5.2 Work done and energy transfer

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS force

Objective

Use $W = Fs$ with the distance along the line of action, tell the energy-transfer story, and link frictional work to temperature rise. Original questions for spec statement 4.5.2.

1 Key knowledge and worked examples

A force does **work** when it causes a displacement:

$$W = Fs$$

- W work done in J; F force in N; s distance **moved along the line of action of the force** in m.
- **1 joule = 1 newton-metre**: 1 J is 1 N moving something 1 m. Convert freely: 240 N · m = 240 J.

Build an explanation that fits the question; identify the force, the energy transfer and any heating:

1. work is done **by the force** on the object;
2. energy is transferred **from** the agent (chemical store of a person, kinetic store of a vehicle) **to** the object;
3. work done **against friction** raises the object's (and surface's) **temperature** – energy dissipates to thermal stores.

Worked example. A child pushes a baby walker 2.8 m along the floor with a horizontal force of 25 N.

- The force and the movement are both horizontal – the distance is along the line of action.

$$W = Fs = 25\ \text{N} \times 2.8\ \text{m} = 70\ \text{J}$$

Worked example (vertical). A crane lifts a 250 kg beam 12 m at steady speed (g = 9.8 N/kg).

- Steady lift means the crane's force equals the weight: $F = mg = 250 \times 9.8 = 2450$ N.

$$W = Fs = 2450 \times 12 = 29\,400\ \text{J} \approx 29\ \text{kJ}$$

- The energy transfers to the beam's gravitational potential store (see topic 1).

Watch the wording: a force at right angles to the motion (a vertical normal force under a horizontally-moving box) does **no** work along that path – s must lie along the force's line of action.

2 Practice

2.1 A box is dragged 8.0 m by a 60 N force along its direction. Calculate the work done. [2]

2.2 A 50 N force does 350 J of work. Calculate the distance moved along its line of action. [2]

2.3 State what happens to the energy when work is done against friction, and give the units equivalence for one joule. [2]

3 Exam-style questions

3.1 A child pulls a toy car 4.5 m across a carpet with a horizontal force of 2.0 N.

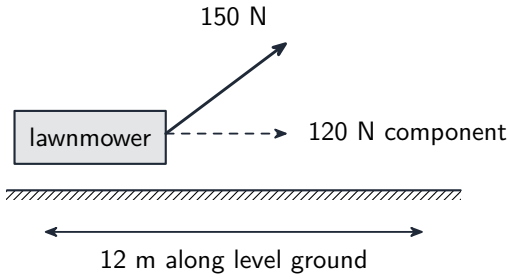
(a) Calculate the work done by the child. [3]

(b) The same pull moves the car the same distance on a smoother floor where friction is smaller. Compare the work done by the pull and the energy dissipated by friction. [2]

(c) The child then pushes with 2.0 N at right angles to the car's motion while it coasts 4.5 m. Explain why this force does no work on the car. [2]

3.2 A gardener pushes a lawnmower with a force of 150 N at an angle along a 12 m stretch of level ground (the force's component along the motion is 120 N).

(a) Explain which distance enters $W = Fs$ here. [1]

(b) Calculate the work done by the 150 N force along the 12 m stretch. [2]

(c) Over the 12 m the frictional force totals 100 N opposing the motion. Calculate the work done against friction and explain the associated energy transfer. [3]