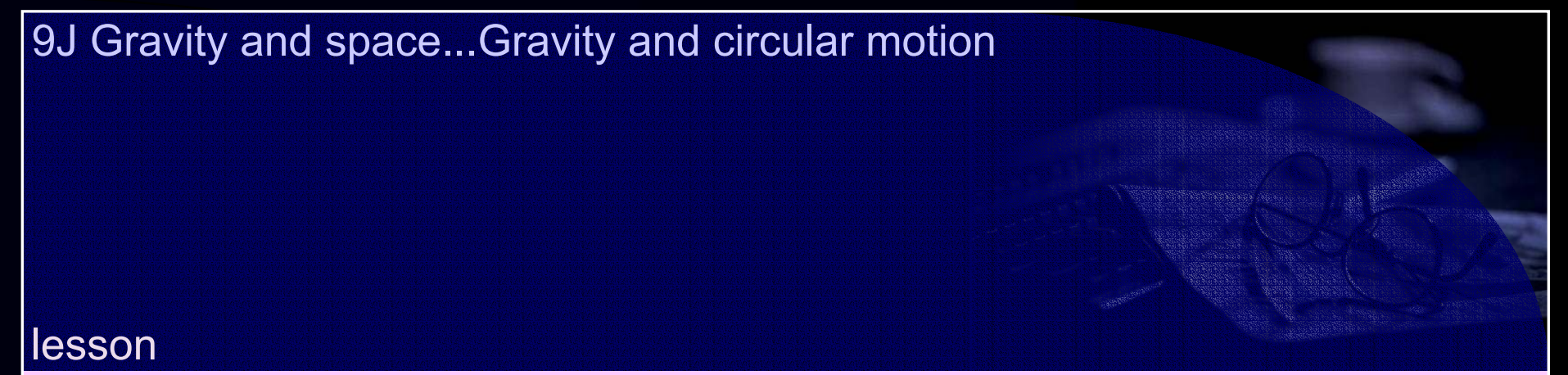
9J Gravity and space...Gravity and circular motion



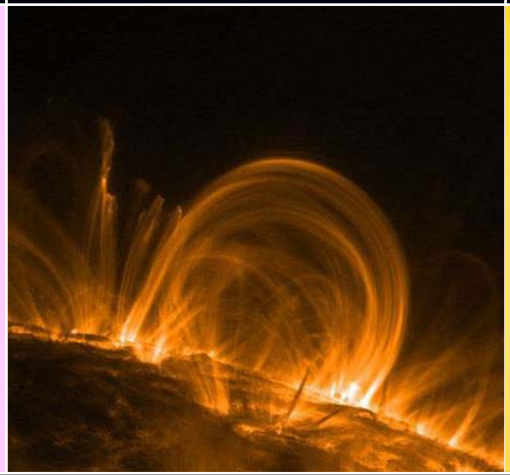
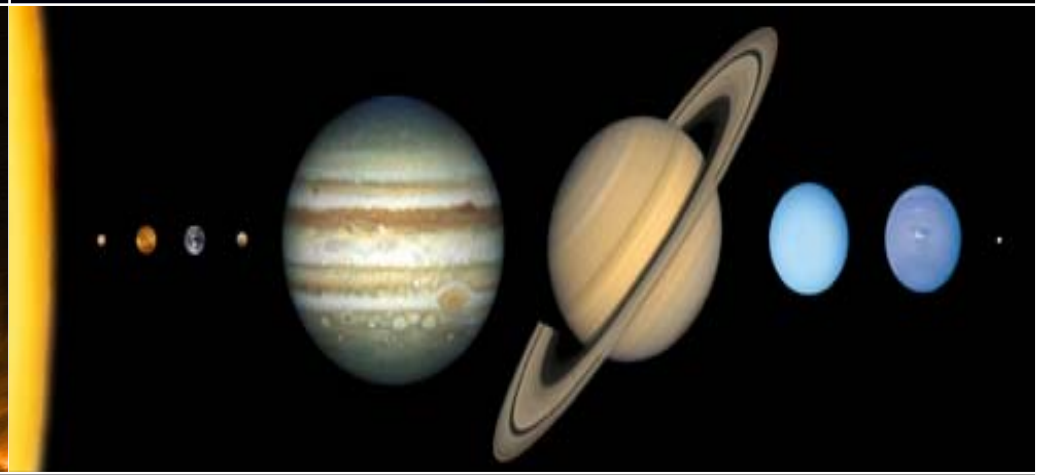
lesson

