Distance and displacement

4.5.6.1.1 · Forces · revision notes

Distance is how far an object moves; displacement is how far it ends up from its starting point in a straight line, with a direction. Expect short recall questions and calculations of distance and displacement for journeys, often with a diagram or a map.

Key facts

- Distance = how far an object moves (scalar, m)
- Displacement = straight-line distance from start to finish, with a direction (vector)
- Displacement needs a magnitude and a direction
- Distance travelled ≥ size of the displacement
- Back at the start → displacement = 0
- Along a line: one direction +, the other −

Notes

Distance

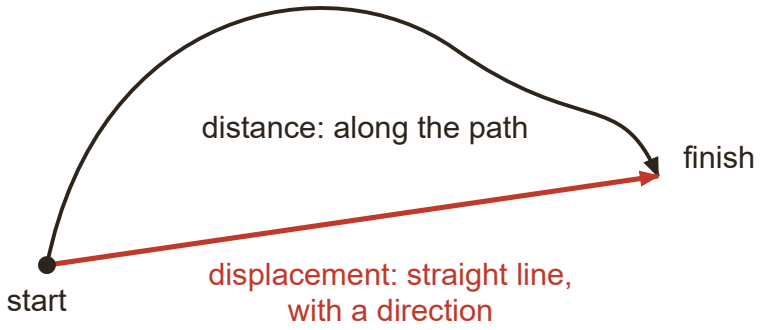
- Distance is how far an object moves along its path.
- Distance does not involve direction, so it is a **scalar** quantity. Its unit is the metre (m).
- For a journey with several parts, add up the lengths of all the parts.

Displacement

- Displacement includes both the distance an object moves, measured in a straight line from the start point to the finish point, and the direction of that straight line.
- Displacement is a **vector** quantity. Give its magnitude and its direction, e.g. 120 m north, or 30 m on a bearing of 045°.
- For motion along a straight line, choose one direction as positive: 5 m to the right is +5 m and 5 m to the left is −5 m.
- On a scale map, measure the straight line from start to finish and use the scale: 3.0 cm on a 1 cm : 20 m map is 3.0 × 20 = 60 m.

Comparing distance and displacement

- The distance travelled is always greater than or equal to the size of the displacement.

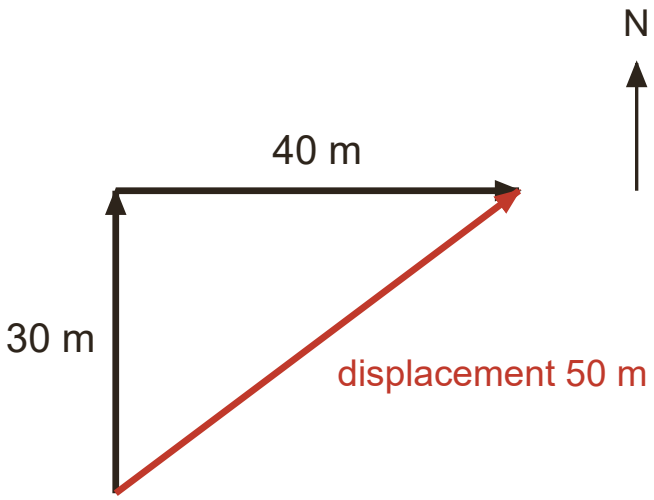


Distance follows the path; displacement is the straight line from start to finish.

- They are equal only when the object moves in one direction along a straight line.
- If an object ends where it started, e.g. after one 400 m lap of a running track, its displacement is zero but the distance travelled is 400 m.

Journeys with a right-angled turn Grade 7+ only

- Draw the two parts of the journey tip-to-tail, to scale. The displacement is the straight line from the start to the finish: measure its length and its angle.
- You can check the magnitude with Pythagoras: 30 m north then 40 m east gives $\sqrt{(30^2 + 40^2)} = 50$ m.



30 m north then 40 m east: displacement = $\sqrt{(30^2 + 40^2)} = 50$ m.

