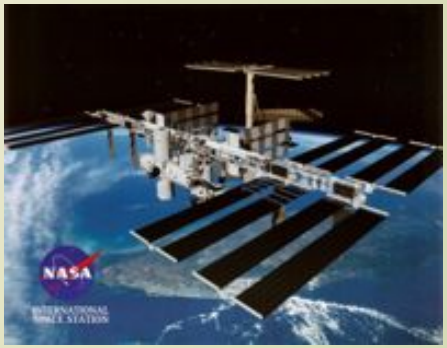
Chapter 11 - Forces

Section 1 - Laws of Motion

What would happen to something in motion in the absence of friction?

It would stay in motion forever!

Newtons First Law!



An object at rest remains at rest and an object in motion maintains its velocity unless it experiences an unbalanced force

Newton's First Law is also known as the "Law of Inertia"

Inertia is the tendency of an object at rest to remain at rest or, if moving, to continue moving at a constant velocity

In other words - "Matter resists any change in motion"

Does the mass of an object have any affect on inertia?

Yes!

More mass = More inertia

Less mass = Less inertia

Could you pitch a bowling ball as if it were a baseball?

Why do you need to wear a seatbelt?

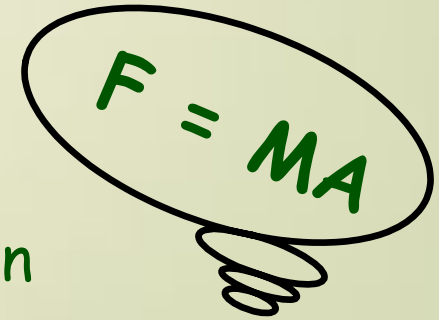
Index Card/Card/Coin Activity

1st Law describes what happens when net force is zero

What happens when there are unbalanced forces?

Acceleration!

Newton's 2nd Law



The unbalanced force acting on an object equals the object's mass times its acceleraiton

Imagine the difference between pushing an empty shopping cart vs. a full cart

Which is easier to push?

Why?

Force = Mass x Acceleration

What if the mass of the shopping carts are the same?

What happens to the acceleration?

Force = Mass x Acceleration

Remember, we measure force in Newtons

A **Newton** = The force that can give a mass of 1 kg of acceleration of 1 m/s^2

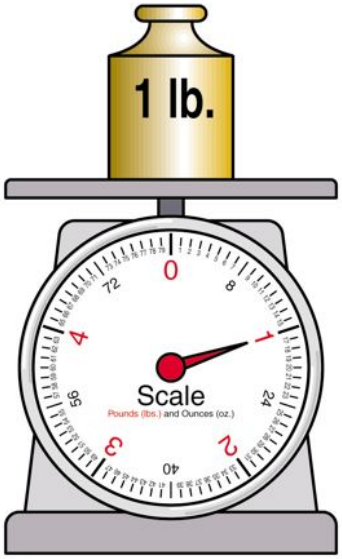
$1\ N = 1\ kg \times 1\ m/s^2$

or

$1\ N = kgm/s^2$

The American unit Pound (lb) is also a unit of force

1 N = 0.225 lb



1 pound = 16 ounces

Practice Using Newtons 2nd Law!

Zookeepers lift a stretcher that holds a sedatd lion. The total mass of the lion and the stretcher is 175 kg, and the upward acceleration of the lion and stretcher is 0.657 m/s^2. What is the force necessary to produce this acceleration?

Section 2 - Gravity

What is gravity?

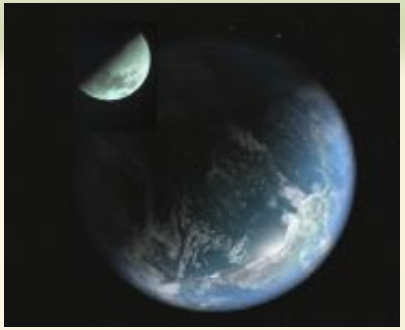
Gravity is a force that is exerted by anything that has mass

Sir Isaac Newton was the first to scientifically explain gravity

Universal Gravitation Equation

$$F = G\frac{m_1 m_2}{d^2}$$

It doesn't matter how big or small an object is... ALL matter is affected by gravity!



