

Power and efficiency

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Paper 1 | Foundation and Higher

Worked solutions and teaching prompts | 31 core parts plus a labelled Higher option

Specification points covered

Power as energy transferred or work done per second: 8463 4.1.1.4 / 8464 6.1.1.4

Conservation and dissipation of energy: 8463 4.1.2.1 / 8464 6.1.2.1

Efficiency using energy and power: 8463 4.1.2.2 / 8464 6.1.2.2

Supporting gravitational potential energy: 8463 4.1.1.2 / 8464 6.1.1.2

Higher only Q6: improving efficiency, 8463 4.1.2.2 / 8464 6.1.2.2

A canal-maintenance team lifts equipment onto an inspection deck and pumps water out of a service chamber. You will compare machines and choose one for a timed job. All data describe paper-based tests, not a practical lifting activity.

Core Questions 1–5: 31 parts, 45 marks. Higher pathway: 31 parts, 47 marks; replace 1(c,d,f) with Q6. Timing is suggested, not classroom-tested. Q6 assesses ways to increase efficiency and is Higher only for both routes. Accept equivalent wording and sensible follow-through. Original PhysicsUK practice, not an official AQA paper or mark scheme.

1 Working with power

The team checks a portable winch. Useful power means the rate of doing the intended lifting work. Each part gives a separate test unless stated otherwise.

1(a) Define power in terms of energy transfer or work done. **[1 mark]**

Answer / mark points: Power is the rate of energy transfer or the rate of doing work: energy transferred or work done per unit time. [1]

1(b) A winch has a useful output power of 300 W. State the useful energy it transfers in each second. **[1 mark]**

Answer / mark points: 300 J in each second. [1]

Teacher prompt: Do not write 300 J per second squared. One watt is one joule per second.

1(c) The winch does 600 J of useful lifting work in 4.0 s. Calculate its mean useful output power. **[1 mark]**

Answer / mark points: $P = W / t = 600 / 4.0 = 150 \text{ W}$. [1]



1 Working with power continued

1(d) In a longer test, a winch does 7200 J of useful work in 30 s. Calculate its mean useful output power. **[1 mark]**

Answer / mark points: $P = W / t = 7200 / 30 = 240 \text{ W}$. [1]

1(e) A winch receives energy at a constant input power of 0.50 kW for 2.0 minutes. Calculate its total energy input in joules. **[2 marks]**

Answer / mark points: $P = 500 \text{ W}$ and $t = 2.0 \times 60 = 120 \text{ s}$. [1 for both SI conversions]
 $E = Pt = 500 \times 120 = 60\,000 \text{ J}$. [1]

Teacher prompt: This is input energy. It is not automatically all useful lifting energy.

1(f) Another test needs 4500 J of useful lifting work. A winch has a constant useful output power of 150 W. Calculate the time required. **[1 mark]**

Answer / mark points: $t = W / P = 4500 / 150 = 30 \text{ s}$. [1]

2 Two hoists doing the same job

Hoists A and B each raise the same 40 kg equipment case vertically through 3.0 m. Each complete lift starts and ends at rest. Take the useful output to be only the case's gain in gravitational potential energy. Table 1 gives the time and total energy input for each complete lift.

Table 1

Hoist	Time for complete lift / s	Total energy input / J
A	8.0	2000
B	12	1500

2(a) Calculate the useful energy output for either 40 kg case lifted through 3.0 m. **[1 mark]**

Answer / mark points: $E_p = mgh = 40 \times 10 \times 3.0 = 1200 \text{ J}$. [1]

Teacher prompt: Include the vertical height, not only mg. Say gravitational potential energy, not just gravitational energy.

2(b) Use Table 1 to calculate the mean useful output power of hoist A. Use 1200 J for the useful energy if needed. **[1 mark]**

Answer / mark points: $P = E / t = 1200 / 8.0 = 150 \text{ W}$. [1]



2 Two hoists doing the same job continued

2(c) Calculate the mean useful output power of hoist B for the same lift. [1 mark]

Answer / mark points: $P = E / t = 1200 / 12 = 100 \text{ W}$. [1]

2(d) A trainee says that hoist A must do more useful work because it has the greater useful power. Explain why this claim is wrong. [2 marks]

Answer / mark points: Both hoists do the same useful work, 1200 J, because they lift the same mass through the same height. [1]

A has the greater useful power because it does this work in a shorter time, not because it does more work. [1]

Teacher prompt: Compare both the size of the useful energy transfer and its rate.

2(e) Calculate the mean input power for each hoist using Table 1. [2 marks]

Answer / mark points: A: $P = E / t = 2000 / 8.0 = 250 \text{ W}$. [1]

B: $P = E / t = 1500 / 12 = 125 \text{ W}$. [1]

Teacher prompt: Input power is not the useful power from parts (b) and (c).

