Exercise walk-through

Gravitational Force ▪ 2.6

eXercise

You must be able to

- state **Newton's law of universal gravitation 万有引力定律**, $F_g = \dfrac{Gm_1 m_2}{r^2}$
- distinguish **mass 质量** (an intrinsic property) from **weight 重量** (a gravitational force)
- calculate the **gravitational field strength 引力场强度** $g = \dfrac{GM}{r^2}$ and use $F_g = mg$
- explain how the force changes with **separation** and with the **masses**

Method — The inverse-square law

$F_g = \dfrac{Gm_1 m_2}{r^2}$ with $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}. **Double the separation → force falls to one quarter** $(1/2^2)$.

Method — Mass versus weight

Mass (in kg) never changes; weight $F_g = mg$ (in N) depends on the local field g. A 60 kg student weighs ≈ 590 N on Earth ($g = 9.8$) but ≈ 100 N on the Moon ($g = 1.6$).

Method — Field of a planet

$g = \frac{GM}{r^2}$ points toward the planet's centre. It is the force per unit mass, so weight $= mg$.

Practice 2.1 ▪ 2 marks

State the difference between the mass and the weight of an object.

Solution 2.1

Worked steps

Mass is the amount of matter (kg), the same everywhere **B1**; weight is the gravitational force on it (N) and depends on the local field **B1**.

Practice 2.2 ▪ 1 mark

Find the weight of a 50 kg crate on Earth (take $g = 9.8$ m s^{-2}).

Solution 2.2

Method: Mass versus weight

Worked steps

$F_g = mg = 50 \times 9.8 = 490$ N **B1**.

Practice 2.3 ▪ 1 mark

The distance between two masses is tripled. State the factor by which the gravitational force changes.

Solution 2.3

Worked steps

it becomes $\frac{1}{9}$ as large $(1/3^2)$ **B1**.

Practice 2.4 ▪ 2 marks

A rock has mass 2.0 kg. State its mass and find its weight on the Moon ($g = 1.6$ m s^{-2}).

Solution 2.4

Method: Mass versus weight

Worked steps

mass $= 2.0$ kg (unchanged) **B1**; weight $= 2.0 \times 1.6 = 3.2$ N **B1**.

Exam-style 3.1 ▪ 1 mark

If the separation between two masses is halved, the gravitational force between them

- **A** halves
- **B** doubles
- **C** is one quarter as large
- **D** is four times as large

Solution 3.1

Method: The inverse-square law

A halves

B doubles

C is one quarter as large

D is four times as large ✓

Worked steps

D.

Exam-style 3.2 ▪ 1 mark

The weight of an object depends on

A its mass only

B the local gravitational field only

C both its mass and the local gravitational field

D neither

Solution 3.2

Method: Mass versus weight

A its mass only

B the local gravitational field only

C both its mass and the local gravitational field ✓

D neither

Worked steps

C.

Exam-style 3.3 ▪ 1 mark

A planet has twice Earth's mass and the same radius.
(a) State how its surface gravitational field compares with Earth's.
(b) A 10 kg object is taken there. State its mass and find its weight (Earth $g = 9.8$ m s^{-2}).

Solution 3.3

Method: Mass versus weight

Worked steps

(a) twice as strong ($g \propto M$ at fixed r) **B1**. (b) mass $= 10$ kg **B1**; weight $= 10 \times (2 \times 9.8) = 196$ N **B1**.