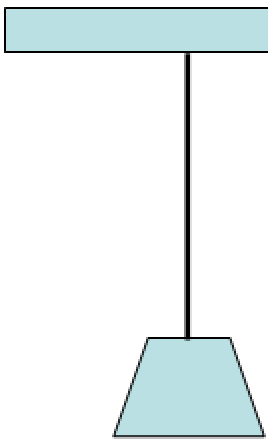


Normal force(F_N): this force acts in the direction perpendicular to the contact surface.

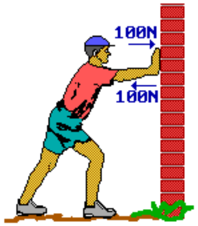


Example 2:

Draw a free body diagram for a mass hanging from a string

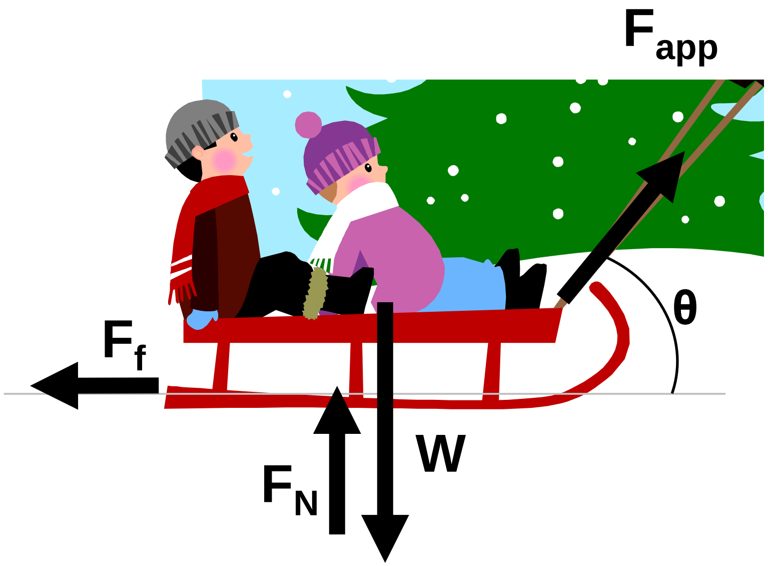


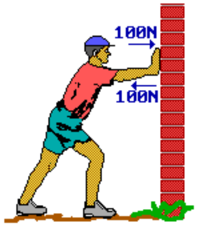
Weight supported
from cable attached
to ceiling



Example 3

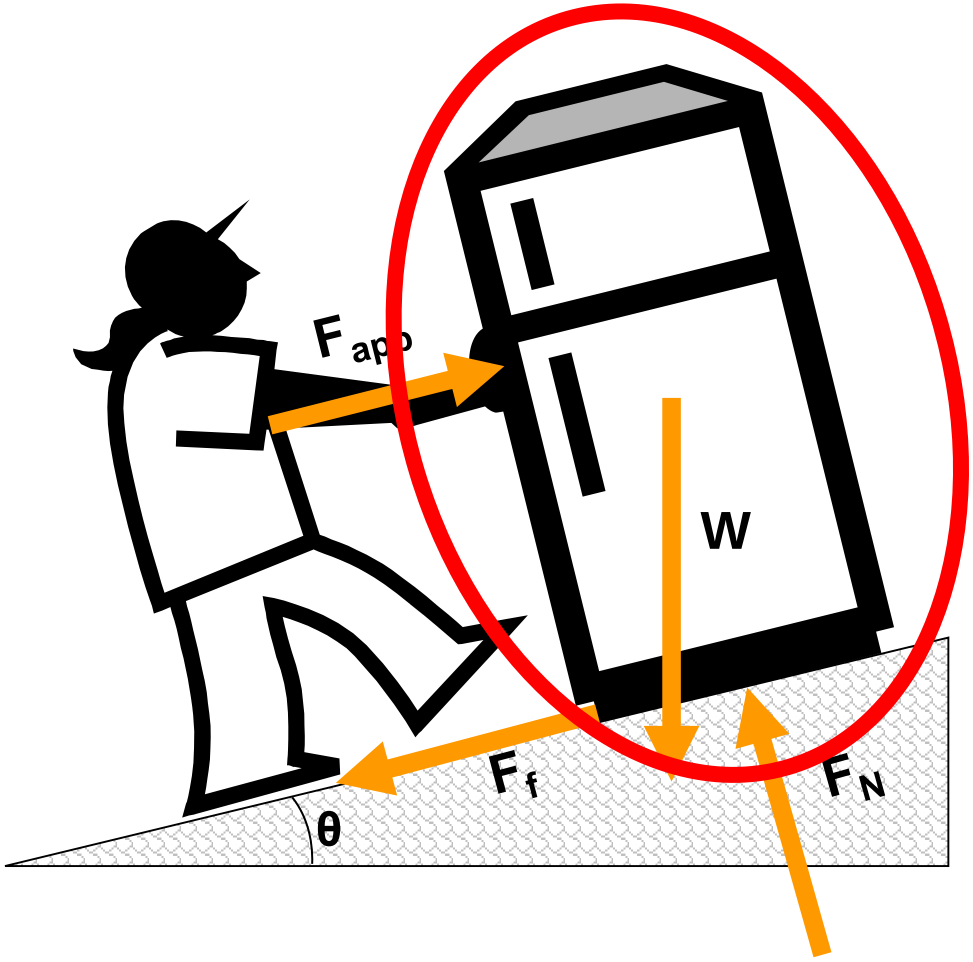
Draw a free body diagram for the picture shown below

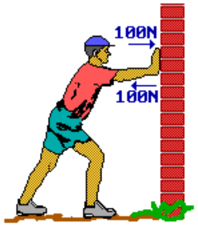




Example 4

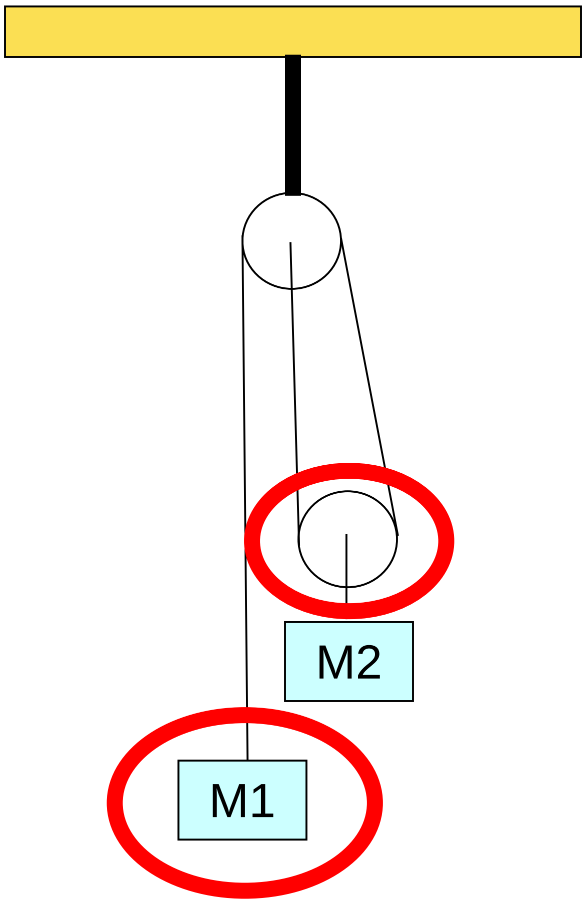
Create a FBD for the refrigerator pictured below.





Example 5:

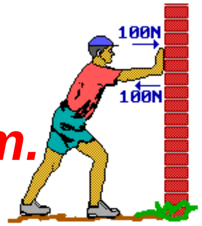
Create a FBD for the pulley system pictured below.



FBD of Mass 1:

FBD of the Mass 2:

Tension Forces (F_T) are equal throughout the system.



NET FORCE

- **Net Force:**- is the vector sum of all the individual forces acting upon an object. A net force may be the result of one more forces. Combing forces may also be referred to as

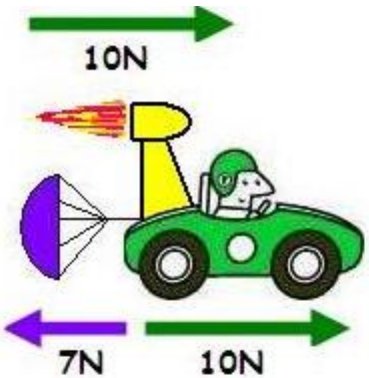
Unbalanced Force (F_{un})

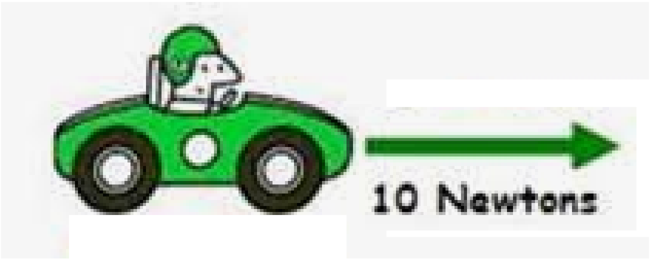
or

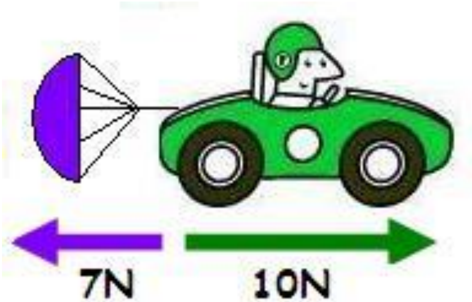
Net Force (F_{net})

or

Resultant Force (F_R)







How To Calculate Net Force In One Dimension?

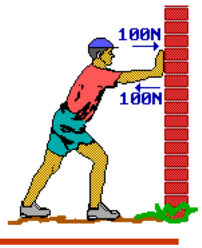
The net force is the sum of all forces acting on the object.

For Linear forces Linear forces, those acting in a straight line, The Forces be simply added arithmetically.

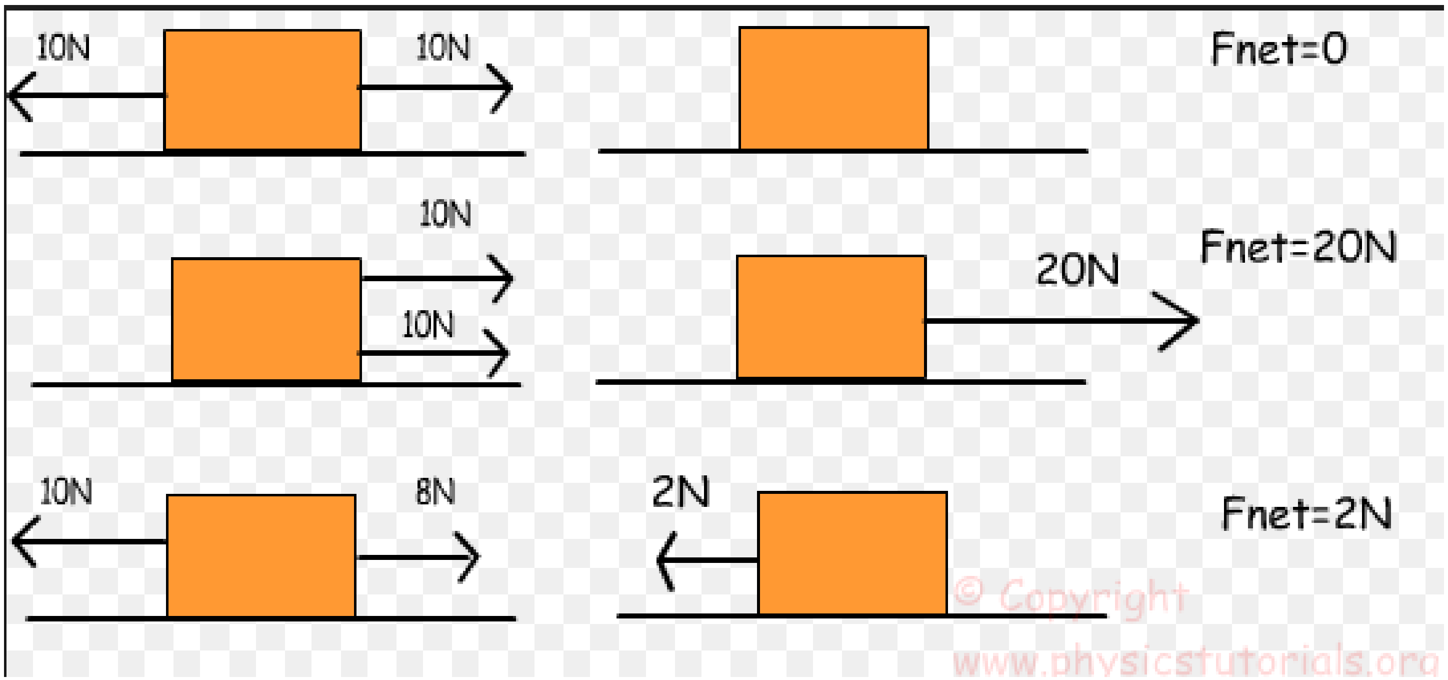
$$F_{net} = F_1 + F_2 + F_3 + ...$$

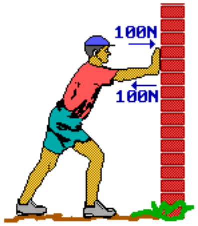
Being the vector sum of all the forces, there may be some negative signs present in the net force equation to indicate that one force is opposite in direction to another force.

A Free Body Diagram is useful in determining the number of forces used in calculating the net force.



The net force will be the single force which could do the same job as all applied forces combined. Both the size and direction of this force is important.

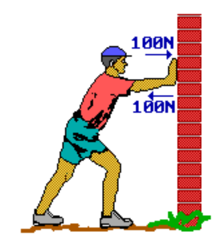




Example 1

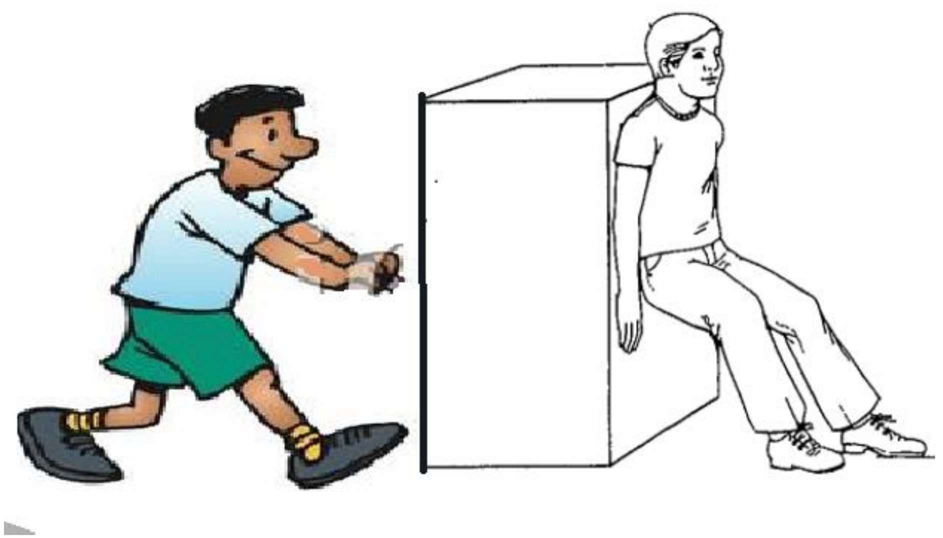
- You push a car with a force of 50 N, your friends pulls with a force of 25 N. Draw free body diagram, and calculate the net force acting upon the car. Will the car move?

50N + 25N = 75 N

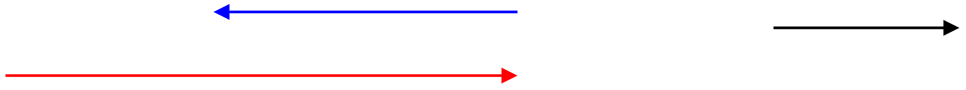


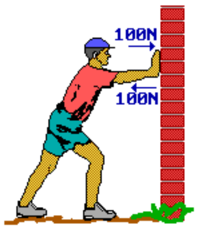
Example 2

You push a box towards your friends with a force of 80N while one friend pushes the box against you with a 55 N, Draw free body diagram and calculate the net force acting upon the car. Will the box move?



(80 N) + (- 55 N) = 25 N

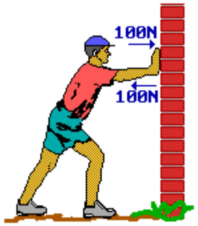




There are two ways to classify the Net forces acting on an object:

1) Balance Forces ($F_{net} = 0$)

2) Unbalance Forces ($F_{net} \neq 0$)



1) Balance Forces ($F_{net} = 0$)

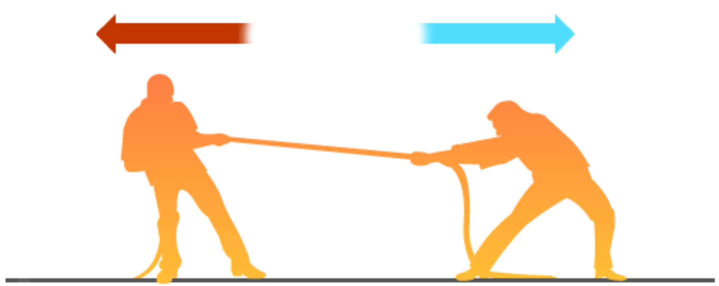
- Balanced forces

  - forces that combine to produce no net force

Ex 1. tug of war with no winner

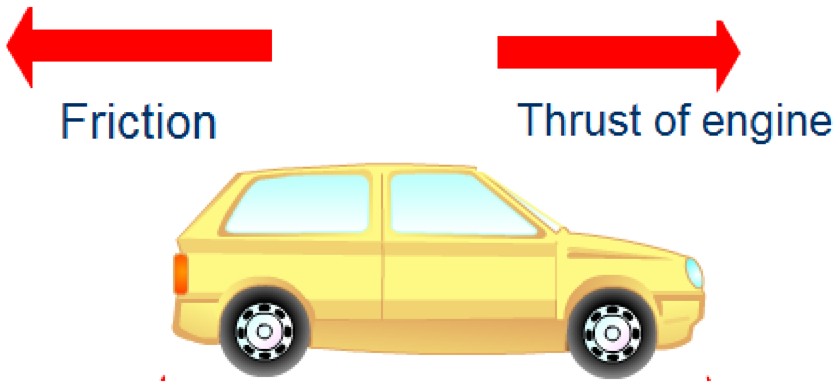
\

(-2 N) + 2 N = 0 N



EX 2: Moving with uniform motion

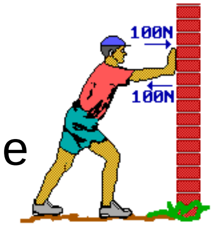
(-100 N) + (100N) = 0N



If the forces on an object are balanced:

1) an object that is not moving stays still

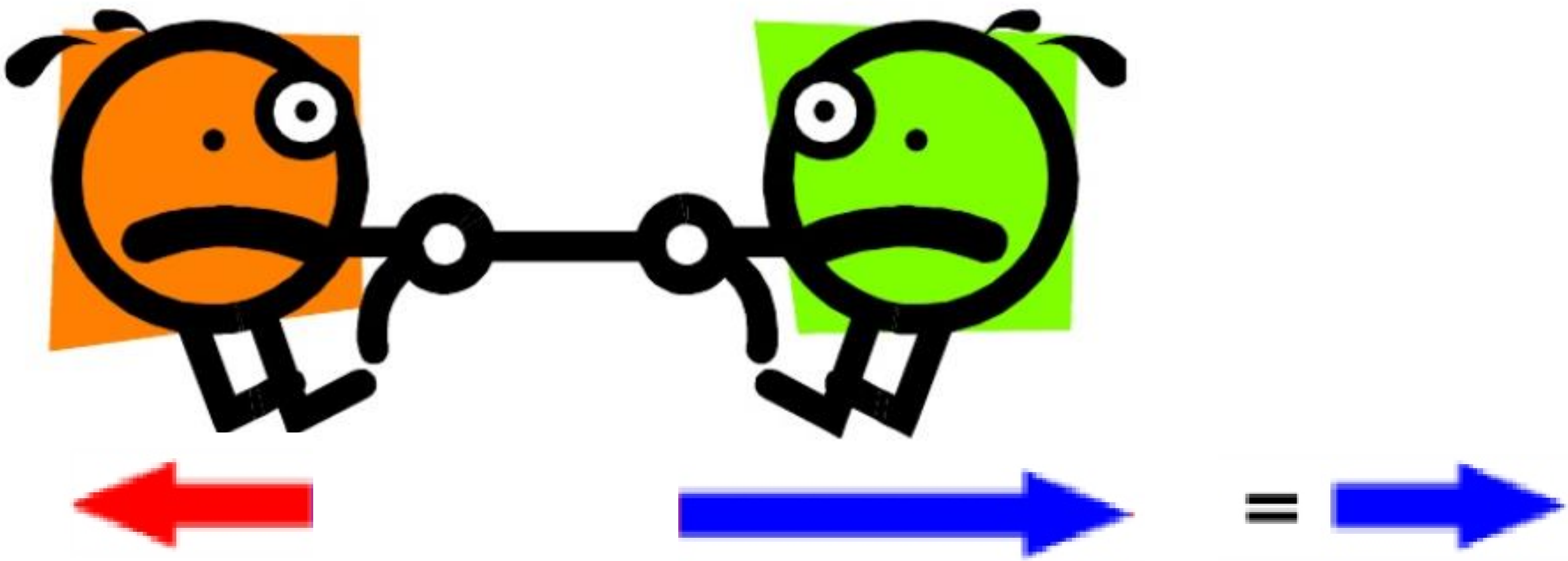
2) an object that is moving continues to move at the same speed and in the same direction



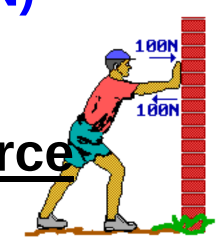
2) Unbalance Forces ($F_{net} \neq 0$)

Unbalanced forces

- **force that results when the net force acting on an object is not <u>equal</u> to 0 N.**



(-20N) + (40N) = (20 N)

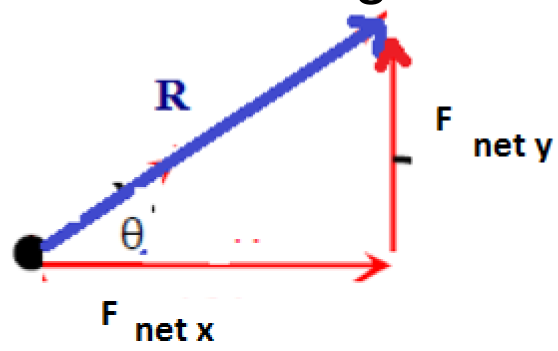


For unbalanced forces the object will move in direction of net force

Steps for find the result force in two dimensions:

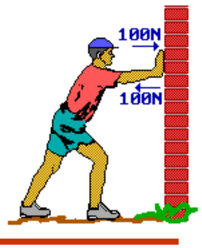
1) Find the net force in the x and y direction

2) Draw a vector diagram. The resultant joins the beginning to the end in a straight line



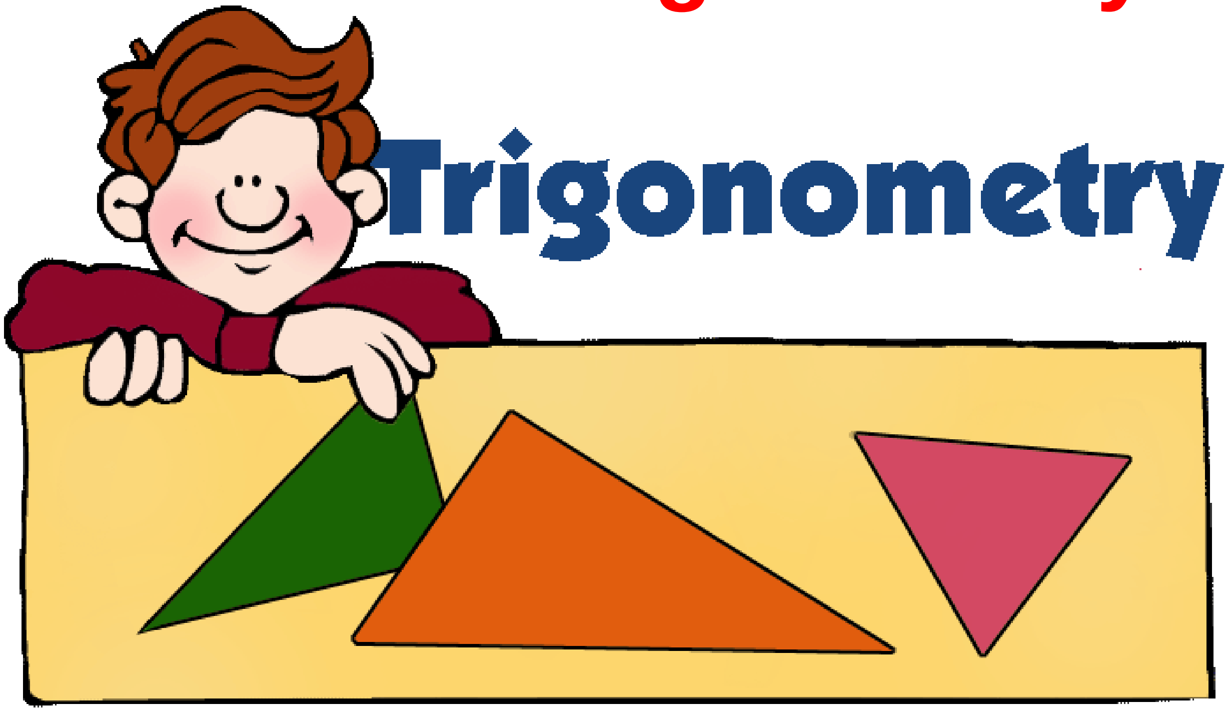
3) The Magnitude of the resultant force (R) is found using Pythagorean Theorem

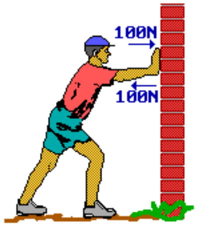
4) The direction of the resultant is given by θ, and is calculated using trigonometry.



Topic 3:

- Trigonometry

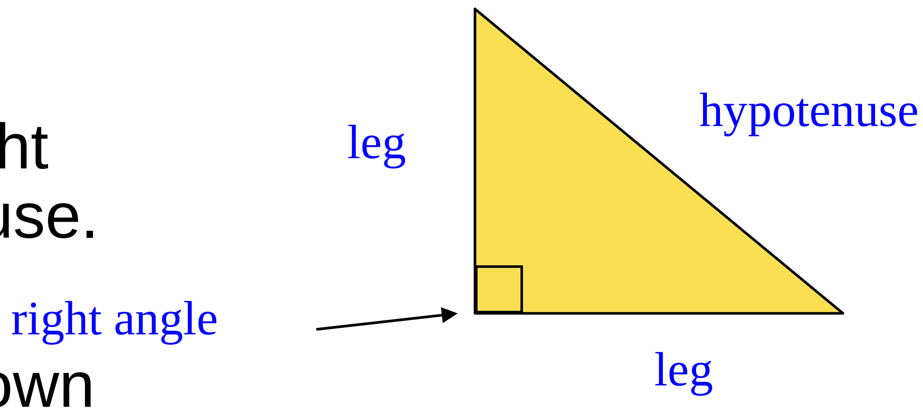


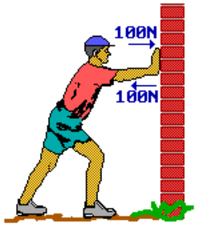


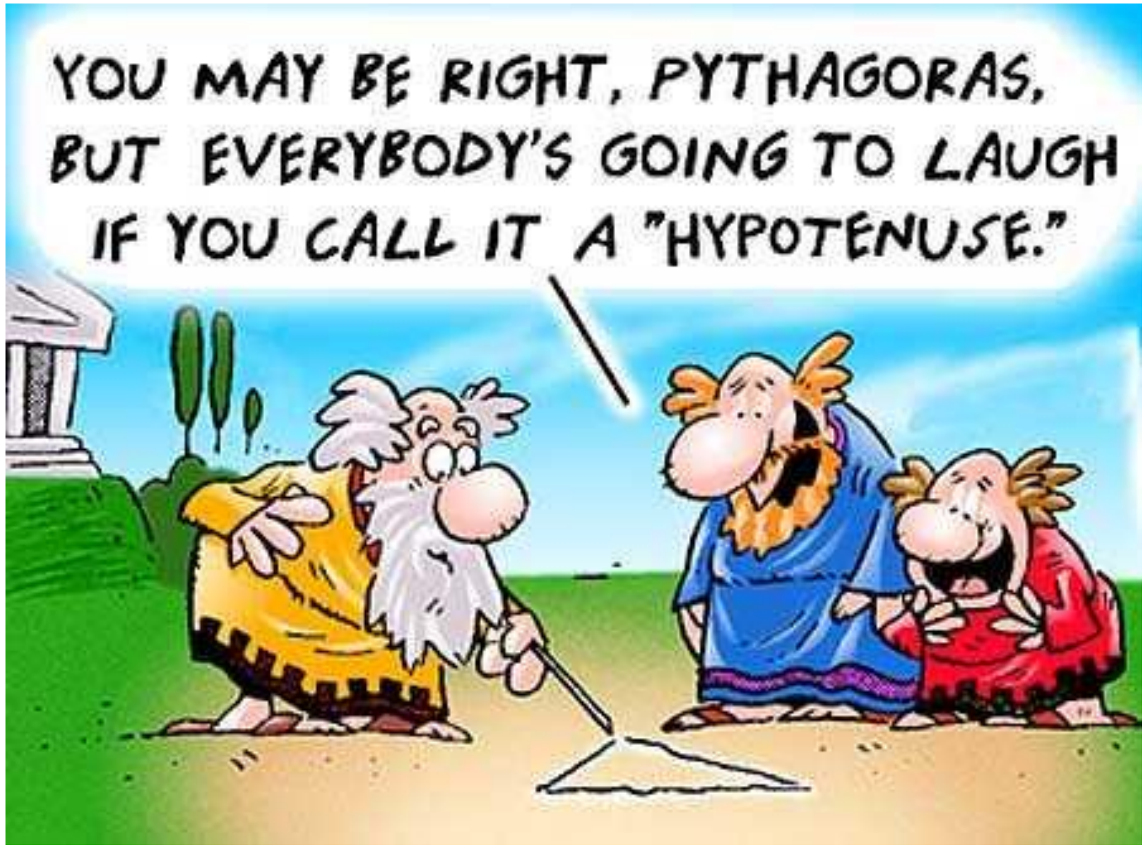
Trigonometry is a branch of mathematics that studies triangles and the relationships between their sides and the angles between these sides.