How to answer each type of question

Explain the difference between distance and displacement

2 marks | Grade 4

1. Distance: the length of the whole path, with no direction.
2. Displacement: the straight line from start to finish, with a direction.

Example. A runner completes exactly one lap of a 400 m track.
State the distance travelled and the displacement of the runner. Explain your answers.

Model answer.

Distance = 400 m, because distance is the length of the path followed (1).
Displacement = 0 m, because the runner finishes at the start point (1).

Calculate distance and displacement along a line

3 marks | Grade 5

1. Distance: add the lengths of all the parts.
2. Displacement: take one direction as positive and the other as negative, then add.
3. Give the displacement with a direction.

Example. A dog runs 35 m east along a beach, then 12 m west.
(a) Calculate the total distance the dog travels.
(b) Calculate the displacement of the dog from its starting point.

Model answer.

(a) 35 + 12 = 47 m (1)
(b) 35 − 12 = 23 m (1) east (1)

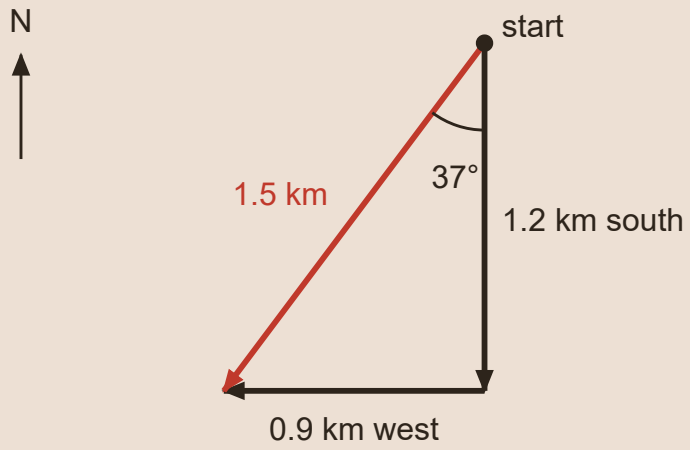
Displacement for a journey with a right-angled turn

3 marks | Grade 7

1. Draw the journey to scale, tip-to-tail, or use Pythagoras for the magnitude.
2. Measure (or calculate) the angle from a stated direction.
3. Give the magnitude and the direction.

Example. A walker walks 1.2 km due south and then 0.9 km due west.
Determine the size and direction of the walker's displacement.

Model answer.



$\sqrt{(1.2^2 + 0.9^2)}$ or a scale drawing (1)

= 1.5 km (1)

direction about 37° west of south (a bearing of about 217°) (1)

Don't lose marks

- Giving a displacement without a direction.
- Adding the parts of an out-and-back journey to find the displacement instead of subtracting them.
- Saying distance and displacement are the same thing.
- In scale drawings, not saying which direction an angle is measured from.

More tips

Memory tricks

- Displacement = 'as the crow flies, plus which way'.
- Distance: add everything. Displacement: use + and − for opposite directions.
- Right-angled journeys often use 3-4-5 triangles: 30 and 40 give 50; 0.9 and 1.2 give 1.5.

Exam technique

- Use the words 'magnitude and direction' when you define displacement.
- If a question uses compass directions, give your answer with a compass direction or a bearing.
- Show your Pythagoras working, or write the scale you used for a scale drawing.

What each grade needs

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

Grade 3

State that distance is a scalar

Distance is how far an object moves; it does not involve direction.

Grade 4

State that displacement is a vector

Displacement is the straight-line distance from the start point to the finish point, with the direction of that line.

Grade 5

Calculate distance and displacement along a line

40 m east then 15 m west: distance 55 m, displacement 25 m east.

Grade 5

Explain why displacement can be zero

After a round trip back to the start, the displacement is zero although the distance travelled is not.

Grade 5

Give displacement as magnitude and direction

For example 25 m east, 300 m on a bearing of 045°, or −5 m along a line.

Grade 7

Find the displacement for a right-angled journey

Use a scale drawing (or Pythagoras): 30 m north then 40 m east is 50 m at about 53° east of north.

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