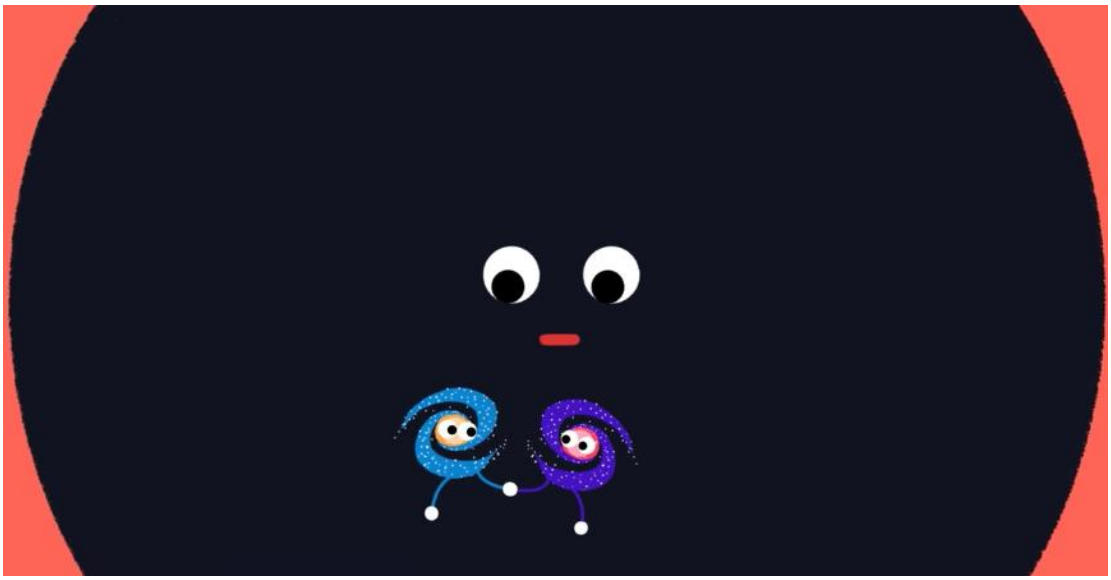
ROYAL OBSERVATORY GREENWICH

The force of gravity

Key Stage 4

Topics covered: Newton's law of gravitation, speed, distance, time, standard form, cosmological units

Watch the video "How will the Universe end?" https://vimeo.com/122515139



The behaviour of gravity was formulated by Isaac Newton:

$$F = \frac{GMm}{r^2} \qquad (1)$$

Where F is the force of gravity in Newtons (the weight of a 1 kg mass is 10 Newtons); M is the mass of the heavier object (e.g. a star) in kilograms; m is the mass of the lighter object (e.g. a planet) in kilograms; r is the distance between the objects in metres; G is the gravitational constant = 6.67 x 10^{-11} Nm^2/kg^2.

Figure 1

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1. Use equation 1 to calculate the gravitational attraction between Valentina the astronaut and the Sun (figure 1). The mass of Valentina, m, is 58 kg; the mass of the Sun, M, is 2 x 10^{30} kg; the distance between Valentina and the Sun, r, is 1.5 x 10^{8} km (convert distance into metres).

Figure 2

A light-year is the distance light travels in one year. The speed of light = 3 x 10^{8} m/s.

$$D = st \qquad (2)$$

D = distance (metres); s = speed (m/s); t = time (seconds)

2. The closest galaxy to us is Andromeda (figure 2). It is 2.5 x 10^{6} light-years away (light takes 2.5 million years to reach us from Andromeda). Calculate the distance to Andromeda in metres (use equation 2).

3. Use equation 1 to calculate the gravitational force between Yukiko the scientist and the nearest galaxy to us, Andromeda (figure 2). The mass of Yukiko, m, is 50 kg; the mass of Andromeda, M, is 1.2 x 10^{12} Suns (multiply this by the mass of the Sun in question 1 to get total mass in kg); use your answer to question 2 for the distance, r.

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The force of gravity: ANSWERS

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1. Gravitational force between Sun and Valentina = 0.34 Newtons
2. 1 light-year = 9.47×10^{15} metres; distance to Andromeda = 2.37×10^{22} metres
3. Gravitational force between Andromeda and Yukiko = 1.42×10^{-11} N