Science Interactive LTD. PO BOX 50764 LONDON NW6 9AT email: sales@science-interactive.co.uk web: www:science-interactive.co.uk

Gravity

Gravity or *gravitational pull* is a type of 'natural force' alongside magnetism. These forces cannot be seen, but we can observe the effects of these forces, for example an apple falling towards Earth. In 1666, Newton was the first person to answer the question 'why objects fall to Earth.' The strength of the *gravitational force* between two objects depends on their *mass* and the *distance between* the two objects. Compared to gravity, magnetic and electrostatic forces are relatively strong. Gravity is the smallest in magnitude. *Design an experiment to show that magnetism and electrostatic forces are stronger than gravity ?*

Gravity in our solar system:

Sun	Sun's surface	Sun at the heart of the solar system and the nine planets
		

The Sun is an average star in our own galaxy the Milky Way. The core temperature is around 14 million degrees Celsius. The Sun consists of hydrogen gas. It has a life span of about 9 billion years and is currently estimated to be around 4.5 billions years old. Its *gravitational pull* keeps all nine planets in orbit alongside meteors, asteroids and the odd comet. It takes light travelling at 300,000kms^{-1} nearly nine minutes to reach the Earth's surface. On any scale, the size of the Sun when compared to the planets is huge. *Order the planets from the Sun outwards ?*

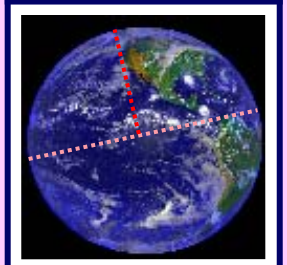
Gravity *Earth's orbit*

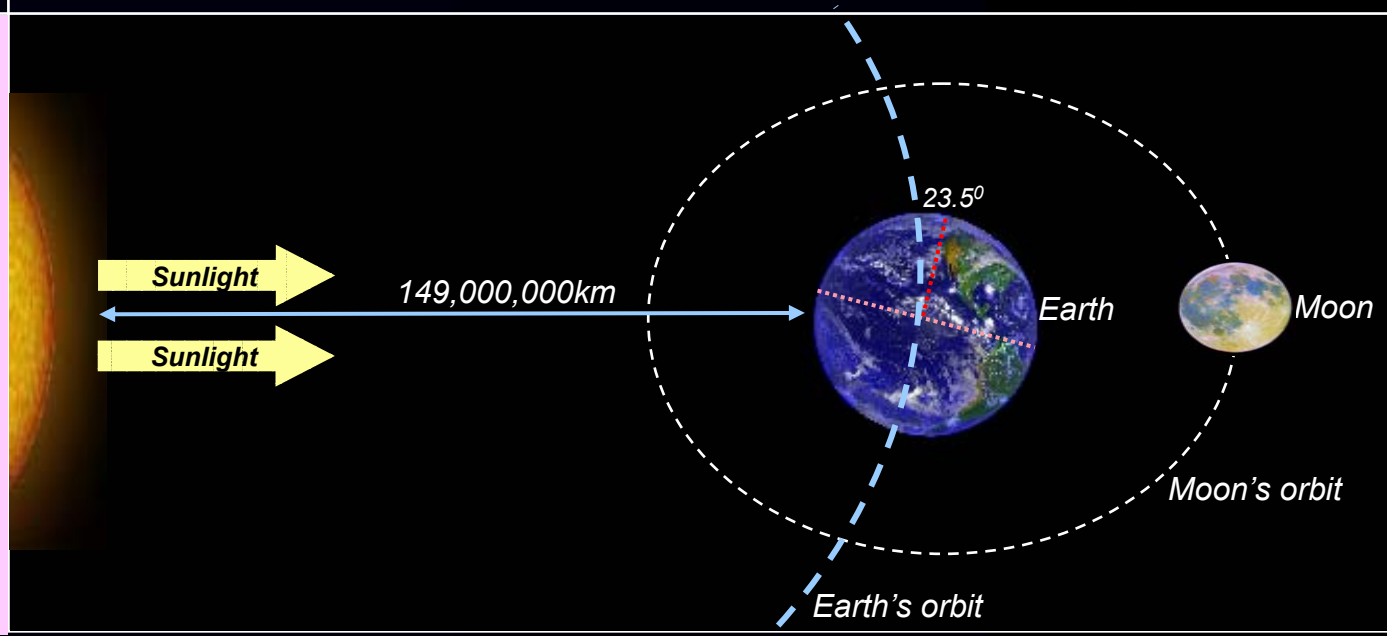
The Earth moves around the Sun, in an orbit. The Earth is kept in orbit or circular motion around the Sun due to the immense 'gravitational pull' exerted on the Earth by the Sun's mass. The Earth's orbit isn't a perfect circle, it is in fact elliptical. The fact that Earth completes one revolution in 365.25 days is the reason for leap years. Every 4 years, we need to add another day (February 29th) to compensate for the extra 0.25 days we get each year. The Earth rotates on its own axis once a day or every 24 hours.

