Lesson 3

Newton's Universal Law of Gravitation

Gravitational attraction exists between all objects in the universe. It is only noticed on a large scale because this force is very close to 0 when both objects are small.

$$F_G \alpha \frac{m_1 m_2}{r^2}$$

This is called an inverse square relationship (see p. 160).

If mass increases, then force increases.
If distance increases, then force decreases.

Example:
What is the effect on the gravitational force if one of the masses is doubled?

Example:
When two masses are a distance r apart, the gravitational force between them is 0.00010 N. What is the new force if one of the masses is tripled and the other is doubled?

Example:
By what factor will the gravitational force between two objects change if the distance between the masses decreases by a factor of 3?

Example:
If two masses each double while the distance between them also doubles, by what factor will the gravitational force change?

To convert the proportionality into an equation, we introduce a proportionality constant G.

G = universal gravitational constant = $6.67\times10^{-11} N\cdot\frac{m^2}{kg^2}$

So,

$$F_G = \frac{Gm_1m_2}{r^2}$$

where,
G = universal gravitational constant
m_1 and m_2 = masses (kg)
r = distance between masses (m)

Example:
What happens to your weight if you go down a mine shaft towards the centre of Earth?

Example:
What is the force of gravity between a girl of mass 49 kg and her cat of mass 5.1 kg if they are separated by a distance of 1.2 m?

Example:
Calculate the force of attraction between a 1.0 kg watermelon and Earth of mass 5.98×10^{24} kg if the object is sitting on Earth's surface.

Note that $g = 9.80\ m/s^2$ and as long as the object is at or near the surface Earth, we use the equation $F = mg$ to find the weight of an object.

Example:
If your mass is 100.0 kg, what will be the gravitational force exerted on you by Earth if you are in a space ship that 12800 km above Earth's surface? (The radius of Earth is 6400 km).