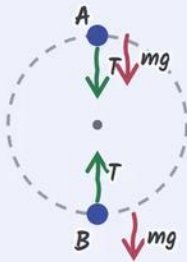


why a satellite stays up, the orbits worth using, and what launch vehicles have to overcome

Why a satellite does not fall *

- a satellite is in fact falling all the time, pulled by gravity exactly as a dropped stone is
- the difference is its sideways speed: it moves forward fast enough that the ground curves away beneath it as it falls
- so it keeps missing the Earth, and that continuous missing is the orbit
- the gravitational pull supplies the centripetal force needed to keep it moving in a curve
- the orbital velocity is the speed at which those two exactly balance, $v_o = \sqrt{\frac{GM}{r}}$
- a higher orbit needs a lower speed but a longer period, which is Kepler's third law seen from close up



a satellite on a circular path with the pull towards the centre marked and its velocity drawn along the tangent: the pull never speeds it up or slows it down, it only bends the path, which is why the motion continues indefinitely

The relations that matter

orbital velocity at radius r from the centre

$$v_o = \sqrt{\frac{GM}{r}}$$

with the height h above the surface

$$r = R + h$$

escape velocity, to leave altogether

$$v_e = \sqrt{\frac{2GM}{R}}$$

so escape velocity relates to orbital

$$v_e = \sqrt{2} v_o$$

period of a circular orbit

$$T = \frac{2\pi r}{v_o}$$

the fourth line is worth remembering on its own: escaping needs only about 1.41 times the speed of orbiting at the same place, not some vastly greater figure

The orbits, and what each is used for

- a geostationary orbit sits about 36000 km above the equator, where the period is exactly 24 hours
- so the satellite keeps pace with the Earth's rotation and appears fixed over one spot on the ground
- that is what allows a dish antenna to be aimed once and left, which is why communication and television satellites use it
- a polar orbit passes over the poles at a few hundred kilometres, with a period of about 100 minutes
- because the Earth turns beneath it, a polar satellite eventually covers the whole surface, which suits weather watching, mapping and remote sensing
- so the choice is between staying over one place and seeing everywhere in turn

