

Exercise walk-through

1.4

Power (4.1.1.4)

AQA · GCSE · Physics

Five situations the specification names

Rising and falling

Describing a change: an object projected upwards trades kinetic for gravitational potential.

A vehicle slowing down empties kinetic and fills the thermal store of the brakes.

Collisions and currents

A moving object hitting an obstacle: kinetic empties, thermal stores fill.

A kettle: electrical work fills the thermal store of the water.

A worked chain from spring to speed

- 1 **Known** $k = 50 \text{ N/m}$, $e = 0.12 \text{ m}$, $m = 0.020 \text{ kg}$; all base units.
- 2 **Store** $E_e = \frac{1}{2}ke^2 = \frac{1}{2} \times 50 \times 0.12^2 = 0.36 \text{ J}$.
- 3 **Transfer** at release all E_e becomes E_k .
- 4 **Rearrange** $v = \sqrt{2E_k/m} = \sqrt{2 \times 0.36/0.020}$.
- 5 **Answer** $v = 6.0 \text{ m/s}$, 2 s.f., unit from $\sqrt{\text{J/kg}}$.

The stairs question, start to finish

- 1 **Known** $m = 60.0 \text{ kg}$, $h = 175 \text{ cm} = 1.75 \text{ m}$, $t = 1.40 \text{ s}$, $g = 9.8 \text{ N/kg}$.
- 2 **Energy** $E_p = mgh = 60.0 \times 9.8 \times 1.75 = 1029 \text{ J}$.
- 3 **Power** $P = E_p/t = 1029/1.40$.
- 4 **Answer** $P = 735 \text{ W}$.
- 5 **Check** her total power is higher: her body also heats and pushes air.

Exercises 2.1·2.2

2.1 A lamp transfers 7.2 kJ in 4.0 minutes. Calculate the power of the lamp. [3]

2.2 A motor does 2400 J of work in 15 s. Calculate its power. [2]

Exercises 2.1·2.2

2.1 A lamp transfers 7.2 kJ in 4.0 minutes. Calculate the power of the lamp. [3]

2.1 Convert: 7.2 kJ = 7200 J (C1); 4.0 min = 240 s (C1).

$$P = \frac{E}{t} = \frac{7200 \text{ J}}{240 \text{ s}} = \mathbf{30 \text{ W}}$$

(answer A1.)

2.2 A motor does 2400 J of work in 15 s. Calculate its power. [2]

2.2

$$P = \frac{W}{t} = \frac{2400 \text{ J}}{15 \text{ s}} = \mathbf{160 \text{ W}}$$

(substitution 1, answer with unit 1.)

Exercise 2.3

2.3 A pump lifts water, giving it 828 J of gravitational potential energy each second. State the useful output power of the pump, and explain why the electrical input power must be greater. [2]

3 Exam-style questions

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2.3 828 J each second is a rate, so the useful power is **828 W**. Some input energy is dissipated – to thermal stores of the motor and by friction in the pipes – so the input power must exceed the useful output.

Exercise 3.1

3.1 A nuclear power station has a power output of 500 MW for 3600 s.

(a) Write down the equation which links energy (E), power (P) and time (t). [1]

(b) Calculate the energy output in J. [3]

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3.1 (a) **$E = Pt$** (or $P = E/t$ in words: energy = power $\times$ time). (b) Convert: 500 MW = 500 000 000 W = 5×10^8 W (C1).

$$E = Pt = 5 \times 10^8 \text{ W} \times 3600 \text{ s} = \mathbf{1.8 \times 10^{12} \text{ J}}$$

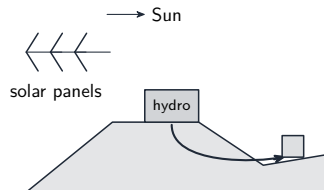
(substitution C1, answer A1 – an unconverted 500 gives 1.8×10^9 for one substitution mark only.)

Exercise 3.2

3.2 A hydroelectric generator transfers 3.0 kW of electrical power. It delivers 2.16×10^7 J to a town.

- (a) Calculate the time taken, in seconds. Give your answer in standard form. [5]

- (b) The town's supply must be reliable. The generator is backed up by solar panels. Explain one reason why the solar panels make the supply more reliable, and one reason why they cannot be the only source. [2]

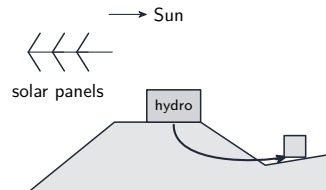


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3.2 (a) Convert: $3.0 \text{ kW} = 3000 \text{ W}$ (C1). Rearrange first.

$$P = \frac{E}{t} \Rightarrow t = \frac{E}{P} = \frac{2.16 \times 10^7 \text{ J}}{3000 \text{ W}}$$

Full solution 3.2

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$$P = \frac{E}{t} \quad \Rightarrow \quad t = \frac{E}{P} = \frac{2.16 \times 10^7 \text{ J}}{3000 \text{ W}}$$

$$t = 7200 \text{ s} = \mathbf{7.2 \times 10^3 \text{ s}}$$

(rearrangement C1, substitution C1, value A1, standard form A1.) (b) Hydro and solar fail at different times – solar stops at night and on dull days, while the river keeps flowing – so combining them covers more of the day; but solar alone is not reliable because its output changes with the weather and the season.

Setup for exercise 3.3

3.3 A funicular railway pulls a 2500 kg carriage up a slope of vertical height 94 m in 3.0 minutes. The motors draw 21 kW of electrical power ($g = 9.8 \text{ N/kg}$).

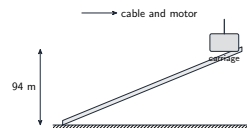
(a) Calculate the gravitational potential energy gained by the carriage. [3]

Exercise 3.3

(b) Calculate the useful output power of the motors. [3]

(c) Calculate the percentage of the input power that is useful. [2]

(d) Give two reasons why the useful power is less than the input power. [2]

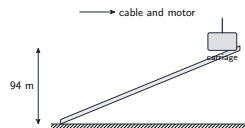


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3.3 (a) Known: mass, height, g .

$$E_p = mgh = 2500 \times 9.8 \times 94 = \mathbf{2.3 \times 10^6 \text{ J}} \text{ (2 s.f.)}$$

(substitution C1, answer A1, unit A1.) (b) Convert: 3.0 min = 180 s (C1).

$$P = \frac{E_p}{t} = \frac{2.303 \times 10^6 \text{ J}}{180 \text{ s}} = \mathbf{12\,800 \text{ W}} \approx 13 \text{ kW} \text{ (2 s.f.)}$$

Full solution on next slide

Full solution 3.3

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(substitution C1, answer A1.) (c) Input power 21 kW = 21 000 W.

$$\% \text{ useful} = \frac{12\,800}{21\,000} \times 100 = \mathbf{61 \text{ \%}} \text{ (2 s.f.)}$$