Solar System Gravity – Teacher Notes

Gravity is a force that attracts objects to each other. The more massive an object is, the stronger is its gravitational force of attraction. Gravity acts over great distances. Gravity is the "glue that binds the Solar system together"

The Formation of the Solar System *(continued from static electricity activities).*

As the clumps of nebula dust held together by static electricity increased in mass they would also have been attracted together by the much stronger force of gravity. The spinning proto-planetary disc pulled larger pieces towards its centre creating the proto-Sun. This became very hot and exploded blowing away most of the surrounding disc. The remaining pieces dispersed, crashed and reassembled to eventually form the planets of the solar system and were held in place by the Sun's gravitational pull. The more massive rocky planets lie closest to the Sun and the less massive gas giants lie farther away. All objects will eventually be pulled into the Sun but if they are massive and moving fast this will take a very long time.
The story goes that Isaac Newton first proposed the existence of gravity when an apple fell from the tree he was sitting under and he realised that Earth pulled things towards itself.

Teacher Demonstration - The effect of gravity on objects in the solar system

Materials

- Half a heavy duty rubbish bag
- A circular bucket or rubbish bin
- A heavy elastic band or gaffer tape
- A heavy object (lead weight or rock) and lighter spherical object (marble or Ping-Pong ball.

Method

1. Stretch a thick flexible plastic membrane such as a single sheet cut from a large bin bag over a circular container (rubbish bin or bucket) and anchor it to keep the membrane taught (elastic bands and gaffer tape).
2. Depress the centre point by placing a sufficiently heavy object (lead weight) on it.
3. Set the marble or Ping-Pong ball spinning round the outer edge of the stretched plastic. If the marble is travelling fast it will not be sufficiently deviated from its forward path. With a little less speed the marble will spiral down towards the denser weight at the centre with increasing speed.
4. Repeat step 3 to confirm observation.

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Observation

What happened to the plastic surface when a heavy weight was placed on it?

The plastic became depressed – It sank down/sagged

What is this depression supposed to represent?

The effect of the Sun's gravity that will change the path of any passing object/body/planet and eventually pull the object down in a curved path towards its centre.

What happened when the marble was moving fast?

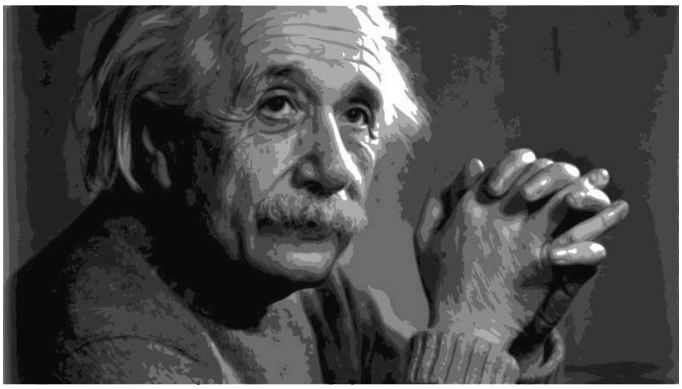
It was only slightly deviated.

What happened when the marble was travelling slower?

It spiralled down towards the heavy weight with increasing speed.

According to Newton, this curved path is due to the gravitational force exerted by the massive object at the centre of the plastic.

According to the great physicist Albert Einstein (1879-1955,) the great mass of the central body distorts space-time and results in a gravitational pull. Einstein proposed a fourth dimension "Time" needed to be included His 'General Theory of Relativity' can be translated as:



Matter tells space how to curve.
Space tells matter how to move.

This explains why planets move around the Sun, why planets closer to the Sun orbit faster than planets further away and why smaller objects are drawn to the gravitational centre of the larger object they orbit.

(Einstein also said "Gravity cannot be held responsible for people falling in love".)

Of course all the planets have their own gravitational "pull "which affect each other, the paths of any moons they may hold and of comets passing by. The eccentric nature of the orbits of Neptune and Uranus suggest that our planets have not always been in their present orbits. Examination of other star systems with exo-planets demonstrates that their gas giants are held closer to the star than in our solar system. Perhaps the combination of circumstances that was necessary to produce life on Earth is less common than we had previously considered.

As an object approaches the Sun, or any massive astronomical body, it experiences the pull of gravity that makes it move faster. The increase of speed makes it shoot past the Sun until it is slowed as gravity opposes then overcomes motion. This is known as the "slingshot" effect. This effect has been used to provide an extra boost to spacecraft after they have left Earth.

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Extension - Weight, mass and gravity

Students will need to know their own weight or guess it. Some students are very sensitive about this information. They may accept a nominal weight of 32kg, the average weight of a year 5 Australian student.

Materials

- A weighing machine
- Access to the Internet

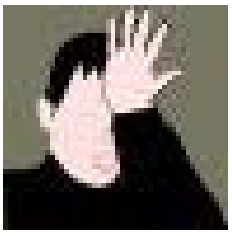
Weight = Mass + Gravity.

Your weight on Earth is a combination of the mass of your body and the gravitational pull of this planet. If you were weighed on a smaller planet or on a moon your mass (the amount of stuff that makes your body) would remain the same because all the body would still be there but your weight would be much less as that moon has a much smaller mass and consequently smaller gravitational pull than the Earth.

A student who weighs 32 kg on Earth will weigh 5.3kg on the moon.
If they survived the horrific heat on the Sun their weight would be an equally horrific 866.3kg.

Your weight on other worlds www.exploratorium.edu/ronh/weight/ will allow you to calculate your weight on planets and moons of our solar system.

	My weight (kg)
Mercury	12
Venus	29
Earth	32
Mars	12
Jupiter	75.6
Saturn	34
Uranus	28.4
Neptune	36



Students may also be horrified to know that that although their body is attracted to the centre of the Earth it is also attracted towards other students body mass and even to the more massive school building!

Your body finds the school attractive! Luckily the mass of your school is very small compared to a planet.
Planet Earth has a mass of 597200000000000000000000kg

Even our Moon, which is quite a relatively small piece of rock in the solar system, can attract the mobile water in Earth's oceans when it is close and pull them upwards creating high and low tides.