The greater the mass the greater the gravitational force

An apple falls to Earth because the Earth has more mass

Force of gravity

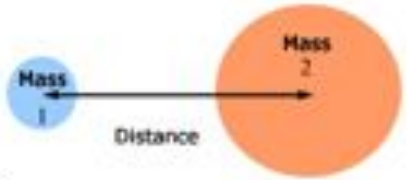
Longhand:

$$\text{Force}_{\text{of gravity}} = \text{Gravitational constant} \times \frac{\text{Mass}_1 \times \text{Mass}_2}{\text{Distance}^2}$$

Shorthand:

$$F_g = G \times \frac{m_1 \times m_2}{D^2}$$

Picture:



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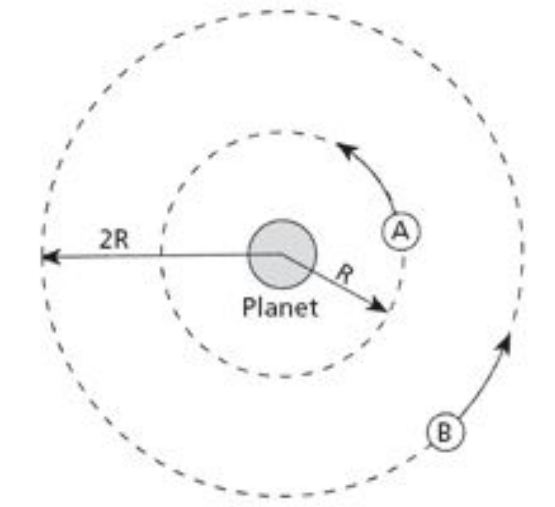
Distance between two objects also affects the force of gravity



If distance is doubled, gravitational force is 1/4 its original value

$$F = G\frac{m_1 m_2}{d^2}$$

Gravity is actually very weak, even though it holds planets, stars, and galaxies together

(Think of a magnet)

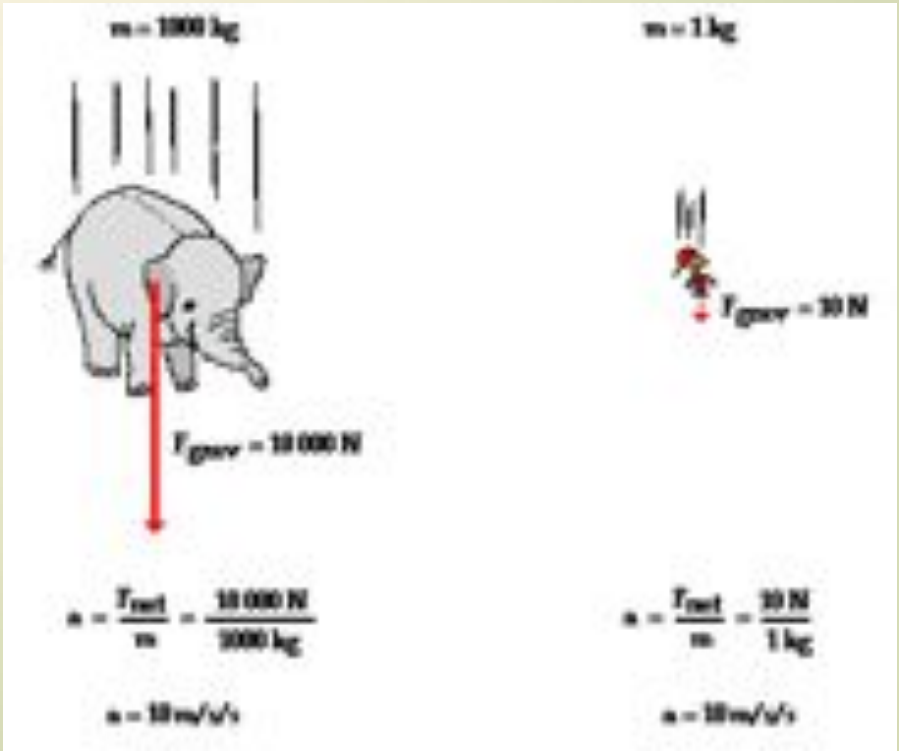
When gravity is the only force acting on an object it is in **free fall**

