Exercise walk-through

Circular Motion ▪ 2.9

eXercise

You must be able to

- define **uniform circular motion** 匀速圆周运动 as motion in a circle at constant speed
- use the **centripetal acceleration** 向心加速度 $a_c = \frac{v^2}{r}$, directed toward the centre
- identify the net force that provides the **centripetal force** 向心力 $F_c = \frac{mv^2}{r}$
- relate the **period** 周期, **frequency** 频率, and speed of circular motion

Method — Centripetal acceleration points inward

Even at constant speed, the **direction** of velocity changes, so there is an acceleration $a_c = \dfrac{v^2}{r}$ toward the centre. A car at 10 m s^{-1} on a 20 m radius bend:

$$a_c = \frac{10^2}{20} = 5.0 \text{ m s}^{-2}.$$

Method — The centripetal force is a role, not a new force

Some **real** force (friction, tension, gravity, normal) provides $F_c = \frac{mv^2}{r}$. For the car, friction supplies it: $F_c = \frac{mv^2}{r}$.

Method — Period and frequency

The object covers one circumference per period: $v = \dfrac{2\pi r}{T}$, and frequency $f = \dfrac{1}{T}$.

Practice 2.1 ▪ 2 marks

A ball moves at 4.0 m s^{-1} in a circle of radius 2.0 m. Find its centripetal acceleration.

Solution 2.1

Method: Centripetal acceleration points inward

Worked steps

$$a_c = \frac{v^2}{r} = \frac{4.0^2}{2.0} = 8.0 \text{ m s}^{-2}$$ M1 A1.

Practice 2.2 ▪ 1 mark

Name the force that keeps a car moving around a flat circular track.

Solution 2.2

Worked steps

friction (between the tyres and the road) B1.

Practice 2.3 ▪ 1 mark

A 0.50 kg ball moves in a circle with centripetal acceleration 8.0 m s^{-2}. Find the centripetal force.

Solution 2.3

Method: Centripetal acceleration points inward

Worked steps

$F_c = ma_c = 0.50 \times 8.0 = 4.0$ N B1.

Practice 2.4 ▪ 1 mark

An object completes a circle in 0.25 s. Find its frequency.

Solution 2.4

Method: Period and frequency

Worked steps

$$f = \frac{1}{T} = \frac{1}{0.25} = 4.0 \text{ Hz}$$ B1.

Exam-style 3.1 ▪ 1 mark

For an object in uniform circular motion, the net force points

A along the velocity

B opposite the velocity

C toward the centre

D away from the centre

Solution 3.1

A along the velocity

B opposite the velocity

C toward the centre ✓

D away from the centre

Worked steps

C.

Exam-style 3.2 ▪ 1 mark

If the speed of an object in a circle doubles (same radius), the centripetal acceleration becomes

A unchanged

B twice as large

C four times as large

D half as large

Solution 3.2

Method: Centripetal acceleration points inward

A unchanged

B twice as large

C four times as large ✓

D half as large

Worked steps

C — $a_c \propto v^2$.

Exam-style 3.3 ▪ 2 marks

A 0.20 kg ball on a string moves in a horizontal circle of radius 0.50 m at 3.0 m s^{-1}.
(a) Find the centripetal acceleration.
(b) Find the tension in the string (the centripetal force).

Solution 3.3

Method: Centripetal acceleration points inward

Worked steps

(a) $a_c = \dfrac{3.0^2}{0.50} = 18$ m s^{-2} M1 A1. (b) $F_c = ma_c = 0.20 \times 18 = 3.6$ N M1 A1.