

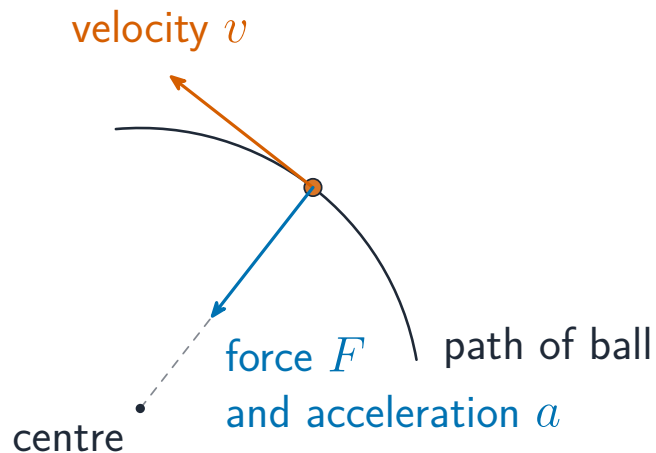
Exercise walk-through

12.2

Centripetal acceleration

A-Level Physics

Centripetal acceleration



Constant **speed**, changing **velocity** – the direction keeps turning, so there *is* an acceleration:

$$a = \frac{v^2}{r} = r\omega^2$$

(equal, because $v = r\omega$ – pick the form matching your data).

a is **perpendicular** to v at every instant. Any part **along** the motion would change the speed.

Exercises 2.1·2.2

2.1 A car drives round a roundabout at a steady $12 \frac{\text{m}}{\text{s}}$. Explain why the car is **accelerating** even though its speed never changes, and state the direction of that acceleration.[3]

2.2 Write **two** forms of the centripetal acceleration equation.

[2]

Exercises 2.1·2.2

2.1 A car drives round a roundabout at a steady $12 \frac{\text{m}}{\text{s}}$. Explain why the car is **accelerating** even though its speed never changes, and state the direction of that acceleration.[3]

2.1

- velocity is a **vector**, so it changes whenever the **direction** of travel changes, even at constant speed
- a changing velocity means the car is accelerating
- that acceleration is directed towards the **centre** of the roundabout, at right angles to the velocity

2.2 Write **two** forms of the centripetal acceleration equation. [2]

2.2

- $a = v^2/r$
- $a = r\omega^2$

Exercises 2.3-2.4

2.3 A 0.20 kg ball is whirled in a horizontal circle of radius 0.50 m at $3.0 \frac{\text{m}}{\text{s}}$. Find the centripetal force. [2]

2.4 State what provides the centripetal force for a car turning a **flat** corner. [1]

Exercises 2.3·2.4

2.3 A 0.20 kg ball is whirled in a horizontal circle of radius 0.50 m at $3.0 \frac{\text{m}}{\text{s}}$. Find the centripetal force. [2]

2.3

- $m = 0.20 \text{ kg}$, $v = 3.0 \frac{\text{m}}{\text{s}}$, $r = 0.50 \text{ m}$
- $F = mv^2/r$

$$F = \frac{mv^2}{r} = \frac{(0.20 \text{ kg})(3.0 \frac{\text{m}}{\text{s}})^2}{0.50 \text{ m}} = \mathbf{3.6 \text{ N}}$$

2.4 State what provides the centripetal force for a car turning a **flat** corner. [1]

2.4

- **friction** between the tyres and the road

Exercise 3.1

3.1 For an object in uniform circular motion, the centripetal force is directed: [1]

☐

A along the velocity

B towards the centre

C away from the centre

D opposite to the velocity

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3.1 For an object in uniform circular motion, the centripetal force is directed: [1]

☐

A along the velocity

B towards the centre

C away from the centre

D opposite to the velocity

3.1 B

- the centripetal force (and the acceleration) is directed **towards the centre**
- **A** is the tangent (velocity); **C** is the fictitious “centrifugal” direction; **D** would reverse the motion

Exercise 3.2

3.2 A car of mass 900 kg turns a corner of radius 30 m at $15 \frac{\text{m}}{\text{s}}$. Calculate the **centripetal force** needed. [3]

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3.2

- $m = 900 \text{ kg}$, $v = 15 \frac{\text{m}}{\text{s}}$, $r = 30 \text{ m}$
- $F = mv^2/r$

$$F = \frac{mv^2}{r} = \frac{(900 \text{ kg})(15 \frac{\text{m}}{\text{s}})^2}{30 \text{ m}} = 6750 \text{ N} \approx \mathbf{6.8 \times 10^3 \text{ N}}$$

Exercise 3.3 (a)

3.3 An electron of mass 9.1×10^{-31} kg moves in a circle of radius 5.3×10^{-11} m. The electric force on it is 8.2×10^{-8} N and provides the centripetal force.

(a) State why the electron is **accelerating** even though its speed is constant. [1]

Exercise 3.3 (a)

3.3 An electron of mass 9.1×10^{-31} kg moves in a circle of radius 5.3×10^{-11} m. The electric force on it is 8.2×10^{-8} N and provides the centripetal force.

(a) State why the electron is **accelerating** even though its speed is constant. [1]

(a) its **velocity is changing direction**, and a changing velocity is an acceleration (towards the centre)

Exercise 3.3 (b)

3.3 An electron of mass 9.1×10^{-31} kg moves in a circle of radius 5.3×10^{-11} m. The electric force on it is 8.2×10^{-8} N and provides the centripetal force.

(b) Calculate the **speed** of the electron.

[3]

Exercise 3.3 (b)

3.3 An electron of mass 9.1×10^{-31} kg moves in a circle of radius 5.3×10^{-11} m. The electric force on it is 8.2×10^{-8} N and provides the centripetal force.

(b) Calculate the **speed** of the electron.

[3]

(b) the electric force is the centripetal force: $F = mv^2/r$, so $v = \sqrt{Fr/m}$

$$v = \sqrt{\frac{Fr}{m}} = \sqrt{\frac{(8.2 \times 10^{-8} \text{ N})(5.3 \times 10^{-11} \text{ m})}{9.1 \times 10^{-31} \text{ kg}}} = \mathbf{2.2 \times 10^6 \frac{m}{s}}$$

Exercise 3.4

3.4 A stone is whirled on a string in a horizontal circle. State what provides the centripetal force, and describe its motion **if the string breaks**. [2]

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3.4

- the **tension** in the string provides it
- if the string breaks the stone flies off along a **straight line (the tangent)**, since there is no longer a centripetal force