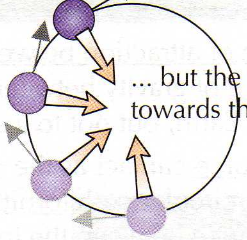
Circular Motion

Circular motion — velocity is constantly changing

1) Velocity is both the speed and direction of an object.
2) If an object is travelling in a circle it is constantly changing direction, which means it's accelerating.
3) This means there must be a force acting on it.
4) This force acts towards the centre of the circle.
5) The force that keeps something moving in a circle is called a centripetal force.

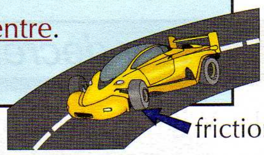
Pronounced sen-tree-pee-tal

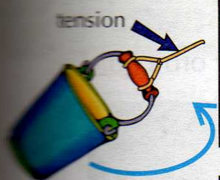


Tension, friction or gravity can provide a centripetal force

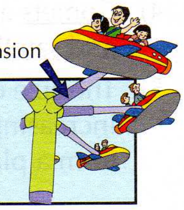
In the exam, you can be asked to say which force is actually providing the centripetal force in a given situation. It can be tension, or friction, or even gravity (see next page). Have a look at these examples:

A car going round a bend:
1) Imagine the bend is part of a circle — the centripetal force is towards the centre.
2) The force is from friction between the car's tyres and the road.





A bucket whirling round on a rope:
The centripetal force comes from tension in the rope.
Break the rope, and the bucket flies off at a tangent.



A spinning fairground ride:
The centripetal force comes from tension in the spokes of the ride.

Centripetal force depends on mass, speed and radius

1) The faster an object's moving, the bigger the centripetal force has to be to keep it moving in a circle.
2) And the heavier the object, the bigger the centripetal force has to be to keep it moving in a circle.
3) You also need a larger force to keep something moving in a small circle — it has 'more turning' to do.

Example

Two cars are driving at the same speed around the same circular track. One has a mass of 900 kg, the other has a mass of 1200 kg. Which car has the larger centripetal force?

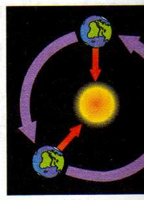
The three things that mean you need a bigger centripetal force are:
more speed, more mass, smaller radius of circle.

In this example, the speed and radius of circle are the same — the only difference is the masses of the cars. So you don't need to calculate anything — you can confidently say:
The 1200 kg car (the heavier one) must have the larger centripetal force.

Gravity and Planetary Orbits

Gravity is not just important for keeping us all stuck to the ground — it's also the force that keep
Moon and satellites orbiting round the Earth, and planets orbiting round stars...

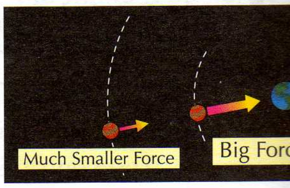
Gravity is the **centripetal force** that keeps **planets in orbit**



1) Gravity is the force of attraction between masses — the larger the masses the greater the force of gravity between them (you're strongly attracted to a big mass like the Earth, but not to a small mass like a toaster).
2) This gravitational force can act as the centripetal force that keeps one object moving in a circular path (orbit) round another. An orbit is possible when there's a balance between the forward motion of the object and the gravitational force pulling it inwards. (If there wasn't a balance, the smaller object would either get pulled inwards or fly off at a tangent.)
3) Planets always orbit around stars. E.g. the Earth orbits around the Sun, and the centripetal f needed is provided by the gravitational attraction between the Earth and the Sun. (And likewise all the other planets in the Solar System of course.)
4) These orbits are all slightly elliptical (elongated circles) with the Sun at one focus of the ellip
5) The further the planet is from the Sun, the longer its orbit takes (see below).

Gravity decreases **quickly** as you get further away

1) With very large masses like stars and planets, gravity is very big and is felt a long way out.
2) The closer you get to a star or a planet, the stronger the force of attraction.
3) To counteract the stronger gravity, planets nearer the Sun move faster, covering their orbit qu
4) Comets are also held in orbit by gravity, as are moons and satellites and space stations.
5) The size of the force of gravity decreases very quickly with increasing distance. E.g. if you double the distance of an object from a planet, the size of the force on it will be four times less.



In **practice** that means...

1) A long way out from the Sun, where Uranus orbits, the Sun's gravitational effect is weaker th here on Earth. So Uranus has a bigger orbit, travels slower and takes longer to complete its orbit than Earth.
2) Likewise, further in towards the Sun, its gravitational effect is stronger. Mercury is nearer th Sun than Earth, so it has a smaller orbit, travels faster and takes less time to complete its orb than Earth.

Example:

Look at the following table of data. Is Planet X closer to or further away from the Sun than Ea

Planet	Orbital period (earth days)	Distance from Sun (km)
Mercury	88	57 910 000
Earth	365	149 600 000
Mars	687	227 940 000
Uranus	30685	2 870 990 000
Planet X	4333	not given

Planet X has a longer orbital perioc Earth. A longer orbital period mear slower orbit speed and a bigger orb i.e. a bigger distance from the Sun.

(Even without knowing the theory, you c probably work that out from the table — remember that if you're stuck in the exa

Satellites

A satellite is any object that orbits around a larger object in space. There are natural satellites, like moons, but these pages just look at the artificial ones that we put there ourselves.