Earth's orbit:

Earth's orbit	Earth's orbit around the Sun

Earth's orbit



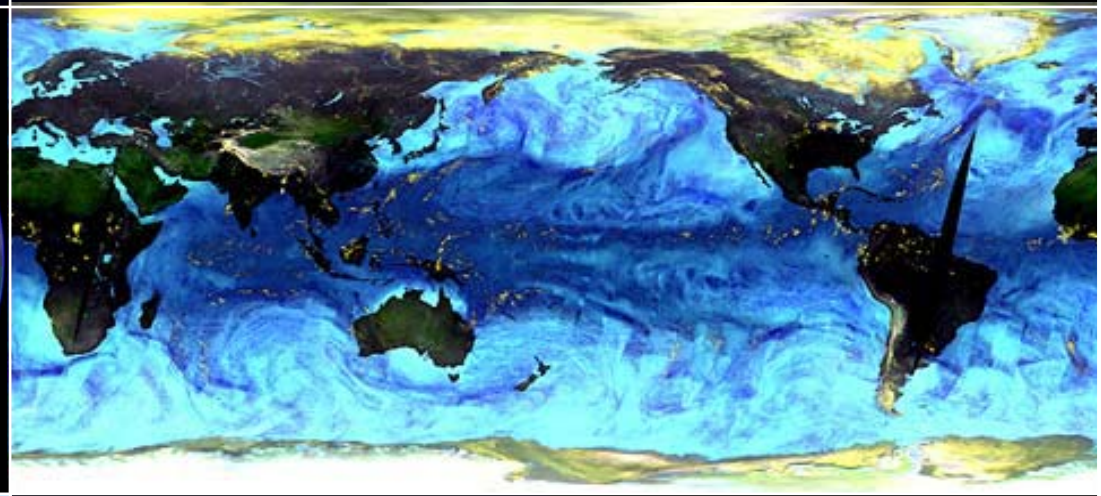


The Earth is kept in orbit around the Sun due to the immense 'gravitational attraction' between the Earth's mass and the Sun's mass. The moon is also held in orbit due to the attraction between the Earth and the moon. The Earth's axis is tilted at 23.5° giving rise to the seasons: Spring, Summer, Autumn and Winter.

Gravity *The Earth*

As far as we know, Earth is the birthplace of humanity. It is believed that Earth is about as old as the rest of the Solar system. This age is thought to be about 4.5 billion years. The value of g (gravitational pull) on Earth is *9.81NKg^{-1}*. This is normally rounded up to *10NKg^{-1}* for convenience during calculations. Therefore, an object with a mass of 60kg would have a weight of 600N, since gravity exerts a force of 10 Newtons on every kilogram. If you move from Earth's surface to space, the gravitational pull of the Earth becomes less until you are completely weightless, far out in space away from the Earth or any other object.

Earth:

Earth	Picture	Surface of Earth
Earth 		
Distance from the sun: **149,600,000km** *Planet radius:* **6,378km** *Planet volume:* **1,086,920,000,000 km^3** *Planet mass:* **5972,500,000,000,000,000,000,000 kg** *Planet moons:* **One** *Planet orbit:* **365 days** *Surface temperature:* **+18^{o}C**		The value of gravity on Earth is *9.81NKg^{-1}*. This means that gravity exerts a force of 9.81N per kilogram of mass. Not including air resistance, all falling objects would accelerate at 9.81metres per second per second towards Earth's surface. Gravity also keeps the moon in its orbit around Earth.

