Exercise walk-through

2.6
Gravitational Force

AP Physics 1

AP PHYSICS 1 • EXERCISE SHEET

2.6 Gravitational Force

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS mass • weight • gravitational field strength • force

Objective

Build the skills to answer exam questions on **gravitational force**.

You must be able to:

- state **Newton's law of universal gravitation** , $F_G = \frac{Gm_1m_2}{r^2}$
- distinguish **mass** (an intrinsic property) from **weight** (a gravitational force)
- calculate the **gravitational field strength** $g = \frac{GM}{r^2}$ and use $F_W = mg$
- explain how the force changes with **separation** and with the **masses**

1 Key knowledge and worked examples

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

■ The inverse-square law

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

■ Mass versus weight

Mass (in kg) never changes; weight $F_W = mg$ (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 ($g = 1.6$).

■ Field of a planet

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

Exercises 2.1·2.3

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]

Exercises 2.1·2.3

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

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

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

2.2

- $F_W = mg = 50 \times 9.8 = 490\ \text{N}$

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

2.3

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

Exercises 2.4·3.1

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]

3.1 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

Exercises 2.4·3.1

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

2.4

- mass = 2.0 kg (unchanged); weight = $2.0 \times 1.6 = 3.2$ N

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

3.1 D

- is four times as large.

Exercise 3.2

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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3.2 C

- both its mass and the local gravitational field.

Exercise 3.3 (a)

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]

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

(a)

- twice as strong ($g \propto M$ at fixed r)

Exercise 3.3 (b)

3.3 A planet has twice Earth's mass and the same radius.

(b) A 10 kg object is taken there. State its mass and find its weight (Earth $g = 9.8\ \text{m s}^{-2}$). [2]

Exercise 3.3 (b)

3.3 A planet has twice Earth's mass and the same radius.

(b) A 10 kg object is taken there. State its mass and find its weight (Earth $g = 9.8\ \text{m s}^{-2}$). [2]

(b)

- mass $= 10$ kg; weight $= 10 \times (2 \times 9.8) = 196$ N