3 Further Mechanics – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

English	**中文**	**Write it 3 times** (English)
projectile	抛射体	
angular speed	角速度	
centripetal acceleration	向心加速度	

Recall

In AS Mechanics you used the suvat equations and $F = ma$. Bring this with you:

- free fall has a constant downward acceleration g;
- a velocity has a size and a direction (it is a vector).

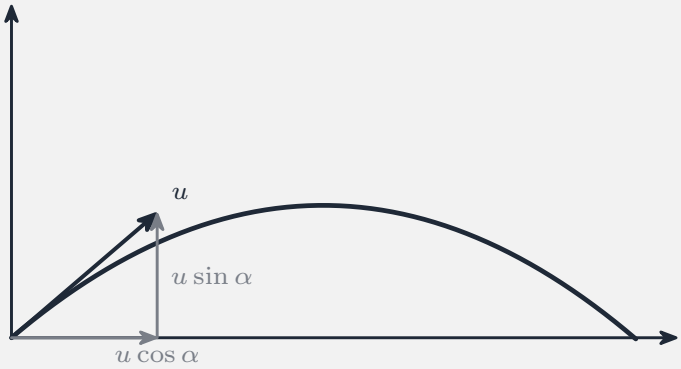
Further Mechanics adds motion in **two directions** (projectiles) and motion in a **circle**. (Take $g = 10$ m s^{-2}.)

New ideas

■ 1 Projectile motion

A **projectile** 抛射体 moves freely under gravity: a constant downward acceleration g, and **no** horizontal acceleration. Treat the horizontal and vertical motions **separately** (they share the same time t).

Launched at speed u and angle α: the path is a parabola, the range on level ground is $\dfrac{u^2 \sin 2\alpha}{g}$, and the greatest height is $\dfrac{u^2 \sin^2 \alpha}{2g}$.



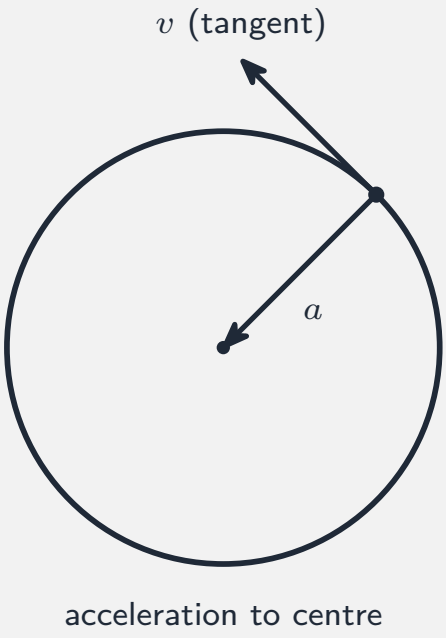
Worked example. $u = 20$ m s^{-1} at $\alpha = 30°$: range $= \dfrac{20^2 \sin 60°}{10} = 34.6$ m.

Micro-check. A projectile is launched. State its horizontal acceleration. [1]

■ 2 Circular motion

For a particle moving in a circle of radius r, the **angular speed** 角速度 ω links to the speed by $v = r\omega$. The acceleration points **towards the centre** —the **centripetal acceleration** 向心加速度:

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



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

Micro-check. A particle moves in a circle with $r = 4$ m and $\omega = 2$ rad s^{-1}. Find its speed v. [1]

Watch out: a projectile's **horizontal** acceleration is zero —gravity acts only vertically, so the horizontal speed never changes. The centripetal acceleration points **towards the centre**, not along the motion, and $v = r\omega$ needs ω in radians per second.

Practice

3.1 Explain why the horizontal and vertical motions of a projectile can be treated **separately**. [2]

3.2 A ball is launched at $u = 30$ m s^{-1} at $\alpha = 30°$. Find the range ($\sin 60° = 0.866$). [2]

3.3 A particle moves in a circle of radius 3 m with angular speed 4 rad s^{-1}. Find its speed. [2]

3.4 Using the particle in 3.3, find its centripetal acceleration ($a = r\omega^2$). [2]

3.5 State the **direction** of the centripetal acceleration. [1]

3.6 Challenge. A ball is thrown **horizontally** at 15 m s^{-1} from a height of 20 m. Find the time it takes to land and how far it travels horizontally. (Take $g = 10$ m s^{-2}.) [3]