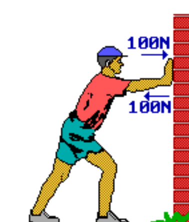
Trigonometry deals with Right Triangles

- A triangle in which one angle is equal to 90° is called right triangle.
- The side opposite to the right angle is known as hypotenuse.
- The other two sides are known as legs.





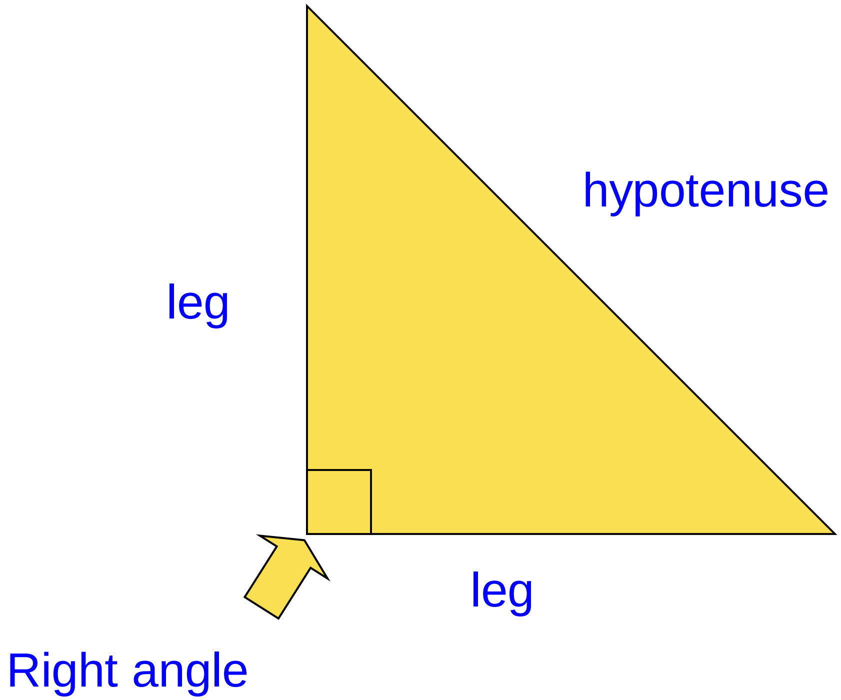

YOU MAY BE RIGHT, PYTHAGORAS, BUT EVERYBODY'S GOING TO LAUGH IF YOU CALL IT A "HYPOTENUSE."


100N
100N

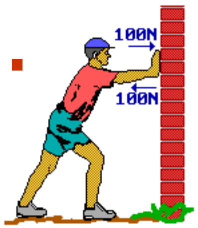
The Pythagorean Theorem

In a right triangle, if a and b are the measures of the legs and c is the hypotenuse, then

$\text{hypotenuse}^2 = \text{leg}^2 + \text{leg}^2$

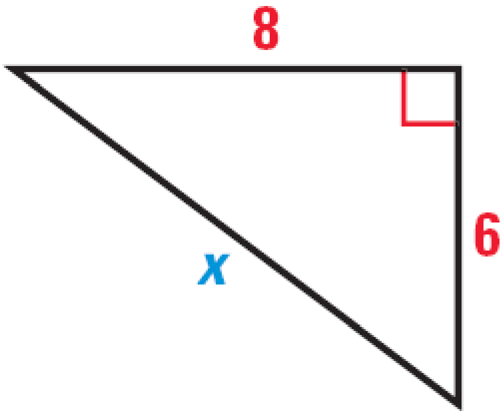


Note: The hypotenuse, c, is always the longest side.



Using the Pythagorean Theorem

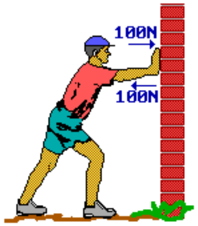
$6^2 + 8^2 = x^2$



$36 + 64 = x^2$

$100 = x^2$

$\sqrt{100} = \sqrt{x^2}$ $\quad 10 = x$

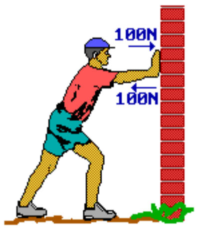


The Trigonometric Functions we will be looking at

SINE

COSINE

TANGENT

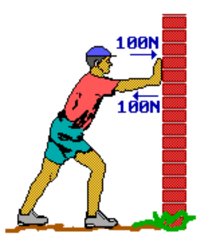


The Trigonometric Functions

SINE

COSINE

TANGENT

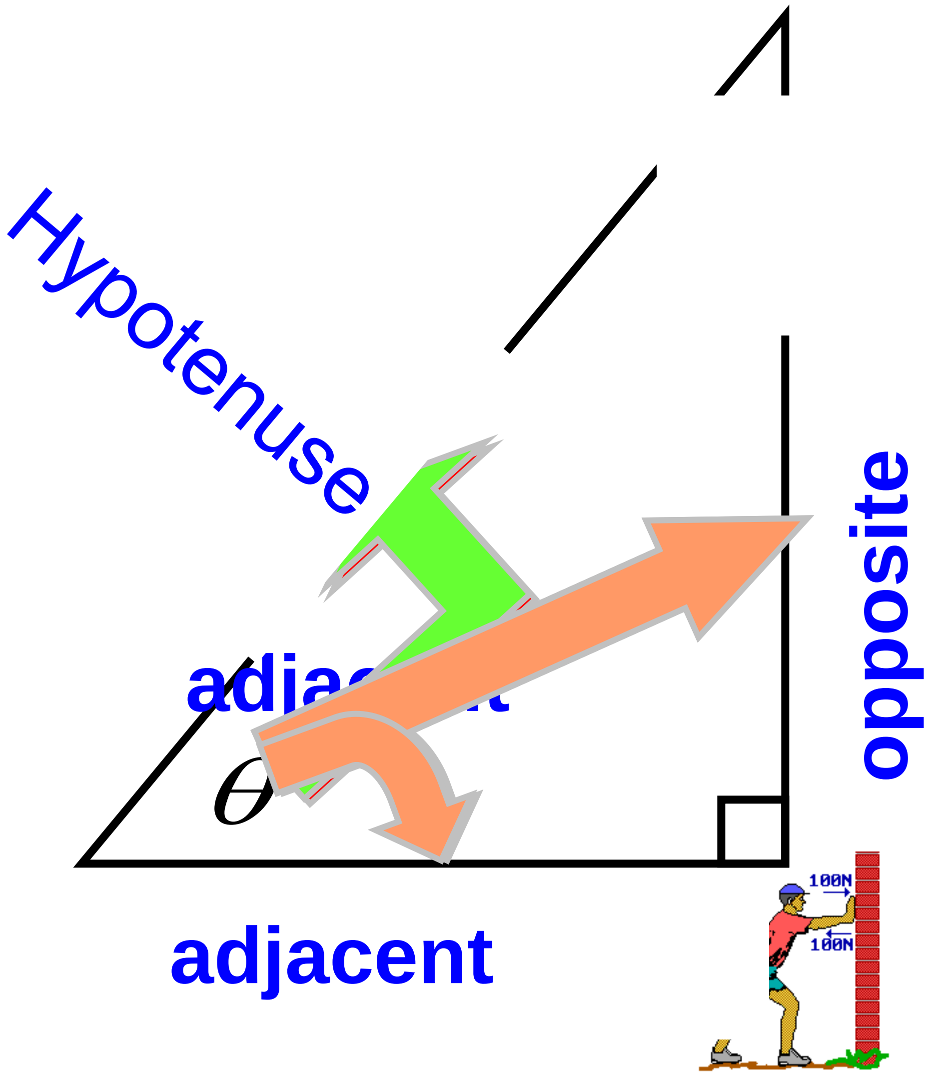


The Trigonometric Functions

$$Sin = \frac{Opp\ \text{Leg}}{Hyp}$$

$$Cos = \frac{Adj\ \text{Leg}}{Hyp}$$

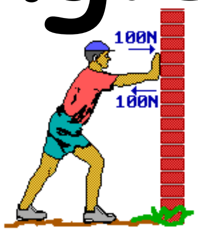
$$Tan = \frac{Opp\ \text{Leg}}{Adj\ \text{Leg}}$$



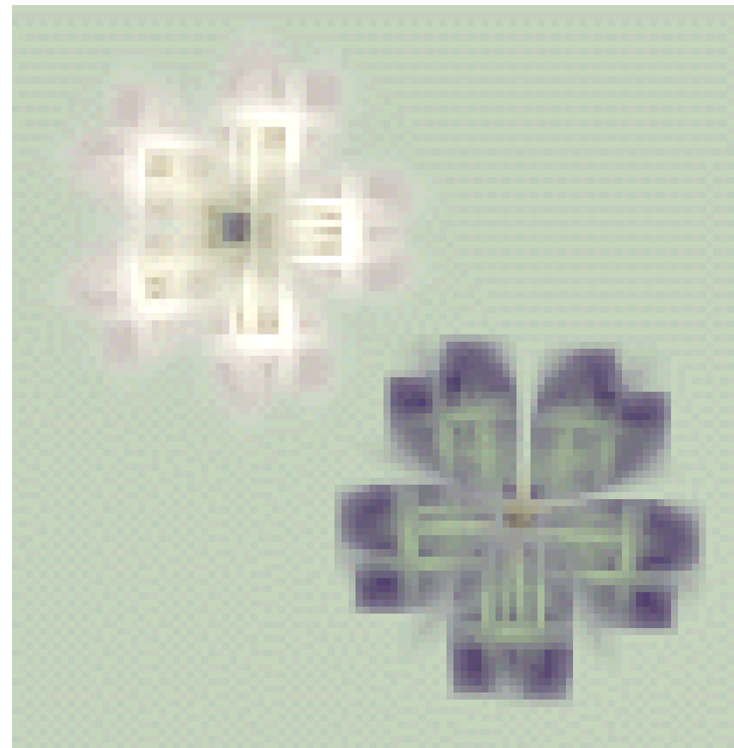
Greek Letter θ

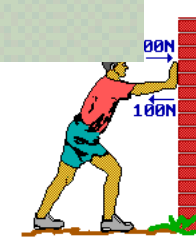
Prounounced "theta"

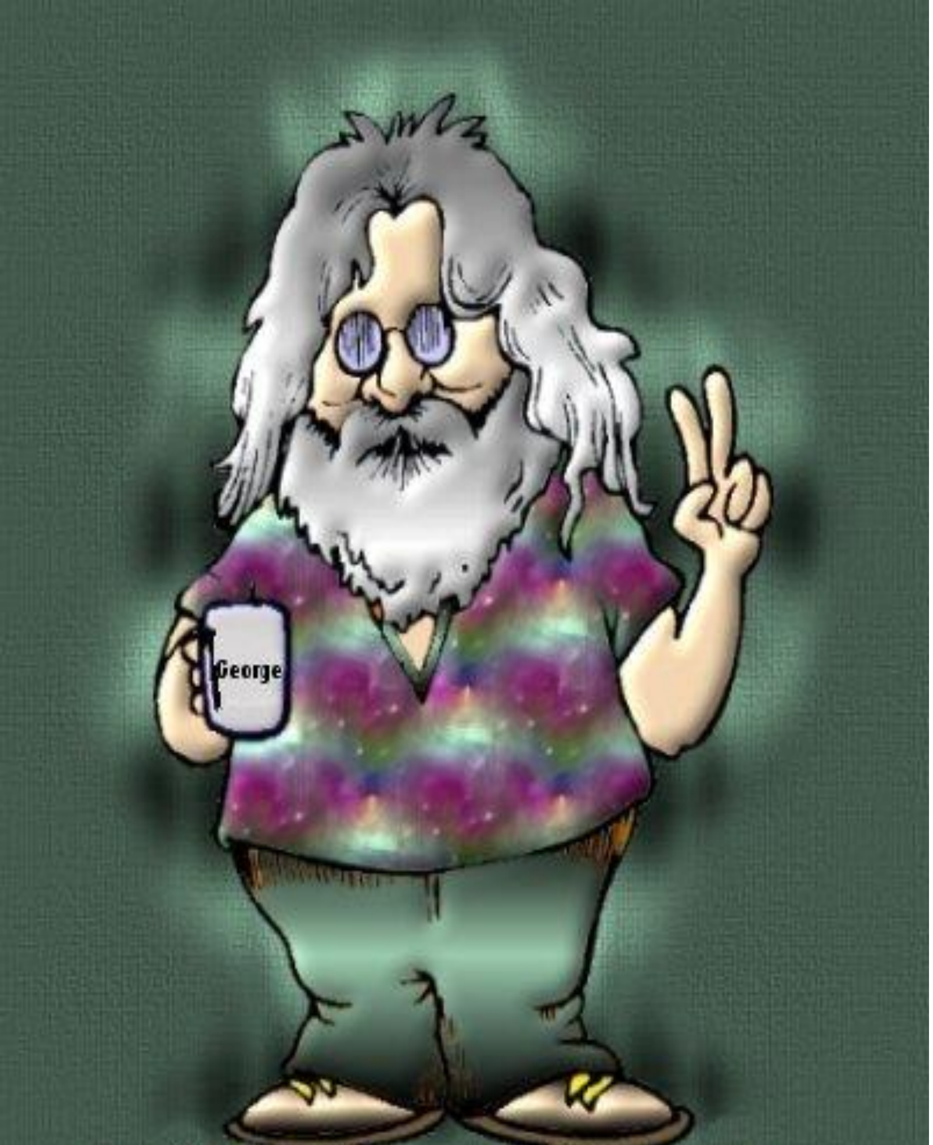
Represents an unknown angle



We need a way to remember all of these ratios…

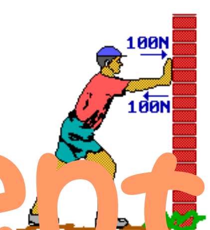




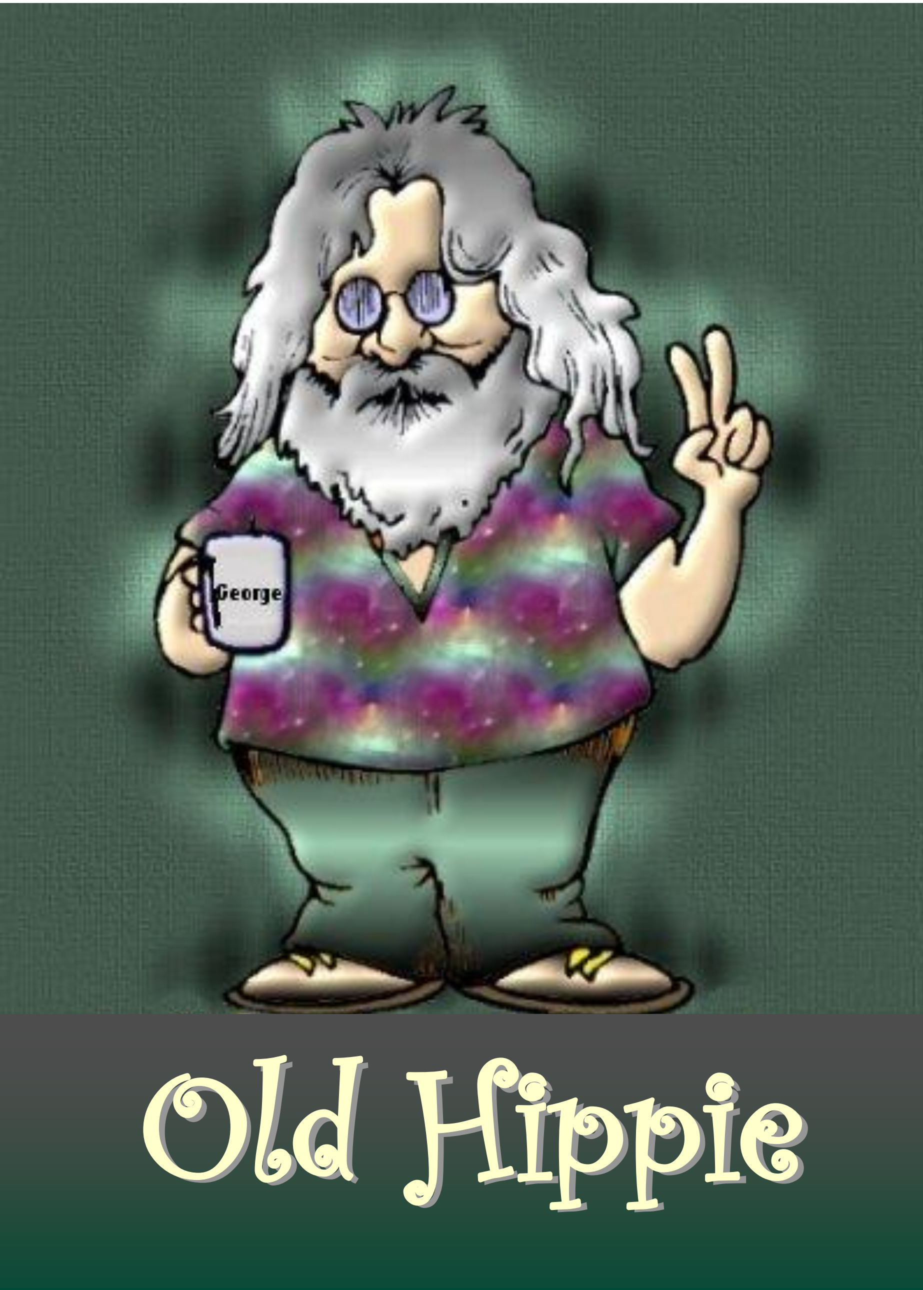


Old Hippie

Some
Old
Hippie
Came
A
Hoppin'
Through
Our
Apartment



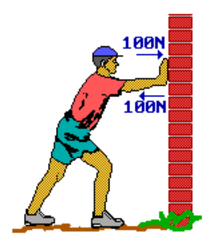
SOHCAHTOA



Sin
Opp
Hyp

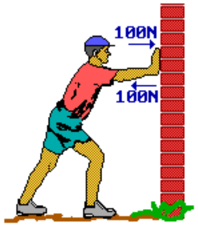
Cos
Adj
Hyp

Tan
Opp
Adj



Finding sin, cos, and tan.

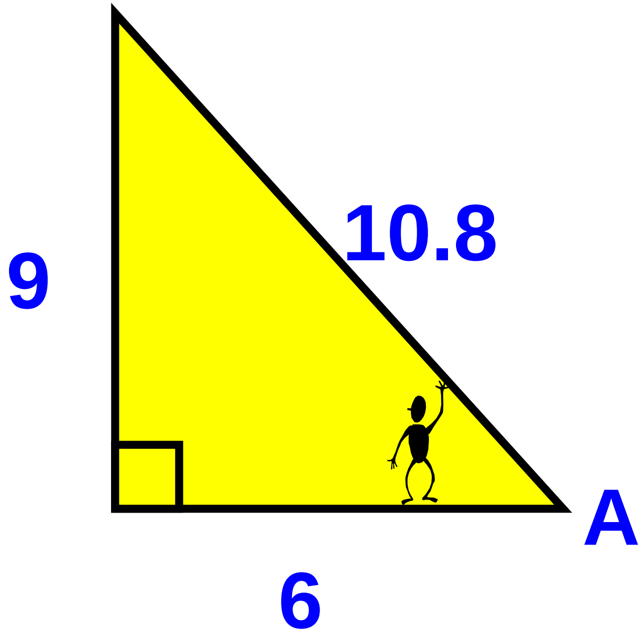
(Just writing a ratio or decimal.)



Example 1

Find the sine, the cosine, and the tangent of angle A.

Give a fraction and decimal answer (round to 4 places).

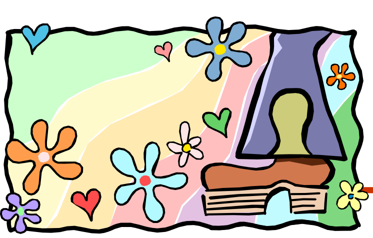


$$\sin A = \frac{opp}{hyp} = \frac{9}{10.8} \approx .8333$$

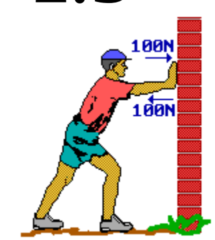
$$\cos A = \frac{adj}{hyp} = \frac{6}{10.8} \approx .5556$$

$$\tan A = \frac{opp}{adj} = \frac{9}{6} \approx 1.5$$

Shrink yourself down and stand where the angle is.

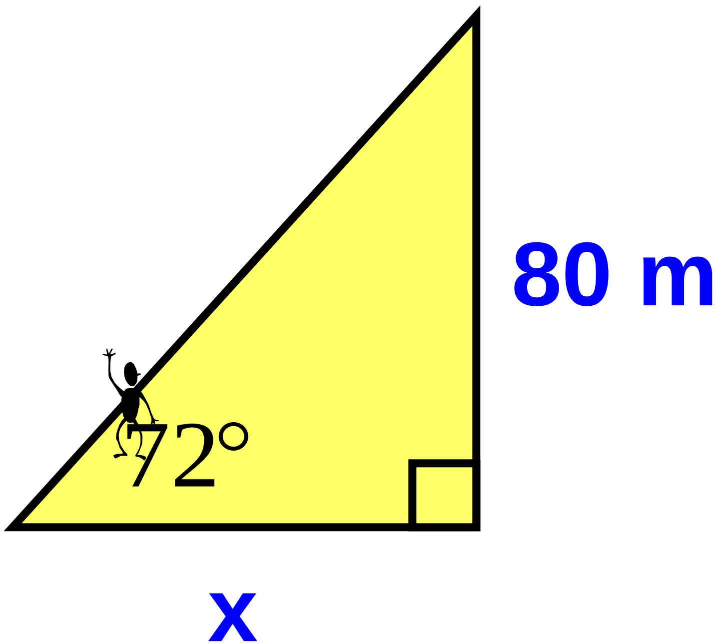


Now, figure out your ratios.



Example 2

Find the missing side. Round to the nearest tenth.



$$\tan(72) = \frac{80}{x}$$

$$x\tan(72) = 80$$

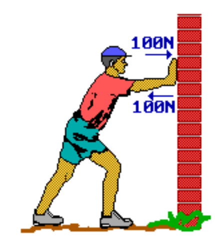
$$x = \frac{80}{(\tan(72))}$$

80	÷	(	tan	72	)	)	=

26 m

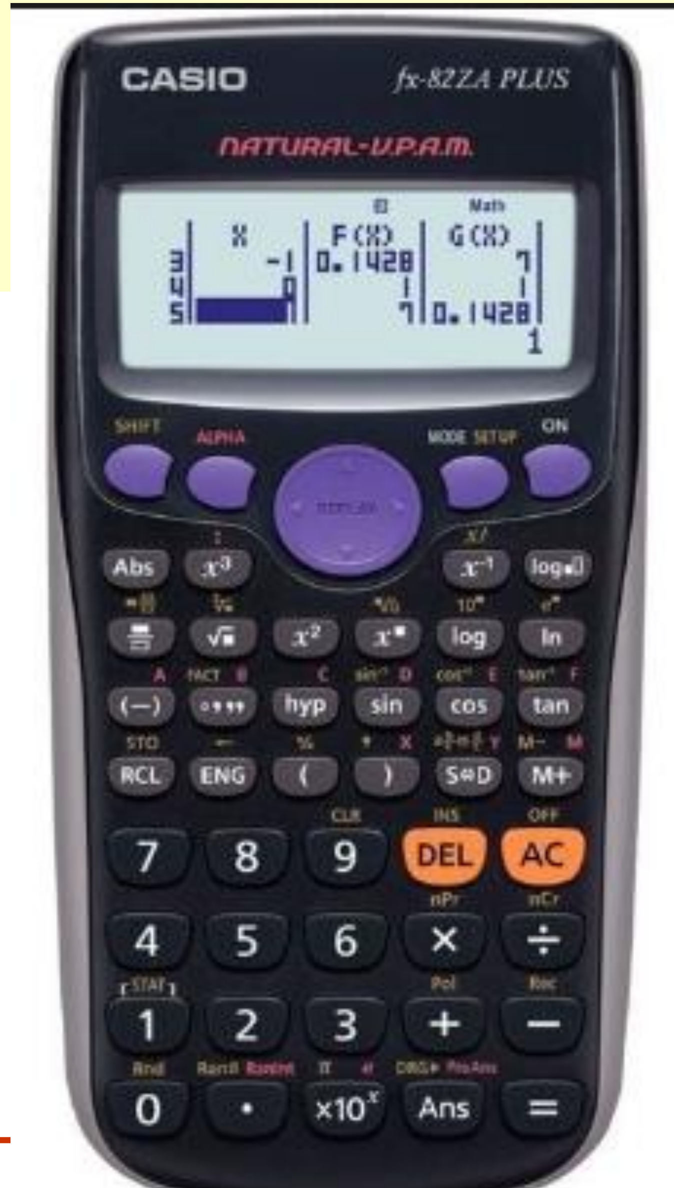
Shrink yourself down and stand where the angle is.

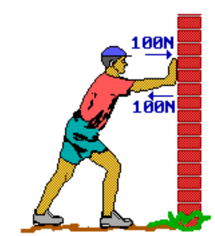
Now, figure out which trig ratio you have and set up the problem.



Finding an angle.

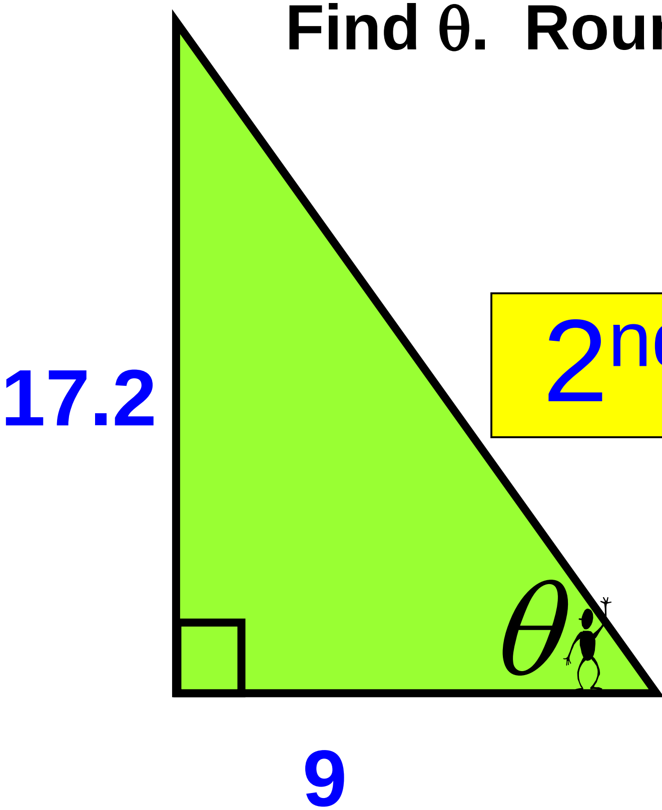
(Figuring out which ratio to use and getting to use the 2nd button and one of the trig buttons.)





