Gravity

6.5.1.3 · Physics · revision notes

Weight is the force acting on an object due to gravity. You must use W = m g, explain the difference between mass and weight, and know that weight acts at the centre of mass. Expect short calculations and explanations comparing weights on the Earth, the Moon and other planets.

Key facts

- W = m g (weight = mass × gravitational field strength)
- g on Earth = 9.8 N/kg
- W ∝ m in a given gravitational field
- Measure weight with a newtonmeter (calibrated spring-balance)
- Units: W in N, m in kg, g in N/kg
- Weight is a force (vector); mass is the amount of matter (scalar)
- Weight acts at the centre of mass

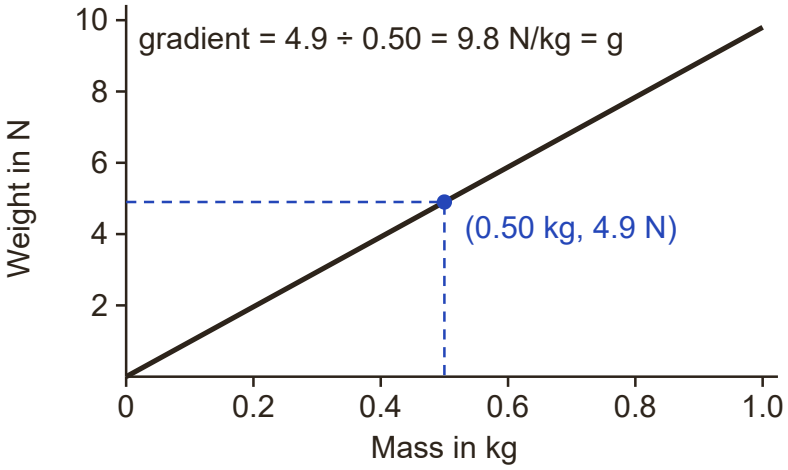
Notes

Mass and weight

- **Mass** is the amount of matter in an object, measured in kilograms (kg). It is the same wherever the object is.
- **Weight** is the force acting on an object due to gravity, measured in newtons (N).
- Close to the Earth, the force of gravity is due to the **gravitational field** around the Earth.
- Weight depends on the **gravitational field strength** (g) at the point where the object is. On the Moon, g is much smaller, so your weight is smaller, but your mass is unchanged.

Calculating weight

- weight = mass × gravitational field strength: **W = m g**
- W in newtons (N), m in kilograms (kg), g in newtons per kilogram (N/kg).
- On Earth, g = 9.8 N/kg. Use the value given in the question.
- Weight and mass are **directly proportional** (W ∝ m): in the same place, doubling the mass doubles the weight.



Weight is directly proportional to mass. The gradient is the gravitational field strength.

- Convert grams to kilograms first: 250 g = 0.25 kg.

Centre of mass and measuring weight

- The weight of an object can be considered to act at a single point, called its **centre of mass**.
- For a uniform, symmetrical object, such as a ruler or a ball, the centre of mass is at its centre.
- Weight is measured using a calibrated spring-balance, called a **newtonmeter**.

How to answer each type of question

Calculate weight

2 marks | **Grade 4**

1. Check the mass is in kg.
2. Write W = m g and substitute.
3. Give the answer in newtons.

Example. A suitcase has a mass of 23 kg.
gravitational field strength = 9.8 N/kg
Calculate the weight of the suitcase.

Model answer.

W = 23 × 9.8 (1)
W = 225.4 N (1)

Two-step: weight in a different gravitational field

3 marks | Grade 6

1. Use the weight and g in the first place to find the mass: m = W ÷ g.
2. The mass is the same everywhere.
3. Use the new value of g to find the new weight.

Example. A piece of equipment has a weight of 96 N on the Moon, where the gravitational field strength is 1.6 N/kg.
Calculate its weight on Earth, where the gravitational field strength is 9.8 N/kg.

Model answer.

m = 96 ÷ 1.6 = 60 kg (1)
W = 60 × 9.8 (1)
W = 588 N (1)

Explain the difference between mass and weight

2 to 3 marks | Grade 5

1. Say what happens to the mass and why (amount of matter unchanged).
2. Say what happens to the weight.
3. Give the reason: a different gravitational field strength.

Example. An astronaut travels from the Earth to the Moon.
Explain what happens to her mass and to her weight.

Model answer.

Her mass stays the same because the amount of matter in her body does not change (1).
Her weight decreases (1)
because the gravitational field strength on the Moon is smaller than on the Earth (1).

Interpret a weight–mass graph

2 to 3 marks | Grade 7

1. A straight line through the origin means weight is directly proportional to mass.
2. Gradient = change in weight ÷ change in mass = g, in N/kg.

Example. A student hangs different masses from a newtonmeter and plots a graph of weight against mass. The line is straight and passes through the origin. A mass of 0.50 kg has a weight of 4.9 N.
(a) What does the graph show about the relationship between weight and mass?
(b) Determine the gradient of the line and state what it represents.

Model answer.

(a) Weight is directly proportional to mass (1).
(b) gradient = 4.9 ÷ 0.50 = 9.8 N/kg (1)
It is the gravitational field strength (1).

Don’t lose marks

- Giving a weight in kg. Weight is a force, so its unit is N.
- Forgetting to convert grams to kilograms before using W = m g.
- Saying an object's mass changes on the Moon. Only its weight changes.
- Using g = 10 N/kg when the question gives 9.8 N/kg.
- Calling g 'gravity'. Its name is gravitational field strength.

More tips

Memory tricks

- Quick check: weight in N is about ten times the mass in kg. A 70 kg person weighs about 700 N (686 N with g = 9.8 N/kg).
- The units give the equation away: kg × N/kg = N.
- Mass is the matter; weight is the pull on it.
- Moon check: g on the Moon is about one-sixth of g on Earth, so weights there are about one-sixth as big.

Exam technique

- Practise using W = m g, with mass in kilograms and weight in newtons.
- Write the equation, substitute the values, then give the answer with a unit. Each step can earn a mark.
- When comparing places, say that g is different so the weight is different, but the mass is the same.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Define weight as the force due to gravity**
Weight is measured in newtons (N); mass is measured in kilograms (kg).

Grade 4 — **Calculate weight using W = m g**
For example, 60 kg × 9.8 N/kg = 588 N.

Grade 5 — **Find mass or g from a weight**
m = W ÷ g and g = W ÷ m.

Grade 5 — **Describe how to measure weight**
Hang the object from a calibrated spring-balance (a newtonmeter).

Grade 5 — **Explain why weight changes but mass does not**
Weight depends on the gravitational field strength where the object is; mass is the amount of matter and stays the same.

Grade 6 — **State where the weight of an object acts**
The weight of an object can be treated as acting at a single point called its centre of mass.

Grade 7 — **Use the proportionality between weight and mass**
W ∝ m, so a graph of weight against mass is a straight line through the origin with a gradient equal to g.

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