Gravitation - Lesson 10
How was the Universal Gravitation Constant Determined?

Sir Henry Cavendish first discovered the Gravitational constant in a famous experiment named *"Weighing the world"* in 1797, more than 100 years later than Newton's law of gravitation. In this experiment, he stuck two steel balls of equal mass to a rigid rod, and he hung the centre of the rod. He connected the other end of the rod to a torsional spring and measured the rotational force experienced by the two balls. Two massive lead balls were fixed at a distance from the steel balls. The lead balls attracted the steel balls, and the rigid rod rotated. Hence, the reading of the force was measured. In this experiment, he measured F, and both the masses were known as well as the distance between them. The only unknown was the Gravitational constant, which was calculated using the above values. The reason this experiment was named "Weighing the world" because by knowing the gravitational constant, one could measure the mass of the earth.

You should, now, be able to answer the following questions:

1. Who discovered the value for the universal gravitational constant?

2. Calculate the universal gravitational constant, G, from the experimental results as given below:
   Mass of the lead ball, M = 160 kg,
   Mass of the steel ball, m = 1 kg,
   Distance between the lead and the steel ball, r = 0.225 m,
   Force experienced by the lead ball, $F = 2.1 \times 10^{-7}$ N

Conclusion

Universal Gravitational Constant was measured in 1797 by Sir Henry Cavendish using an apparatus which could measure the force between two solid lead and steel balls kept at a distance.

Note to Teacher

The goal of the text is to introduce Sir Henry Cavendish and his famous experiment. This lesson tries to illustrate different parts of the experiment that led to the discovery.

Student Worksheet

1. How was the force measured in the above experiment?
2. Why was the experiment named "Weighing the world"?

Answers

1. Sir Henry Cavendish

2. Given,
   Mass of the lead ball, $M = 160\ kg$,
   Mass of the steel ball, $m = 1\ kg$,
   Distance between the lead and the steel ball, $r = 0.225\ m$,
   Force experienced by the lead ball, $F = 2.1 \times 10^{-7}\ N$
   The gravitational force between two objects is given by,

$$F = G\frac{Mm}{r^2}$$
$$2.1 \times 10^{-7} = G\frac{160 \times 1}{0.225^2}$$
$$\implies G = \frac{(2.1 \times 10^{-7}) \times 0.225^2}{160 \times 1}$$
$$G = 6.64 \times 10^{-11}\ N\,m^2\,kg^{-2}$$

Student Worksheet Answers

1. By using a torsional spring meter

2. Because by knowing the gravitational constant, one could measure the mass of the earth.