Gravity *working out its values around the solar system*

If you were to stand on the surface of any of these four objects found in our solar system (Earth, Mars, Jupiter & moon) you could use a Newton meter to determine the value of gravity. If you measure the weight of a one kilogram mass, its weight determined by the Newton meter would give you the value of g (gravity) on any planet. On Jupiter, an object with a mass of one kilogram would have a weight of 26 Newtons. Therefore the value of g for Jupiter is *26 Newtons per kilogram* or *26 NKg^{-1}*. *Look at the examples below and complete the calculations ?*

Gravity and its value around the solar system:

Planet	Earth	Mars	Jupiter	Moon
Picture				
Gravity	9.81N/Kg	8N/Kg	26N/Kg	1.6N/Kg
Mass	60Kg	500Kg	0.1Kg	100Kg
Weight	Calculation: 60Kg x 10N 600N	Calculation: _____ _____?	Calculation: _____ _____ ?	Calculation: _____ _____?

Gravity *in action one*

Although we can't directly observe the force of gravity, we can see the effects of gravity, here on Earth. Gravity on Earth causes all objects to accelerate and fall towards the Earth's surface. The old saying "*what goes up must come down*" is very true. The leaning tower of Pisa is slowly falling to the ground. Recently, the tilt or lean increased so much that engineers had to remove soil from underneath the foundations so that the tower moved from a fifteen to an eleven degree tilt. Engineers believe this is a '*safe tilt*.' Anymore than eleven degrees and the famous tower of Pisa is at risk of collapsing.

Gravity in action:

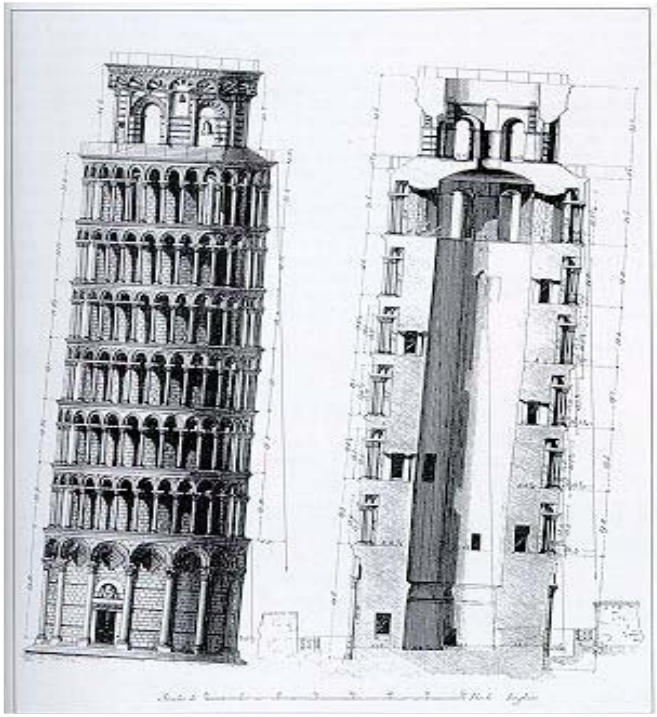
	Rollercoaster	Airplanes	Leaning tower of Pisa
Diagram			
Notes	Gravity and the force it exerts on your body will accelerate you from the start giving you the sensation of falling. During a rollercoaster ride, nothing beats that 'falling sensation.'	All aircraft uses vast amounts of aviation fuel propelling the plane in the forward and upwards direction. Failure of the planes four jets would result in the plane crash landing.	The old saying "what goes up must come down" is very true. The leaning tower of Pisa is slowly falling to the ground. Without constant intervention, this landmark would have already collapsed.

Gravity *in action two*

A free falling object, not subjected to air resistance will accelerate to Earth at 9.81 per second per second. You may have heard of Galileo's experiment, where he allegedly dropped a *heavy and light ball* with the same shape from *the leaning tower of Pisa* at the same time. He observed them falling, accelerating at the same rate and hitting the ground at exactly same time. This is because, all objects regardless of their mass accelerate at the same rate (assuming no air resistance.) *In a vacuum, which would land first a feather or a coin ?*

Galileo's experiment and the leaning tower of Pisa:

Leaning tower of Pisa



Notes

Galileo's experiment: The two balls with very different masses are released at the same time. They also hit the ground at the same time, proving that all objects accelerate at the same rate, regardless of their mass, due to gravity's pull.

Calculation: Calculating acceleration, we can use a value for g of 10m/s^2. Work out the velocity of the accelerating object after, 1,2,3,4,5 & 6 seconds assuming there is no air resistance. What is the object's final velocity ?

Calculation

Time (s)	Velocity
1	10ms^{-1}
2	
3	
4	
5	
6	
10	