Example 3:

Find θ. Round to four decimal places.



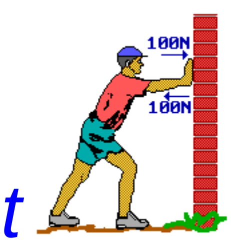
$$\tan\theta = \frac{17.2}{9}$$

2nd	tan	17.2	÷	9	)

$$\theta \approx 62.3789^\circ$$

Shrink yourself down and stand where the angle is.

Now, figure out which trig ratio you have and set up the problem.



Make sure you are in degree mode (not radians)

SUMMARY

When we are trying to find a

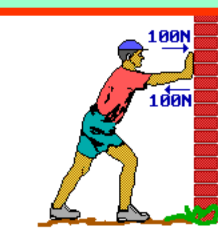
side

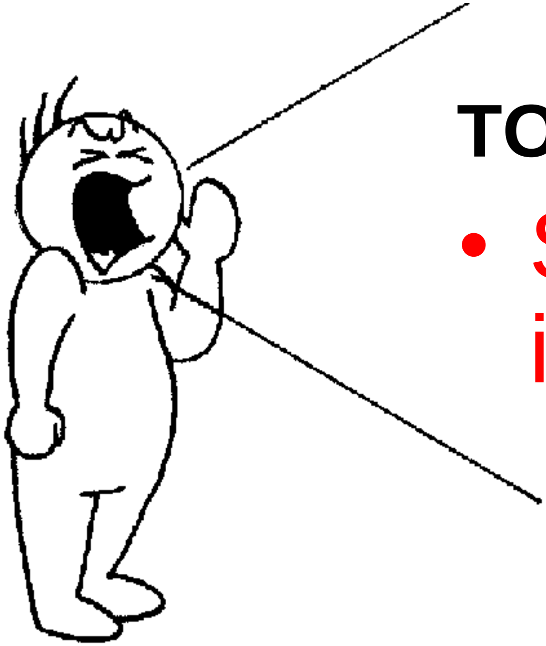
we use sin, cos, or tan.

When we are trying to find an

angle

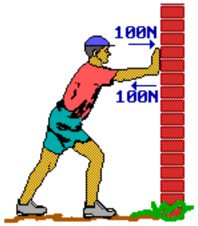
we use $\sin^{-1}$, $\cos^{-1}$, or $\tan^{-1}$.





TOPIC 4

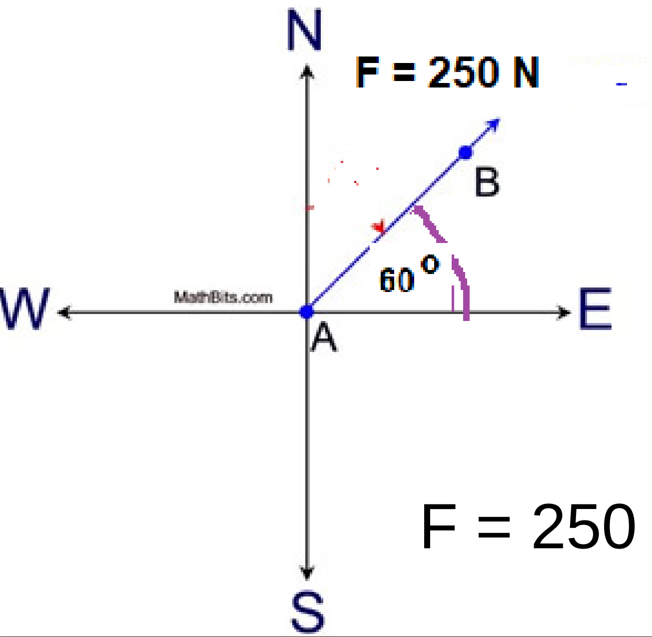
- Splitting forces into its components



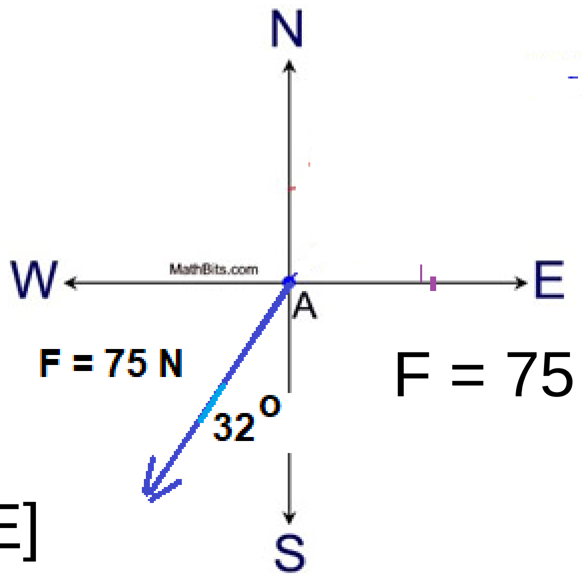
What Is The Navigation Method?

Navigation Method: method commonly used to show direction for vector quantities in two dimension: using compass bearings north [N], south[S], east [E] and west [W] to identify direction.

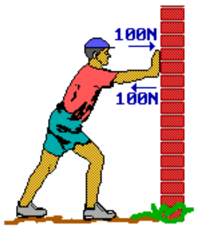
To draw this vector, start with the second compass bearing you are given in the square brackets and then move the angle in the direction of the first bearing you are given.



F = 250 [60 ° N of E]



F = 75 [32° W of S]



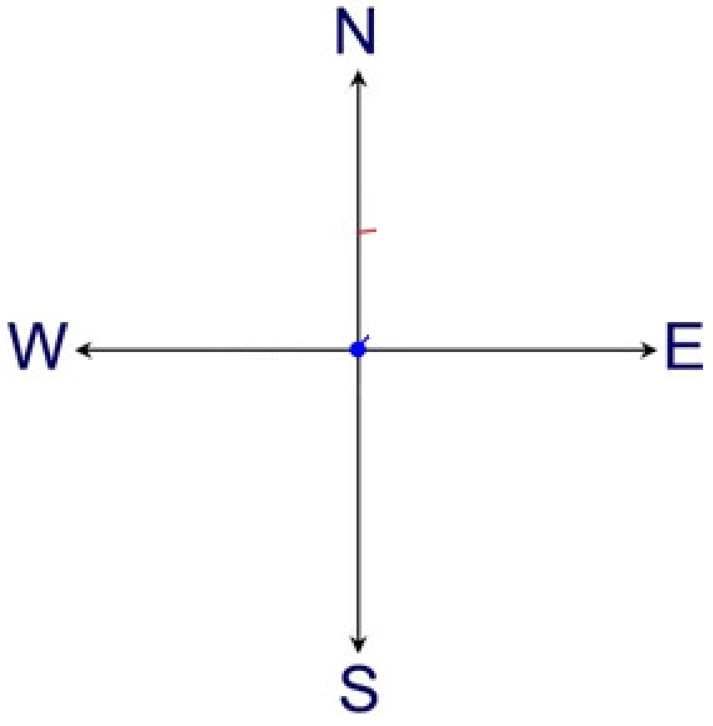
Example 1:

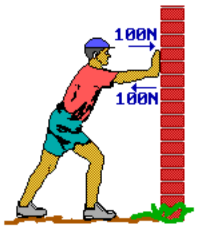
Draw the following forces using the Navigation Method

A) F = 25N [15 ^{o} E of N]

B) F = 300 N [36 ^{o} N of W]

C) F = 600 N [78 ^{o} W of S]

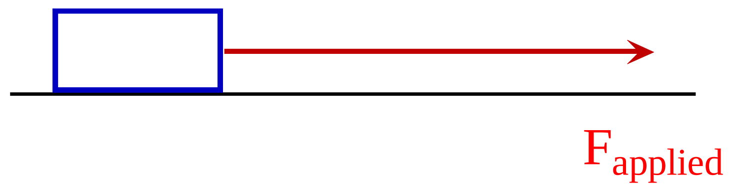




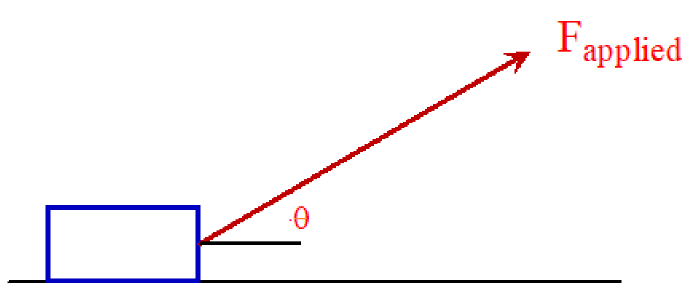
Forces At An Angles – Vector Components

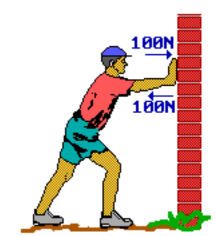
Suppose we have a small 10 kg box sitting on a flat floor. We want to move the box to the right across the floor.

The most efficient way might be to attach a line to the box and pull with a horizontal force (parallel to the floor).

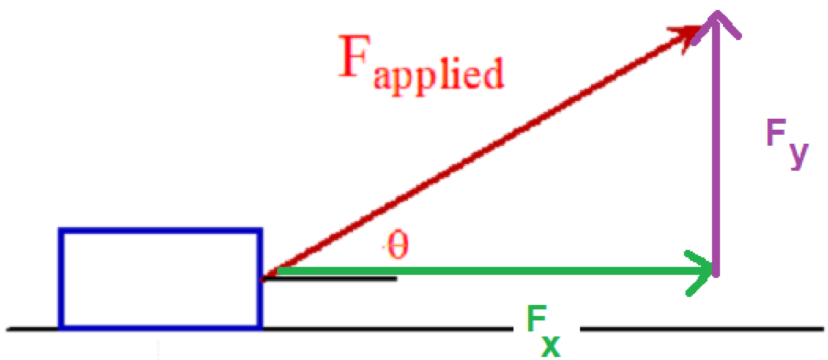


However, this might mean having to actually get down on the floor – not the most comfortable or practical position. Instead, we might use the same line and pull at an angle ɵ above the horizontal. How would this affect our “pulling ability” ?





Any force acting at an angle (θ) above the horizontal can be replaced by two forces, horizontal force component (F_x) and vertical force component (F_y). So, how do you find the horizontal and vertical components a result force:

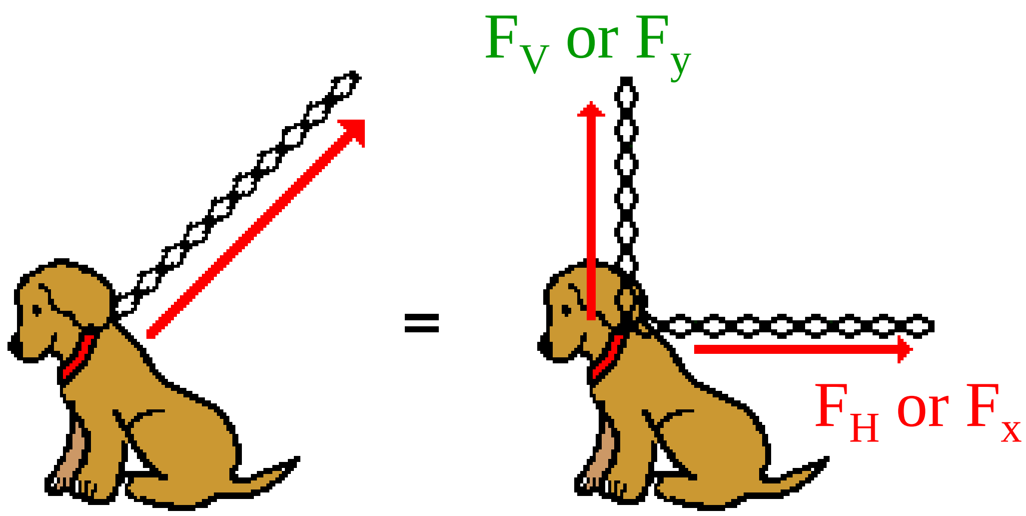


Horizontal Component (F_x)	Vertical Component (F_y)
From the diagram: $$\cos\theta = \frac{F_x}{F_{app}}$$ **Cross Multiple:** $$F_x = F_{app} Cos\theta$$	**From the diagram:** $$\sin\theta = \frac{F_y}{F_{app}}$$ **Cross Multiple** $$F_y = F_{app} \sin\theta$$

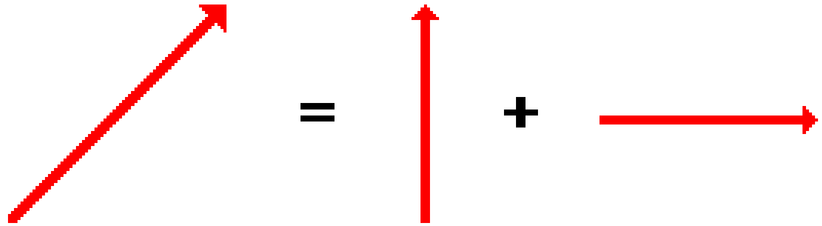
Whenever a force is applied at an angle, it can be resolved or broken up into two parts or components:

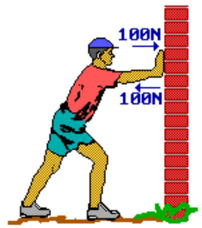
- A vertical or y-component

- An horizontal or x -component



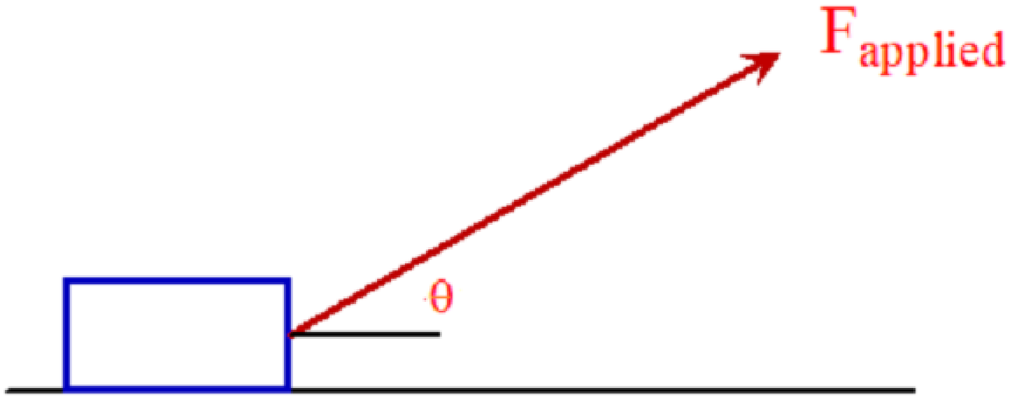
The upward and rightward force of the chain is equivalent to an upward force and a rightward force by two chains.





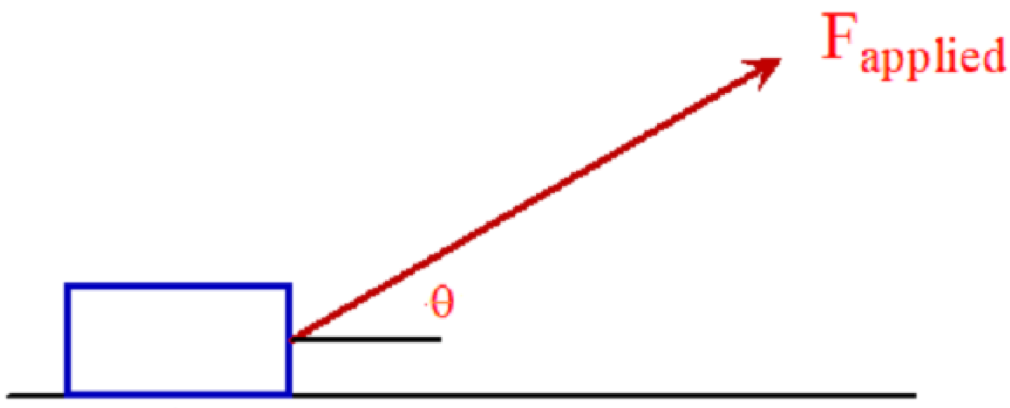
Example 1:

A 100.0 N force is applied to a box at various, increasing angles – Note how the components change:



	F_x	F_y
0°		
15°		
30°		
45°		
60°		
75°		
90°		

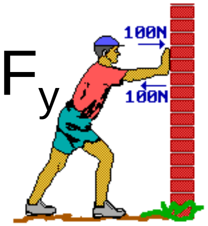
What do you notice?



As the angle from the x-axis increases (steeper), x-component decreases & y-component increases.

As the angle from the x-axis decreases (less steep), x-component increases & y-component decreases.

At an angle of 45 ^{o}, the F_x component is equal to the F_y component of the force



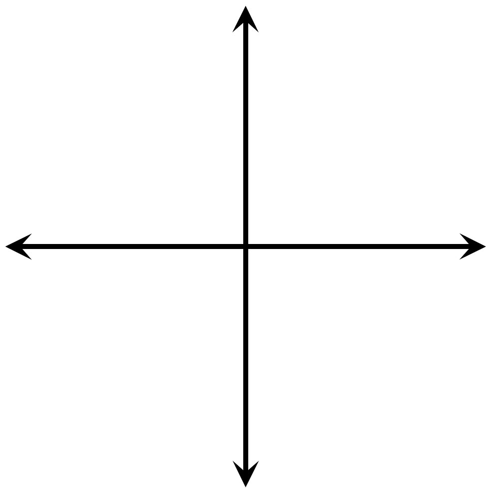
Formulas for Resolving Forces into Componen

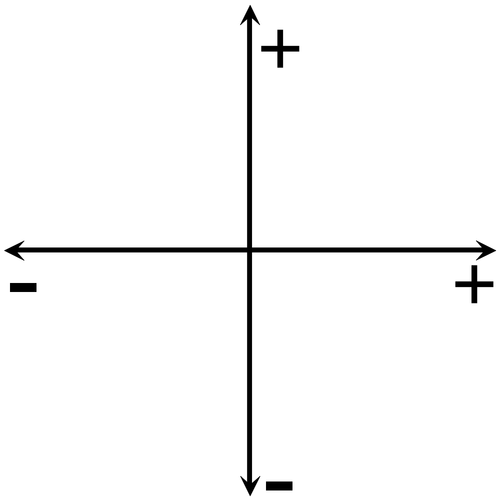
If a force is directed at an angle θ from the horizontal, then:

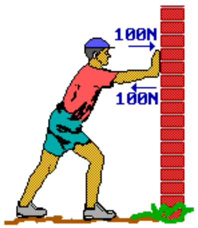
$$F_x = F \cdot \text{Cos}\ \theta \qquad F_y = F \cdot \text{Sin}\ \theta$$

Don't Forget:

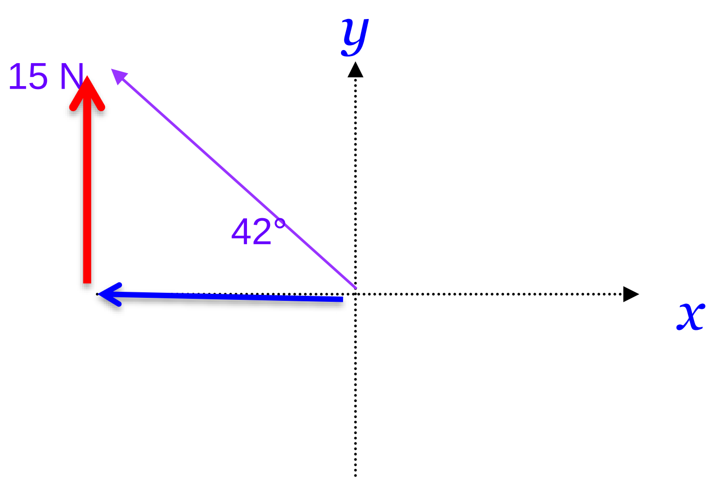
- To use these formulas, **the angle must be measured above or below the x-axis (or horizontal)**







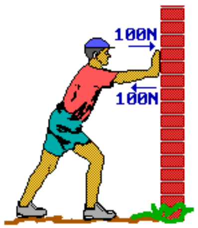
Example2:



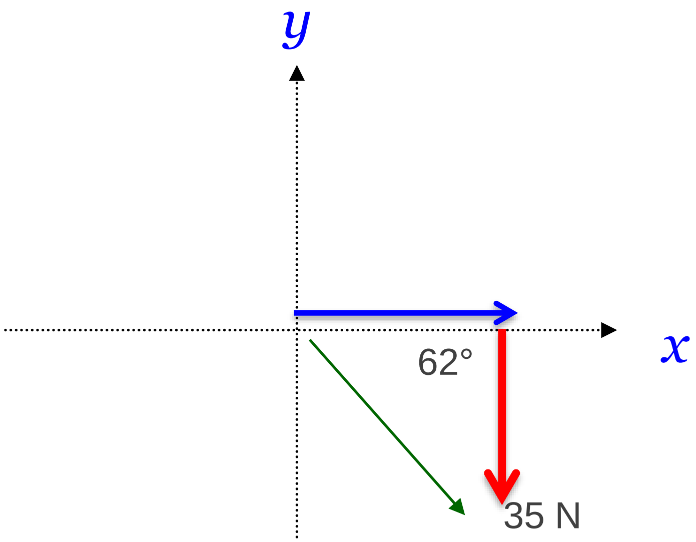
$$F_X = 15 \times \text{Cos } 42 = -1.1 \text{ N}$$

$$F_Y = 15 \times \text{Sin } 42 = 10.0 \text{ N}$$

Note that force is a vector quantity, therefore, direction is important

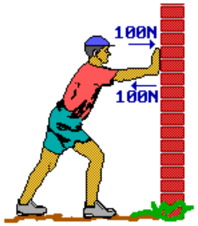


Example 3:



$$F_X = 35 \times \text{Cos } 62 = 16.4 \text{ N}$$

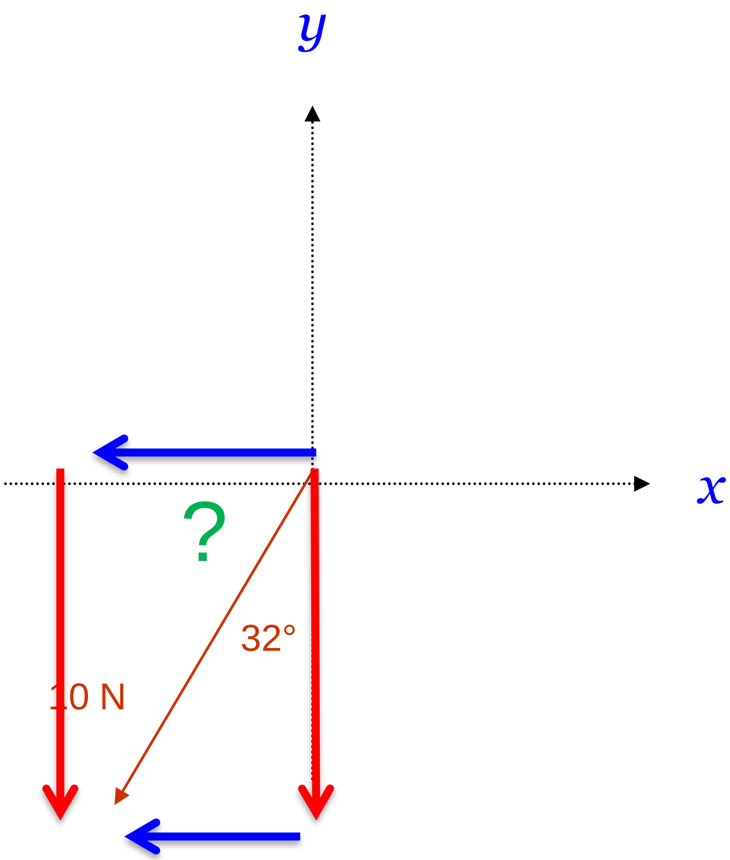
$$F_Y = -35 \times \text{Sin } 62 = -30.9 \text{ N}$$



Examples 4:

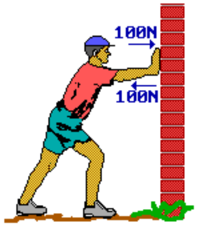
Notice that **F x** is opposite the angle this time. Therefore, we will try to find the other angle(?)

? = 90 -32 =58



$$F_X = -10 \times \cos 58 = -5.30\ N$$

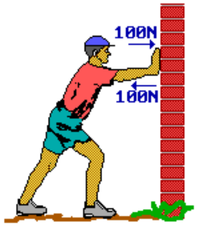
$$F_Y = -10 \times \sin 58 = -8.48\ N$$



Examples 5:

A force of 100.0 N is applied at an angle of 30.0º E of N.

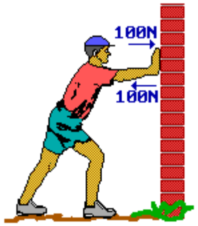
Find the x and y components of this force:



Examples 6:

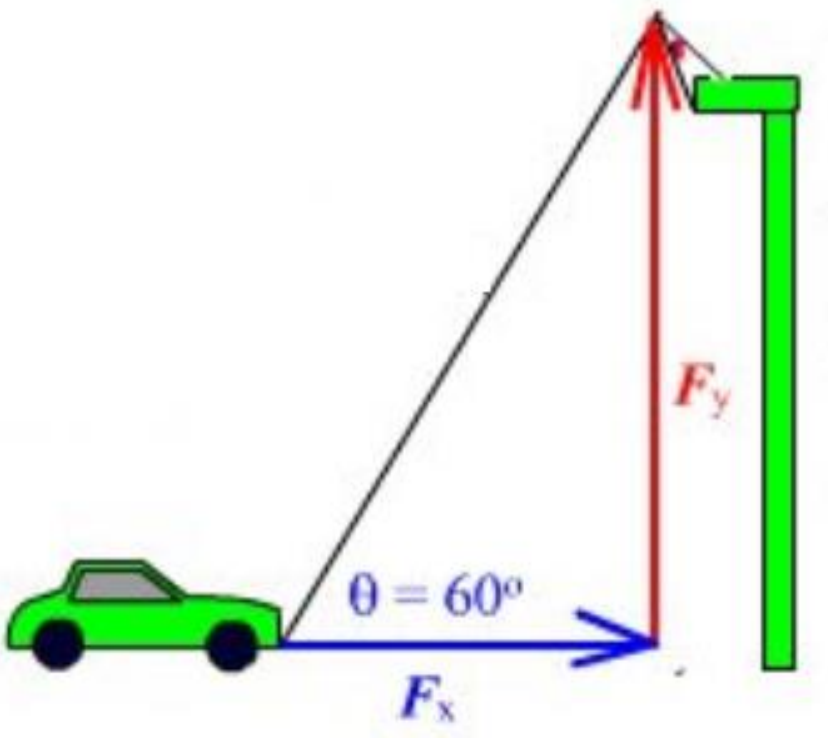
A force of 500.0 N is applied at an angle of 25.0º S of W.

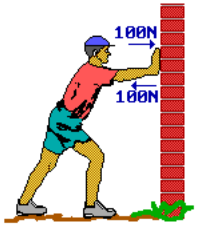
Find the x and y components of this force:



Examples 7:

A car has become stuck and is being towed using a cable that makes an angle of 60.0º above the horizontal. The 3000.0 N force from the winch is directed along the cable. Calculate the horizontal and vertical components of the force.

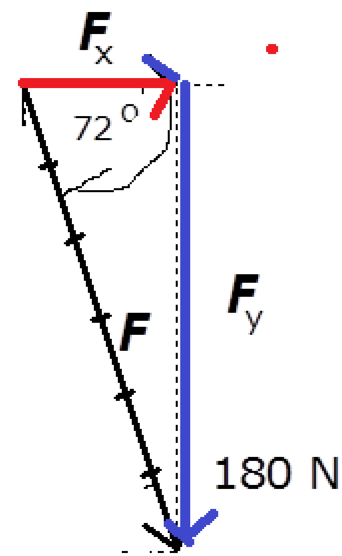


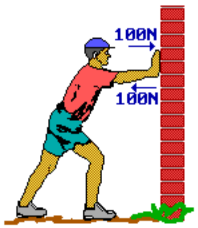


Example 8:

Farmer Brown is cutting sods to cover a bare spot on his lawn. He pushes on the cutter with a force of 180 N at an angle of 72º with the ground. What part of this force is straight down, and what part is used to displace the sod?

