

3.2 Work

Name: _____ Class: _____ Date: _____

Total: 14 marks**KEY WORDS** work 功 • work-energy theorem 功能定理 • normal force 法向力 • kinetic energy 动能

Objective

Build the skills to answer exam questions on **work**.**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: $W_{net} = \Delta K$

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.

■ 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.

■ 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.

■ Work-energy theorem

The net work equals the change in kinetic energy:

$$W_{net} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2.$$

2 Practice

Now apply the methods above.

2.1 A 20 N force pushes a crate 4 m in its own direction. Find the work done. [2]

2.2 State the work done by a force acting perpendicular to the motion. [1]

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

2.4 State what the net work done on an object equals. [1]

3 Exam-style questions

3.1 The work done by a force perpendicular to the displacement is [1]

- **A** maximum
 - **B** zero
 - **C** negative
 - **D** equal to Fd
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3.2 The work-energy theorem states that the net work equals the change in [1]

- **A** momentum
 - **B** kinetic energy
 - **C** mass
 - **D** velocity
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3.3 A 30 N force drags a sled 5 m at 37° above the horizontal.

(a) Find the work done by the force. [2]

- (b) State why the vertical component does no work here. [1]

3.4 A 2 kg block speeds up from 3 m s^{-1} to 5 m s^{-1} .

- (a) Find the change in kinetic energy. [2]
(b) State the net work done on it. [1]

Solutions

2.1 $W = Fd \cos 0 = 20 \times 4 = 80 \text{ J}.$

2.2 Zero.

2.3 $W = 50 \times 2 \times \cos 60^\circ = 50 \text{ J}.$

2.4 The change in its kinetic energy.

3.1 B — $\cos 90^\circ = 0$, so no work.

3.2 B — net work equals the change in kinetic energy.

3.3 (a) $W = 30 \times 5 \times \cos 37^\circ = 120 \text{ J}.$ (b) The vertical component is perpendicular to the horizontal displacement.

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