9.2.3 Gravity in Space

The Solar System is held together by gravity

3.1 Describe a **gravitational field** in the region surrounding a massive object in terms of its **effects on other masses** in it

- **Gravitational field**: field which any mass will experience a gravitational force; a vector
- A mass **produces a gravitational field** in the space surrounding it, **attracting masses** towards it
- See 9.2.1 Gravity

3.2 Define **Newton's Law of Universal Gravitation**

- **Newton's Law of Universal Gravitation**: force of **gravitational attraction** (always positive) between masses

$$F = G\frac{m_1 m_2}{d^2}$$

Where F = force of gravity (N), G = universal gravitational constant, m_1 and m_2 = masses (kg), d = distance (m)

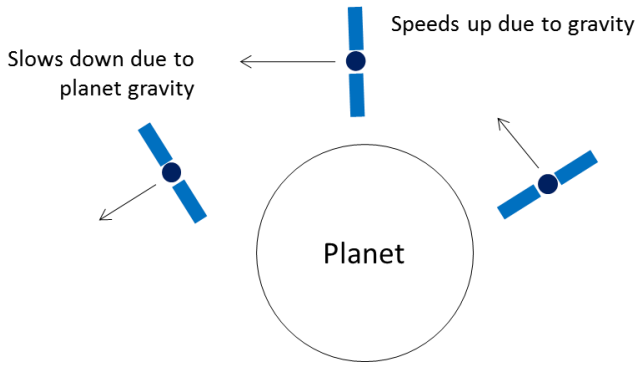
- Force inversely proportional to distance squared

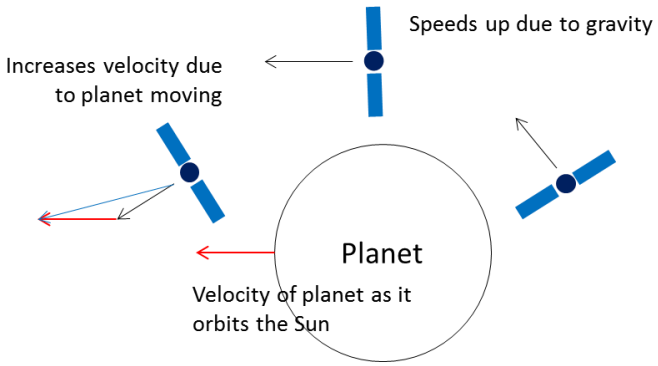
3.3 Discuss the importance of Newton's Law of Universal Gravitation in **understanding and calculating the motion of satellites**

- Force of gravitational attraction is the **centripetal force** in uniform circular motion
- $F_c = G\frac{m_{earth}m_{satellite}}{r^2}$ where r is the radius of orbit
    - By equating $F_c = F_a$ $v = \sqrt{\frac{Gm_e}{r}}$ where v is the orbital velocity
- Therefore, the **required orbital velocity** is determined through distance from centre of Earth

3.4 Identify that a **slingshot effect** can be provided by planets for **space probes**

- **Slingshot effect**: use of **planet's gravitational field** to gain extra speed with little fuel
- As space probe passes a planet, speed **increases** then **decreases** due to gravity of the planet
- However, planet is **orbiting the Sun** – **velocity of the planet is added to velocity of probe**
    - Momentum conserved, so the planet loses (insignificant) amount of velocity





3.P1 Present information and use available evidence to **discuss the factors affecting the strength of the gravitational force**

- Various **variations in gravitational acceleration** is due to:
  - **Altitude:** Further away, less gravity (mountains, valleys, satellites)
  - **Local crust density:** more dense, more gravity
  - **Oblation**/shape: greater radius at equator than poles
- The **spin of the Earth** generates a centrifuge effect, less gravity especially at equator
  - However, it is not acting as an inertial frame of reference

3.P2 Solve problems and analyse information using: $\boldsymbol{F = G\frac{m_1 m_2}{d^2}}$

- $F = G\frac{m_1 m_2}{d^2}$ measures **gravitational force** between two objects
  - Note that $F \propto \frac{1}{d^2}$