This force causes an acceleration of 9.8 m/s^2 and is abbreviated as ***g***

Why do all objects fall at the same rate?

$$F = MA$$

$$F = G\frac{m_1 m_2}{d^2}$$



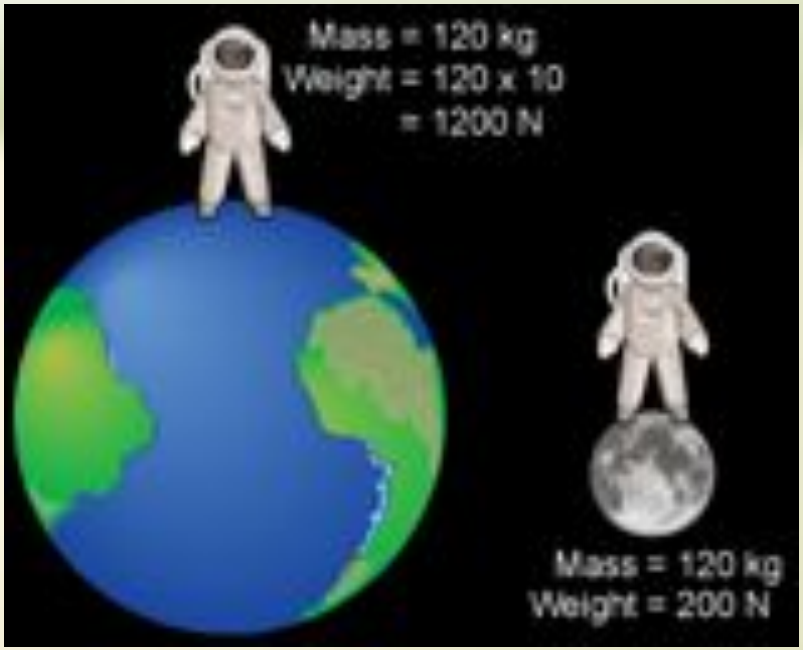
The force on an object due to gravity is called its **weight**

Force = Mass x Acceleration

Weight = Mass x Free-fall acceleration

w= mg

Weight and Mass are NOT the same!!



Mass is a measure of the amount of matter in an object

Weight is the gravitational force an object experiences because of its mass

Weight influences the shapes of many things

Large animals have strong skeletons

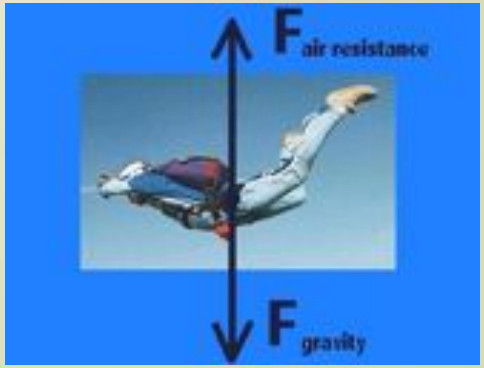
Trunks of trees

Shapes of bridges

If you throw a penny of the top of a skyscraper does it keep accelerating until it hits the ground?

NO!