Solution





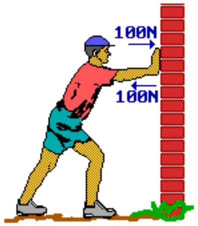
Summary of resolving force into components

If a force F is directed at an angle of θ with the horizontal, then the horizontal (F_x) and vertical (F_y) components are calculated as follows:

$$F_x = F \cos\theta \quad \text{and} \quad F_y = F \sin\theta$$

Force components should be given direction

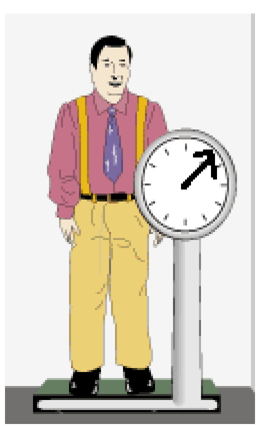
Magnitude of F_x and F_y are equal at an angle of 45 degrees



What Is Apparent Weight?

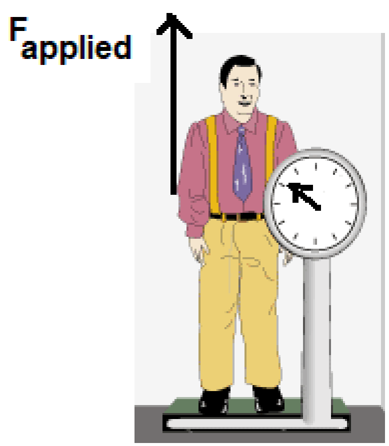
Apparent Weight (Effective Weight) is a property of objects that corresponds to how heavy an object is. The apparent weight of an object will differ from the weight of an object whenever the force of gravity acting on the object is not balanced by an equal but opposite normal force. It is the reading you get on a scale. The apparent weight is equals to normal force.

Just standing there!



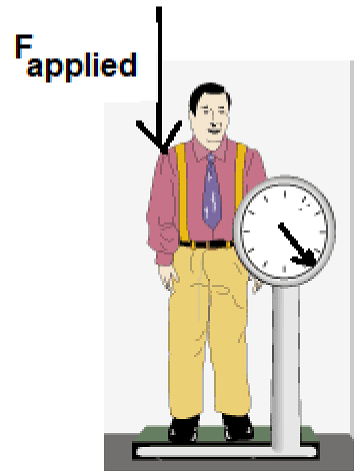
Apparent Weight = True Weight

Someone pulling up !



Apparent Weight < True Weight

Someone pushing down !



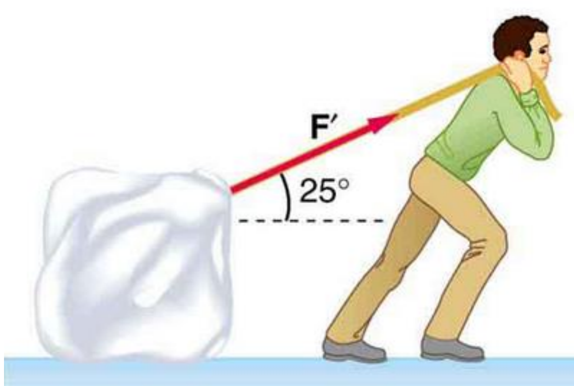
Apparent Weight > True Weight

Example 9:

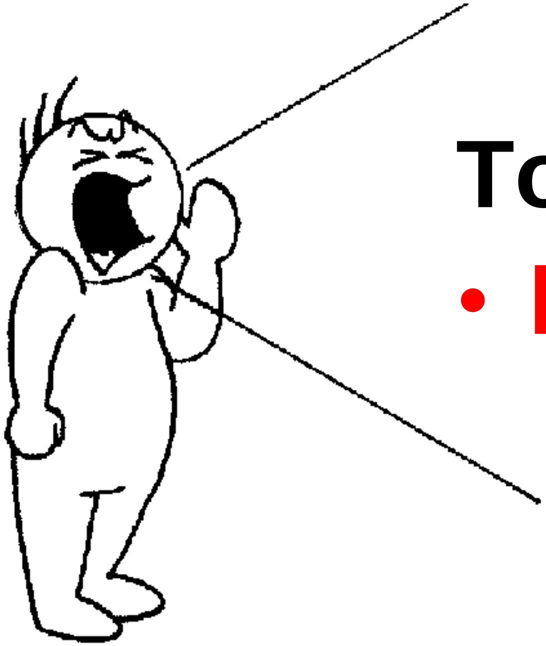
A force of 950 N is exerted on a heavy object by means of a rope which is held at an angle of 25^o to the horizontal.

(a) What are the vertical and the horizontal components of the force?

(b) The object has a mass of 130 kg. The rope, however, tends to lift the object, thus decreasing the force between the object and the ground. Calculate the "effective" weight of the object against the ground.

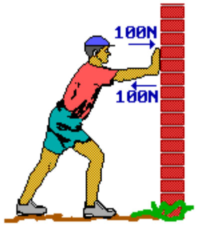


(c) Calculate the effective or apparent weight if the object was pushed with the same amount of force and at the same angle. What do you notice?

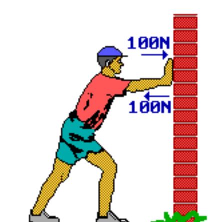


Topic 5

- **Newton's First Law**




1. Explain Newton's First Law of Motion in your own words.
!
Yakka Foob Mog. Grug Pubbawup Zink Wattoom Gazork. Chumble Spuzz.
I LOVE LOOPHOLES.
© 1995 Watterson/Dist. by Universal Press Syndicate


100N
100N

Sir Isaac Newton

Sir Isaac Newton was one of the greatest scientists and mathematicians that ever lived. He was born in England on December 25, 1643. He was born the same year that Galileo died. He lived for 85 years.

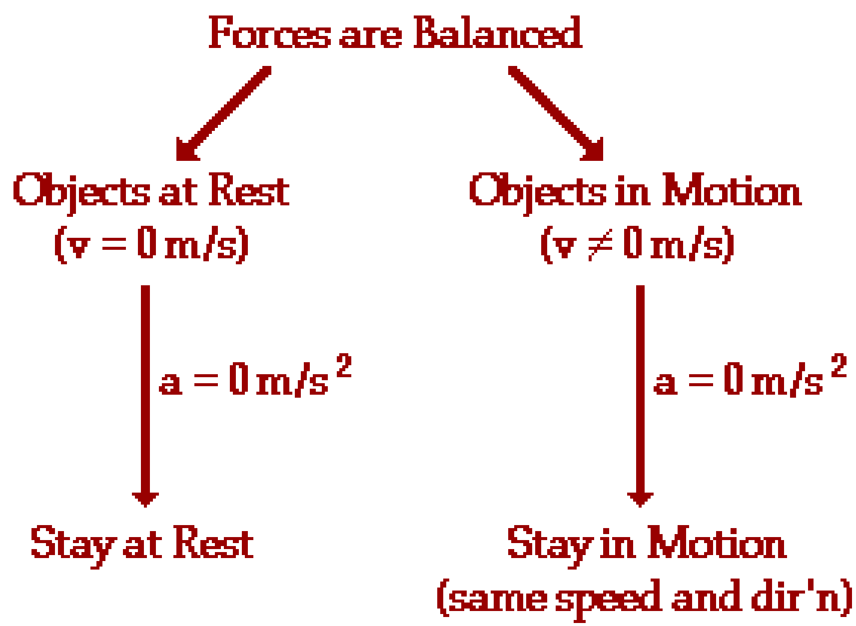
Isaac Newton was raised by his grandmother. He attended Free Grammar School and then went on to Trinity College Cambridge. Newton worked his way through college. While at college he became interested in math. physics, and astronomy. Newton received both a bachelors and masters degree.

While Newton was in college he was writing his ideas in a journal. Newton had new ideas about motion, which he called his three laws of motion. He also had ideas about gravity, the diffraction of light, and forces, Newton's ideas were so good that Queen Anne knighted him in 1705. His accomplishments laid the foundations for modem science end revolutionized the world. Sir Isaac Newton died in 1727.

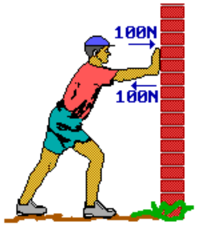
Newton's First Law (Sometimes called INERTIA):

Objects at rest tend to stay at rest, and objects in motion tend to stay in motion in a straight line unless acted upon by an external unbalanced force.

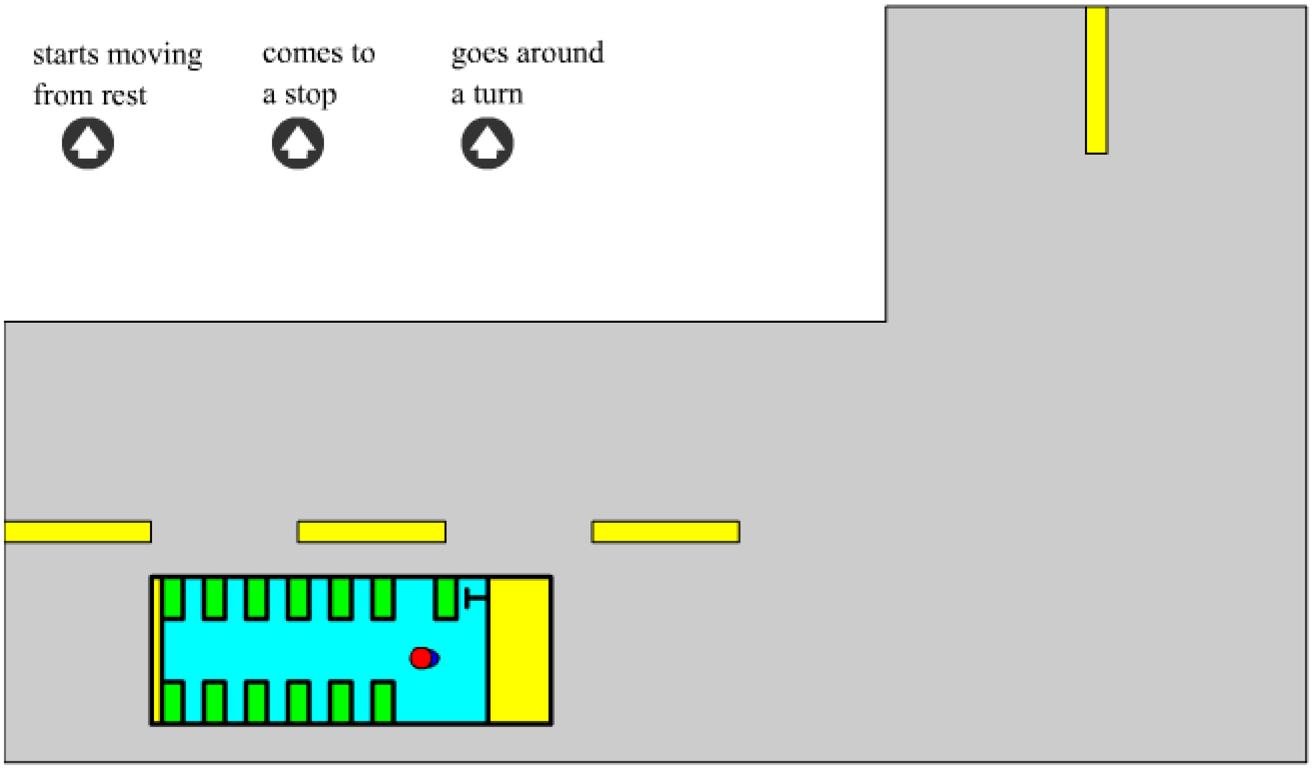
There are actually two parts to the 1^{st} law:



Acceleration is = 0 m/s ^{2}



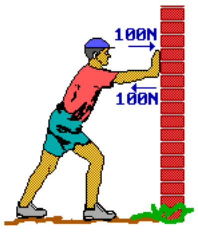
Consider the following Example of student (wearing a red cap) standing on in a bus



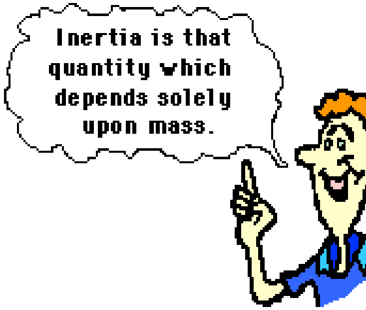
In each case the student's body resisted changes in its motion (Inertia)...

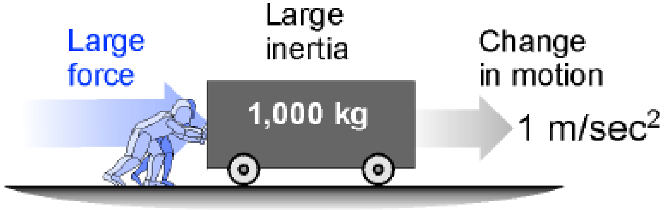
- If it was stopped it tended to remain that way.
- If it was moving in a straight line it tended to remain that way.

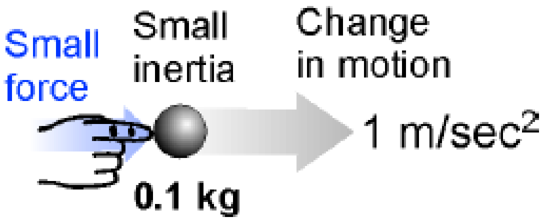
Inertia: is the resistance an object has to a change in its state of motion.

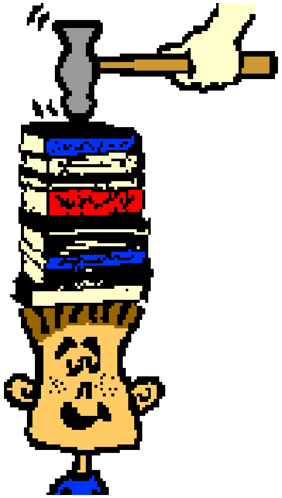


Inertia *is that quantity which is solely dependent upon mass. The more mass which an object has, the more inertia it has - the more tendency it has to resist changes in its state of motion.*

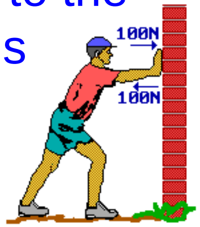








An example which demonstrates this may be seen by placing several massive books upon a persons head. A wooden board is placed on top of the books and a hammer is used to drive a nail into the board. Due to the large mass of the books, the force of the hammer is sufficiently resisted (inertia).



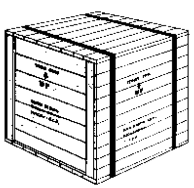
Using Inertia

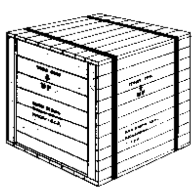
- Suppose you are sitting at the edge of a pond with a very smooth ice surface.

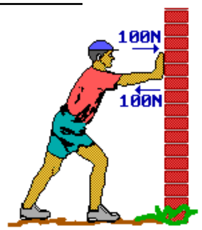
- Your two friends each push an **identical wooded crate** towards you. One crate is empty but the other contains a heavy load of firewood.

- There is very little friction with the ice and both crates slide towards you with the **same velocity**.

- How could you use Inertia to determine which crate was empty and which was loaded with firewood?



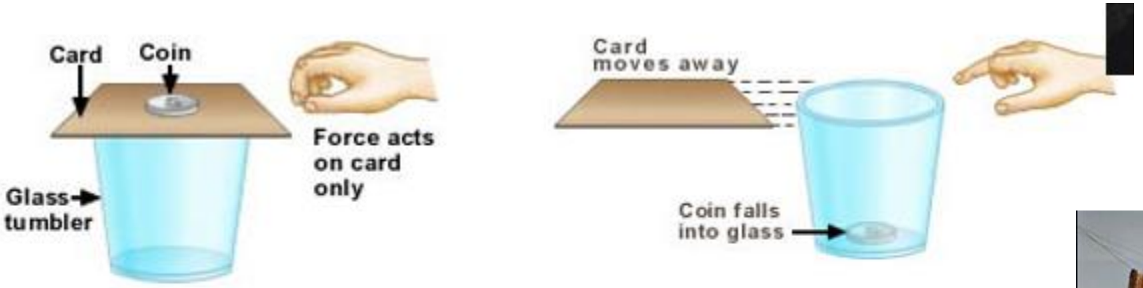




<u>Examples of Part I</u> - If an object is stopped (at rest) it tends to remain that way.

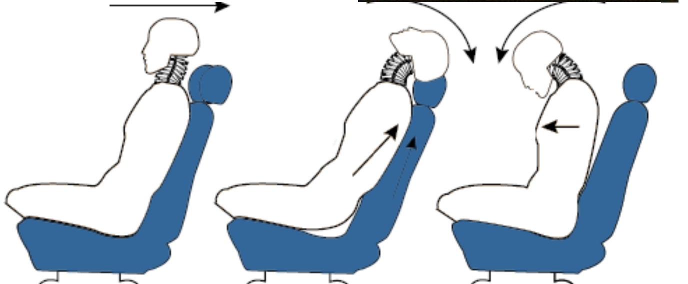
- the old Magician's trick of pulling the table cloth from underneath the dishes

-Card and coin on a GLASS



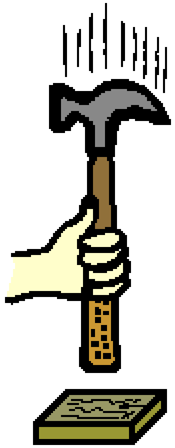
- Dust being removed from a mat.

-headrests are placed in cars to prevent whiplash injuries during rear-end collisions.



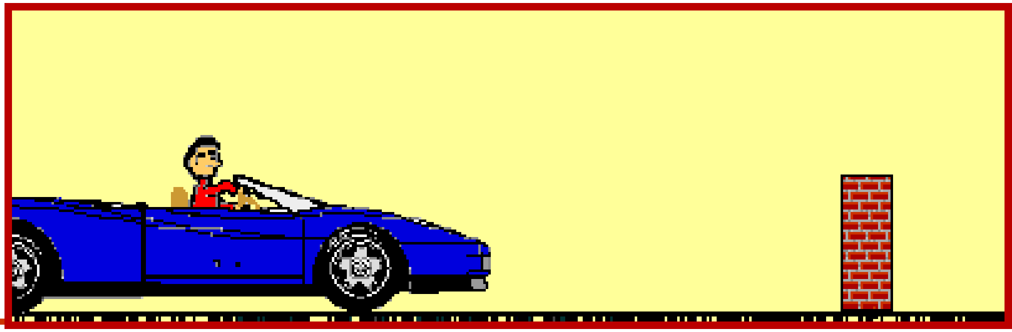
Examples Part II - If an object is moving at a constant speed in a straight line it tends to remain that way.

-the head of a hammer can be tightened onto the wooden handle by banging the bottom of the handle against a hard surface.

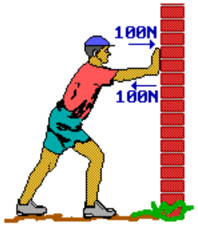


-Snow is removed by stamping you feet.

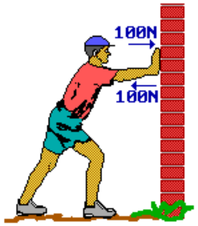
-Getting thrown from a car in an accident



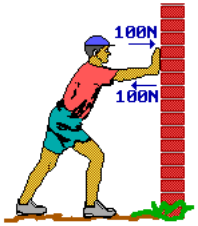
Why Are Seat Belts Placed in Cars?



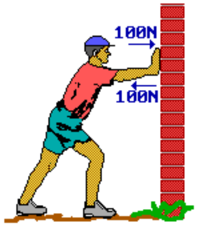
Why Does Wood Fall Out Of The Truck If You Accelerate Fast?



How Do You Remove the Bottom Boxes?



Is This Safe? Why or Why Not?

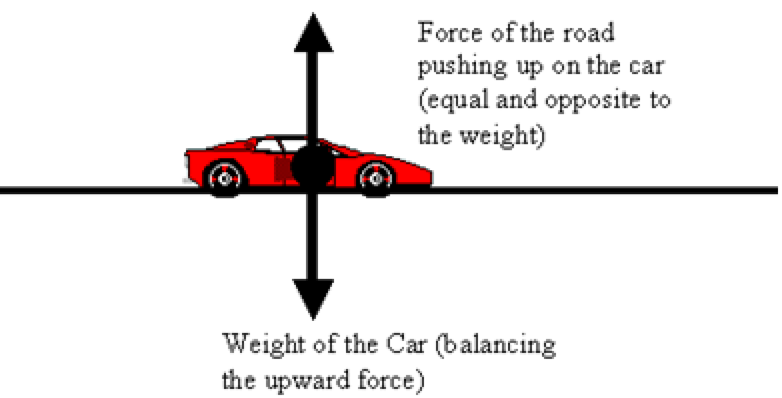


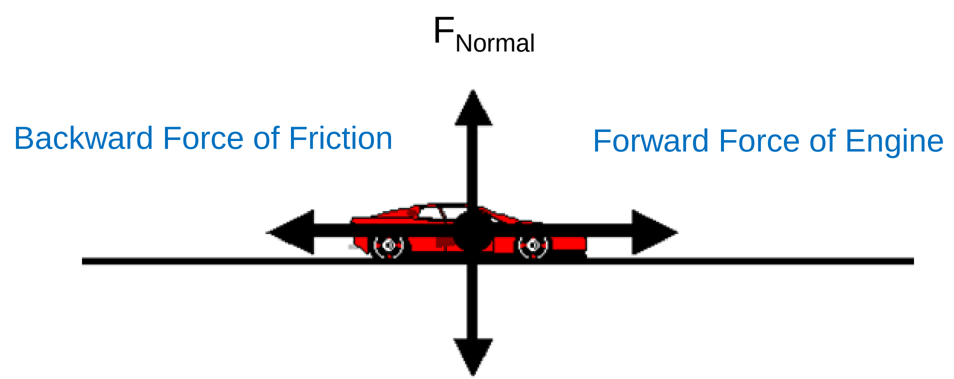
Newton’s First Law – Balanced Forces

- In order for Newton’s First Law to apply, **all <u>forces</u> that act on an object must be <u>balanced</u>.**
- In other words, once you add up all the forces, the Net Forces (or Unbalanced Force) on the object must be 0.
- **If forces are balanced, the object will maintain its state of motion:**

If it was at rest, it stays at rest

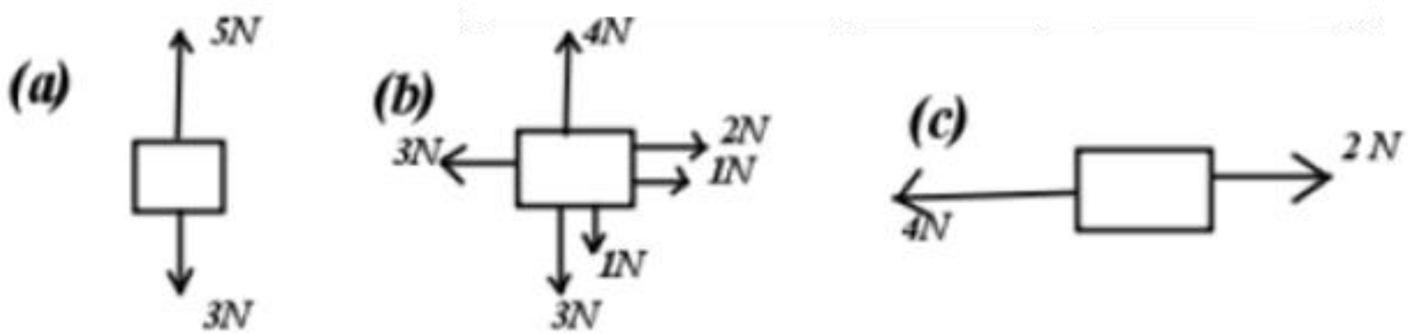
- If it was in motion, it stays in motion

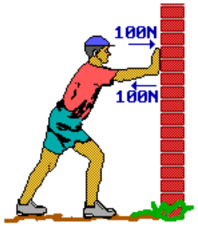




Example 1 :

Determine which of the following is obeying Newton’s First Law.

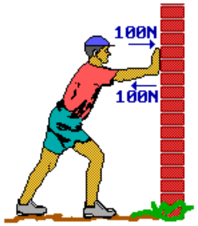




Example 2:

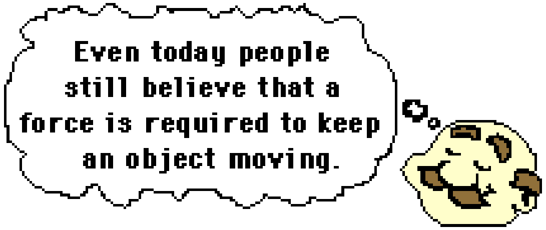
A) You see a car pass by at a fixed speed in a straight line. Are there any forces acting on it?

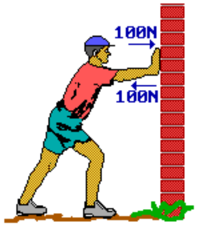
B) If the force of friction between is 1000N, how is the car able to travel with uniform motion



Example 3:

A driver pushes his car at a fixed speed along a level straight road. A "special" set of bathroom scales between the driver's hands and the car indicates he is pushing with a force of 400 N. What is the force of friction acting on the car?





Inertial Frames of Reference

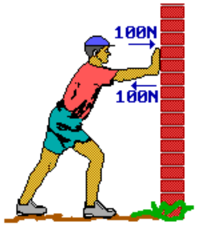
Frame of reference is a place from which motion is observed.

Inertial frame of reference is one in which Newton's first Law is valid. It is a frame of reference that is not accelerating. ($a = 0\ m/s^2$)

Question: Explain whether each is an inertial or a non-inertial frame of reference.

1) On a train going across the prairies at constant speed.

2) On board the *MV Joseph and Clara* just as it leaves the dock and starts to pick up speed.



Inertial and Non-inertial Frames of Reference

Remember, a **frame of reference** is a place from which motion is observed.

- **An inertial frame of reference is one in which Newton's First Law is valid.**

When there is **no motion** or When there is **uniform motion** (Constant speed in straight line)

Example: Box at rest on the floor. — Car travelling uniformly at 12 m/s along a straight stretch of roadway.

- **A Non-Inertia frame of reference is one where Newton's First Law is NOT Valid.**

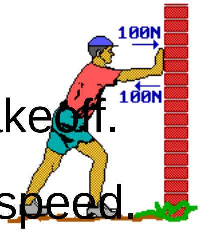
There is **acceleration** involved in a non- inertia reference frame:

Either: The magnitude of an object's velocity changes (speeds up or slows down).

or The direction of an object's velocity changes (object travels around a turn).

Example: A car applies its brakes and stops. An airplane accelerates at takeoff.

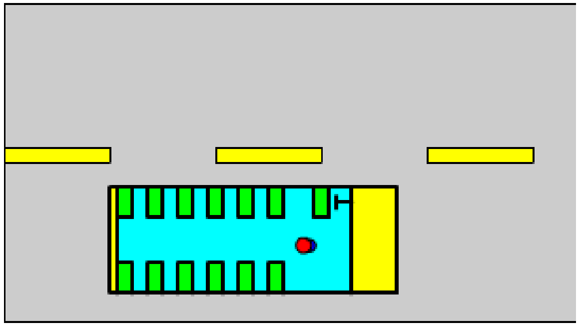
A motorcycle travels around a turn in the highway, at a constant speed.



Inertial and Non-inertial Frames of Reference

A bus: Two different examples.

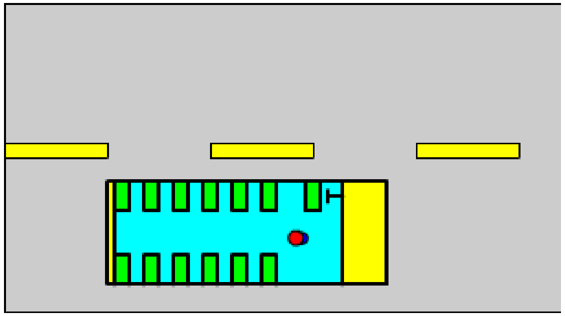
I. Bus is in uniform motion down a very smooth road. So, it is **constant speed in a straight line**.



A small red ball is placed on floor of bus?

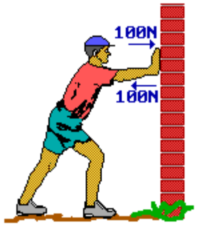
How does the ball behave?

II. Bus is in motion and driver very slightly touches the brake. This causes the bus to have a **small negative acceleration**. Perhaps this acceleration is so slight that it is not felt by the passengers



A small red ball is placed on floor of bus?

