Exercise walk-through

Gravitational Force ▪ 2.6

eXercise

You must be able to

- find **weight** 重量 near Earth's surface: $W = mg$
- use **Newton's law of universal gravitation** 万有引力定律: $F = \dfrac{GMm}{r^2}$
- explain that gravity is an inverse-square force
- distinguish mass (constant) from weight (depends on g)

Method — Weight near a surface

$$W = mg.$$

A 5 kg mass on Earth ($g = 9.8$ m s^{-2}) weighs $W = 5 \times 9.8 = 49$ N.

Method — Universal gravitation

Between any two masses,

$$F = \frac{GMm}{r^2},$$

where r is the centre-to-centre distance. Doubling r quarters the force (inverse square).

Method — Mass versus weight

Mass is the same everywhere; weight changes with g. On the Moon ($g \approx 1.6$ m s^{-2}) the 5 kg mass weighs only 8 N, but its mass is still 5 kg.

Practice 2.1 ▪ 2 marks

Find the weight of a 12 kg object on Earth ($g = 9.8$ m s^{-2}).

Solution 2.1

Method: Weight near a surface

Worked steps

$W = mg = 12 \times 9.8 = 118$ N M1 A1.

Practice 2.2 ▪ 1 mark

In $F = GMm/r^2$, what happens to the force if r doubles?

Solution 2.2

Worked steps

It falls to one quarter (inverse square) B1.

Practice 2.3 ▪ 2 marks

State one quantity that stays the same and one that changes when you travel from Earth to the Moon.

Solution 2.3

Method: Mass versus weight

Worked steps

Mass stays the same; weight changes (because g changes) B1 B1.

Practice 2.4 ▪ 2 marks

A 2 kg mass weighs 3.2 N on the Moon. Find the Moon's g.

Solution 2.4

Method: Mass versus weight

Worked steps

$g = W/m = 3.2/2 = 1.6$ m s^{-2} M1 A1.

Exam-style 3.1 ▪ 1 mark

The gravitational force between two masses is proportional to

A r

B $1/r$

C $1/r^2$

D r^2

Solution 3.1

Method: Universal gravitation

A r

B $1/r$

C $1/r^2$ ✓

D r^2

Worked steps

C — gravity follows an inverse-square law.

Exam-style 3.2 ▪ 1 mark

An astronaut's mass on the Moon compared with on Earth is

A smaller

B larger

C the same

D zero

Solution 3.2

A smaller

B larger

C the same ✓

D zero

Worked steps

C — mass is the same everywhere.

Exam-style 3.3 ▪ 1 mark

Two satellites orbit a planet. Satellite B is twice as far from the centre as satellite A.
(a) State how the gravitational force on B compares with that on A (same mass).
(b) Explain using the inverse-square law.

Solution 3.3

Method: Universal gravitation

Worked steps

(a) The force on B is one quarter of that on A **B1**. (b) Doubling r makes $1/r^2$ one quarter, so the force is quartered **M1** **A1**.

Exam-style 3.4 ▪ 1 mark

A rock has a mass of 3 kg.
(a) Find its weight on Earth ($g = 9.8$ m s^{-2}).
(b) State its weight and mass on a planet where $g = 20$ m s^{-2}.

Solution 3.4

Method: Weight near a surface

Worked steps

(a) $W = 3 \times 9.8 = 29.4$ N B1. (b) Mass still 3 kg; weight $= 3 \times 20 = 60$ N B1 B1.