1.1 Forces interactions and motion

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS resultant force • limit of proportionality

Objective

Build the skills to answer exam questions on **forces and motion** : contact and non-contact forces, scalars and vectors, weight, stretching springs, motion graphs and Newton's three laws.

You must be able to:

- tell scalars from vectors, and contact forces from non-contact forces
- use $W = mg$ and $F = ke$
- find speed, acceleration and distance from motion graphs
- use Newton's laws and $F = ma$, and describe a spring investigation

1 Key knowledge and worked examples

Forces and motion

idea	equation or rule
scalar and vector	a scalar has size only (speed, mass, distance); a vector has size and direction (velocity, force, displacement)
weight	$W = mg$, with $g = 9.8$ N/kg on Earth; mass stays the same everywhere
spring	$F = ke$ (e = extension in m) up to the limit of proportionality
speed	$v = \frac{s}{t}$; the gradient of a distance–time graph
acceleration	$a = \frac{\Delta v}{t}$; the gradient of a velocity–time graph; the area under it is the distance
Newton's first law	balanced forces: an object stays still or keeps the same velocity
Newton's second law	resultant force $F = ma$
Newton's third law	two objects push or pull on each other with equal and opposite forces

Worked example 1: weight. Find the weight of a 65 kg student on Earth.

1. Known: $m = 65$ kg, $g = 9.8$ N/kg.
2. Rule: $W = mg$.
3. Numbers: 65×9.8.
4. Result: $W = 637$ **N**.

Worked example 2: a resultant force. A 1200 kg car has a driving force of 3000 N and resistive forces of 600 N. Find its acceleration.

1. Known: resultant force $= 3000 - 600 = 2400$ N; $m = 1200$ kg.
2. Rule: $a = \frac{F}{m}$.
3. Numbers: $\frac{2400}{1200}$.
4. Result: $a = 2.0$ **m/s²**.

Answer shapes: write the equation, put in the numbers in SI units (m, kg, s), then give the answer with its unit.

2 Practice

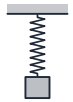
2.1 Sort these quantities into scalars and vectors. [2]

speed | velocity | mass | force

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2.2 A spring has spring constant 40 N/m. It is stretched by 0.15 m. Calculate the force on the spring. [2]

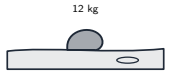


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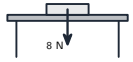
2.3 A rock has a mass of 12 kg. On the Moon $g = 1.6$ N/kg. Calculate the weight of the rock on the Moon. What is its mass on Earth? [2]



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2.4 A book rests on a table. The Earth pulls the book down with a force of 8 N. Describe the force that pairs with this force in Newton's third law. [2]

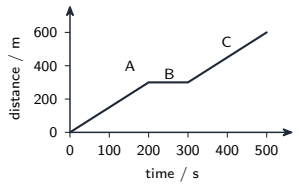


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3 Exam-style questions

3.1 The distance–time graph shows a walk. Calculate the speed in part A. Describe the motion in part B. [3]

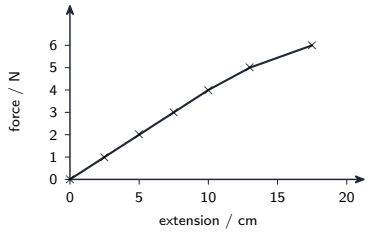


3.2 A trolley of mass 0.80 kg accelerates at 0.50 m/s^2. Friction on the trolley is 0.10 N. Calculate the resultant force on the trolley and the pulling force. [3]



3.3 A student hangs weights on a spring and measures the extension. The graph shows the results.

(a) Use the straight part of the graph to calculate the spring constant. [3]



(b) Write down the force at the limit of proportionality. Calculate the elastic potential energy stored when the extension is 7.5 cm. [4]

(c) A bag hangs on the spring and stretches it by 6.0 cm. Calculate the mass of the bag. [3]

(d) Describe how the student did this investigation and how they made the results accurate. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- scalars: speed, mass; vectors: velocity, force

2.2

- $F = ke = 40 \times 0.15 = \mathbf{6.0}$ N

2.3

- weight $= 12 \times 1.6 = \mathbf{19.2}$ N
- mass on Earth is still **12** kg

2.4

- the book pulls the Earth, upwards, with a force of 8 N

3.1

- speed $= 300 \div 200$
- $= \mathbf{1.5}$ m/s
- part B: the walker is **stationary**

3.2

- $F = ma = 0.80 \times 0.50$
- resultant force $= \mathbf{0.40}$ N
- pulling force $= 0.40 + 0.10 = \mathbf{0.50}$ N

3.3

(a) gradient of the straight part, e.g. 4.0 N at 10 cm; 10 cm = 0.10 m; $k = 4.0 \div 0.10 = \mathbf{40}$ N/m

(b) about **4** N; $E = \frac{1}{2}ke^2$; $\frac{1}{2} \times 40 \times 0.075^2 = \mathbf{0.11}$ J

(c) $F = 40 \times 0.060 = 2.4$ N; $m = 2.4 \div 9.8 = \mathbf{0.24}$ kg

(d) points to include:

- hang the spring from a clamp stand with a vertical metre rule beside it; measure its length with no weight (K)
- add 1 N weights one at a time and measure the new length; extension = new length − original length (K)
- read the rule at eye level, using a pointer on the spring, to avoid parallax (App)
- repeat while removing the weights, find means and plot force against extension (An)

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.