Our Dynamic Universe

Gravitation

1) The Sun has a mass of 2 x 10^{30} kg, determine the gravitational force between the Sun and these planets. [**G = 6.67 X 10^{-11} Nm² kg⁻²**]

Planet	Mass of Planet	Distance from the Sun
Mercury	3.3 X 10^{23} kg	5.8 X 10^7 km
Venus	5.0 X 10^{24} kg	1.1 X 10^8 km
Mars	6.4 X 10^{23} kg	2.3 X 10^8 km

2) The asteroid called Ceres was discovered in 1801. It has a mass of 9.5 X 10^{20} kg. It orbits the Sun at a distance of approximately 4 X 10^{11} m. It takes around 5 years to orbit the Sun.
Calculate the gravitational force of attraction between the Sun and Ceres.

3) Rearrange the Gravitational force of attraction equation to determine the units of G, the universal gravitational constant.

4) Copy these diagrams showing the gravitational field lines around the Earth and when viewed nearer the surface.

5) Show that on the Earth's surface the gravitational field strength g is given by the formula $$g = \frac{GM}{r^2}$$

Find the value of M, the mass of the Earth if g = 9.8 N kg⁻¹, the radius of the Earth is 6,400 km and the universal gravitational constant is 6.67 X 10^{-11} Nm²kg⁻²

6) Two men are standing close to each other having a conversation. Using your knowledge of physics, estimate the gravitational force of attraction between the two men.

7) The equation of the force of gravitational attraction is given below.

$$F = G\frac{Mm}{r^2}$$

   a) Name the constant G and write down its units.
   b) State what happens to the force between two masses when the distance between them is
      i) doubled
      ii) halved

8) A 5 kg bowling ball is sat on the floor a distance of 2 metres away from a 2 g marble.
   a) Determine the force of gravitational attraction between the bowling ball and the marble.
   b) State the size of the gravitational force of attraction between the marble and bowling ball.
   c) Explain why you do not see the marble accelerating towards the bowling ball.

9) A 200 kg satellite orbits the Earth at a distance of 36,000 km above the Earth's surface. The Earth has a mass of 6.0×10^{24} kg and has a radius of 6,000 km.

   a) Calculate the gravitational force of attraction the Earth has on the satellite.
   b) Explain why the satellite orbits around the earth without falling to the surface.

10) In deep space two protons of mass 1.67×10^{-27} kg are separated by a distance of 3 femtometre. (1 femtometre = 1×10^{-15}m)
    Calculate the gravitational force of attraction between the two protons.

Answers to Gravitation

1   Mercury F = 1.31×10^{22} N, Venus F = 5.51×10^{22} N, Mars F = 1.61×10^{21} N

2   7.92×10^{17} N

8   a) 1.67×10^{-13} N b) the same

9   a)   45 N   b)   53,000 km

10   2.1×10^{-35} N