Planetary Motion

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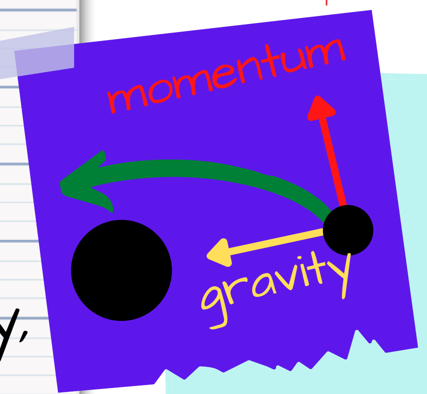
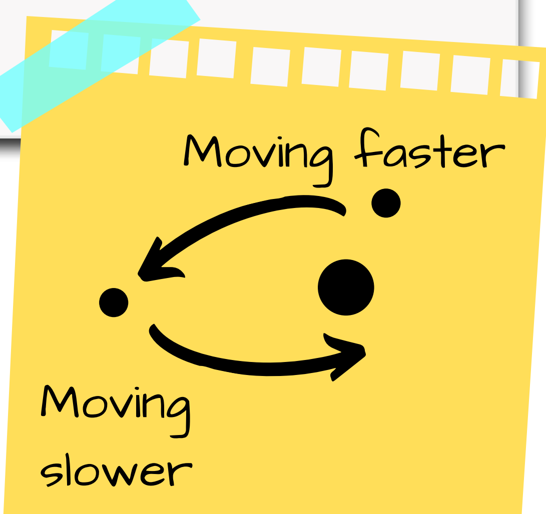
Orbits

An orbit is caused by the momentum of a satellite, and the gravity of the object it is orbiting.

An object, if there are no external forces on it, will continue to move forwards at the same speed, and so will have the same momentum in a continually straight direction. However, the satellite is pulled back the gravity, and so stays in orbit. If the momentum of an object was greater, it would pull away from the gravity and drift off. If the momentum was too small, the gravity would pull the satellite onto the surface of the object and it would crash. The momentum and gravity need to be balanced. The speed a satellite needs to have to stay in orbit is known as the orbital velocity.

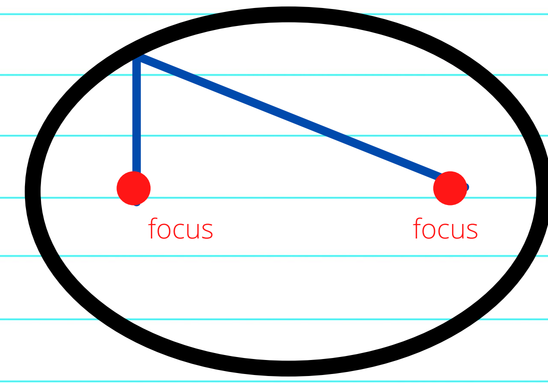


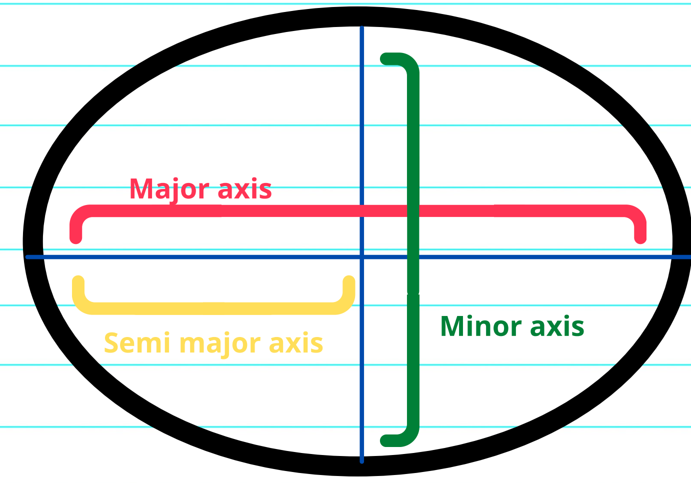
Satellites move quicker when they are closer to centre of mass, or the object they are orbiting, as the gravitational pull is stronger. Thus the orbital velocity needs to be higher for satellites to stay in orbit. This is also what causes orbits to be elliptical. As satellites move faster, they are able to pull further away. But as they move away from the centre of mass, their velocity decreases, and they are pulled back. This causes orbits to be elliptical.



Ellipses

An ellipse has two points called focus. The sum of the distance to the focus through any point of the ellipse is always the same.



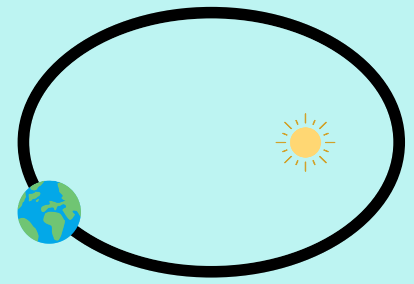


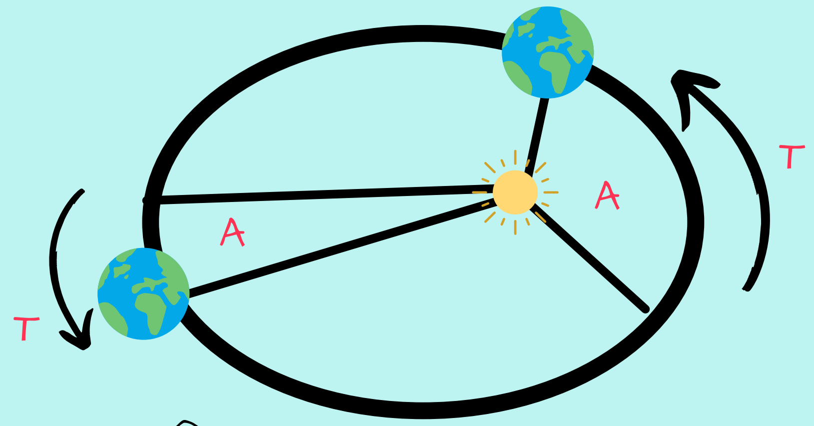
In an ellipse, the longest axis is the major axis; the smallest axis is the minor axis; half the major axis is a semi-major axis

Kepler's laws of planetary motion

Kepler's laws describe how planets move around the Sun in the Solar System, but they can also be applied to other objects such as comets.

Kepler's first law/law of orbits: All the planets orbit the Sun, and the Sun is at one of the focus of their elliptical orbit. So the distance from the planet and the Sun changes through the orbit.





Kepler's Second Law/law of areas: A planet travels the same area of space in the same time, anywhere during their orbit.This means that the Earth's velocity is slower when away from the Sun that when closer to the Sun (as it travels a longer distance when closer in the same amount of time as it travels when further from the Sun).

Kepler's Third Law/law of periods: A planet's orbital period is proportional to its semi-major axis. This means that larger the semi-major axis, the longer the orbital period of a planet. Thus the inner planets have a shorter orbital period than the outer planets of the Solar system

$$T^2 = a^3$$

where T (sometimes written P) is the Orbital Period (in Earth years) and a the length of the semi-major axis (in Astronomical Units)

Diagrams not to scale