AQA AS Work, Energy, Power and Materials worksheet

35–40 minutes independent practice + 15–20 minutes review | 40 marks

Specification points covered

- 3.4.1.7(a–c) Work done, energy transfer and W = Fs.
- 3.4.1.7(d–f) Kinetic and gravitational potential energy.
- 3.4.1.8(a–d) Power, P = W/t, P = Fv and efficiency.
- 3.4.2.1(a–d) Hooke's law, stiffness and elastic strain energy.
- 3.4.2.1(e–h) Tensile stress, tensile strain and Young modulus.
- 3.4.2.1(i–k) Stress–strain curves, elastic and plastic behaviour.
- 3.4.2.2(a–d) Measuring Young modulus and analysing uncertainties.
- 8.2.RP4 Determination of Young modulus by experiment.

Mountain rescue cable system

A rescue team selects a cable, powers a winch and controls a stretcher on a steep access route.
Follow every energy transfer and connect macroscopic cable behaviour to stress, strain and Young modulus.

1. Lifting the stretcher

1. Define work done, power and efficiency. Include the energy-transfer idea in each definition. [3 marks]

2. A rescue winch lifts a 180 kg stretcher vertically through 35.0 m at constant speed. Calculate the useful work done against gravity. [2 marks]

3. The lift takes 48.0 s. Calculate the useful output power of the winch. [2 marks]

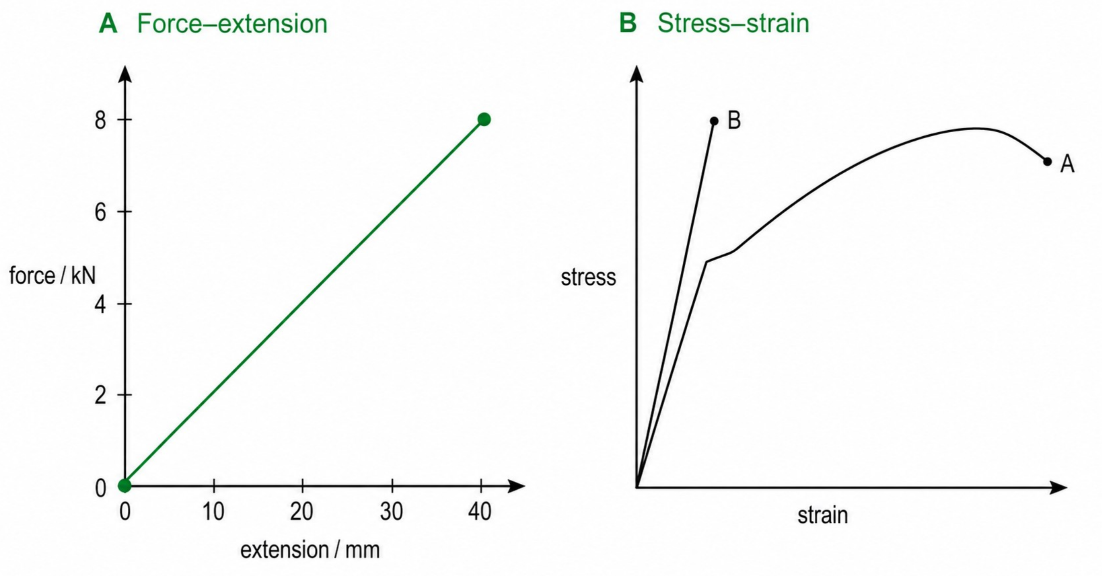
2. Power on the access slope

4. The electrical input power is 1.75 kW. Calculate the efficiency of the winch. **[2 marks]**

5. A tracked carrier of total mass 240 kg climbs an 18.0° slope at a constant 1.20 m s^{-1}. Resistive forces total 180 N. Calculate the required driving force and useful mechanical power. Explain why P = Fv uses the driving force here even though the resultant force is zero. **[4 marks]**

3. Elastic line and material behaviour

6. Panel A of the figure shows the force–extension graph for an elastic rescue line. Calculate the elastic strain energy stored at an extension of 40.0 mm. [3 marks]



7. Use panel A to calculate the stiffness of the line. [2 marks]

8. Panel B shows stress–strain curves for materials A and B. Identify the ductile and brittle material. For material A, distinguish its elastic and plastic behaviour and explain how the graph shows that it can absorb more energy before fracture. [3 marks]

4. Selecting the cable

9. A steel cable has length 18.0 m, cross-sectional area 1.80×10^{-4} m^2 and Young modulus 1.90×10^{11} Pa. Calculate its extension under a tension of 22.0 kN. [3 marks]

10. For the cable in Question 9, calculate the tensile stress and tensile strain. State what each quantity represents. [3 marks]

11. Candidate cable materials have these properties. S: Young modulus 190 GPa, yield stress 620 MPa, failure strain 0.18. T: 210 GPa, 1000 MPa, 0.020. U: 80 GPa, 350 MPa, 0.35. The cable requires yield stress above 500 MPa and visible ductile deformation before failure. Select the best material and justify why each alternative is accepted or rejected. [4 marks]

5. Energy control and testing

12. During a controlled descent the 180 kg stretcher loses 12.0 m of height and reaches a speed of 3.00 m s^{-1} from rest. Calculate the energy transferred from the stretcher's mechanical energy to other stores. [3 marks]

13. Design an experiment to determine the Young modulus of a metal wire. Include measurement of original length and diameter, repeated diameter readings with a micrometer, incremental loading within the elastic region, extension measurement, stress and strain calculation, a graph, uncertainty reduction and safety. [6 marks]

Review and improve

- □ I identify the force that transfers energy before using P = Fv.
- □ I keep stress, strain, stiffness and Young modulus distinct.
- □ I use areas and gradients of material graphs with correct units.