1.2 Forces and movement

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

Objective

Build the skills to answer exam questions on **forces and movement** : scalars and vectors, resultant force, $F = ma$, weight, stopping distances, terminal velocity and Hooke's law.

You must be able to:

- find resultant forces and use $F = ma$ and $W = mg$
- explain the factors that affect stopping distance
- explain terminal velocity
- analyse a spring experiment and find the limit of proportionality

1 Key knowledge and worked examples

Forces

idea	equation or rule
resultant force	add forces in the same direction; subtract opposite forces
force and acceleration	$F = m \times a$
weight	$W = m \times g$, with $g = 10$ N/kg on Earth
stopping distance	thinking distance + braking distance
Hooke's law	extension is directly proportional to the force, up to the limit of proportionality: $F = kx$

Worked example 1: $F = ma$. A resultant force of 3000 N acts on a 1200 kg car. Find its acceleration.

1. Known: $F = 3000$ N; $m = 1200$ kg.
2. Rule: $a = F \div m$.
3. Numbers: $3000 \div 1200$.
4. Result: 2.5 $\mathbf{m/s^2}$.

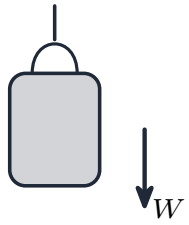
Worked example 2: a spring. A spring has $k = 40$ N/m. Find its extension with a 6.0 N load.

1. Known: $F = 6.0$ N; $k = 40$ N/m.
2. Rule: $x = F \div k$.
3. Numbers: $6.0 \div 40$.
4. Result: 0.15 $\mathbf{m}$ (15 cm).

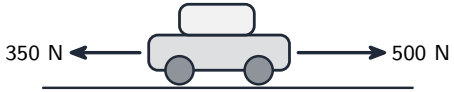
Answer shapes: for terminal velocity, compare the sizes of the forces at each stage: weight against air resistance.

2 Practice

2.1 Calculate the weight of a 6.0 kg bag on Earth. [2]



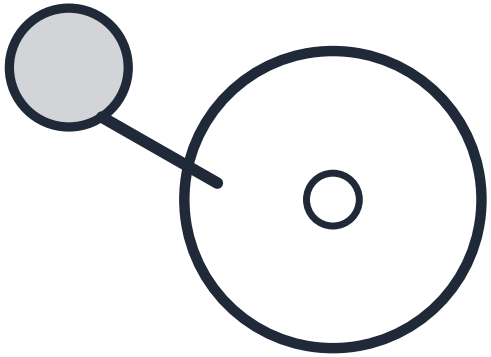
2.2 A car's engine gives a forward force of 500 N. Air resistance and friction total 350 N. Calculate the resultant force and give its direction. [2]



2.3 Explain the difference between a scalar and a vector quantity, giving an example of each. [2]

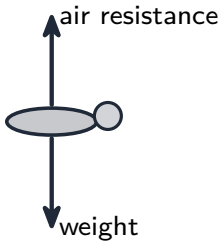


2.4 Give **two** factors that increase a driver's thinking distance. [2]

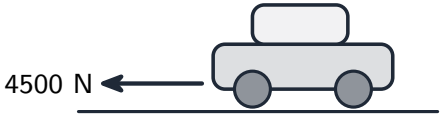


3 Exam-style questions

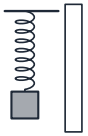
3.1 A skydiver jumps from a plane. Explain why she reaches a terminal velocity. [3]



3.2 A 900 kg car travelling at 20 m/s brakes with a resultant force of 4500 N. Calculate its deceleration and the time it takes to stop. [3]



3.3 A student hangs loads on a spring and measures its length. The results are shown.



load / N	0	1	2	3	4	5	6
length / cm	20.0	22.0	24.0	26.0	28.0	30.5	34.0

(a) Calculate the extension for a load of 3.0 N, and the spring constant in N/m. [3]

(b) Use the results to find the limit of proportionality. Explain your answer. [4]

(c) An unknown mass makes the spring 25.0 cm long. Calculate the mass. [3]

(d) Describe how the student should carry out this experiment accurately and safely. [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

- 6.0×10
- **60** N

2.2

- $500 - 350 =$ **150** N
- forwards

2.3

- a scalar has size only, e.g. speed, mass, energy
- a vector has size and direction, e.g. velocity, force

2.4

Any two (1 mark each): greater speed, tiredness, alcohol or drugs, distractions such as a phone

3.1

- at first her weight is greater than air resistance, so she accelerates
- as her speed increases, air resistance increases
- when air resistance equals her weight, the resultant force is zero and she falls at constant speed

3.2

- $a = 4500 \div 900 = 5.0$ m/s^2
- $t = 20 \div 5.0 =$ **4.0** s

3.3

(a) $26.0 - 20.0 = 6.0$ cm; $k = 3.0 \div 0.060 =$ **50** N/m

(b) up to 4.0 N each newton adds 2.0 cm; from 4.0 to 5.0 N it adds 2.5 cm, and from 5.0 to 6.0 N, 3.5 cm; so extension is no longer proportional to force; limit of proportionality at about 4.0 N

(c) extension 5.0 cm; $F = 50 \times 0.050 = 2.5$ N; mass $= 2.5 \div 10 =$ **0.25** kg

(d) points to include:

- clamp the spring to a stand, with a metre rule held vertically beside it (K)
- measure the length with no load, reading at eye level to avoid parallax (K)
- use a fixed pointer on the bottom of the spring (App)
- add loads in equal steps and measure the length each time (K)
- calculate extension = length − original length; plot force against extension (An)
- safety: clamp the stand to the bench and keep feet away in case the masses fall (App)

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.