AP PHYSICS 1 • EXERCISE SHEET

3.2 Work

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

KEY WORDS work 功 • angle 角度 • energy 能量 • joules 焦耳

Objective

Build the skills to answer exam questions on **work**.

You must be able to:

- define **work** 功 as $W = Fd\cos\theta$
- explain how the **angle** 角度 between force and displacement makes work positive, negative, or zero
- calculate the work done by a constant force
- find the work done by a variable force from the **area** under a force-position graph

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ The work formula

$W = Fd\cos\theta$, where θ is the angle between the force and the displacement. Work is a scalar, measured in joules.

■ The sign of work

- $\theta < 90°$ → **positive** work (energy added)
- $\theta = 90°$ → **zero** work (e.g. the normal force on a box sliding along a flat floor)
- $\theta > 90°$ → **negative** work (e.g. friction opposing motion)

■ Variable force

The work done by a changing force is the **area under the force-versus-position graph**.

2 Practice

2.1 A 30 N force pushes a box 4.0 m in the direction of the force. Find the work done. [1]

2.2 State the work done by the normal force on a box sliding along a flat floor, and why. [2]

2.3 A 50 N force drags a crate 10 m at 37° above the horizontal ($\cos 37° \approx 0.80$). Find the work done. [2]

2.4 A force-position graph is a rectangle 10 N tall and 3.0 m wide. Find the work done. [1]

3 Exam-style questions

3.1 The work done by a force is zero when the angle between the force and the displacement is [1]

- **A** 0°
- **B** 45°
- **C** 90°
- **D** 180°

3.2 Friction acting on a sliding object does [1]

- **A** positive work
- **B** negative work
- **C** zero work
- **D** undefined work

3.3 A child pulls a sled with a 40 N force at 30° above the horizontal for 20 m ($\cos 30° \approx 0.87$).

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

(b) Explain why the vertical component of the pull does no work here. [1]

Solutions

2.1 $W = Fd = 30 \times 4.0 = 120$ J.

2.2 zero — the normal force is perpendicular to the motion ($\theta = 90°$, $\cos 90° = 0$).

2.3 $W = 50 \times 10 \times 0.80 = 400$ J.

2.4 area $= 10 \times 3.0 = 30$ J.

3.1 **C**.

3.2 **B**.

3.3 (a) $W = 40 \times 20 \times \cos 30° = 800 \times 0.87 = 696$ J. (b) the sled moves horizontally, so the vertical component is perpendicular to the displacement and does no work.