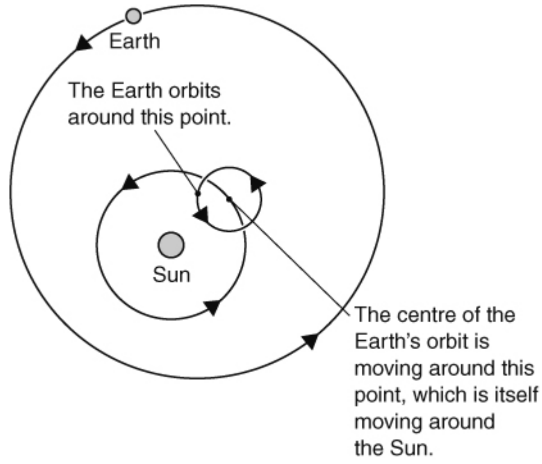
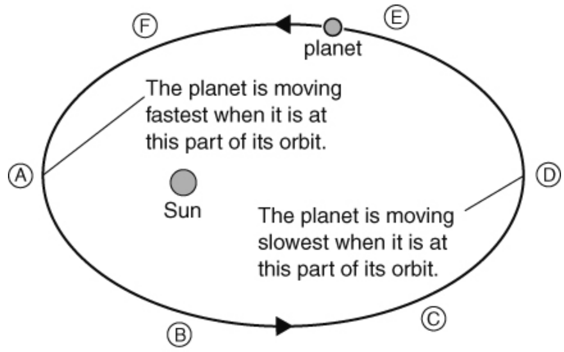
When Copernicus developed his ideas about a Sun-centred Solar System, he still put his planets in circular orbits. At that time, everyone believed that the Universe was made by God and God would only have used 'perfect' shapes like circles. Copernicus' model was a little simpler than Ptolemy's but it still needed lots of complicated adjustments to make the predictions of the model match the observations.



Copernicus' model

Tycho Brahe (1546–1601) was an astronomer who worked in Denmark and Prague. He spent years making detailed observations of the positions of the planets. In 1600 he took on Johannes Kepler (1571–1630) as an assistant and asked him to study the orbit of Mars, which was very difficult to predict using Copernicus' model.

Kepler started by working out the speed of Mars at different places around its orbit and discovered that its speed changed. This discovery eventually led him to the idea that the orbits of the planets were ellipses, not circles. Once he worked out the orbits of the planets using this idea, his model matched observations very well. It took Kepler 8 years to make all the calculations and check his theory but his theory is now accepted by astronomers everywhere. He published his ideas in 1609.



Note that the orbits of the planets are almost circular – the ellipse in this diagram is exaggerated.

Kepler's model

At the time, no one knew why Kepler's ideas worked. It wasn't until Isaac Newton (1642–1727) published his ideas about gravity in 1687 that scientists could explain why the speeds of the planets changed at different places in their orbits.

1 **a** What did Copernicus assume about the shapes of the orbits of the planets?

b What do you think he assumed about the speeds of the planets in their orbits?

2 **a** When Kepler started work on the orbit of Mars, what did he start by calculating?

b How were Kepler's assumptions about orbits different to Copernicus'? (*Hint*: there are two ways.)

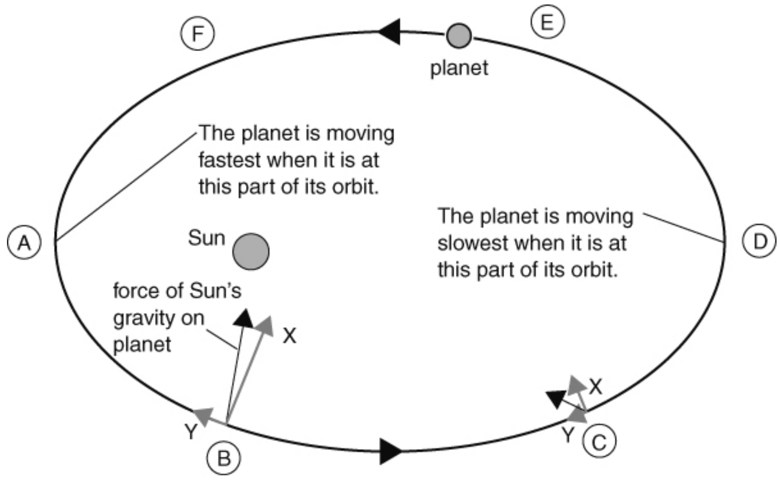
3 Make a copy of the diagram above showing a planet in an elliptical orbit.

a Draw an arrow on your diagram at A showing the direction the Sun's gravity is pulling on the planet.

b Why doesn't the planet move directly towards the Sun from point A?

a Describe the effect of the Sun's gravity on the planet at A.

The arrows on the diagram below show how the Sun is pulling on the planet when it is at points B and C. You can think of the pull of the Sun's gravity being partly at right angles to the orbit (represented by the arrows labelled X), and partly along the orbit (arrows labelled Y). X and Y are called components of the force.



Note that the orbits of the planets are almost circular – the ellipse in this diagram is exaggerated.

4 Why is the force on the planet smaller at C than it is at B?

5 **a** What effect will the Y part of the force have on the speed of the planet at B?

b Draw arrows similar to the ones at B and C for positions D to F. Show the X and Y components at each place.

c Use the information on the diagram above to explain why the planet is slowing down at C.

d Use the information on your diagram to explain why the planet is speeding up at E.

I can…

- recall how Kepler arrived at his model of the Solar System
- use ideas about forces to explain why the speed of a planet changes.