3.3 Circular motion

Name: _____ Class: _____ Date: _____ **Total: 16 marks**

KEY WORDS angular speed • centripetal acceleration • vertical circle • horizontal circle • circular motion

Objective

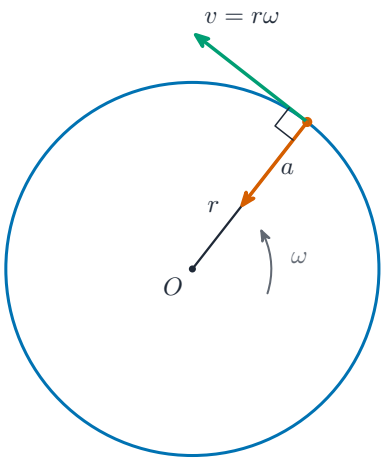
Build the skills to answer exam questions on **circular motion** – **angular speed**, **centripetal acceleration**, the **conical pendulum**, and motion in a **vertical circle**. Take $g = 10$ m s^{-2}.

You must be able to:

- use $v = r\omega$ and $a = r\omega^2 = \dfrac{v^2}{r}$
- analyse a horizontal circle (conical pendulum)
- use energy + the centripetal equation for a vertical circle

1 Key knowledge and worked examples

■ Centripetal force



Velocity points along the tangent; acceleration points inward to the centre

$r = 2$ **m,** $\omega = 3$ **rad s^{-1}:** $v = r\omega = 6$ m s^{-1}; $a = r\omega^2 = 18$ m s^{-2}.

Centripetal force $= ma = \dfrac{mv^2}{r}$, provided by tension, friction or a component of weight.

■ Key knowledge: A vertical-circle contact condition

Write the radial force equation at the top before using energy. A light string can pull, not push; its tension must stay non-negative.

■ Worked example: A vertical-circle contact condition

For a particle on a string of length 1 m, at the top $T + mg = mv^2/r$. At limiting tension $T = 0$, $v_{\text{top}}^2 = gr = 10$. From bottom to top, energy gives $v_{\text{bottom}}^2 = v_{\text{top}}^2 + 4gr = 50$. Thus the limiting bottom speed is $\sqrt{50} \approx 7.07\,\text{m}\,\text{s}^{-1}$.

2 Practice

2.1 A particle moves in a circle of radius 0.5 m at 4 m s^{-1}. Find its acceleration. [2]

2.2 Convert an angular speed of 120 rev/min to rad s^{-1}. [2]

3 Exam-style questions

3.1 The centripetal acceleration of a particle moving at speed v in a circle of radius r is: [1]

☐ **A** $\dfrac{v}{r}$
B $\dfrac{v^2}{r}$
C vr
D $\dfrac{r}{v^2}$

3.2 A particle of mass 0.2 kg is attached to a string of length 0.5 m and whirled in a horizontal circle on a smooth table at 3 rev s^{-1}.

(a) Find the angular speed in rad s^{-1}. [2]

(b) Find the tension in the string. [3]

3.3 A conical pendulum has a bob of mass 0.4 kg on a string of length 1 m, which makes an angle of 30° with the vertical.

(a) Find the tension in the string. [3]

(b) Find the angular speed of the bob. [3]