19 Worksheet (A2)

Data needed to answer questions can be found in the Data, formulae and relationships sheet.

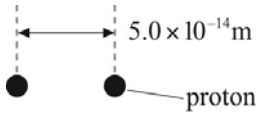
1 Define **gravitational field strength** at a point in space. [1]

2 Show that the gravitational constant G has the unit N m^2 kg^{-2}. [2]

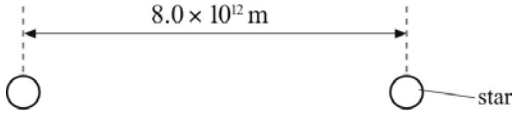
3 The gravitational field strength on the surface of the Moon is 1.6 N kg^{-1}.
What is the weight of an astronaut of mass 80 kg standing on the surface of the Moon? [2]

4 Calculate the magnitude of the gravitational force between the objects described below.
You may assume that the objects are 'point masses'.

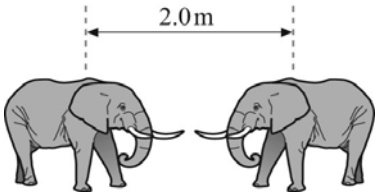
a two protons separated by a distance of 5.0×10^{-14} m
(mass of a proton = 1.7×10^{-27} kg) [3]



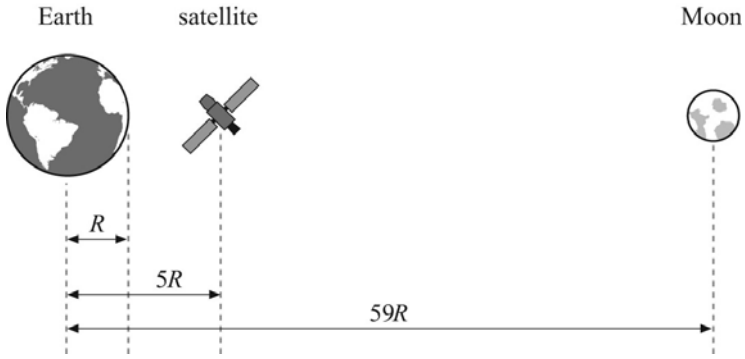
b two binary stars, each of mass 5.0×10^{28} kg,
with a separation of 8.0×10^{12} m [2]



c two 1500 kg elephants separated by a distance of 5.0 m [2]



5 The diagram shows the Moon and an artificial satellite orbiting round the Earth.
The radius of the Earth is R.



a Write an equation for the gravitational field strength g at a distance r from the centre of an isolated object of mass M. [1]

b By what factor would the gravitational field decrease if the distance from the centre of the mass were doubled? [2]

c The satellite orbits at a distance of $5R$ from the Earth's centre and the Moon is at a distance of $59R$. Calculate the ratio:

$$\frac{\text{gravitational field strength at position of satellite}}{\text{gravitational field strength at position of Moon}}$$ [3]

6 The planet Neptune has a mass of 1.0×10^{26} kg and a radius of 2.2×10^{7} m.
Calculate the surface gravitational field strength of Neptune. [3]

7 Calculate the radius of Pluto, given its mass is 5.0×10^{23} kg and its surface gravitational field strength has been estimated to be 4.0 N kg^{-1}. [3]

8 A space probe of mass 1800 kg is travelling from Earth to the planet Mars. The space probe is midway between the planets. Use the data given to calculate:

a the gravitational force on the space probe due to the Earth [3]

b the gravitational force on the space probe due to Mars [2]

c the acceleration of the probe due to the gravitational force acting on it. [3]

Data

separation between Earth and Mars = 7.8×10^{10} m

mass of Earth = 6.0×10^{24} kg mass of Mars = 6.4×10^{23} kg

9 An artificial satellite orbits the Earth at a height of 400 km **above its surface**. The satellite has a mass 5000 kg, the radius of the Earth is 6400 km and the mass of the Earth is 6.0×10^{24} kg. For this satellite, calculate:

a the gravitational force experienced [3]

b its centripetal acceleration [2]

c its orbital speed. [3]

10 **a** Explain what is meant by the term **gravitational potential** at a point. [2]

b Write down the gravitational potential energy of a body of mass 1 kg when it is at an infinite distance from another body. [1]

c The radius of the Earth is 6.4×10^6 m and the mass of the Earth = 6.0×10^{24} kg. Calculate the potential energy of the 1 kg mass at the Earth's surface. [3]

d Write down the minimum energy required to remove the body totally from the Earth's gravitational field. [1]

11 The planets in our solar system orbit the Sun in almost circular orbits.

a Show that the orbital speed v of a planet at a distance r from the centre of the Sun is given by:

$$v = \sqrt{\frac{GM}{r}}$$ [4]

b The mean distance between the Sun and the Earth is 1.5×10^{11} m and the mass of the Sun is 2.0×10^{30} kg.
Calculate the orbital speed of the Earth as it travels round the Sun. [2]

12 There is a point between the Earth and the Moon where the net gravitational field strength is zero. At this point the Earth's gravitational field strength is equal in magnitude but opposite in direction to the gravitational field strength of the Moon.
Given that:

$$\frac{\text{mass of Earth}}{\text{mass of Moon}} = 81$$

calculate how far this point is from the centre of the Moon in terms of R, where R is the separation between the centres of the Earth and the Moon. [4]

Total: _____ Score: %
57

