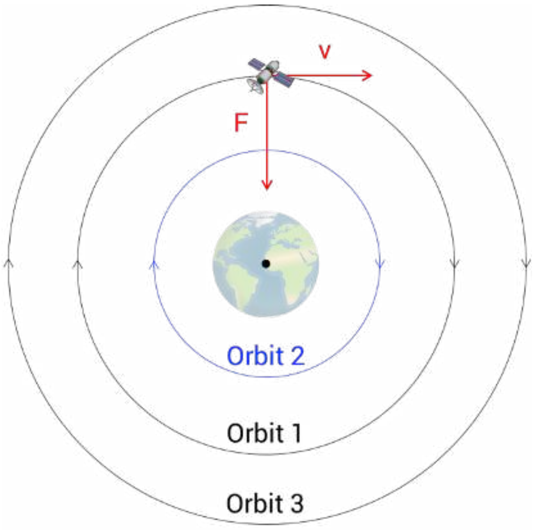
0 1 A communications satellite is in orbit around the Earth, as shown below.



0 1 . 1 Draw an arrow onto the diagram to indicate the direction in which the centripetal force on the satellite is acting. Label this arrow **F**.

Arrow (labelled F) directed towards centre of Earth [1].

0 1 . 2 Write down the origin of this centripetal force.

Gravity (the gravitational force exerted on the satellite by the Earth) [1].

0 1 . 3 Draw a second arrow onto the diagram to indicate the direction of the velocity of the satellite at the point shown. Label this arrow **v**.

Arrow (labelled v) directed to right [1].

0 1 . 4 Although the speed of the satellite in its current orbit (orbit 1) is constant, its velocity is constantly changing. Explain why.

Velocity is a vector: the *direction* of the satellite is constantly changing as it follows its circular orbit around the Earth [1].

0 1 . 5 The speed of the satellite is **reduced** and it moves to a new orbit. Which of the above orbits will it move to: orbit 2 or orbit 3?

Orbit 2 (as highlighted above) [1].

0 1 . 6 Explain your previous answer.

When the speed of the satellite decreases, the gravitational / centripetal force acting on it will cause its height above the surface / orbital radius to change as shown [1].

When it has reached orbit 2, the gravitational / centripetal force acting on it will be *just* strong enough to keep it moving in a circle at this height above the surface / at this orbital radius [1].

Centri-what-now?! This is a fairly tricky concept. Think of it this way: if we tried to (somehow) pull the satellite closer to Earth when it was in orbit 2, then let go of it again, it would naturally drift back into orbit 2 because it would be travelling too quickly for a lower orbit. It would stop drifting away from the Earth (and therefore settle into orbit 2) at the point at which the centripetal force acting on it (due to gravity) was *just* strong enough to maintain its circular motion about the Earth.

Think about what happens when a car drives round a bend in the road too quickly: if the friction between the tyres and the road isn't strong enough, then the car will drift towards the outside of the bend (to a larger radial distance from the centre of curvature of the bend) until the frictional force (acting towards the centre of curvature) is just strong enough to maintain the circular motion of the car.

You could also approach this question the other way round: if the speed of the satellite was *increased* then it would be moving too quickly to remain in orbit 1 – in other words, the centripetal (gravitational) force acting on it in orbit 1 would no longer be strong enough to maintain its circular motion. It would then drift outwards, settling into orbit 3. In this orbit, the gravitational force exerted on the satellite by the Earth is lower (because it is further from the Earth), but it is just strong enough to keep an object moving in the circular path of this orbit.

Don't feel too bad if this all seems very confusing at first – this is a topic which many A-level Physics students find confusingly – but do at least try to ensure that you understand the above answer for your exam.

0 2

Some information on the orbit of the eight planets about the Sun is shown in the below table.

Planet	**Average distance from Sun** (million km)	**Time taken to orbit Sun** (years)
Mercury	58	0.24
Venus	108	0.62
Earth	150	1
Mars	228	1.88
Jupiter	780	12
Saturn	1430	29
Uranus	2880	84
Neptune	4500	165

0 2 . 1

Show that the orbital speed of the Earth around the Sun is approximately equal to 30 km/s.

Circumference of orbit (assumed to be circular):
$C = 2 \pi r$
$C = 2 \times \pi \times 150{,}000{,}000 = 9.4248 \times 10^8$ km

Number of seconds in 1 year:
$t = 365.25 \times 24 \times 60 \times 60 = 3.15576 \times 10^7$ s

$v = s \div t$
$v = C \div t$
$v = 9.4248 \times 10^8 \div 3.15576 \times 10^7$
v= **29.86 km/s**

0 2 . 2

The asteroid belt is located between Mars and Jupiter.

A particular asteroid takes 5.2 years to orbit the Sun, and travels at a speed of 17.2 km/s. Calculate its distance from the Sun.

$t = 5.2$ years $= 1.641 \times 10^8$ s
$s = v\,t$
$2 \pi r = v\,t$
$r = v\,t \div (2 \pi)$
$r = (17.2 \times 1.641 \times 10^8) \div (2 \pi)$
r = **4.49×10^8 km**

Watch out: this question asks for the answer to be given in kilometres, so if you did your working in metres, don't forget to convert back by dividing by 1000 for your final-line answer.