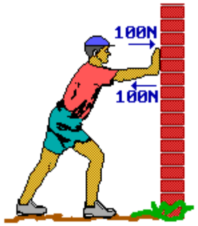
How does the ball behave?



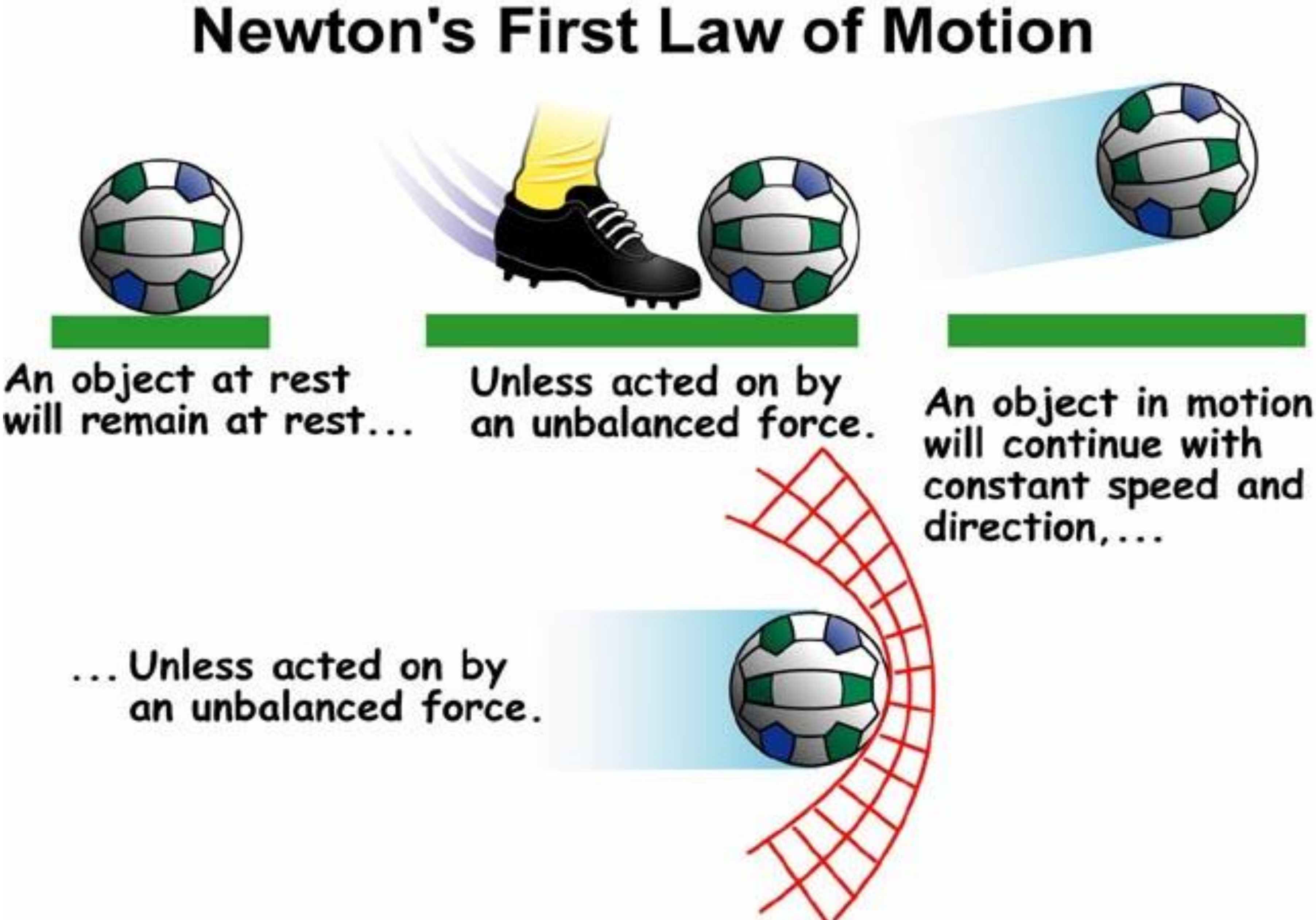
Which example is inertial and which is non-inertial?

Practice Homework

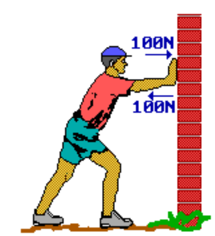
1. Watch Professor Mac's Summary of First Law (6:31)
   Copy and paste the link below to your browser:
   http://www.youtube.com/watch?v=BlFGN2zlDYc
   https://tinyurl.com/pq8ctmx

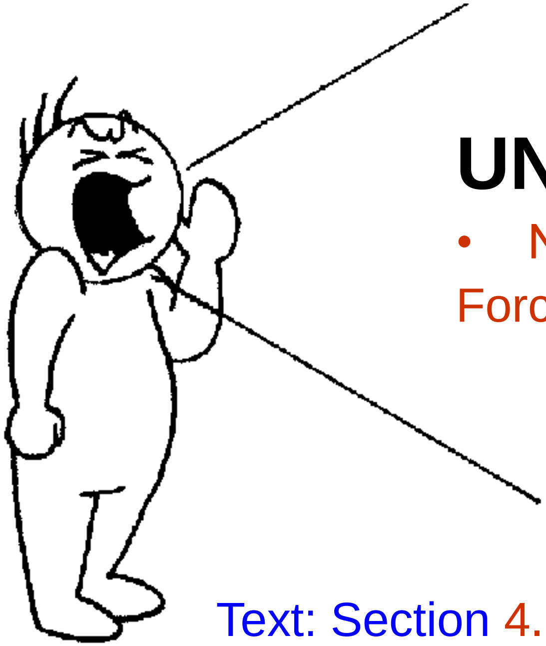


SUMMARY


Newton's First Law of Motion
An object at rest will remain at rest...
Unless acted on by an unbalanced force.
An object in motion will continue with constant speed and direction,...
...Unless acted on by an unbalanced force.

A study of inertia: a physics student at rest



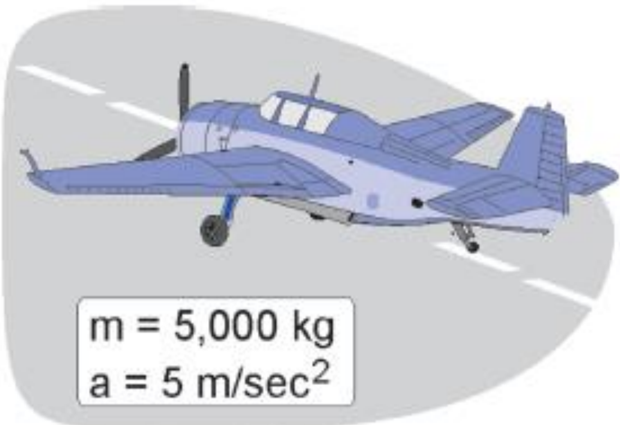


UNIT 2 Topic 8

- Newton's Second Law

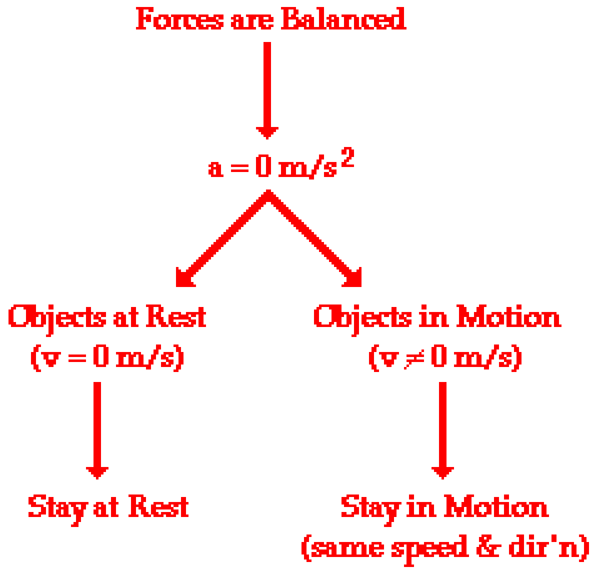
Force, Mass, and Acceleration

Text: Section 4.2

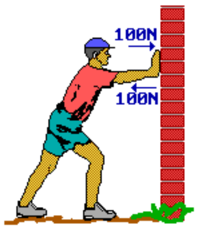


Newton's first Law indicated that an object will behave in one of two ways when the net force or unbalanced force is zero.

1) Either it will be AT REST
2) It will be moving AT A FIXED SPEED IN A STRAIGHT LINE.



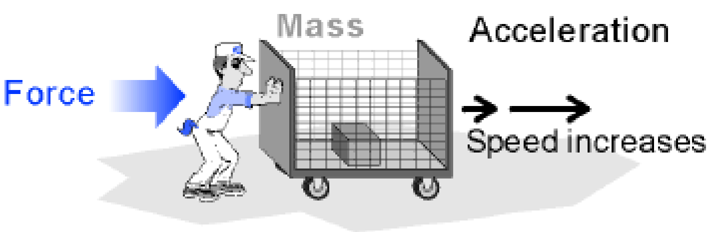
However, in the real world a lot of objects experience an unbalanced force that causes it to accelerate. Hence, Newton's Second Law considers objects where the Net force is not equal to zero.

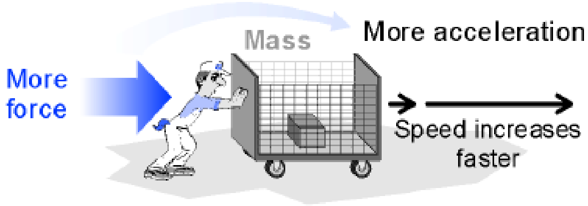


What Affects Acceleration?

1)AMOUNT OF FORCE

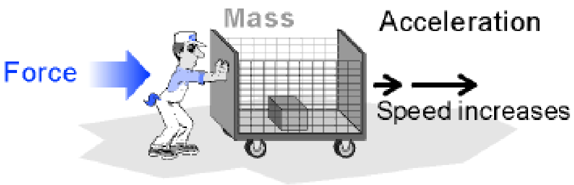
- **MORE FORCE = MORE ACCELERATION**

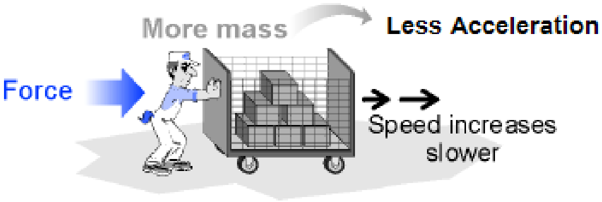


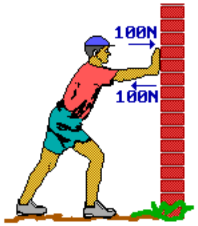


2) MASS OF OBJECT

- **MORE MASS = LESS ACCELERATION**

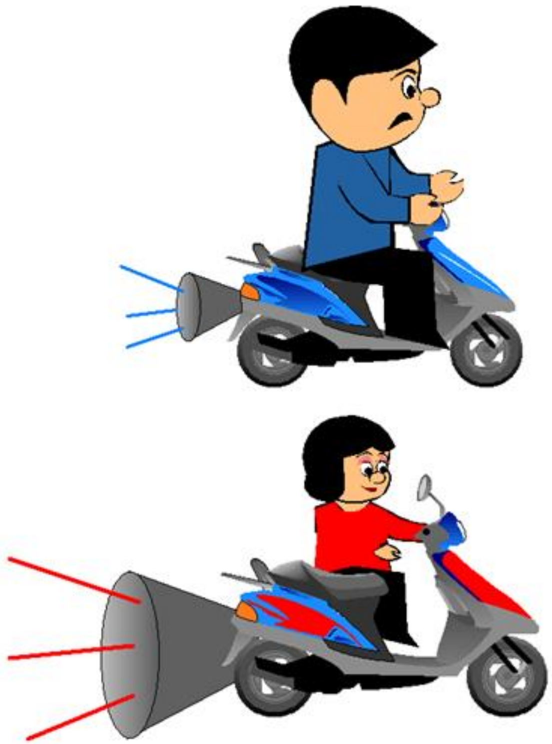


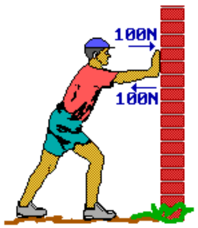




Question:

According to Newton, who would win the race? Explain your answer?



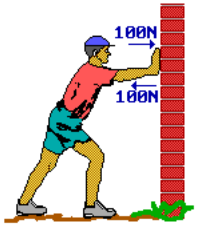


Newton's Second Law

The acceleration of an object is directly proportional to the force acting on the object and inversely proportional to the mass of the object."

$$a = \frac{F_{net}}{m}$$

From the formula we can see that **m/s² = N/kg**

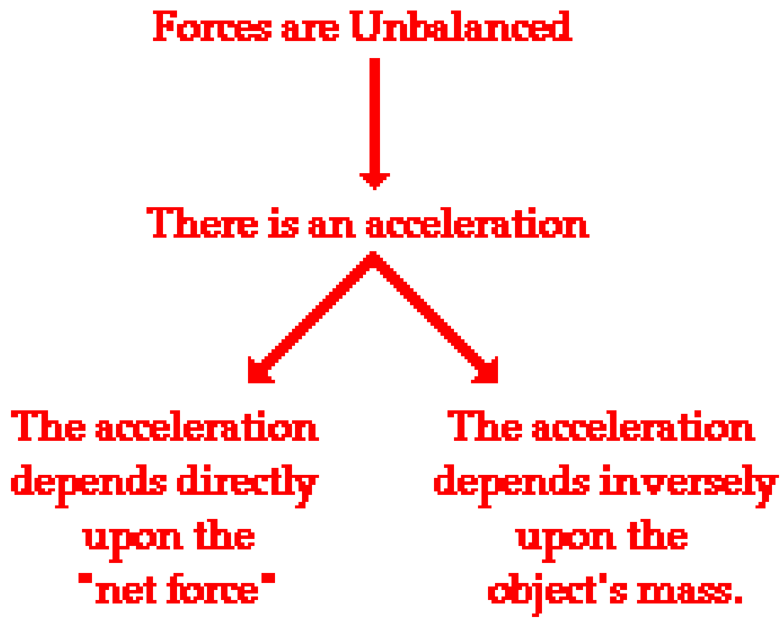


Three Forms of Newton's Second Law

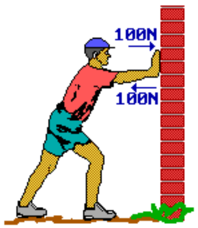
:

Use . . .	if you want to find . . .	and you know . . .
$a = \frac{F}{m}$	The acceleration (a)	The net force (F) and the mass (m)
$F = ma$	The net force (F)	The acceleration (a) and the mass (m)
$m = \frac{F}{a}$	The mass (m)	The acceleration (a) and the net force (F)

The presence of an unbalanced force or Net force will accelerate an object - changing either its speed, its direction, or both its speed and direction.

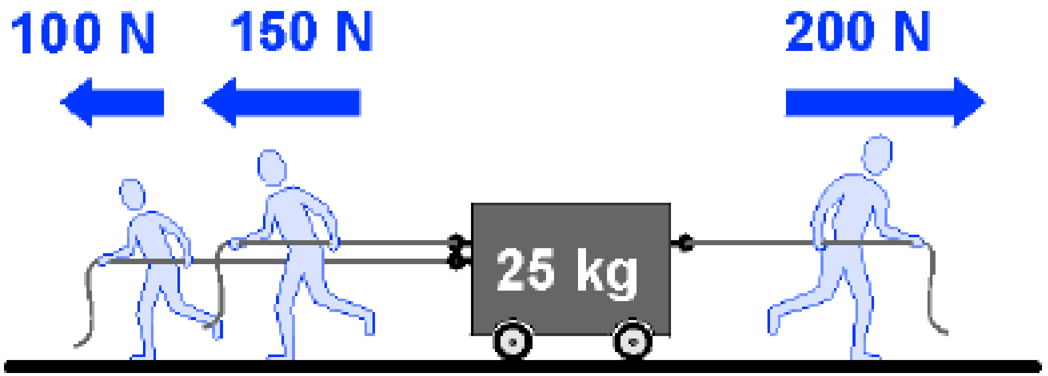


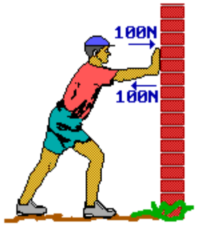
Newton's laws declare that a net force (an unbalanced force) causes an acceleration and the acceleration is in the same direction as the net force.



Example 1:

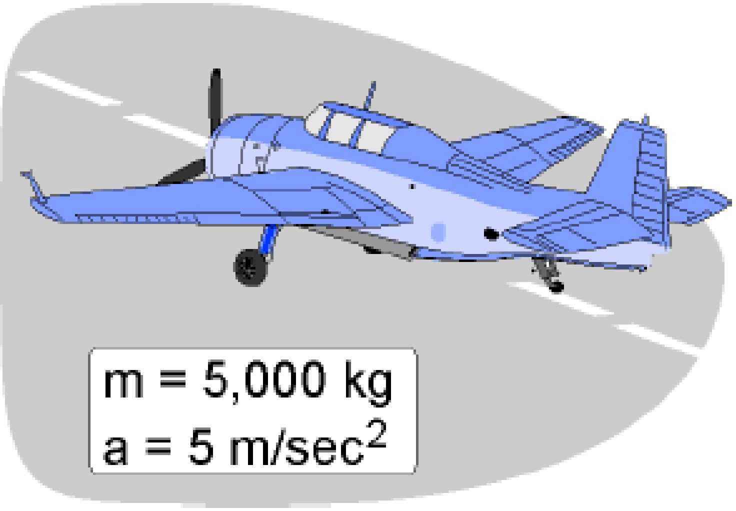
- Three people are pulling on a wagon applying forces of 100 N,150 N, and 200 N. The wagon has a mass of 25 kilograms. Determine the acceleration and the direction the wagon moves.

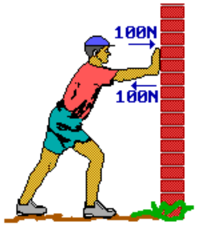




Example 2:

An airplane needs to accelerate at 5.0 m/sec^2 to reach take-off speed before reaching the end of the runway. The mass of the airplane is 5,000 kg. How much force is needed from the engine?



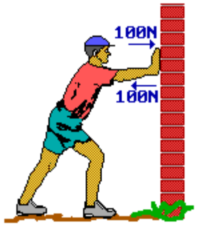


Example 3

The combined mass of a rider and his motorcycle is 650 kg. The engine needs a tune-up and is able to exert a force of 150 N only.

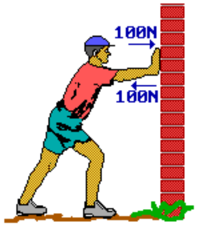
(A) At what rate does the bike accelerate?

(B) How long will it take for the speedometer to reach 75 km/hr?



Example 4:

A child jerks a 12 kg toboggan across a very slippery ice patch (no friction). The rope attached to the toboggan makes an angle of 30.0 ^{o} with the ground. If the force applied along the rope is 55 N, what will be the acceleration of the toboggan on the ice?



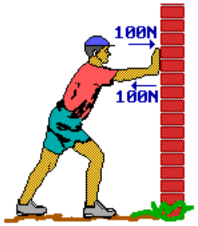
Example 5

A 65 kg person is standing in an elevator. Calculate the person's apparent weight for the following situations:

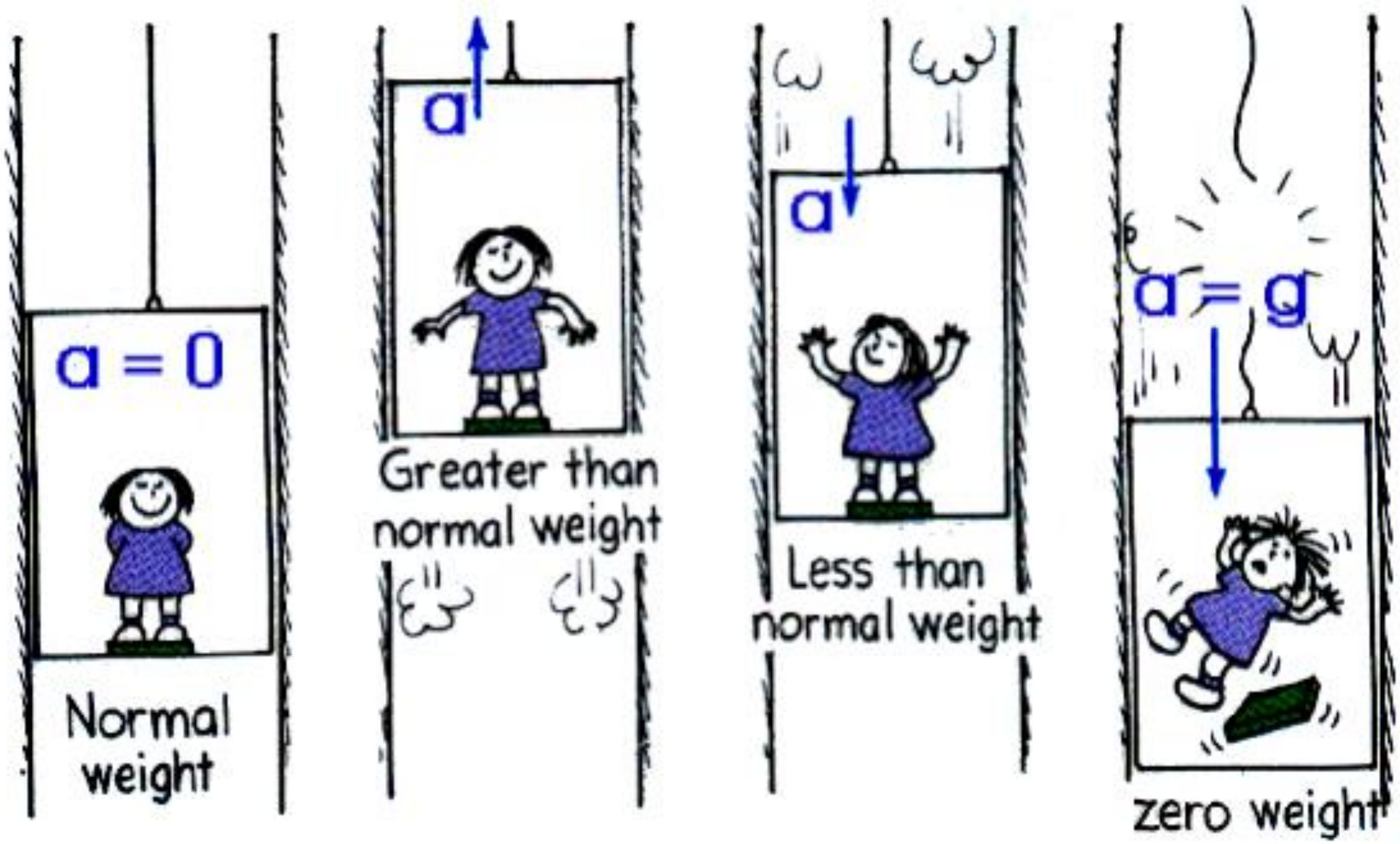
A) An elevator is moving with a constant speed upwards.

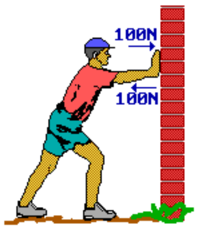
B) An elevator going up accelerates at 0.62 m/s^2 .

C) As an elevator goes down, it slows with an acceleration of 0.71 m/s^2.

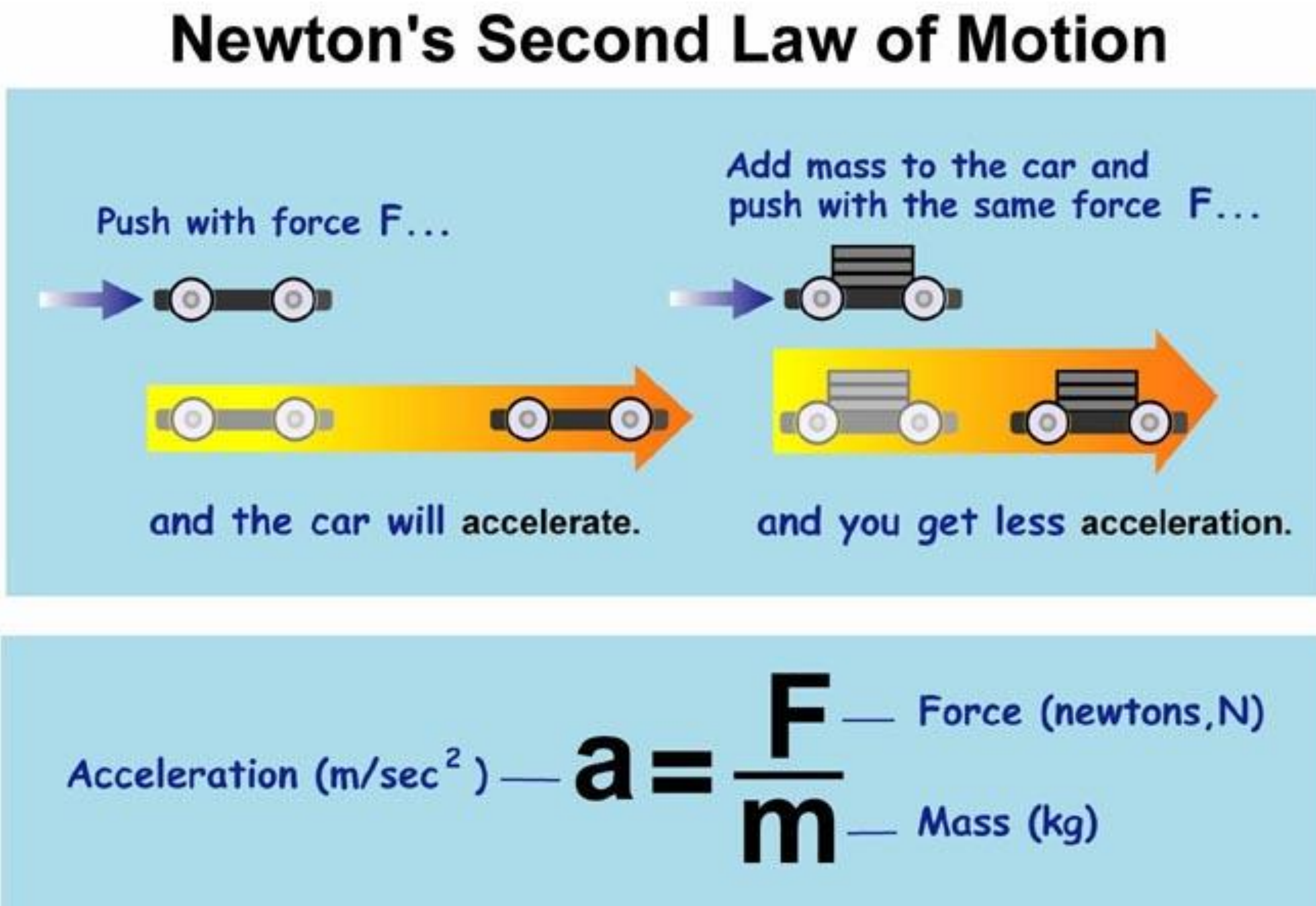


Summary of Apparent Weight

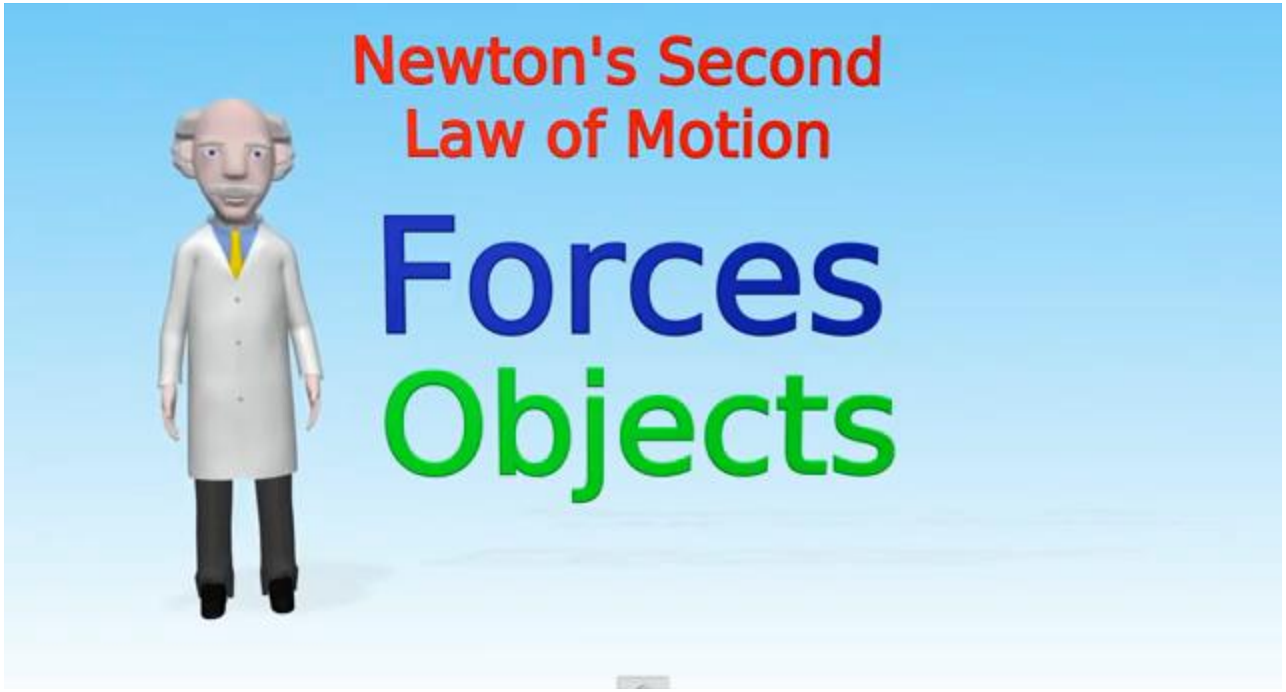




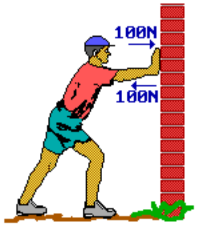
Summary


Newton's Second Law of Motion
Push with force F...
Add mass to the car and push with the same force F...
and the car will accelerate.
and you get less acceleration.
Acceleration (m/sec²)
a = F/m
Force (newtons, N)
Mass (kg)