2(f) Calculate hoist B's efficiency as a decimal and as a percentage. [2 marks]

Answer / mark points: Efficiency = $1200 / 1500 = 0.80$. [1]

Percentage efficiency = $0.80 \times 100 = 80\%$. [1]

2(g) Explain why hoist B is more efficient even though hoist A has the greater useful output power. [2 marks]

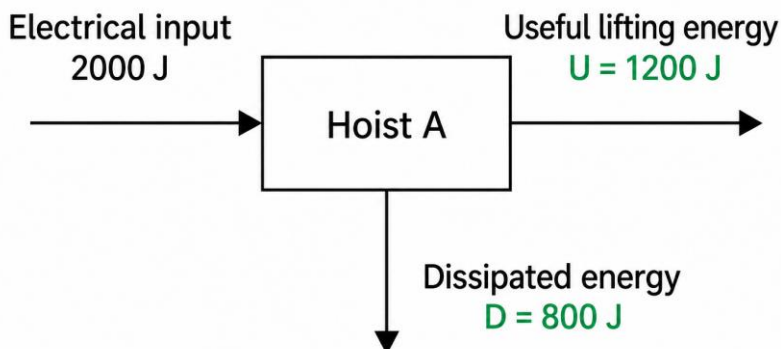
Answer / mark points: B needs only 1500 J input for the same 1200 J useful output, compared with A's 2000 J input. [1]

A larger fraction of B's input becomes useful output; being quicker does not establish a larger useful fraction. [1]



3 Accounting for every joule

Figure 1 represents hoist A's lift from Question 2. U is the useful lifting energy and D is the energy dissipated. Together these account for the full 2000 J input. Arrow widths do not represent energy amounts.



Energy transfers not to scale

Figure 1

3(a) Calculate the dissipated energy D in Figure 1. Use $U = 1200 \text{ J}$ from Question 2 if needed. [1 mark]

Answer / mark points: $D = \text{total input} - \text{useful output} = 2000 - 1200 = 800 \text{ J}$. [1]

3(b) Calculate hoist A's efficiency as a decimal and as a percentage. [2 marks]

Answer / mark points: Efficiency = $1200 / 2000 = 0.60$. [1]

Percentage efficiency = $0.60 \times 100 = 60\%$. [1]

3(c) A trainee says that the dissipated energy has disappeared. Explain what happens to this energy and why it is less useful for lifting. [2 marks]

Answer / mark points: It increases the internal energy of the mechanism and surroundings, for example through friction and heating. [1]

The energy is spread into less useful stores instead of increasing the case's gravitational potential energy; it has not been destroyed. [1]

Teacher prompt: Do not say energy is used up or that friction destroys energy. Accept a clear thermal-energy-store description.



3 Accounting for every joule continued

3(d) A trainee interprets 60% efficiency as “60 J wasted for every 100 J input”. Calculate the actual dissipated energy for a 100 J input at 60% efficiency. **[1 mark]**

Answer / mark points: Useful output = 60 J; dissipated energy = $100 - 60 = 40$ J. [1]

3(e) A report claims that a motor in steady operation receives 90 W of total input power and provides 110 W of useful output power, with no other energy source or store being depleted. Calculate the claimed efficiency and explain why the report is inconsistent. **[2 marks]**

Answer / mark points: Claimed efficiency = $110 / 90 = 1.22$, or about 122%. [1]
This is greater than 1 (100%); under the stated conditions useful output cannot exceed total input because energy is conserved. [1]

Teacher prompt: A temporary release from an energy store could change an energy balance, but the question explicitly excludes that case.

4 Finding unknown outputs and inputs

The team checks other machines using separate test results. Use each part's stated data; do not assume the machines have the same efficiency.

4(a) A pump receives 9000 J in a test and has efficiency 0.40. Calculate the useful energy output. **[1 mark]**

Answer / mark points: Useful output = efficiency $\times$ input = $0.40 \times 9000 = 3600$ J. [1]

4(b) A hoist provides 3000 J of useful output at efficiency 0.75. Calculate its total energy input. **[1 mark]**

Answer / mark points: Input = useful output / efficiency = $3000 / 0.75 = 4000$ J. [1]

Teacher prompt: Input must exceed useful output here. Multiplying by 0.75 would give the wrong quantity.

