Scalar and vector quantities

4.5.1.1 · Forces · revision notes

Scalar quantities have size (magnitude) only; vector quantities have size and direction. You need to sort quantities into the two groups and show vectors as arrows. It is usually tested with short recall and tick-box questions, and it underpins the rest of the Forces topic.

Key facts

- Scalar = magnitude only
- Scalars: distance, speed, mass, time, energy, temperature
- Vector arrow: length = magnitude, arrow direction = direction of the quantity
- Vector = magnitude and direction
- Vectors: displacement, velocity, acceleration, force, weight, momentum
- Mass is a scalar (kg); weight is a force, so it is a vector (N)

Notes

Scalars and vectors

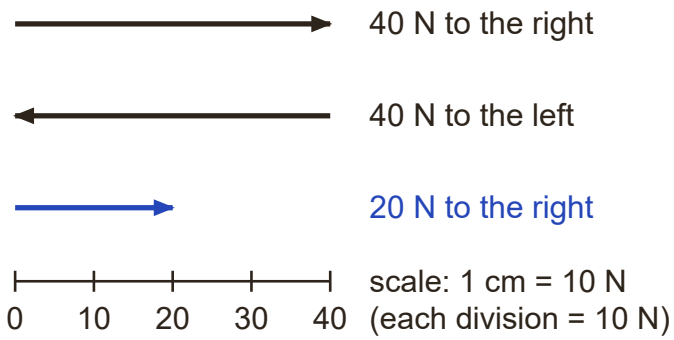
- A **scalar** quantity has **magnitude** (size) only.
- A **vector** quantity has magnitude **and** an associated direction.
- Scalars: distance, speed, mass, time, energy, temperature, power, density.
- Vectors: displacement, velocity, acceleration, force (every force, including weight and friction) and momentum.

Pairs to know

- Distance (scalar) and displacement (vector): displacement is the straight-line distance from start to finish, with a direction.
- Speed (scalar) and velocity (vector): velocity is speed in a given direction.
- Mass (scalar, in kg) and weight (vector, in N): weight is a force, so it has a direction, towards the centre of the Earth.

Drawing vectors as arrows

- A vector quantity can be shown by an arrow.
- The **length** of the arrow shows the magnitude, drawn to a scale.
- The **direction** of the arrow shows the direction of the vector quantity.



Length shows the size (to scale); the arrowhead shows the direction.

- Two arrows of the same length pointing opposite ways show vectors of the same size in opposite directions.
- For motion along a line, you can show direction with a sign: choose one direction as positive, so the opposite direction is negative (e.g. +8 m/s and −8 m/s). Grade 6+ only

How to answer each type of question

Tick-box: identify scalar or vector quantities 1 to 2 marks Grade 3

1. Ask: does this quantity need a direction to describe it fully?
2. If yes, it is a vector; if no, it is a scalar.
3. Tick exactly the number of boxes asked for.

Example. Which **two** of these are vector quantities?
energy / force / mass / speed / velocity

Model answer.

force (1)
velocity (1)

Describe the difference between a scalar and a vector

2 marks | Grade 4

1. Write one sentence about the scalar: magnitude only.
2. Write one sentence about the vector: magnitude and direction.

Example. Speed is a scalar quantity. Velocity is a vector quantity.
Describe the difference between speed and velocity.

Model answer.

Speed has magnitude (size) only (1).

Velocity has magnitude and direction: it is speed in a given direction (1).

Read or draw a vector arrow to scale

1 to 2 marks | Grade 5

1. Use the scale to convert between length and magnitude.
2. Length = magnitude ÷ value of 1 cm; magnitude = length × value of 1 cm.

Example. A force diagram uses a scale of 1 cm = 10 N.
(a) What length of arrow represents a force of 45 N?
(b) An arrow on the diagram is 2.5 cm long. What force does it represent?

Model answer.

(a) 45 ÷ 10 = 4.5 cm (1)

(b) 2.5 × 10 = 25 N (1)

Explain using the idea of a vector

2 marks | Grade 6

1. Say that the quantity is a vector, so direction matters.
2. Apply this to the situation: same size but different direction means a different vector.

Example. Two cars pass each other on a straight road. Each car is travelling at 20 m/s.
A student says the cars have the same velocity. Explain why the student is wrong.

Model answer.

Velocity is a vector, so it includes direction (1).

The cars have the same speed but move in opposite directions, so their velocities are different (e.g. +20 m/s and −20 m/s) (1).

Don’t lose marks

- Calling mass a vector or weight a scalar. Weight is a force, so it is a vector.
- Writing 'a vector has direction' without saying it also has magnitude. You need both for the mark.
- Thinking acceleration is a scalar. Acceleration is a change in velocity, so it has a direction.

- Thinking energy is a vector because it is 'transferred'. Energy is a scalar.
- Drawing force arrows that are not to a consistent scale, so a bigger force has a shorter arrow.

More tips

Memory tricks

- Direction test: if it makes sense to add 'to the left' or 'northwards', the quantity is a vector.
- Learn the pairs scalar-first: distance/displacement, speed/velocity, mass/weight. The second word in each pair is the vector.
- Every force is a vector, so weight, friction, tension, drag and upthrust are all vectors.
- Energy is never a vector: it has no direction, even though it is transferred from place to place.

Exam technique

- For 'describe the difference', write one clear sentence about each type of quantity.
- In tick-box questions, ticking more boxes than asked for usually scores zero for that part.
- Whenever you compare speed with velocity, or distance with displacement, mention direction.

What each grade needs

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

Grade 3 — **Define scalar and vector quantities**
A scalar has magnitude only; a vector has magnitude and an associated direction.

Grade 4 — **Sort common quantities into scalars and vectors**
Distance, speed, mass, time, energy and temperature are scalars; displacement, velocity, acceleration, force and momentum are vectors.

Grade 5 — **Represent a vector with an arrow**
The length of the arrow shows the magnitude and the way it points shows the direction.

Grade 6 — **Draw and read vector arrows to scale**
With a scale of 1 cm = 5 N, a 4.0 cm arrow represents a 20 N force.

Grade 7 — **Explain scalar–vector pairs such as speed and velocity**
Two objects can have the same speed but different velocities if they move in different directions.

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