Watch Professor Mac's Summary of Second Law
Copy and paste the link below to your browser:



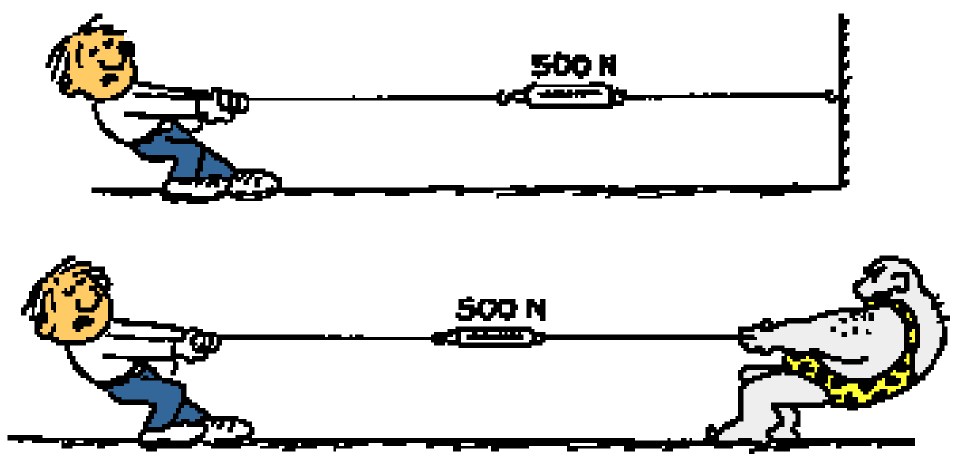
https://www.youtube.com/watch?v=-KxbIIw8hlc

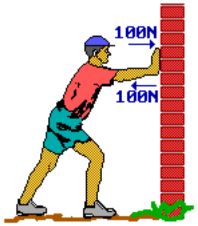


Topic 7

- **Newton's Third Law**

Text: Section 4.5

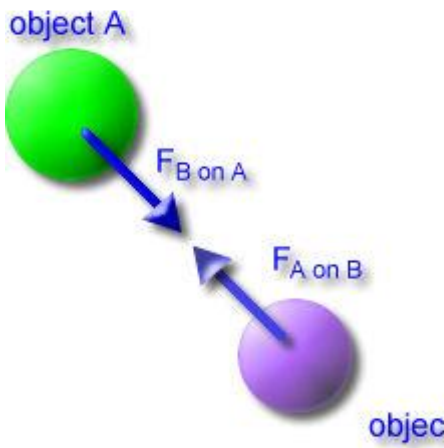




Newton's Third Law:

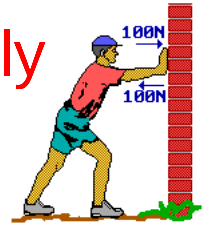
– If Object A exerts a force on Object B then Object B exerts an equal but opposite force on Object A

- $F_{A\ on\ B} = -F_{B\ on\ A}$



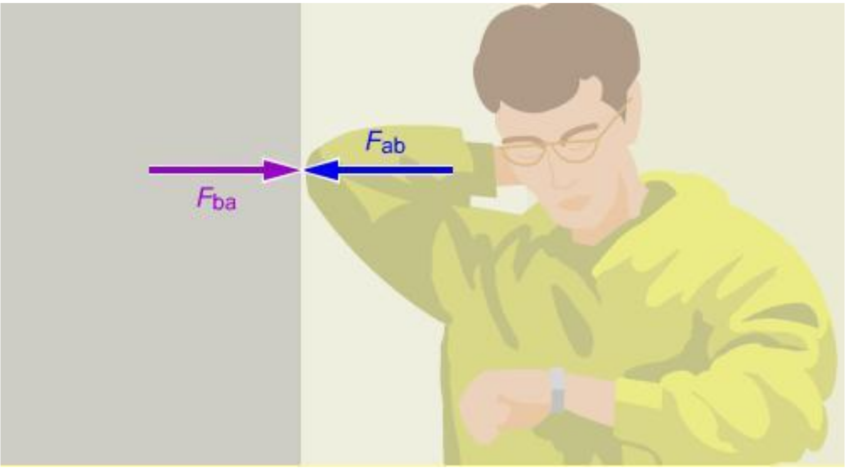
There are two important things to point out:

- (1) the minus sign indicates that the directions are opposite.
- (2) there are two objects and the so-called "action" and "reaction" forces act on different objects (namely each other).

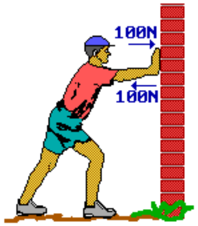


Newton's Third Law

"For every action, there is an equal and opposite reaction"



$F_{\text{man on wall}} = -F_{\text{wall on the man}}$



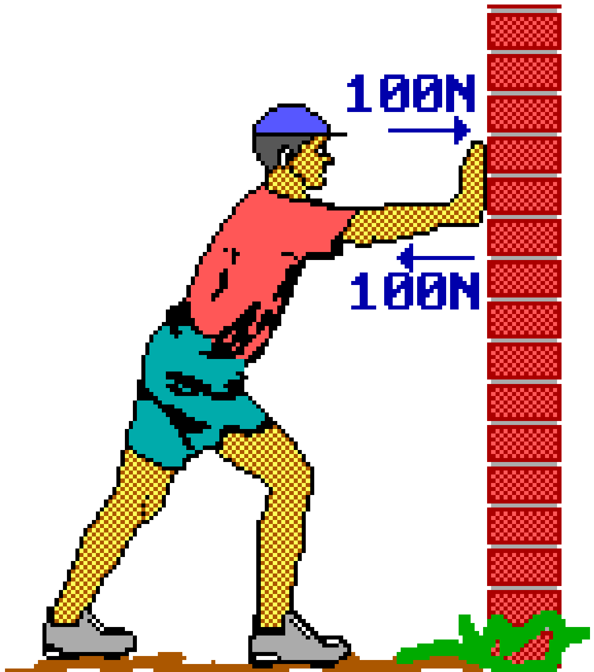
Newton’s Third Law Implies

No Force exists in nature without its EQUAL and OPPOSITE reaction force.

Forces exist in pairs.

Action and Reaction Forces act on DIFFERENT bodies.

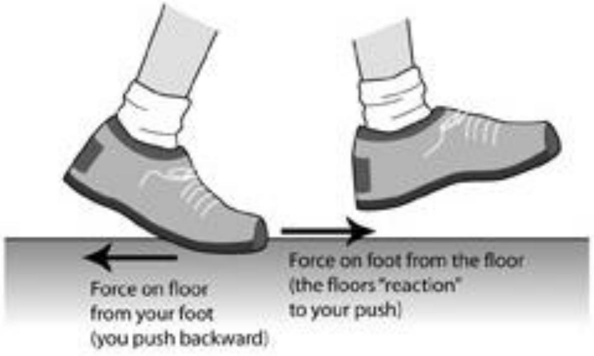
Need to objects in the system



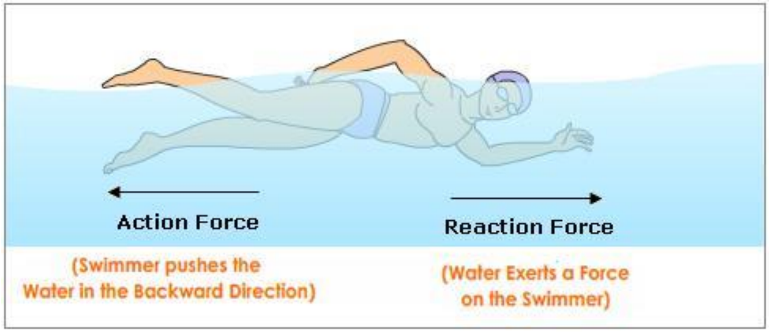
Examples of Newton's Third Law:

Bird Flying: . A bird flies by use of its wings. The wings of a bird push air downwards. In turn, the air reacts by pushing the bird upwards.

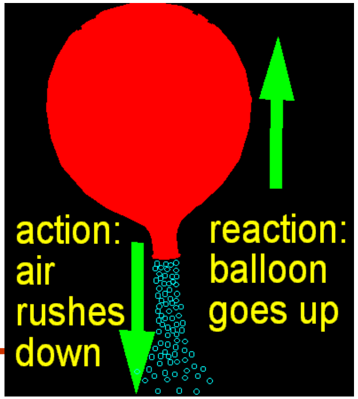
Walking on a flat surface: Your leg and foot push backwards on the floor (the action force) and the floor pushes forward on you with an equal and opposite force.



Swimming: As you swim you move your arm backwards, pushing on the water. The water reacts in the opposite direction to your push and drives you in a forward direction.

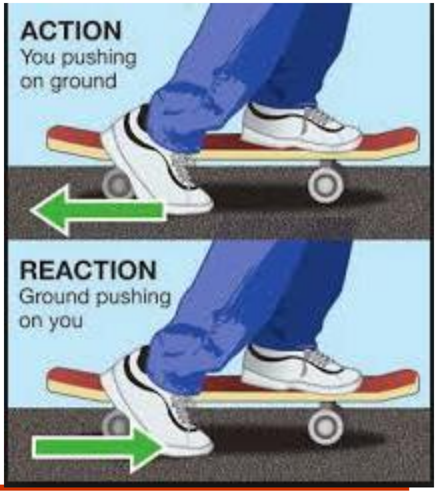


Air being released from a balloon. The stretched elastic of the balloon squeezes the air within the balloon and it is forced out the rear of the balloon. As a reaction force, the air forces the balloon forward.

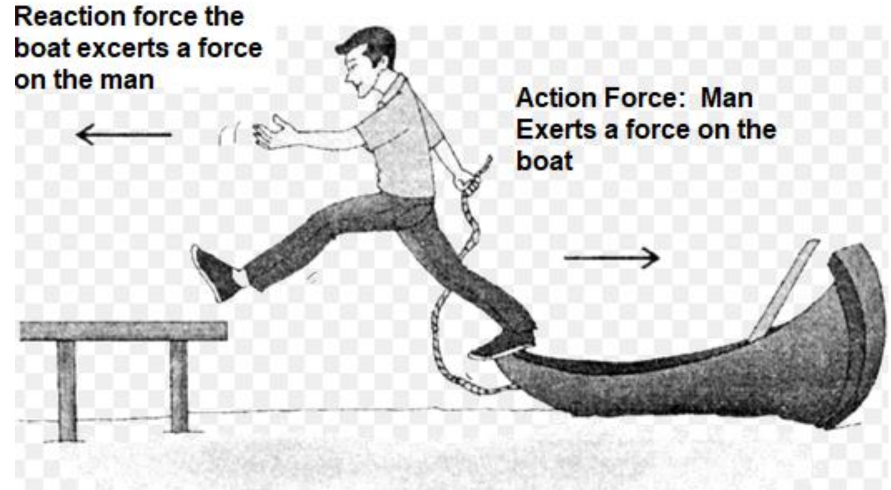


Rocket Launch: As the shuttle’s booster rockets ignite, burning exhaust gasses are forced downward with tremendous force – This is the action force.   The reaction force is the gases pushing back up against the boosters.

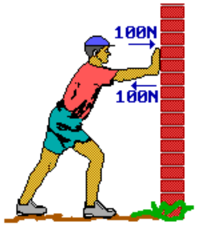
Skate Boarding: Action force is the backward force the person exerts on the ground. The reaction force is the forward force that the ground exerts on the person



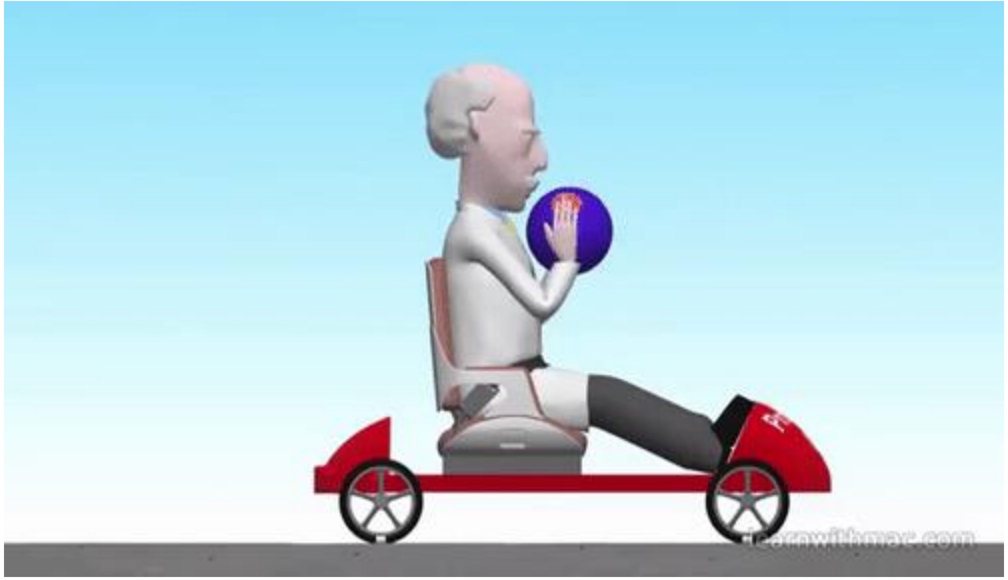
Man stepping out of the Boat. as your legs propel your body towards the dock, they also apply to the boat an equal force in the opposite direction, which pushes it away from the dock.

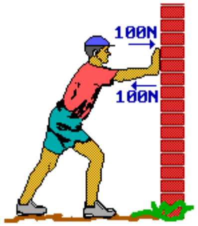


Firing a gun: when you **fire a gun** and the bullet comes hurtling out of the front, an equal and opposite reaction means the **gun** recoils into your shoulder.


100N
100N

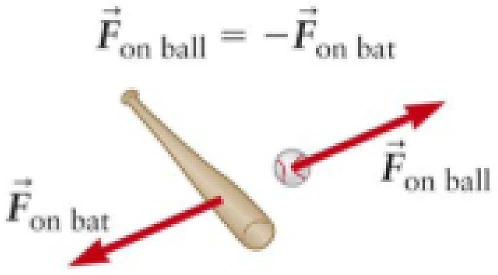
Use Newton’s Third Law to explain the following:

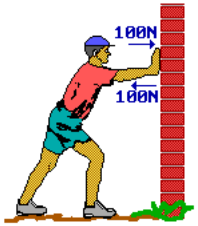




Example 1:

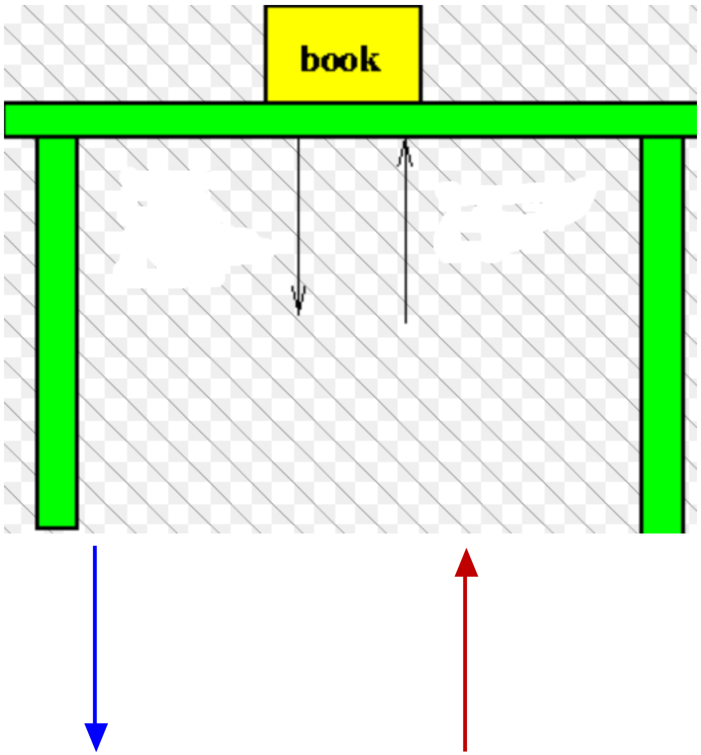
Use Newton's Third Law to explain a bat hitting the ball





Example 2:

Use Newton's Third Law to explain a 50 N object sitting on a table



- The book (object A) is pushing downwards on the desk with a force of 5.0 N → **Action Force.**

- The Desk (object B) is pushing upward on the book with a force of 5 N → **Reaction Force.**

$-F_{\text{Book on Table}}$ (Action Force)

$F_{\text{Table on Book}}$ (Reaction Force)

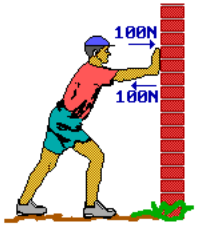
$$-F_{\text{Book on Table}} = F_{\text{Table on Book}}$$

$$-F_{\text{B on T}} = F_{\text{T on B}}$$

$$-5.0\text{ N} = 5.0\text{ N}$$

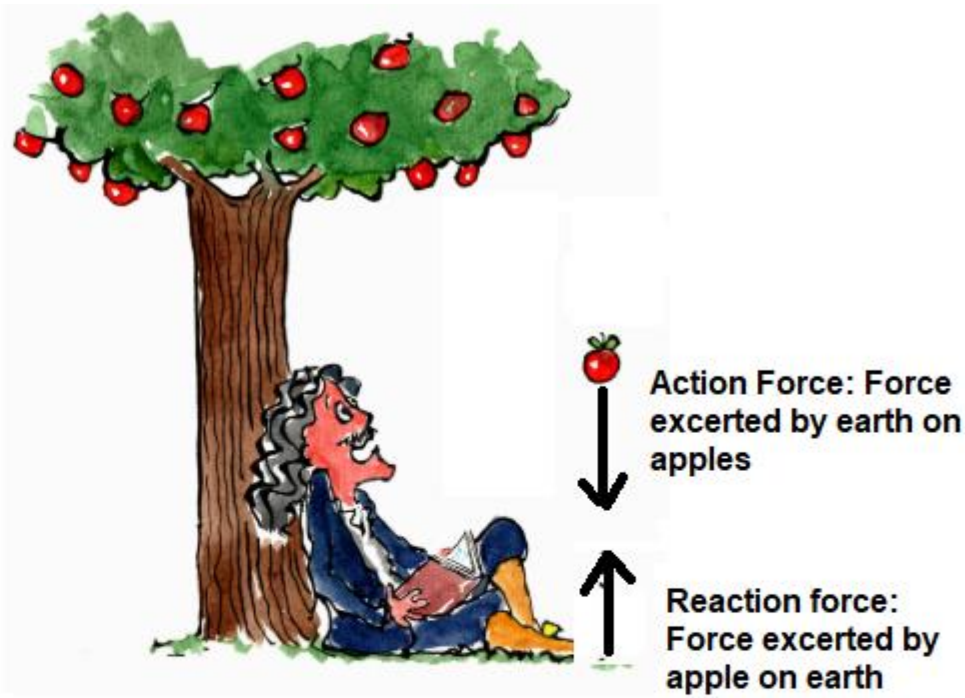
Action Force acts on the table.

Reaction Force act on the book.

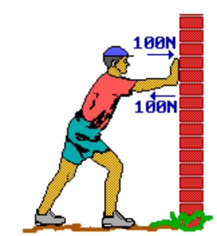


Example 3:

A) Use Newton's Third law to explain an apples falling to earth

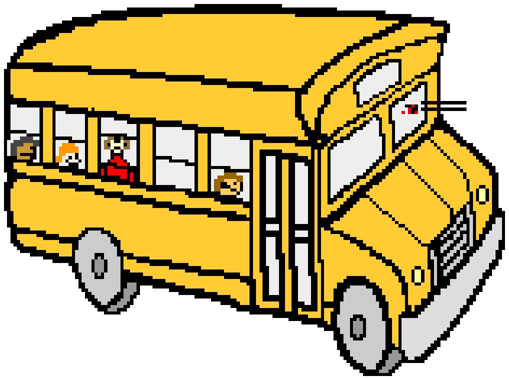


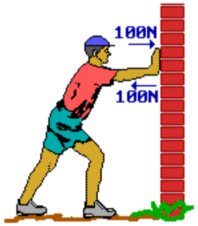
B) Why doesn't the earth accelerate towards the apple?



Example 4:

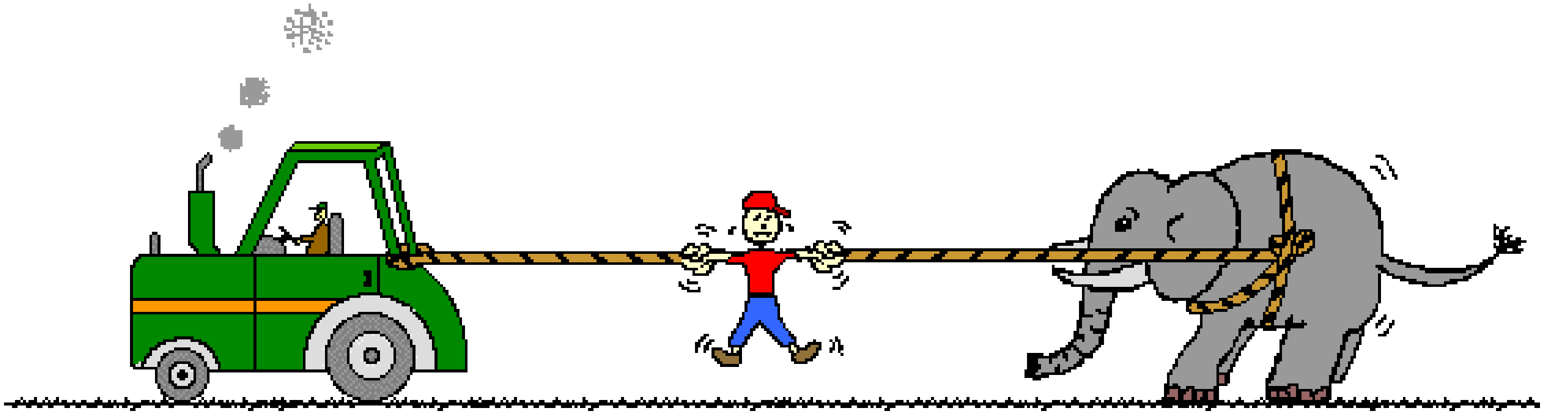
- While driving down the road, an unfortunate bug strikes the windshield of a bus. Quite obviously, this is a case of Newton's third law of motion. The bug hit the bus and the windshield hit the bus. Which of the two forces is greater: the force on the bug or the force on the bus?

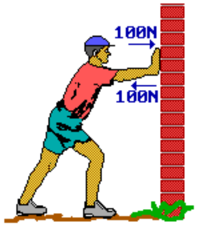




Example 5:

Identify the action –reactions pairs for the picture below:





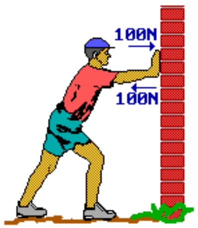
Example 6:

Identify the action –reactions pairs for the picture below:

"Mary and Jane both want to dance with John. Mary pulls on one of his arms with a force of 50N,and Jane pulls on the other arm in the opposite direction with a force of -50 N. "

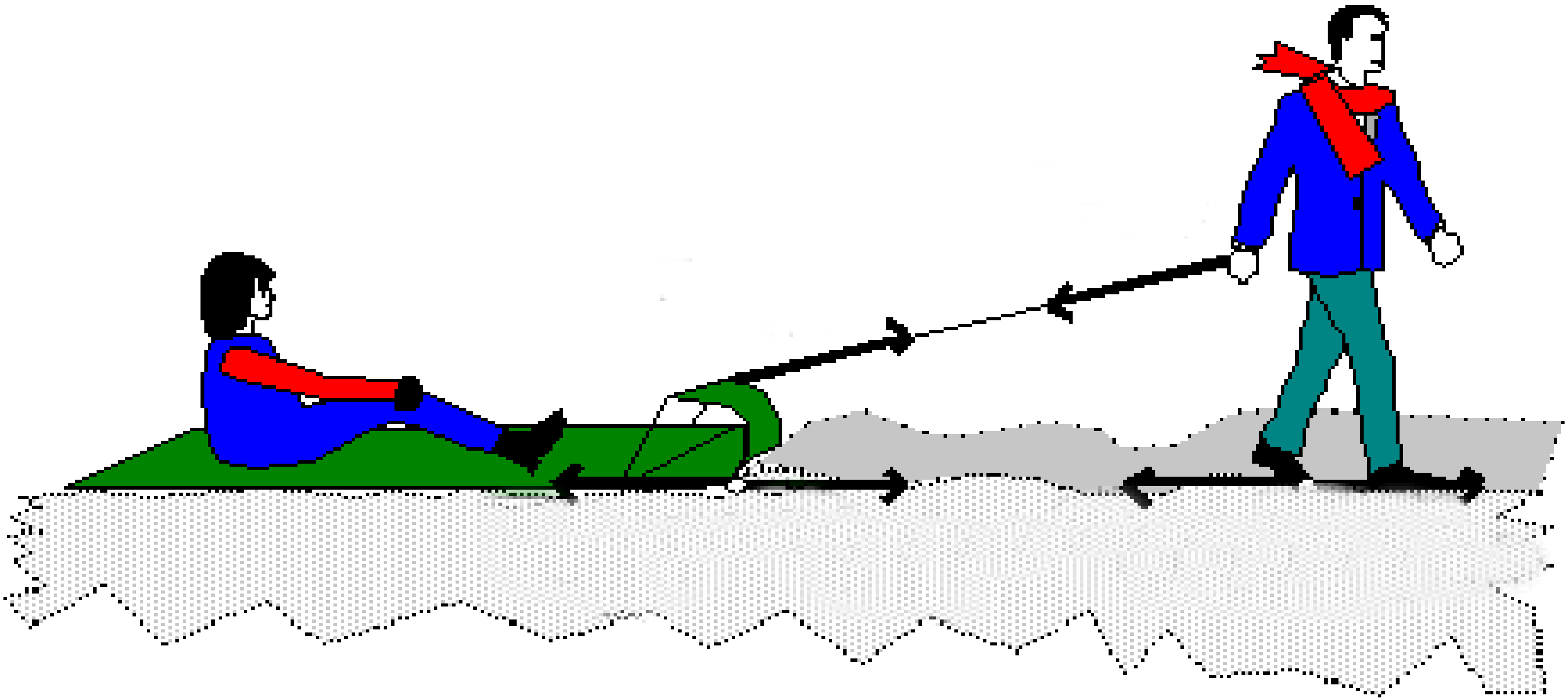
-

Jane **John** **Mary**



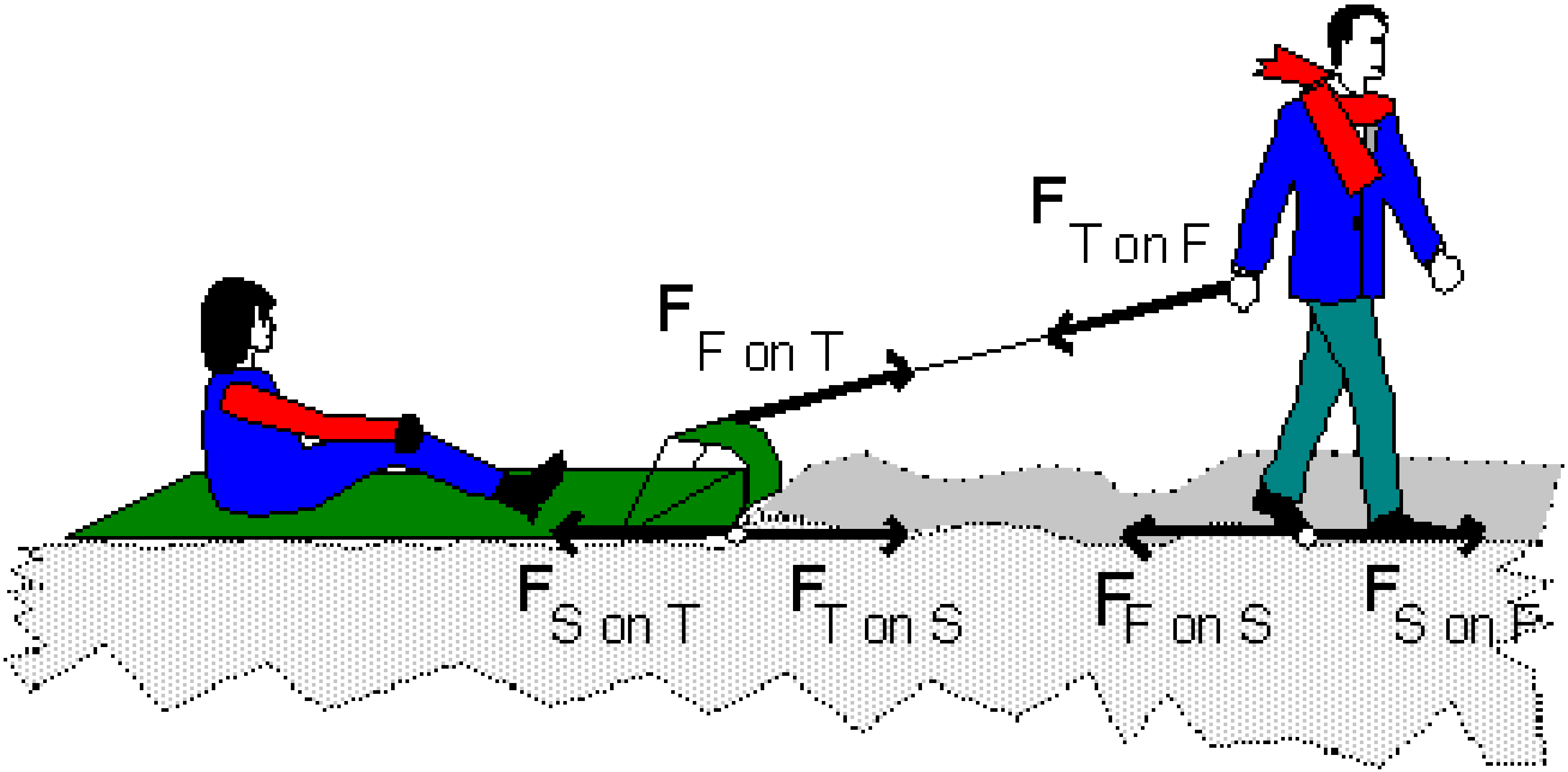
Example 7:

A)Apply Newton's 3rd Law of Motion to the situation where a father drags his daughter on a toboggan. Draw and label all



B) All action reaction forces are balanced. Therefore they cancel out and it is impossible for the man and toboggan to move forward."

