2.1 Forces work and power

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

Objective

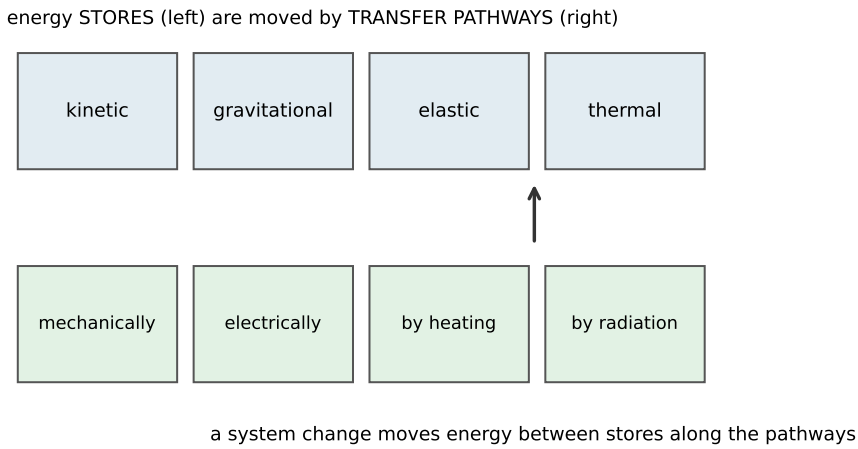
Cover forces and energy (3.2.1): W = Fd with friction heating, elastic energy ½ke^2, GPE = mgh, KE = ½mv^2 with the doubling rules, and power P = E/t. Original OxfordAQA practice.

1 Key knowledge and worked examples

■ **Four equations, one chain**

$$W = Fd \qquad E_e = \tfrac{1}{2}ke^2 \qquad E_p = mgh \qquad E_k = \tfrac{1}{2}mv^2 \qquad P = E/t$$

Worked check. A 0.3 kg ball is dropped and falls 5 m (g = 10 N/kg): GPE lost $= 0.3 \times 10 \times 5 = 15$ J → speed at the ground $\frac{1}{2}(0.3)v^2 = 15$, $v = \sqrt{100} = 10$ m/s.



2 Practice

2.1 Calculate the work done by a 12 N force over 25 m. [2]

2.2 A spring (k = 400 N/m) is stretched 0.10 m. Calculate the elastic energy stored. [2]

2.3 Calculate the GPE gained by a 65 kg climber rising 40 m (g = 10 N/kg). [2]

2.4 Calculate the KE of a 1000 kg van at 15 m/s. [2]

2.5 A kettle transfers 180 000 J in 120 s. Calculate its power. [2]

3 Exam-style questions

3.1 A 60 kg skater starts 8 m up a slope and freewheels down (g = 10 N/kg, ignore friction). Calculate the GPE lost and her speed at the bottom. [4]

3.2 Explain, with the doubling rules, why a car at 30 m/s has four times the kinetic energy it had at 15 m/s, and one road-safety consequence. [3]

3.3 A crane's motor supplies 2500 W and lifts a 500 kg load at a steady 0.4 m/s (g = 10 N/kg). Calculate the useful power and the efficiency. [4]

3.4 An arrow of mass 0.15 kg is fired at 40 m/s. Calculate its kinetic energy, and the average force on it if it stops in 0.02 m of target. [4]

Solutions

2.1 $W = 12 \times 25 = 300$ J.

2.2 $E_e = \frac{1}{2} \times 400 \times 0.01 = 2$ J.

2.3 $E_p = 65 \times 10 \times 40 = 26\,000$ J.

2.4 $E_k = \frac{1}{2} \times 1000 \times 225 = 112\,500$ J.

2.5 $P = 180\,000/120 = 1500$ W.

3.1 GPE $= 60 \times 10 \times 8 = 4800$ J; all to KE: $\frac{1}{2} \times 60 \times v^2 = 4800$; $v = \sqrt{160} = 12.6$ m/s.

3.2 $E_k \propto v^2$: doubling speed quadruples KE; at 30 m/s the van carries 4× the energy of 15 m/s; so braking must remove four times the energy – the braking distance grows far more than twice, demanding lower speed limits and bigger following gaps.

3.3 Useful power = force × speed = $mg \times v = 5000 \times 0.4 = 2000$ W; efficiency = $2000/2500 = 0.8 = 80\%$.

3.4 $E_k = \frac{1}{2} \times 0.15 \times 1600 = 120$ J; work done by the target = $F \times d = 120$ J; $F = 120/0.02 = 6000$ N.