

2.6 Gravitational Force

Name: _____ Class: _____ Date: _____

Total: 11 marks**KEY WORDS** mass 质量 • weight 重量 • gravitational field strength 引力场强度 • force 力

Objective

Build the skills to answer exam questions on **gravitational force**.**You must be able to:**

- state **Newton's law of universal gravitation** 万有引力定律, $F_g = \frac{Gm_1m_2}{r^2}$
- distinguish **mass** 质量 (an intrinsic property) from **weight** 重量 (a gravitational force)
- calculate the **gravitational field strength** 引力场强度 $g = \frac{GM}{r^2}$ and use $F_g = mg$
- explain how the force changes with **separation** and with the **masses**

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ The inverse-square law

$F_g = \frac{Gm_1m_2}{r^2}$ with $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$. **Double the separation $\rightarrow$ force falls to one quarter ($1/2^2$).**

■ 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 $\approx 590 \text{ N}$ on Earth ($g = 9.8$) but $\approx 100 \text{ N}$ on the Moon ($g = 1.6$).

■ Field of a planet

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

2 Practice

2.1 State the difference between the mass and the weight of an object. [2]

2.2 Find the weight of a 50 kg crate on Earth (take $g = 9.8 \text{ m s}^{-2}$). [1]

2.3 The distance between two masses is tripled. State the factor by which the gravitational force changes. [1]

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

3 Exam-style questions

3.1 If the separation between two masses is halved, the gravitational force between them [1]

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

3.2 The weight of an object depends on [1]

- **A** its mass only
 - **B** the local gravitational field only
 - **C** both its mass and the local gravitational field
 - **D** neither
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3.3 A planet has twice Earth's mass and the same radius.

(a) State how its surface gravitational field compares with Earth's. [1]

(b) A 10 kg object is taken there. State its mass and find its weight (Earth $g =$

9.8 m s^{-2}).

[2]



Solutions

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

2.2 $F_g = mg = 50 \times 9.8 = 490 \text{ N}$.

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

2.4 mass = 2.0 kg (unchanged); weight = $2.0 \times 1.6 = 3.2 \text{ N}$.

3.1 D.

3.2 C.

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