A falling object stops accelerating when the force of air resistance becomes equal to the gravitational force (weight) on the object



The maximum speed something can reach while falling is called **terminal velocity**

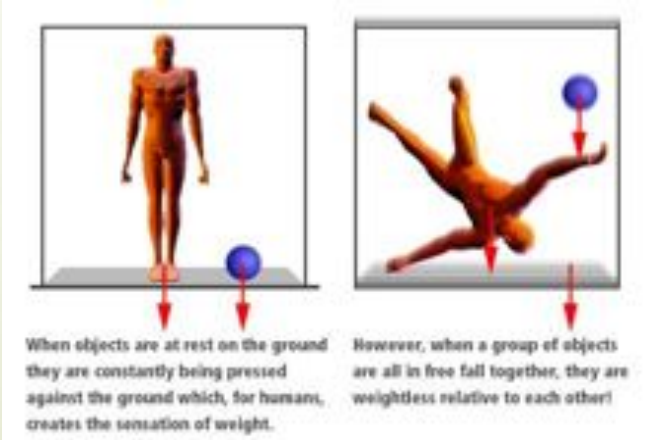
Are you really "weightless" when you are in space?

No!

No matter what there is a small amount if gravity...therefore you have weight

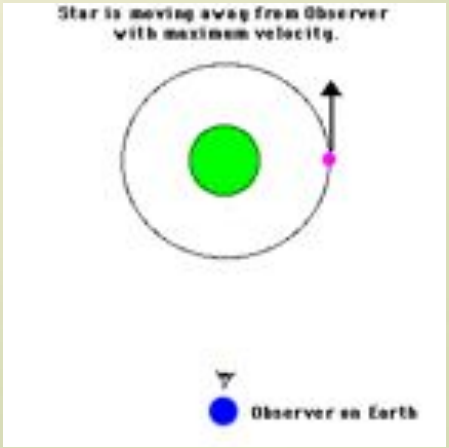
Why then do the astronauts in space appear to be weightless?

They are actually in **free fall**!



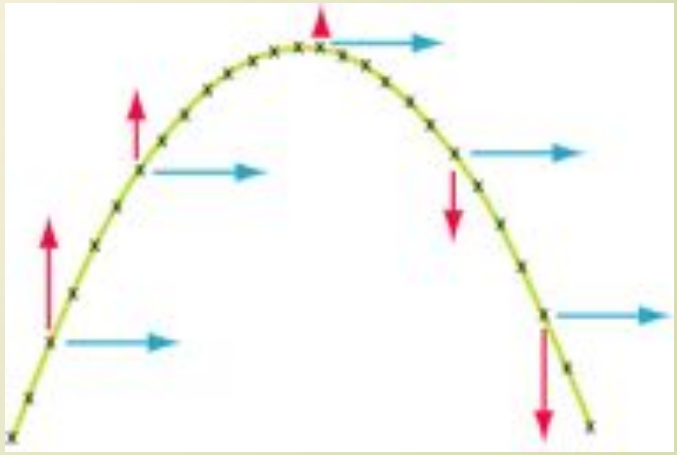
In space there is no air resistance, therefore gravity in the only force

An **orbit** is formed when an object is moving forward but is also in free fall



The orbit of the space shuttle around Earth is an example of **projectile motion**

Projectile motion is the curved path an object follows when thrown



Has a horizontal component
and a vertical component

Which would hit the ground first?

A bullet shot out of a gun

or

A bullet dropped from the same height and at the same time as the bullet being shot

Neither! They would hit at the same time!

Section 3 -Newton's Third Law

Think about the forces involved in kicking a soccer ball

1.) Your foot exerts a force on the ball

AND

2.) The ball exerts an equal and opposite force on your foot

Because your foot has more mass than the ball, the ball experiences the greater change in velocity

ALL forces come in pairs called **action-reaction pairs**

Newton's Third Law

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

When you sit in a chair, your weight pushes down on the chair, and the chair pushes back up with a force equal to your weight

Equal forces don't always have equal effects

When you drop a ball, it falls to the ground due to the force of gravity

But the force of gravity also pulls the Earth toward the ball

Because Earth is so massive, its acceleration is very small

Which would take longer to stop if the same braking force were applied?