Satellites are set up by humans for many different purposes

You need to know a few examples of what satellites are used for:

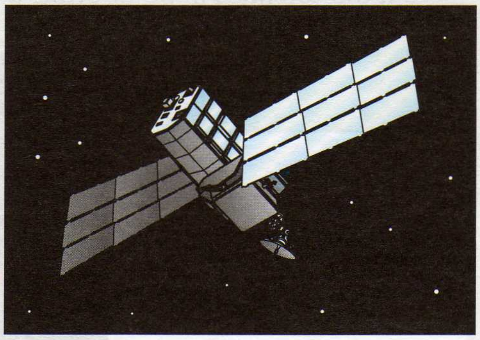
1) Monitoring weather and climate.

2) Communications, e.g. phone and TV.

3) Space research, such as the Hubble Telescope.

4) Spying

5) Navigation, e.g. the Global Positioning System (GPS).



Communications satellites stay over the same point on Earth

1) Communications satellites are put into quite a high orbit over the equator.

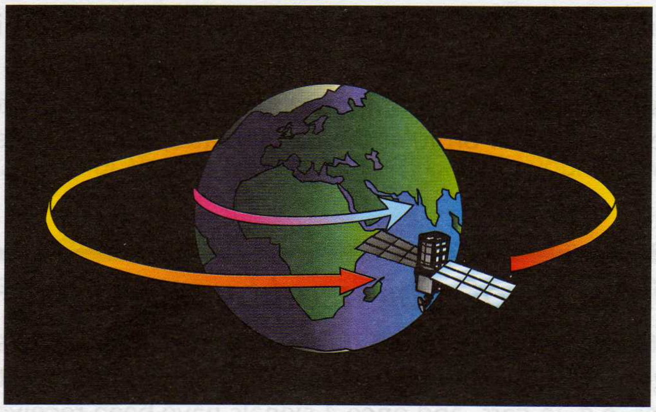
2) This orbit takes exactly 24 hours to complete.

3) This means that the satellites stay above the same point on the Earth's surface, because the Earth rotates below them.

4) So this type of satellite is called a geostationary satellite (geo (= Earth)–stationary) or sometimes a geosynchronous satellite.

5) They're ideal for telephone and TV because they're always in the same place and can transfer signals from one side of the Earth to the other in a fraction of a second.

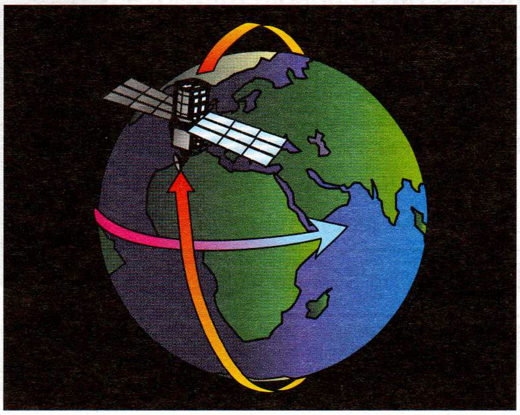
6) There's room for about 400 geostationary satellites around the Earth — any more than that and the signals will begin to interfere.



Satellites

Low polar orbit satellites are for weather and spying

1) In a low polar orbit, the satellite sweeps over both poles whilst the Earth rotates beneath it.
2) The time taken for each full orbit is just a few hours.
3) Each time the satellite comes round it can scan the next bit of the globe.
4) This allows the whole surface of the planet to be monitored each day.
5) Geostationary satellites are too high to take good weather or spying photos, but the satellites in polar orbits are nice and low.



Example

The table gives data about two satellites.

Q1: Which satellite would be more useful for transmitting TV signals? Why?

Q2: Which satellite would be more useful for monitoring Earth's weather? Why?

	Orbital period (in Earth days)	Distance from Earth (km)	Position
Satellite A	0.07	800	Pole to pole
Satellite B	1	35 800	Around equator

Satellite B would be more useful for transmitting TV signals. This satellite is in a high orbit ar
the equator which takes exactly one day — so it's in a geostationary orbit.

Satellite A would be more useful for monitoring Earth's weather. This satellite is in a fast, low
It sweeps over both poles (i.e. a polar orbit) as the Earth rotates, scanning the whole Earth.

Know the two main kinds of orbit used by satellites

There are other kinds of satellite as well, e.g. GPS (Global Positioning System) satellites, which a
different kind of orbit altogether. They work by transmitting their position and the time. These s
are received by GPS devices, e.g. in cars, and once 4 signals have been received, the device ca
out its exact location. It's all clever stuff. And you don't need to learn it, which is even better.

Warm-Up and Exam Questions

Another page of questions for your enjoyment. Make sure you can do them all properly...

Warm-Up Questions

1) What's the general name for a force that keeps an object moving in a circle?
2) What force keeps satellites in orbit around the Earth?
3) What shape are the planets' orbits around the Sun?
4) Suggest two uses for satellites.

Exam Questions

1 A car is being driven round a circular track at constant speed.

(a) Name two forces acting on the car.

(1 mark)

(b) Are all the forces acting on the car balanced or unbalanced? Give a reason for your answer.

(2 marks)

2 Levi is writing a report on different types of satellite. He is researching two satellites, A and B. Satellite A transmits television signals while B is used to monitor the weather.

(a) What type of orbit does satellite A use?

(1 mark)

(b) How long does satellite A take to complete one orbit?

(1 mark)

(c) Satellite B is able to take pictures of the whole surface of the Earth in one day without changing its orbit.

(i) Describe how this is possible.

(2 marks)

(ii) Which satellite is closer to the Earth, A or B? Give a reason for your answer.

(1 mark)

3 The Earth is, on average, 1.39 times further from the Sun than Venus.

(a) Which planet, Earth or Venus, travels faster? Explain your answer.

(2 marks)

(b) Which planet, Earth or Venus, experiences a stronger gravitational force from the sun.

(1 mark)