Astronomy **Summary Knowledge Organiser** – Chapter 8 (Topic 8) **Planetary motion and gravity**

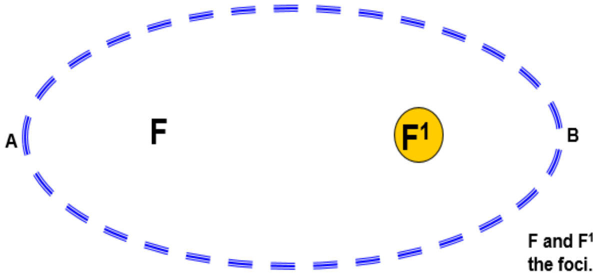
Kepler's 3 laws of planetary motion

1st Law - Each planet has an **elliptical** orbit with the Sun at one focus.
2nd Law - An imaginary **Sun-Planet line** sweeps out an equal area in any stated period of time.
3rd Law - The orbital period of a planet squared is **proportional** to its mean distance from the Sun cubed.

Kepler's First Law

Kepler identified that all planets move in **ELLIPTICAL ORBITS** around the Sun. The Sun is not at the center of the planetary orbits. All ellipses have 2 foci, at one focus is the Sun, whilst the other focus is empty(see below).
The elliptical orbit's of planets means that the **Planet-Sun distance is constantly changing** as the planet goes around its orbit. This is why the distance between planets and the Sun is always given as a **mean distance**.

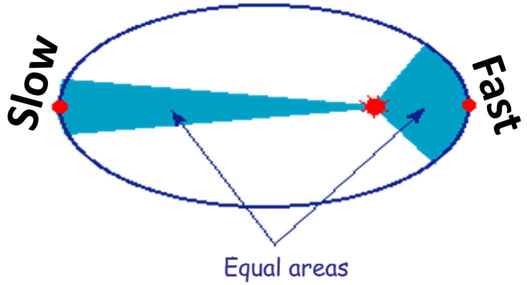
Point **A** is the **Aphelion,** the point in an orbit where a planet is furthest Away from the Sun.
Point **B** is the **perihelion,** the point in an orbit where a planet is closest to the Sun.

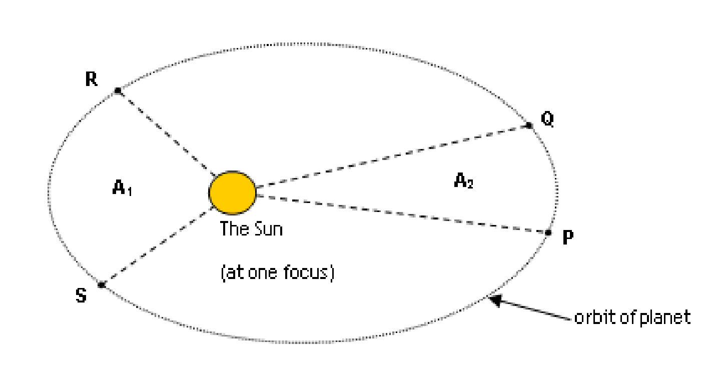


F and F¹ are the foci.

Kepler's second Law

Kepler concluded that since planets travel **fastest** when close to perihelion (**between points R and S** on the image to the right) the imaginary planet-Sun line will **'sweep out' the same area of space** as it does when the planet is close to aphelion (**between points P and Q**) and travelling slower.





Kepler's second law of planetary motion. Areas A1 and A2 are equal and 'swept out' in the same interval of time. A planet therefore travels faster from **R** to **S** than from **P** to **Q**.

Kepler's Third Law

Kepler also linked the **ORBITAL PERIOD of a planet** to its **DISTANCE from the Sun**. He created a formula that proved the link between a planets 'time taken to orbit the Sun' (**T**) and its 'distance from the Sun' (**r**) (the **radius** of its orbit, measured in **Astronomical Units**).

Simply put …….

$$T^2 \propto r^3$$

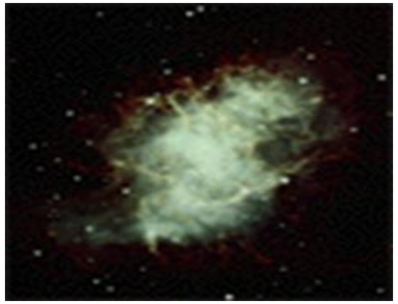
$$\frac{T^2}{r^3} = \text{a constant}$$

When T is given in years and r is given in Astronomical Units.

Newton devised the **law of universal gravitation** that stated 'every body in the Universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of their distance apart'.

$$F = \frac{G M_1 M_2}{r^2}$$

Standing on a **neutron star** makes you unimaginably weighty. Not only is the star very **massive** to start with (about the same as the Sun), but it is also incredibly **small** (about the size of San Francisco), so you are very close to the centre.



Your weight is a measure of the pull of gravity between you and the body you are standing on. This force of gravity depends on a few things. First, it depends on your mass and the mass of the planet you are standing on. If you double your mass, gravity pulls on you twice as hard. If the planet you are standing on is twice as massive, gravity also pulls on you twice as hard. On the other hand, the farther you are from the center of the planet, the weaker the pull between the planet and your body. The force gets weaker quite rapidly. If you double your distance from the planet, the force is one-fourth. If you triple your separation, the force drops by one-ninth. Ten times the distance, one-hundredth the force.