AP PHYSICS C: MECHANICS • EXERCISE SHEET

2.10 Circular Motion

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS centripetal force 向心力 • centripetal acceleration 向心加速度 • friction 摩擦力 • force 力 • net force 合力

Objective

Build the skills to answer exam questions on **circular motion**.

You must be able to:

- use the **centripetal acceleration** 向心加速度: $a_c = \dfrac{v^2}{r}$
- use the **centripetal force** 向心力: $F_c = \dfrac{mv^2}{r}$, directed toward the centre
- identify which real force provides the centripetal force (gravity, tension, friction, normal)
- explain that speed can be constant while velocity changes direction

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Centripetal acceleration and force

An object moving in a circle of radius r at speed v accelerates toward the centre:

$$a_c = \frac{v^2}{r}, \qquad F_c = ma_c = \frac{mv^2}{r}.$$

For $m = 2$ kg, $v = 4$ m s^{-1}, $r = 8$ m: $F_c = \dfrac{2(4)^2}{8} = 4$ N.

■ A real force supplies it

Centripetal force is not a new force – it is provided by tension (a ball on a string), gravity (a satellite), friction (a car turning), or the normal force.

■ Constant speed, changing velocity

In uniform circular motion the speed is constant, but the direction keeps changing, so the velocity changes – there is an acceleration toward the centre.

2 Practice

Now apply the methods above.

2.1 State the direction of the centripetal acceleration. [1]

2.2 A 3 kg ball moves in a circle of radius 2 m at 4 m s^{-1}. Find the centripetal force. [2]

2.3 Name the force that keeps a car turning on a flat road. [1]

2.4 An object has $v = 6$ m s^{-1} and $r = 3$ m. Find its centripetal acceleration. [2]

3 Exam-style questions

3.1 For uniform circular motion, the net force points [1]

- **A** along the velocity
- **B** toward the centre
- **C** away from the centre
- **D** upward

3.2 Doubling the speed of an object in a fixed circle changes the centripetal force by a factor of [1]

- **A** 2
- **B** 4
- **C** 1/2
- **D** 1

3.3 A 0.5 kg ball on a string moves in a horizontal circle of radius 1 m at 3 m s^{-1}.

(a) Find the centripetal force. [2]

(b) State what provides this force. [1]

3.4 A car of mass 1000 kg rounds a curve of radius 50 m at 10 m s^{-1}.

(a) Find the centripetal acceleration. [2]

(b) Find the friction force needed to keep it on the curve. [1]

Solutions

2.1 Toward the centre of the circle.

2.2 $F_c = \dfrac{mv^2}{r} = \dfrac{3(4)^2}{2} = 24$ N.

2.3 Friction (between the tyres and the road).

2.4 $a_c = \dfrac{v^2}{r} = \dfrac{6^2}{3} = 12$ m s^{-2}.

3.1 **B** — the centripetal force points toward the centre.

3.2 **B** — $F_c \propto v^2$, so doubling v gives $2^2 = 4$ times.

3.3 (a) $F_c = \dfrac{0.5(3)^2}{1} = 4.5$ N. (b) The tension in the string.

3.4 (a) $a_c = \dfrac{10^2}{50} = 2$ m s^{-2}. (b) $F = ma_c = 1000 \times 2 = 2000$ N.