Is this argument correct?



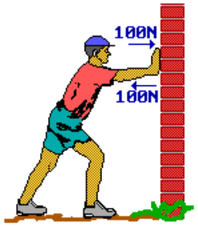
No, this reasoning is not correct. If we want to determine if the man will move forward, we need only consider the forces that act on the man. There are two:

1. The backward force of the toboggan.
2. The forward force of the snow (which was a reaction to his backwards push as he walked).

If the forward force is greater than the resistance of the toboggan, the toboggan will experience an **unbalanced force** and it will accelerate and move forward.

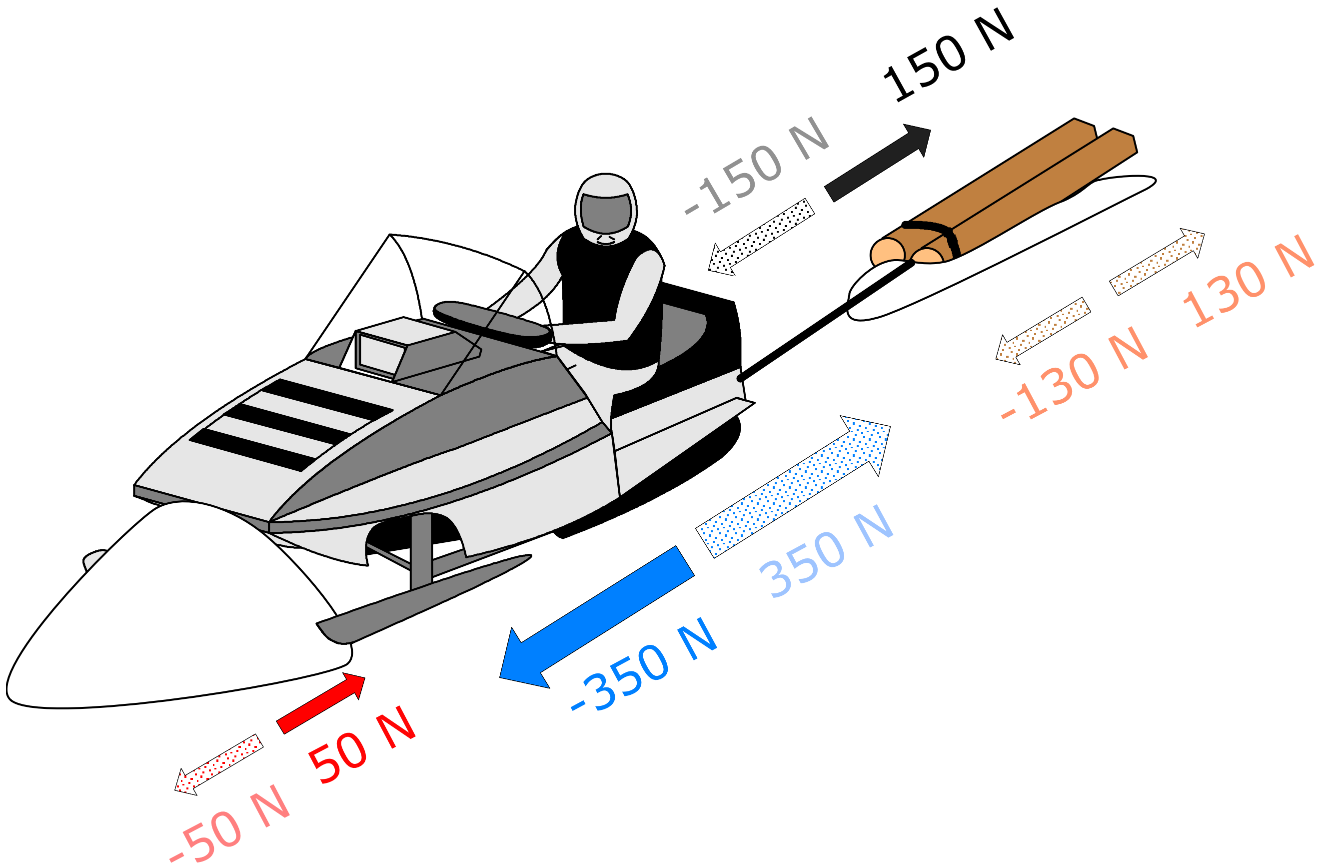
Which of Newton’s laws deals with unbalanced forces?

Sometimes the 2nd and 3rd law are both used to solve problems



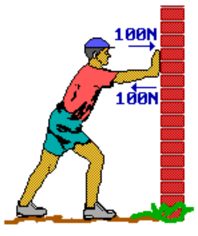
Example 8:

A) How many action –reaction forces are shown below?

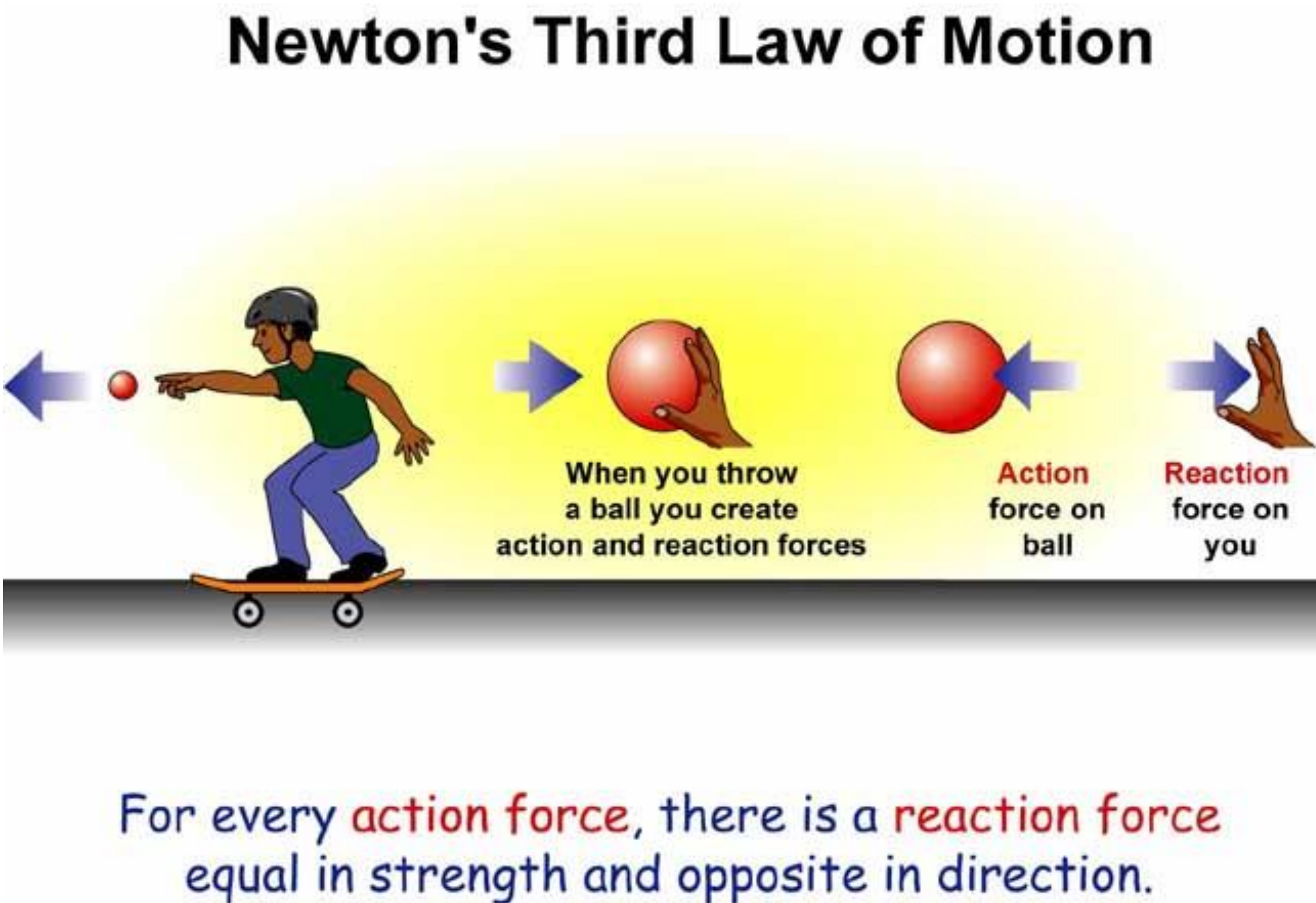


B) Draw a FBD for the ski –doo?

C) What is the net force acting on the ski doo?

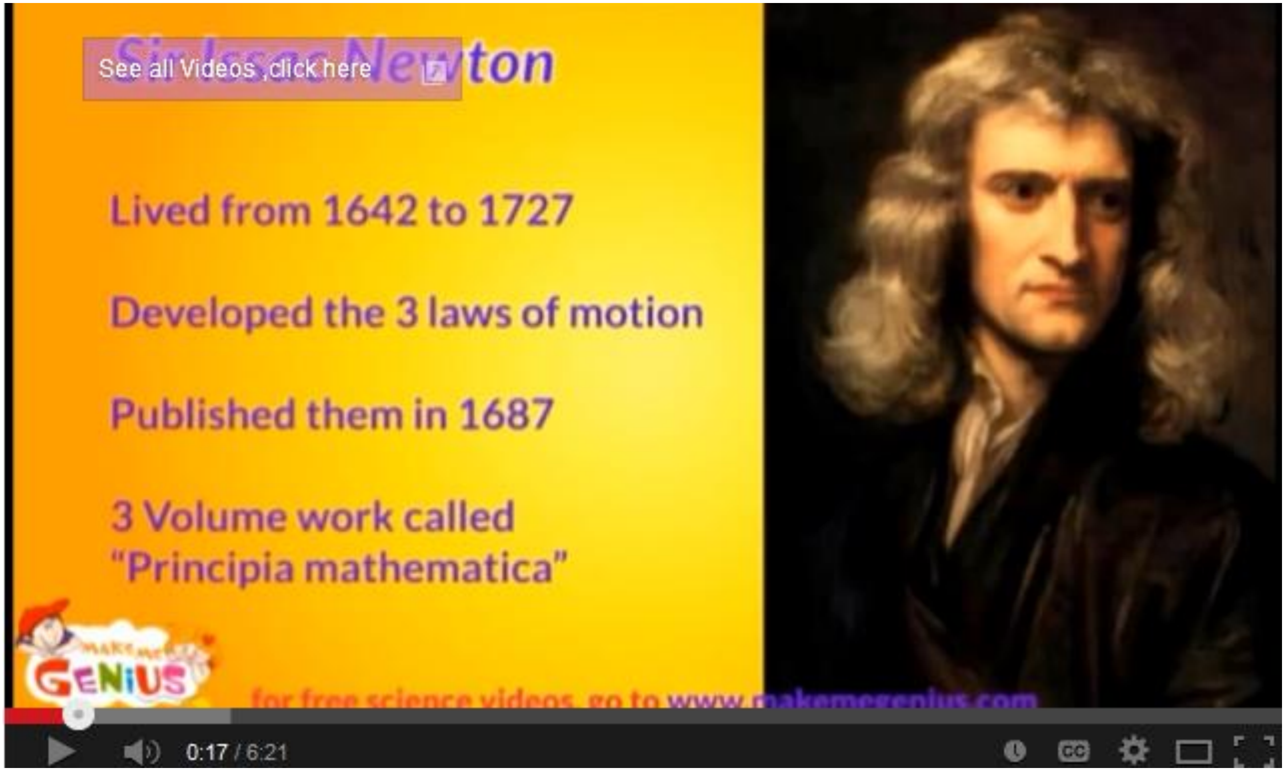


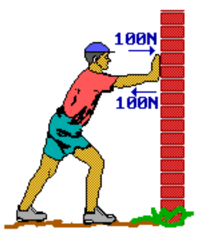
Summary

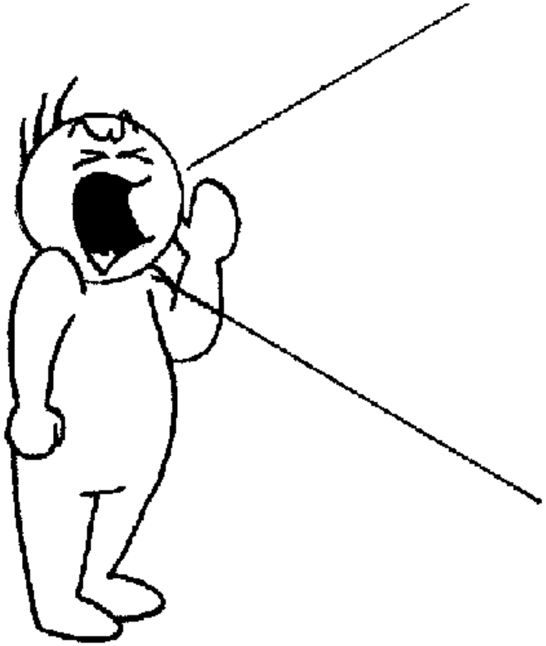

Newton's Third Law of Motion
When you throw a ball you create action and reaction forces
Action force on ball
Reaction force on you
For every action force, there is a reaction force equal in strength and opposite in direction.

For a summary of all three laws go to:

http://quietube6.com/v.php/http://www.youtube.com/watch?v=mn34mnnDnKU

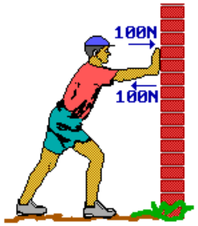






Topic 8

- **Problem Solving With Newton's Law**



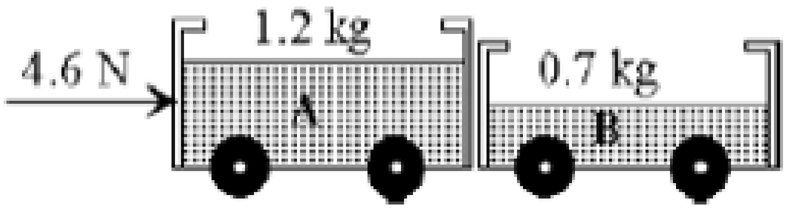
Problem-Solving Strategy: Applying Newton's Laws of Motion

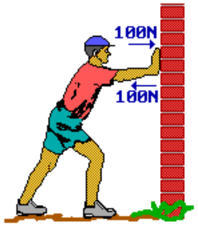
- Identify the physical principles involved by listing the givens and the quantities to be calculated.
- Sketch the situation, using arrows to represent all forces.
- Determine the system of interest. The result is a free-body diagram that is essential to solving the problem.
- Apply Newton's second law to solve the problem. If necessary, apply appropriate kinematic equations from the chapter on motion along a straight line.
- Check the solution to see whether
- it is reasonable.

Example 1 :

Two dynamics carts are resting side by side , as shown, on a level frictionaless surface. A force of 4.6 N is applied to the larger of the two. Use this information to find the force B exerts on cart A

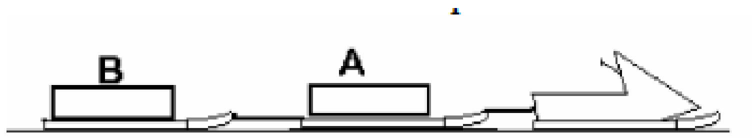
Given





Example 2:

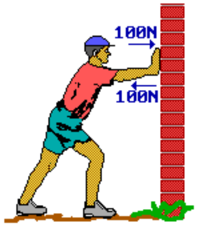
A 250.0 kg Skidoo is hauling a tandem load of firewood as shown in the diagram. Sled A and its firewood has a mass of 350.0 kg while sled B and its firewood has a mass of 180.0 kg. The skidoo pulls with a force of 2.90×10^3 N [R]. Ignore any friction.



(A) What will be the acceleration of sled A?

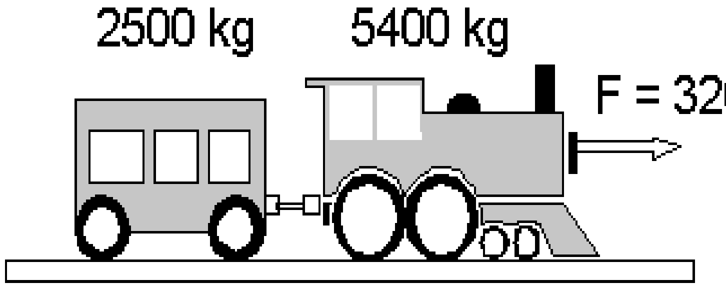
(B) With what force does sled B pull back on sled A?

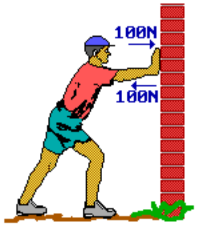
(C) Consider sled B in isolation. How would the answer to part B change if sled B experiences a frictional force of 5.0×10^2 N [L].



Example 3 :

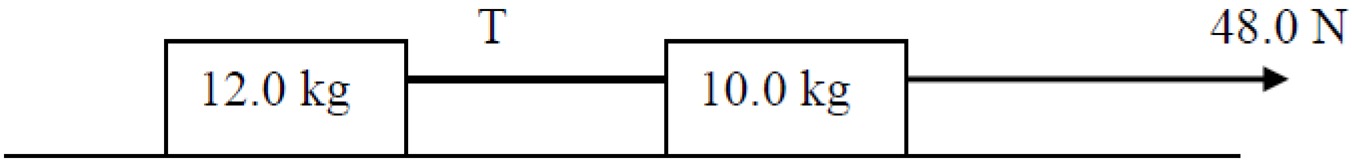
A train consists of a locomotive with a mass of 5400 kg and a passenger car with a mass of 2500 kg. A force of 3200 N is accelerating the entire train. Find the force exerted on the passenger car by the locomotive. (assume there is no friction)





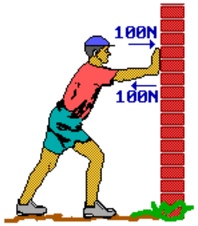
Example 4 :

Two boxes on a frictionless table are connected by a rope. A force of 48.0 N is applied as shown



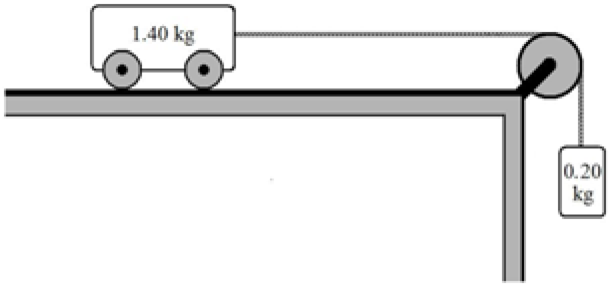
A) Calculate the magnitude of the acceleration of the blocks.

B) Calculate the magnitude of the tension, T, in the connecting rope



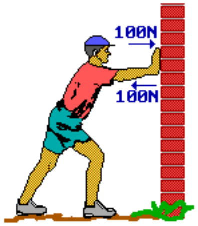
Example 5 :

A dynamics cart is connected to a 0.20 kg hanging mass by a massless string over a frictionless pulley. The force of friction between the cart and the table is 0.36 N.



A) Calculate the magnitude of the acceleration of the system when the 0.20 kg mass is released

B) Calculate the tension in the string when the 0.20 kg mass is released.



Example 6 :

The total mass of a skydiver and her gear is 65 kg. What air friction is she experiencing when her free-fall acceleration is reduced from 9.8 to 7.2 m/s^2

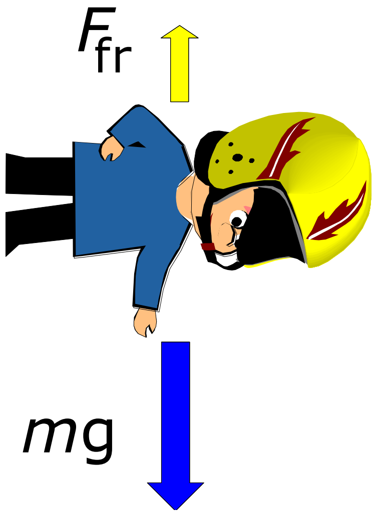
Given:

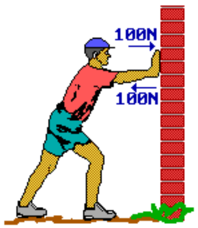
m = 65 kg,

g = 9.8 m/s^2

a = 7.2 m/s^2

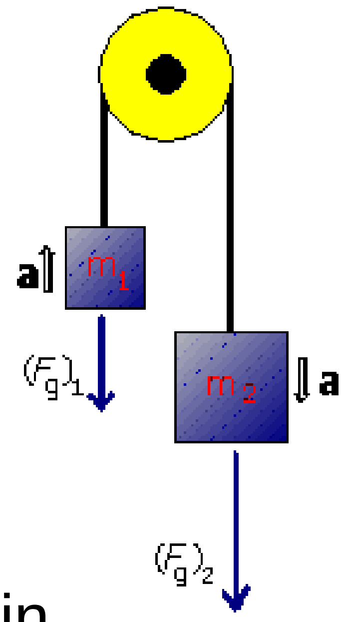
F_{fr} = ?





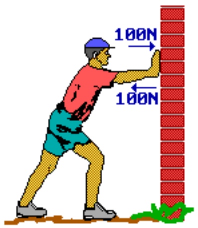
Example 7 :

A 25 kg block (m_1)and a 35 kg block (m_2) are connected by a rope over a frictionless pulley as shown.



A) Calculate the magnitude of the acceleration of the system of blocks.

B) Calculate the magnitude of the tension in the connecting rope.

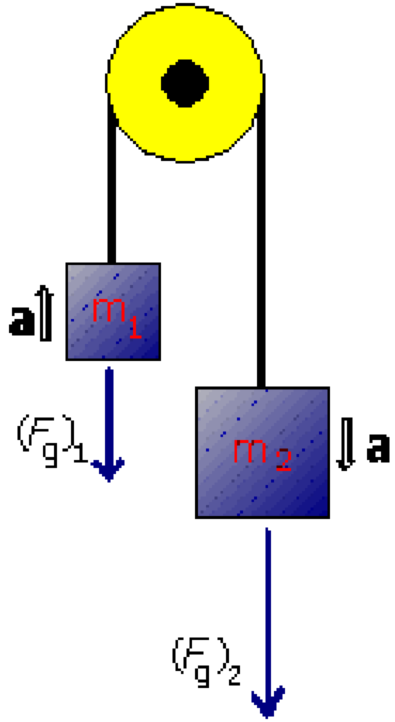


The two masses can be viewed as a single system with a total mass of

$m s_{ystem} = m_{sys} = m_1 + m_2$

The net or unbalanced force on the system is just the difference between the two weights:

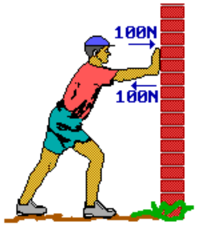
$F_{net} = (F_g)_2 - (F_g)_1$



$$a_{sys} = \frac{F_{net}}{m_{sys}}$$

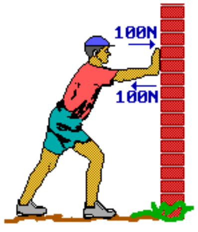
$$\begin{aligned} a_{sys} &= \frac{F_{net}}{m_{sys}} \\ &= \frac{(F_g)_2 - (F_g)_1}{m_1 + m_2} \\ &= \frac{(mg)_2 - (mg)_1}{m_1 + m_2} \\ &= \frac{(35 x 9.8) - (25 x 9.8)}{35 + 25} \\ &= 1.6 \text{ m/s}^2 \end{aligned}$$

The **magnitude** of the acceleration of both hanging objects is 1.6 m/s^2. For the smaller mass, ***a***1 = 1.6 $^{m/s2}$ [upward], and for the larger mass, ***a***2 = 1.6 m/s2 [downward].



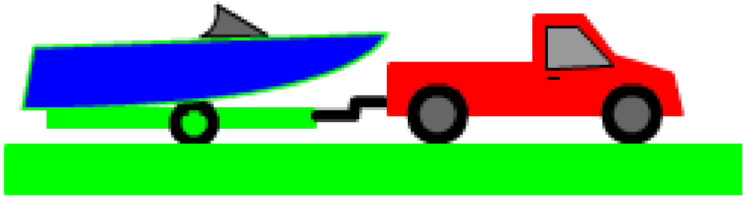
Example 8:

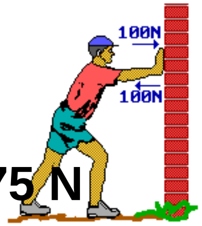
A model rocket with a mass of 0.600 kg accelerates from rest to 140.0 m/s in 4.5 s. Calculate the average force that the rocket applies to the exhaust gasses that are pushed out the nozzle at the rear of the rocket.



Example 9:

A pickup truck has a mass of 2100 kg. Its engine applies an accelerating force of 3800 N. If the truck is attached to a 750 kg trailer, how much force will the trailer apply to the pickup? (assume there is no friction).