A large truck or a compact car?

A fast-moving car or a slow moving car of the same mass?

The large truck and the fast moving car have more **momentum**

momentum = mass x velocity

$p = mv$

What would the units for momentum be?

kgm/s

Momentum is why a large truck will always win in a collision with a car

Calculate the momentum of a 6.00 kg bowling ball moving at 10.0 m/s down the alley toward the pins

$p = mv$

Force is related to change in momentum

When you force an object to change is motion, you force it to change its momentum

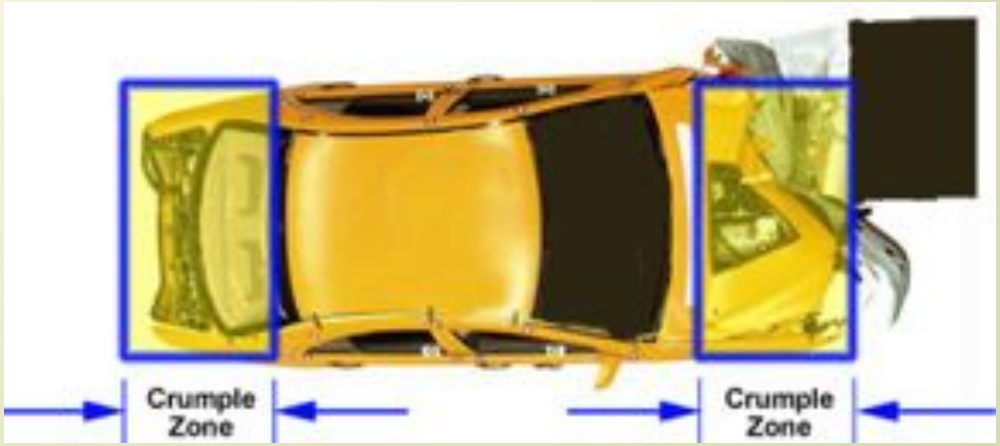
As the time period of the momentum's change becomes longer, the force needed to cause the change the momentum becomes smaller

A baseball catcher moves their glove back during the catch to decrease the impact force

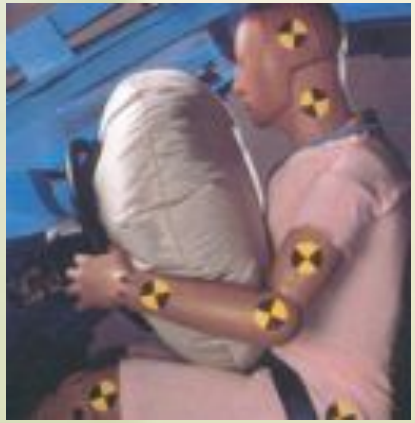
Practical applications of momentum

Bending your knees when landing

Collapsible zones of cars



Airbags



Momentum is conserved in collisions

The total amount of momentum in an isolated system is conserved

Imagine two cars crashing:

