Velocity

4.5.6.1.3 · Forces · revision notes

Velocity is speed in a given direction, so it is a vector. You need to explain the difference between speed and velocity and, on the Higher tier, explain why an object moving in a circle at constant speed has a changing velocity.

Key facts

- Velocity = speed in a given direction
- Unit of velocity: m/s, with a direction
- Along a line: + for one direction, − for the opposite direction
- Grade 8+ only Changing velocity = acceleration, which needs a resultant force
- Velocity is a vector; speed is a scalar
- Velocity changes if the speed OR the direction changes
- Grade 7+ only Circular motion at constant speed: velocity is changing, so the object is accelerating

Notes

Speed and velocity

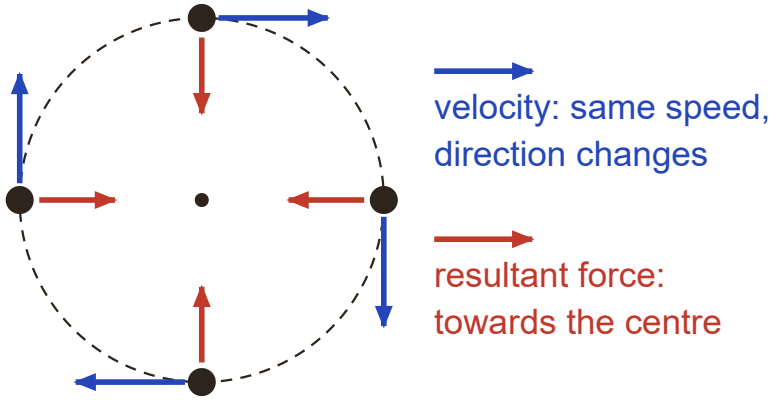
- The **velocity** of an object is its speed in a given direction.
- A **vector** quantity has magnitude and direction; a **scalar** quantity has magnitude only. Velocity and displacement are vectors; speed and distance are scalars.
- Velocity has the same unit as speed, m/s, but you also give a direction, e.g. 25 m/s north.
- Along a straight line, you can show direction with a sign: +3 m/s forwards, −3 m/s backwards.

When does velocity change?

- Velocity changes if the speed changes, if the direction changes, or if both change.
- A car going round a bend at a steady 15 m/s has a constant speed but a changing velocity.
- Two objects with the same speed moving in different directions have different velocities.
- A change in velocity is an acceleration, and it needs a resultant force.

Motion in a circle Grade 7+ only

- An object moving in a circle at a constant speed is changing direction all the time.
- Velocity includes direction, so the object's velocity is changing all the time.
- So the object is accelerating, even though its speed stays the same. A resultant force acts on it, towards the centre of the circle.



Moving in a circle at a steady speed: the velocity keeps changing direction, so the object is accelerating.

- Examples: a satellite or a moon in a circular orbit, a car driving round a roundabout at a steady speed, a ball whirled round on a string.

How to answer each type of question

Explain the difference between speed and velocity 2 marks Grade 4

1. Say that speed is a scalar: magnitude only.
2. Say that velocity is a vector: speed in a given direction.

Example. Explain the difference between speed and velocity.

Model answer.

Speed is a scalar: it has magnitude only (1).

Velocity is a vector: it is speed in a given direction (1).

Velocities with signs

3 marks **Grade 6**

1. Choose a positive direction.
2. Give each velocity a sign.
3. Change in velocity = final velocity − initial velocity.

Example. A ball moving at 5.0 m/s to the right hits a wall and bounces back at 4.0 m/s to the left. Take 'to the right' as positive.
(a) Write down the velocity of the ball before it hits the wall.
(b) Write down the velocity of the ball after it bounces.
(c) Calculate the change in velocity of the ball.

Model answer.

(a) +5.0 m/s (1)

(b) −4.0 m/s (1)

(c) −4.0 − (+5.0) = −9.0 m/s, i.e. 9.0 m/s to the left (1)

Compare velocities in a situation

2 marks **Grade 6**

1. Check whether the speed changes.
2. Check whether the direction changes.
3. If either changes, the velocity changes.

Example. A lorry travels at a steady speed of 20 m/s, first along a straight road and then round a bend.
Compare the lorry's velocity on the straight road with its velocity on the bend.

Model answer.

On the straight road the velocity is constant, because the speed and the direction are both constant (1).

On the bend the direction changes, so the velocity changes even though the speed stays at 20 m/s (1).

Explain circular motion

3 marks | Grade 7

1. State that velocity is a vector (speed in a given direction).
2. Say that the direction of motion changes continuously.
3. Conclude that the velocity changes, so the object is accelerating.

Example. The Moon moves around the Earth in an almost circular orbit at a constant speed. Explain why the Moon is accelerating.

Model answer.

Velocity is a vector: it is speed in a given direction (1).
The Moon's direction of motion is changing all the time (1)
so its velocity is changing, and a change in velocity is an acceleration (1).

Don't lose marks

- Saying velocity is 'the same as speed'.
- Saying an object moving in a circle at constant speed is not accelerating.
- Giving a velocity without a direction or a sign.
- After a bounce, subtracting the speeds (5 − 4 = 1 m/s) instead of the velocities (−4 − 5 = −9 m/s).

More tips

Memory tricks

- Velocity = speed + direction.
- Steering wheel test: turning the wheel changes your velocity, even if the speedometer reading stays the same.
- Circle at constant speed = changing velocity = accelerating. This is a favourite Higher 'explain' question.

Exam technique

- Whenever a question says 'velocity', think about direction as well as speed.
- For circular motion, use the chain: direction changes → velocity changes → accelerating (→ resultant force).
- Use the word 'vector' when you explain what velocity is.

What each grade needs

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

Grade 3 — **Define velocity**
The velocity of an object is its speed in a given direction.

Grade 4 — **Explain the difference between speed and velocity**
Speed is a scalar (magnitude only); velocity is a vector (magnitude and direction).

Grade 5 — **Use + and − signs for velocity**
Along a line, e.g. +4 m/s to the right and −4 m/s to the left.

Grade 6 — **Explain when velocity changes**

Velocity changes if the speed changes, if the direction changes, or if both change.

Grade 7

Explain circular motion: constant speed, changing velocity

The direction of motion changes all the time, so the velocity changes even though the speed stays the same.

Grade 8

Link changing velocity to acceleration and force

A changing velocity is an acceleration, so there must be a resultant force on the object.

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