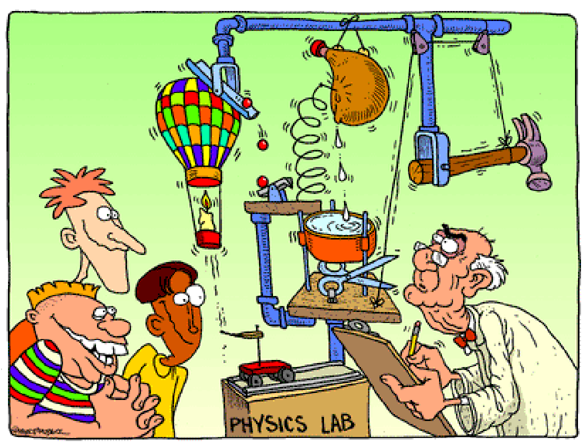


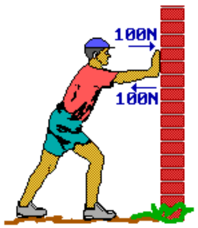


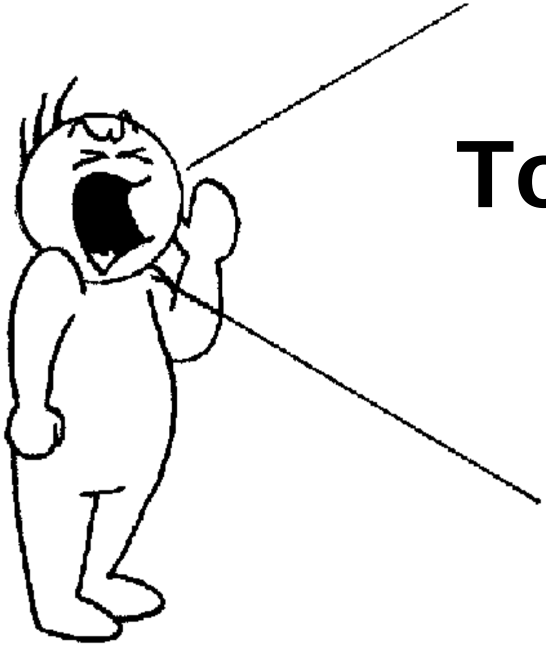
Answer:975 N

Activity

- Worksheet: **Friction and Newton's 2nd Law**
- Read Text: Pages
- Extra Practice Questions: # ? p.?
- Core Lab 3: *Kinetic Friction*





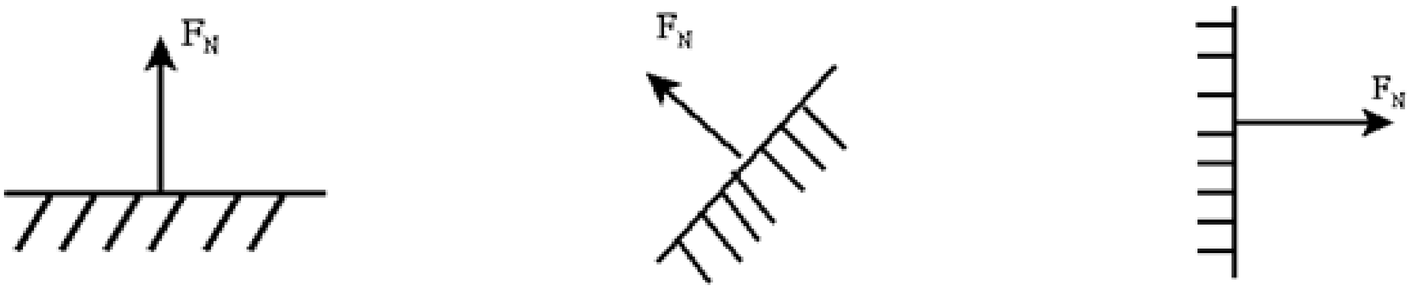


Topic 9

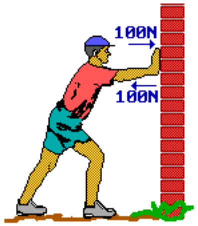
Friction

Remember Normal force (F_N):

The Normal force (F_N): the reaction force of surface pushing back when the body receiving the action force is a surface.

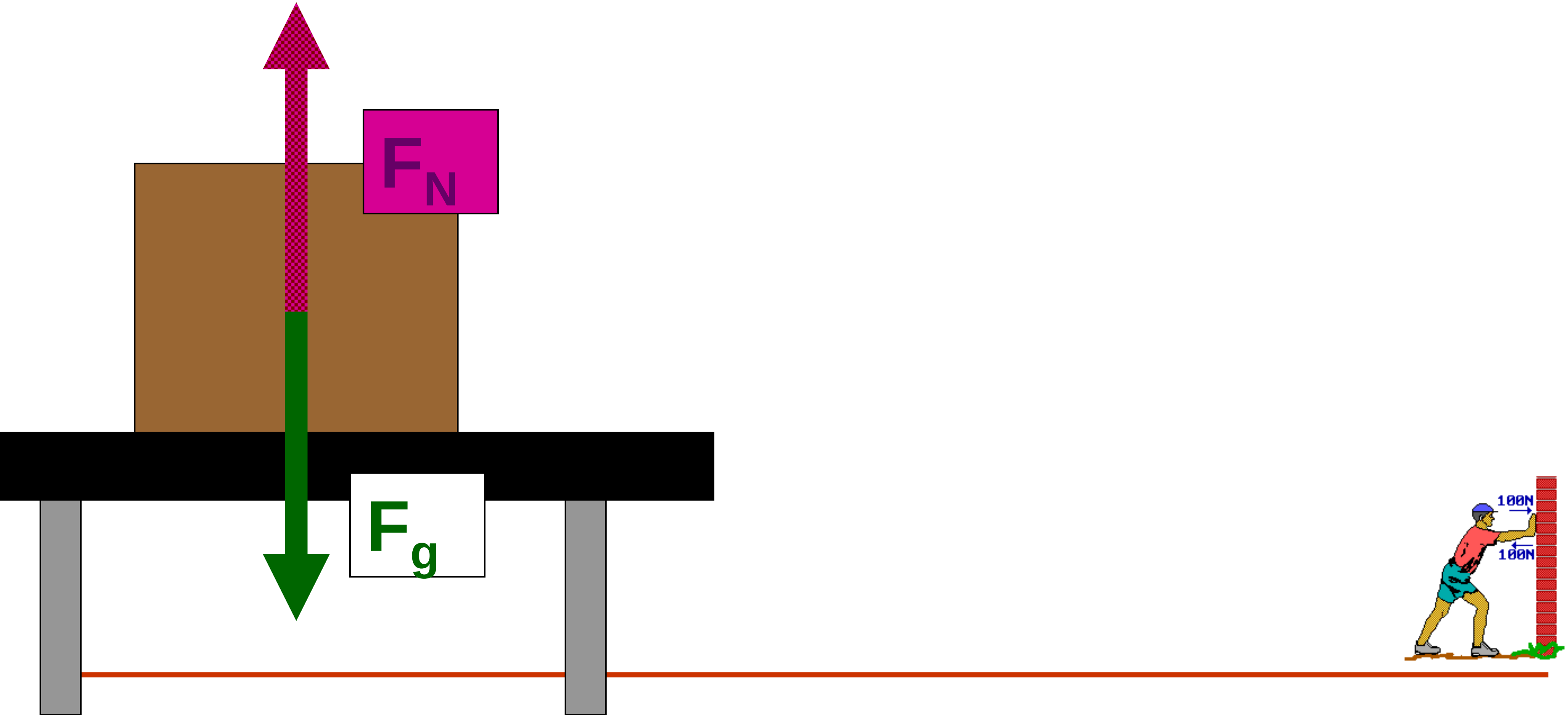


Note that the Normal force is always perpendicular to the surface



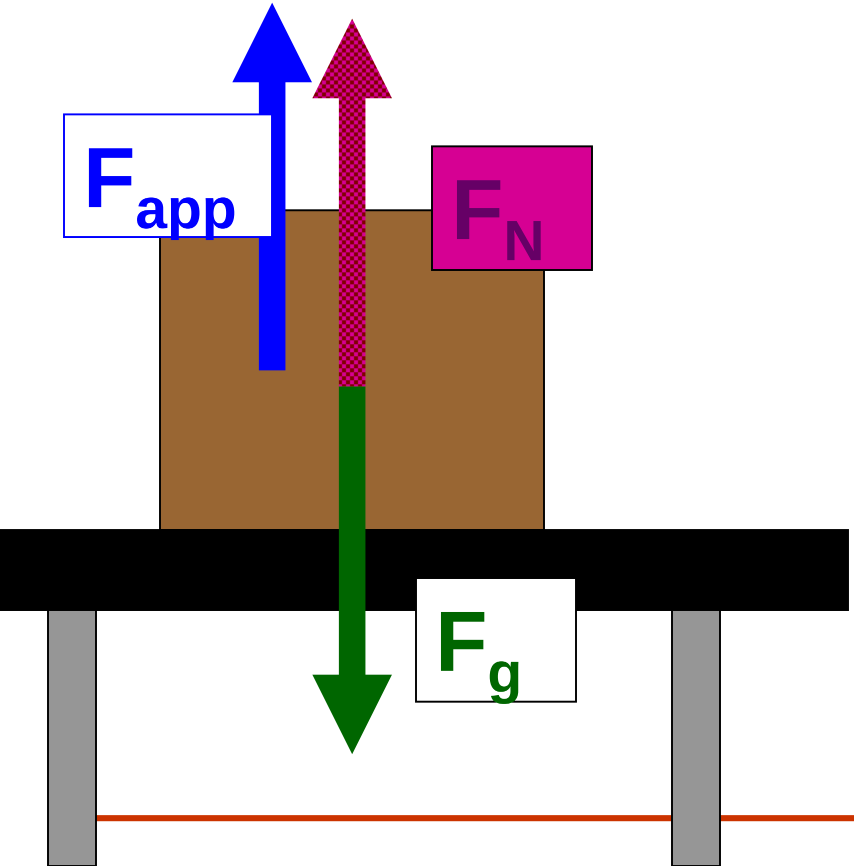
Example 1:

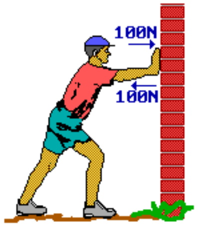
What is the Normal Force for a 10 kg Book resting on a table?



Example 2:

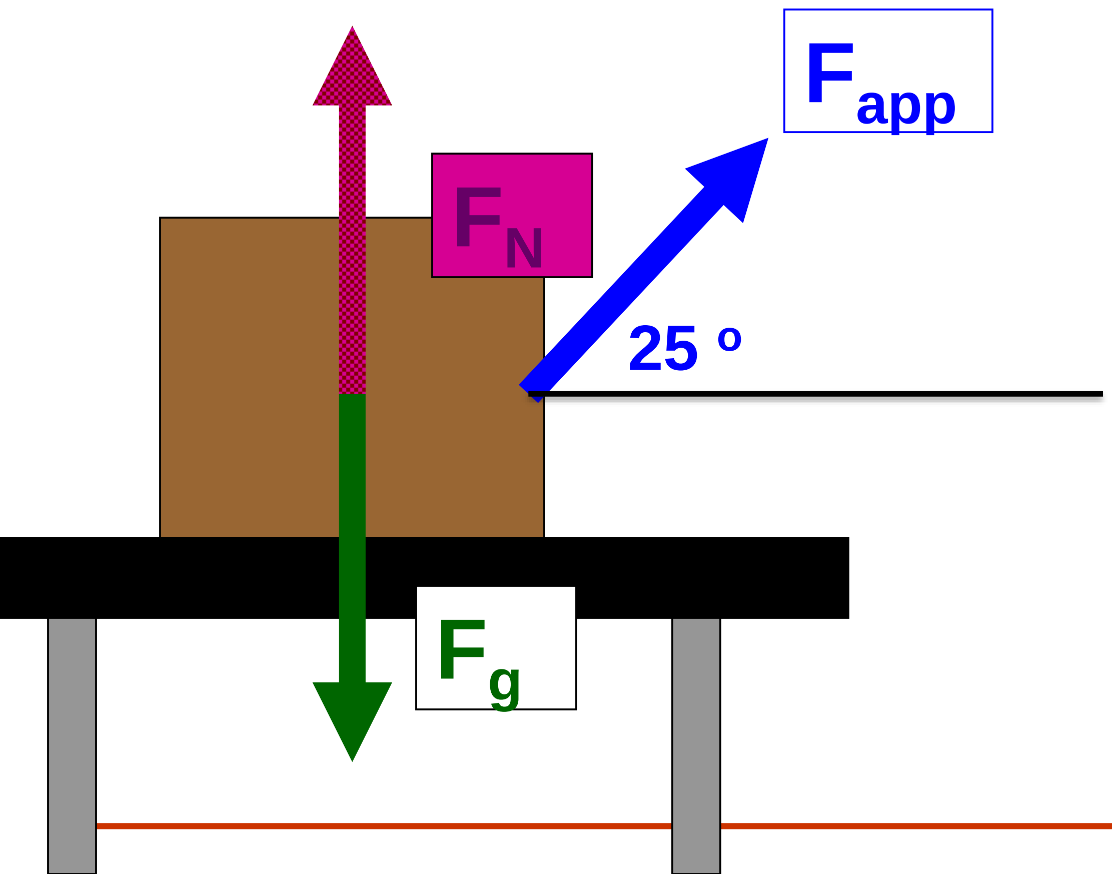
A 2.3 kg box is sitting on a desk. A string is pulling the box straight up with a force of 8.5 Find the normal force.

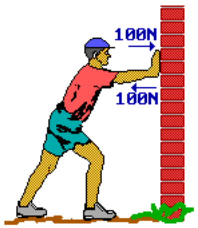




Example 3:

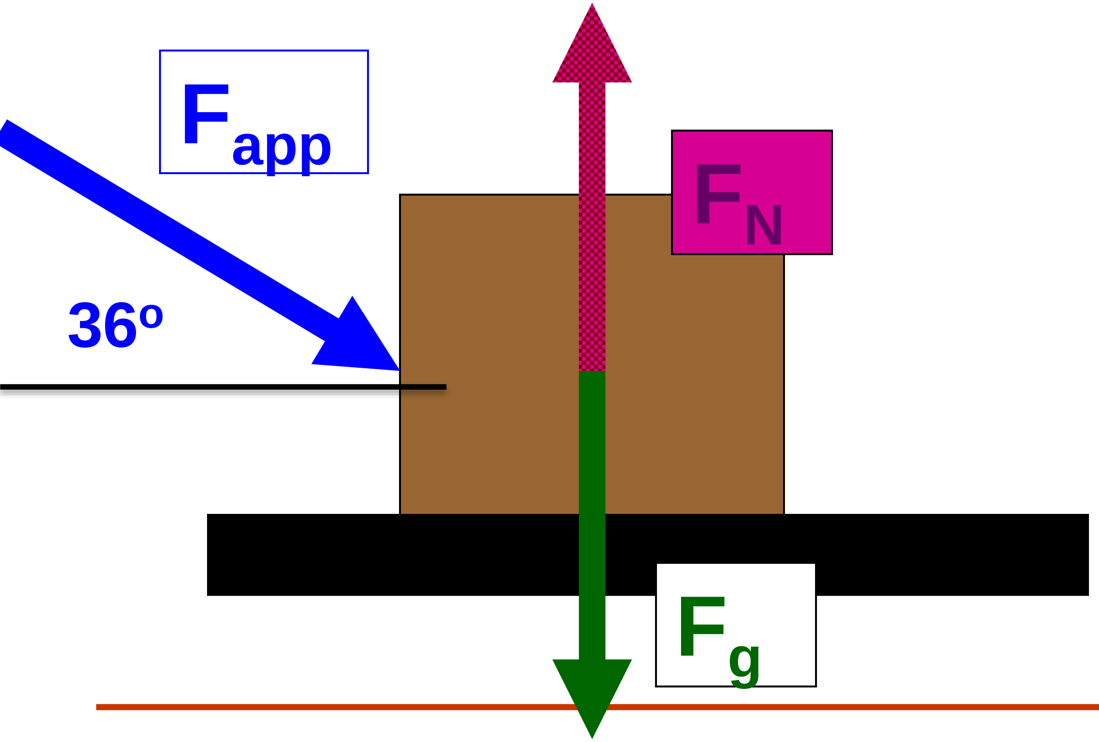
A 4.5 kg box is being pulled to the right by a 30 N force at 25 degrees above the horizontal. What is the normal force

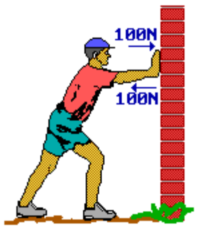




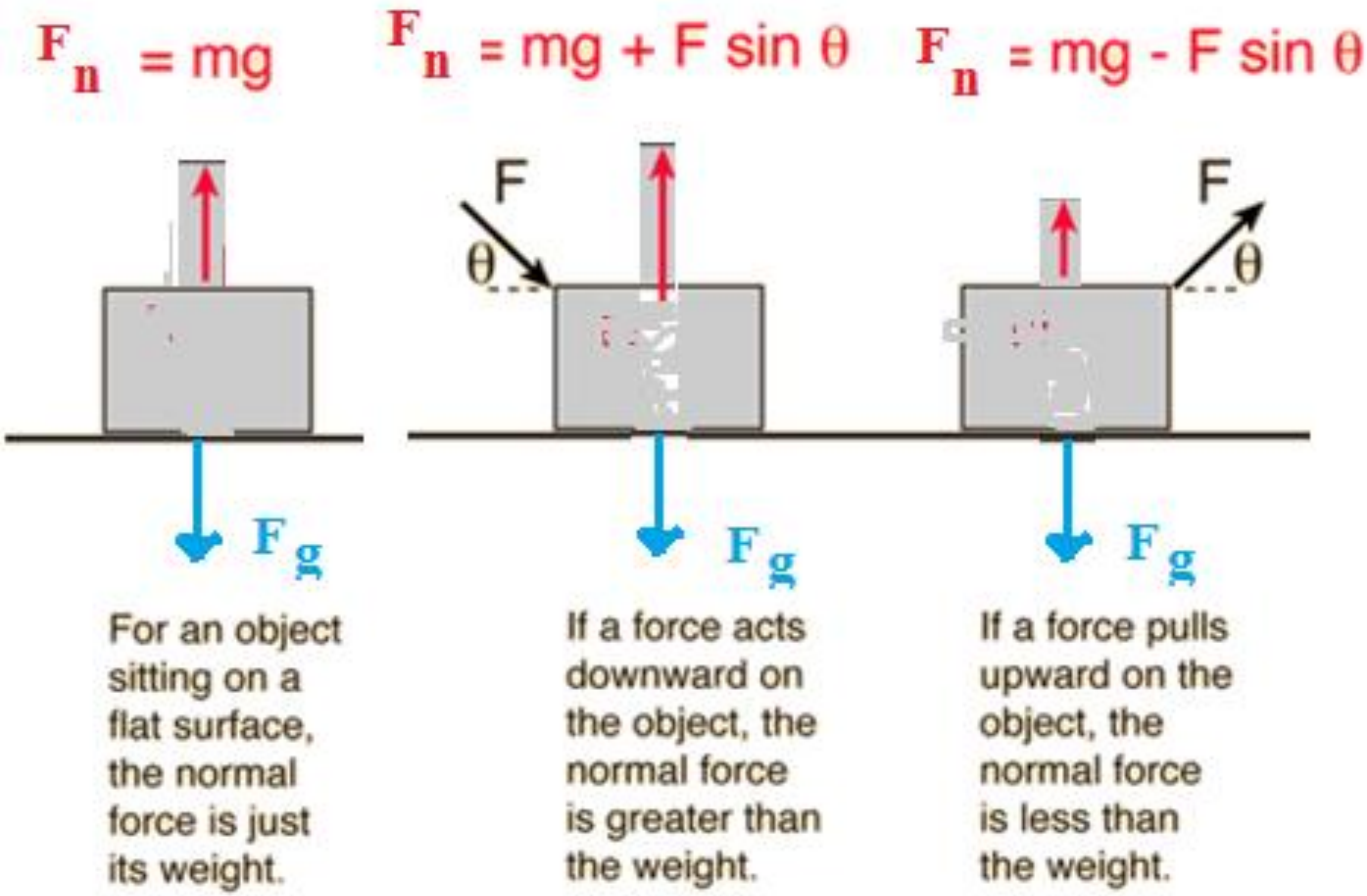
Example 4:

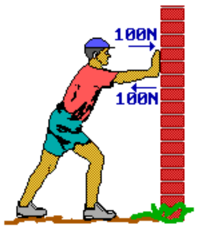
What is the normal force acting on a 2.0 kg mass which is being pushed by a force of 41 N along a rigid handle that makes an angle of 36º to the horizontal?





Note: Three Ways to Calculate Normal Force

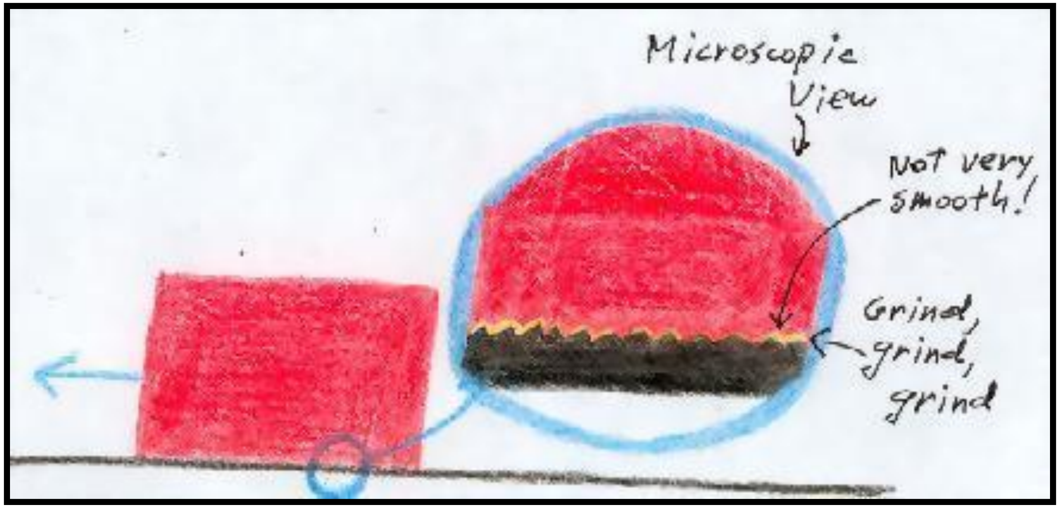




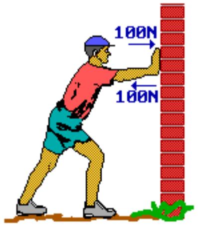
FRICTION

Friction (***F**$_{fr}$*)is *the force that results when one object moves against another. Friction ALWAYS opposes motion.*

Although two objects might look smooth, microscopically, they're very rough and jagged.

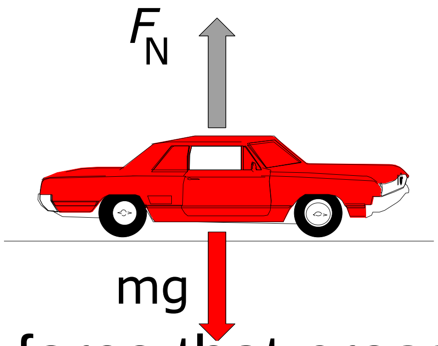


As they slide against each other, their contact is anything BUT smooth. They both kind of grind and drag against each other. This is where friction comes from.



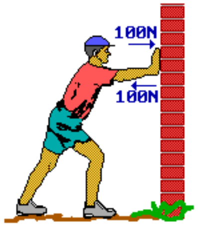
There are two factors that may affect friction:

1) Weight of the object (Normal force, F_N)



Normal force: the force that presses two surfaces together. In most cases, the normal force will be the weight of an object that is resting on the surface.

2) Smoothness of the surface (type of material, μ)



Formula for Friction:

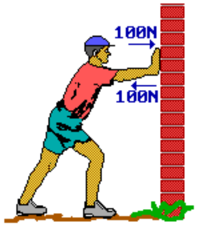
friction force = coefficient of friction x normal force

or

$$F_f = \mu F_N$$

The Greek letter μ is called the coefficient of friction and has no units because it is a ratio of two forces F_f / F_n

Force of Friction is affected by two factors:



Coefficient of Friction

Where:

μ (mu)= coefficient of friction. It indicates how rough or smooth the surface is. The higher the value of the coefficient of friction, the rougher the surface

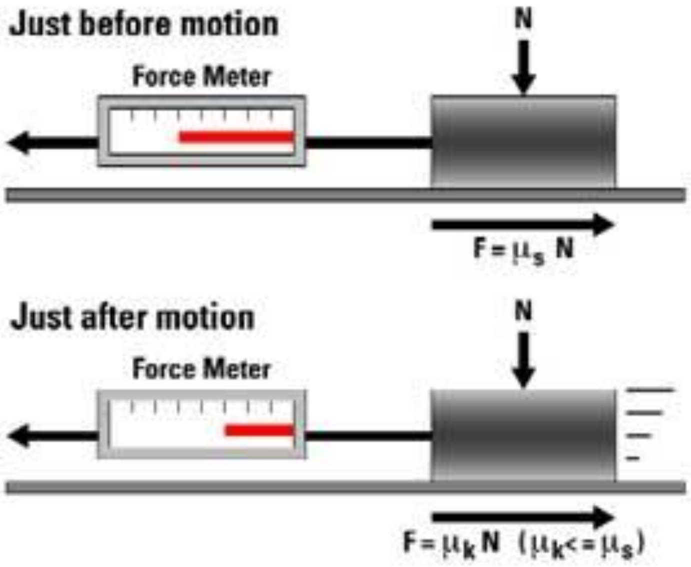
There are two types of frictional forces:

μ_k = coefficient for kinetic friction

μ_s = coefficient for static friction

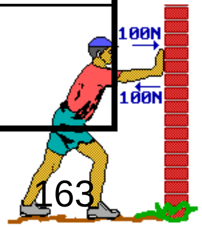
Static friction > Kinetic friction

Therefore, it takes more force to start moving an object



Coefficient of Friction

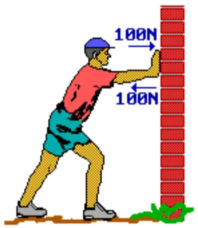
Material on Material	μ_s = static friction	μ_k = kinetic friction
steel / steel	0.6	0.4
add grease to steel	0.1	0.05
metal / ice	0.022	0.02
brake lining / iron	0.4	0.3
tire / dry pavement	0.9	0.8
tire / wet pavement	0.8	0.7



Example 5:

A force of 42 N is needed to start a box sliding across the floor. The weight of the box is 55 N.

A) Draw a FBD for the box.
B) How large is the force of friction?
C) Is the frictional force static or kinetic?
D) What is the coefficient of friction?

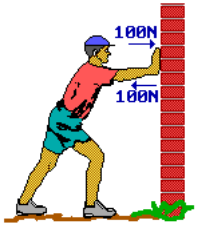


Example 6:

The coefficient of kinetic friction and the crate is 0.4000.
The crate has a mass of 75 kg.

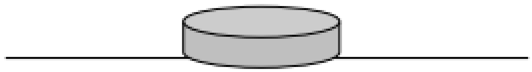
A) What is the force of kinetic friction?

B) What force is needed to keep the object moving at a constant velocity?



Example 7:

A hockey puck has a mass of 1.0 kg. The coefficient of kinetic friction between the puck and ice is 0.15. A force of 2.6 N is applied horizontally to the puck to push it to the right.



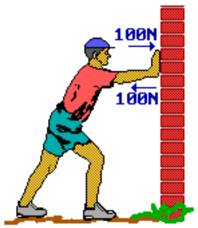
A) Draw a FBD for the box.

B) What is the normal force acting on the puck?

C) What is the force of kinetic friction?

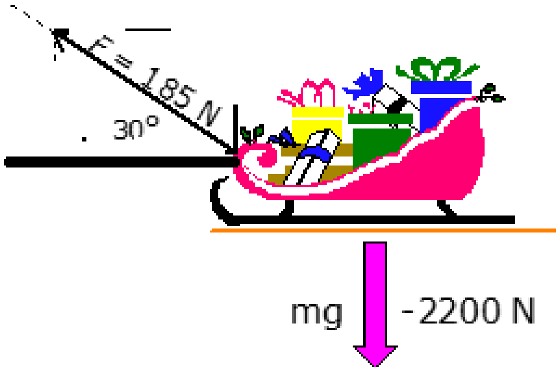
D) What is the net force acting horizontally on the puck?

E) What is the acceleration of the puck?



Example 4:

A force of 185 N at an angle of 30º is needed to drag a 2200 N sleigh at a fixed speed.



A) Draw a FBD for the sled.

B) What is the normal force acting on the puck?

C) What is the force of kinetic friction?

D) What is the coefficient of kinetic friction?