4(c) A lifting unit has total input power 400 W and useful output power 250 W. Calculate its efficiency as a decimal and as a percentage. **[2 marks]**

Answer / mark points: Efficiency = $250 / 400 = 0.625$. [1]
Percentage efficiency = 62.5%. [1]

4(d) A pump provides 120 W of useful output power at efficiency 0.60. Calculate its total input power. **[1 mark]**

Answer / mark points: Input power = useful output power / efficiency = $120 / 0.60 = 200$ W. [1]



4 Finding unknown outputs and inputs continued

4(e) A lifting unit receives 1.2 kJ with efficiency 80%. Calculate its useful output energy in joules. [2 marks]

Answer / mark points: Input = 1200 J and efficiency = 0.80. [1 for correctly matched conversions]
Useful output = $0.80 \times 1200 = 960$ J. [1]

4(f) A pump receives 500 J and dissipates 150 J during a test. Calculate its useful energy output and its percentage efficiency. [2 marks]

Answer / mark points: Useful output = $500 - 150 = 350$ J. [1]
Efficiency = $350 / 500 \times 100 = 70\%$. [1]

Teacher prompt: 150 / 500 describes the dissipated fraction, not the useful efficiency.

5 Choosing a pump for the job

A pump must transfer 120 kg of water from a service chamber to a tank 2.5 m higher within 45 s. At most 8000 J of input energy is available for this job. The useful output is only the water's increase in gravitational potential energy; ignore any change in kinetic energy. Assume the input powers and efficiencies in Table 2 stay constant during the job.

Table 2

Pump	Total input power / W	Efficiency as a decimal
X	100	0.30
Y	180	0.40

5(a) Calculate the useful energy needed to raise the 120 kg of water through 2.5 m. [1 mark]

Answer / mark points: $E_p = mgh = 120 \times 10 \times 2.5 = 3000$ J. [1]

5(b) Calculate pump X's useful output power from Table 2. [1 mark]

Answer / mark points: Useful output power = efficiency $\times$ input power = $0.30 \times 100 = 30$ W. [1]

5(c) Calculate pump Y's useful output power. [1 mark]

Answer / mark points: Useful output power = $0.40 \times 180 = 72$ W. [1]



5 Choosing a pump for the job continued

5(d) Calculate the time pump X needs to do the job. Use 3000 J for the required useful energy if needed. **[1 mark]**

Answer / mark points: $t = \text{useful energy} / \text{useful power} = 3000 / 30 = 100 \text{ s}$. [1]

5(e) Calculate the time pump Y needs to do the job. Give a sensible rounded answer, but keep the unrounded value for later work. **[1 mark]**

Answer / mark points: $t = 3000 / 72 = 41.666\dots \text{ s}$, or about 42 s. [1]

5(f) Calculate the total input energy needed by each pump to complete this same job. **[2 marks]**

Answer / mark points: X: input energy = useful output / efficiency = $3000 / 0.30 = 10\,000 \text{ J}$. [1]

Y: input energy = $3000 / 0.40 = 7500 \text{ J}$. [1]

Teacher prompt: Also accept input power $\times$ unrounded time. If their rounded 42 s is used, accept 7560 J for Y with sensible follow-through.

5(g) Recommend a pump for this job. Use the 45 s deadline and 8000 J input-energy limit, and explain why simply choosing the smaller input power would be misleading. **[3 marks]**

Answer / mark points: Choose Y: about 42 s is within the 45 s deadline. [1]

Its 7500 J input is within 8000 J. [1]

X has the smaller input power but runs for 100 s and needs 10 000 J; power alone does not determine the energy needed for the job. [1]

Teacher prompt: The decision uses the actual task and useful fraction. Y uses less input energy despite having a greater input power.



6 Higher tier only improving the hoist

Higher only, both routes. Hoist A originally uses 2000 J to provide 1200 J of useful lifting energy in 8.0 s. The team wants less energy dissipated in the mechanism, without changing the load, height or lifting time.

6(a) Describe one physical change to the hoist mechanism that could increase the efficiency of its intended lifting transfer. Explain how the change reduces dissipation. **[2 marks]**

Answer / mark points: Lubricate moving bearings or gears to reduce friction. [1]
Less energy is transferred to internal energy by friction, so a larger fraction of the input can provide the intended lifting output. [1]

Teacher prompt: Accept another justified reduction of a relevant unwanted transfer. “Make it smoother” or “make it slippery” without the friction/transfer link is insufficient.

6(b) After a suitable change, the hoist requires 1600 J input for the same 1200 J useful output. Calculate its new percentage efficiency. **[1 mark]**

Answer / mark points: Efficiency = $1200 / 1600 \times 100 = 75\%$. [1]

6(c) The improved hoist still completes the same lift in 8.0 s. Has its mean useful output power changed? Support your answer with a calculation and a reason. **[2 marks]**

Answer / mark points: Mean useful power = $1200 / 8.0 = 150 \text{ W}$, unchanged. [1]
The useful work and time are unchanged; the improvement reduces input energy and dissipation rather than changing the rate of useful lifting work. [1]

Teacher prompt: Improving efficiency need not increase useful power when the useful task and its duration are fixed.

Review and improve

Power is a rate, not a quantity of energy. A quicker machine is not necessarily more efficient. Compare useful and total quantities over the same task or time interval. Energy is conserved even when it is dissipated.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

