Exercise walk-through

Work ▪ 3.2

eXercise

You must be able to

- calculate **work 功**: $W = Fd\cos\theta$
- explain that only the force component along the displacement does work
- state that a perpendicular force does zero work
- apply the **work-energy theorem 功能定理**: $W_{net} = \Delta K$

Method — Work done by a force

$$W = Fd\cos\theta,$$

where θ is the angle between the force and the displacement. A 10 N force pulling a box 3 m in its own direction ($\theta = 0$) does $W = 10 \times 3 = 30$ J.

Method — Angled and perpendicular forces

At an angle θ, only $F\cos\theta$ does work. If $\theta = 90^\circ$, $\cos 90^\circ = 0$, so the force does **no work** – like the normal force on a sliding box, or gravity on a horizontal path.

Method — Work-energy theorem

The net work equals the change in kinetic energy:

$$W_{net} = \Delta K = \tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2.$$

Practice 2.1 ▪ 2 marks

A 20 N force pushes a crate 4 m in its own direction. Find the work done.

Solution 2.1

Method: Work done by a force

Worked steps

$W = Fd\cos 0 = 20 \times 4 = 80$ J **M1** **A1**.

Practice 2.2 ▪ 1 mark

State the work done by a force acting perpendicular to the motion.

Solution 2.2

Worked steps

Zero B1.

Practice 2.3 ▪ 2 marks

A 50 N force acts at $60°$ to a 2 m displacement. Find the work done.

Solution 2.3

Method: Work done by a force

Worked steps

$W = 50 \times 2 \times \cos 60^\circ = 50$ J **M1** **A1**.

Practice 2.4 ▪ 1 mark

State what the net work done on an object equals.

Solution 2.4

Worked steps

The change in its kinetic energy B1.

Exam-style 3.1 ▪ 1 mark

The work done by a force perpendicular to the displacement is

A maximum

B zero

C negative

D equal to Fd

Solution 3.1

Method: Work done by a force

A maximum

B zero ✓

C negative

D equal to Fd

Worked steps

B — $\cos 90^\circ = 0$, so no work.

Exam-style 3.2 ▪ 1 mark

The work-energy theorem states that the net work equals the change in

A momentum

B kinetic energy

C mass

D velocity

Solution 3.2

Method: Work-energy theorem

A momentum

B kinetic energy ✓

C mass

D velocity

Worked steps

B — net work equals the change in kinetic energy.

Exam-style 3.3 ▪ 2 marks

A 30 N force drags a sled 5 m at 37° above the horizontal.
(a) Find the work done by the force.
(b) State why the vertical component does no work here.

Solution 3.3

Worked steps

(a) $W = 30 \times 5 \times \cos 37^\circ = 120$ J M1 A1. (b) The vertical component is perpendicular to the horizontal displacement B1.

Exam-style 3.4 ▪ 2 marks

A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1}.
(a) Find the change in kinetic energy.
(b) State the net work done on it.

Solution 3.4

Method: Work-energy theorem

Worked steps

(a) $\Delta K = \frac{1}{2}(2)(5^2 - 3^2) = 16$ J M1 A1. (b) 16 J B1.