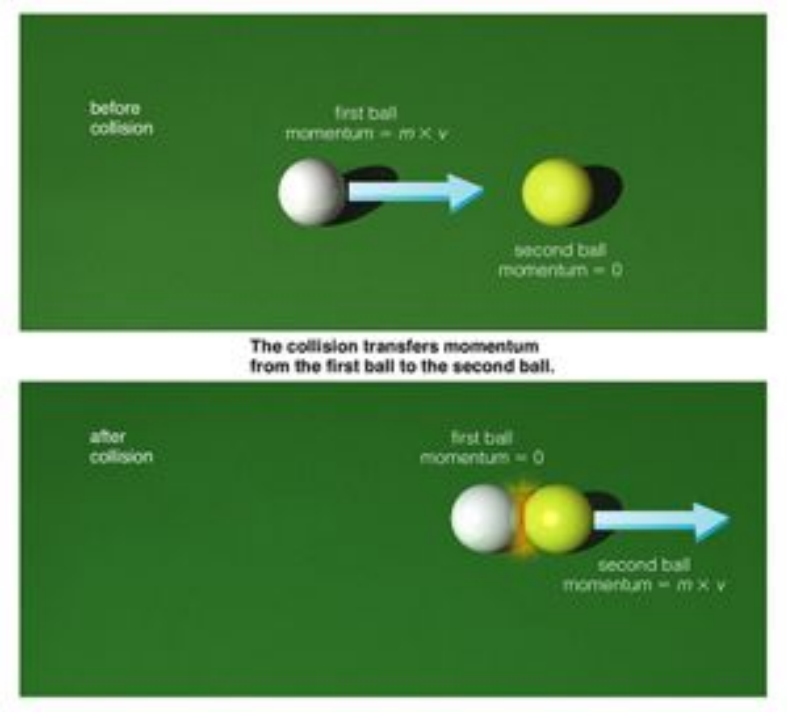
Figures are taken crash test with cars

Sometimes the cars bounce off of each other and move in opposite direcitons

If the cars become locked together, they will continue in the direction of the car with the most momentum

Momentum is transferred

When a moving object hits another, some or all of its momentum is transferred to the other object



Think about pool:

The moving cue ball hits another ball. The cue ball stops, but the other ball starts moving

Action-reaction forces also explain this

Newton's Third Law and Momentum explain rocket propulsion

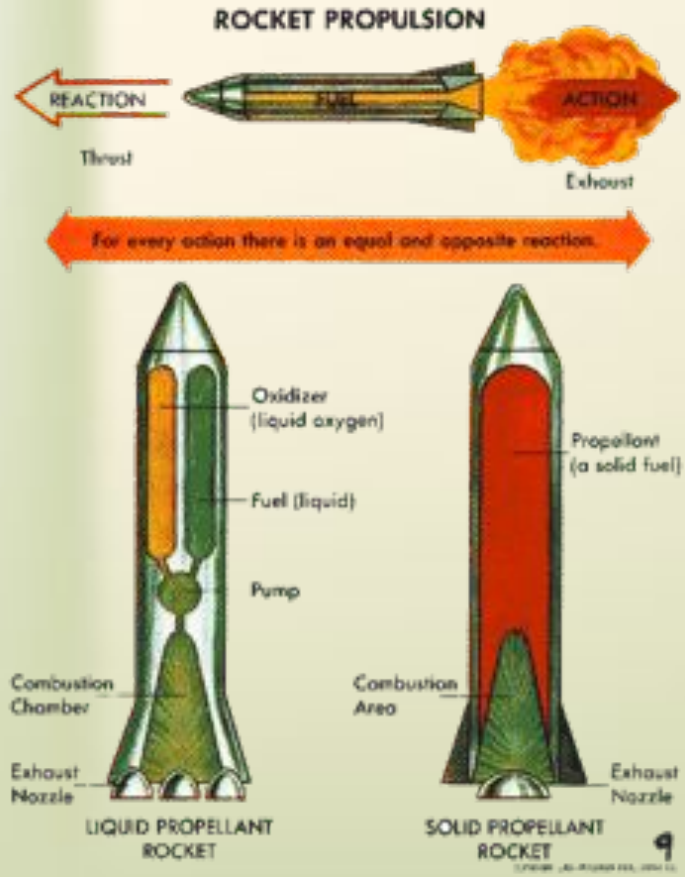
How does a rocket work?

Many people think that the hot gases flowing out of the nozzle push against the atmosphere

Not true - Wouldn't work in space if this were true

Rocket Propulsion

When fuel is forced out the nozzle, the gases actually push back against combustion chamber of the rocket, accelerating it forward



It is NOT pushing against the gases in the atmosphere