

Covering teacher guide

Power and rates of energy transfer

Start here / subject briefing

Before this lesson: Consolidation after power as energy/work per time, simple rearrangements and kW/minute conversions have been taught. Both courses and tiers use the same power-only route. Useful lift energies are supplied: no GPE or efficiency calculation is required.

Power is a rate: how much energy is transferred or work is done each second. One watt is one joule per second. Divide energy by time to find mean power, multiply power by time to find energy, or divide energy by power to find time. Convert kW to W and minutes to seconds first. A quicker machine may do exactly the same useful work at greater useful power. Input and useful output are different labels; one must not be substituted for the other.

Words and symbols you will need

Term	Plain-English meaning
Power P, watts W	Energy transfer/work per second. One W equals one J/s.
Energy E / work W, joules J	An amount transferred. W as a work symbol is different from W as the unit watt.
Mean power	Total energy/work divided by the complete time interval.
Useful / input	Useful serves the specified task. Input is total energy or power supplied.
kW and minutes	Multiply kW by 1000 for W; multiply minutes by 60 for seconds.

Help pupils choose a method

1. Identify the unknown and label every given energy/power as input or useful.
2. Convert kW to W and minutes to seconds.
3. Choose $P=E/t$, $E=Pt$ or $t=E/P$ with matching quantities.
4. State the correct unit; compare useful work separately from time and rate.

Use the supplied model - pupil page 2

Pupil page 2's maintained power model gives 400 W. The added time model gives 120 s, and the different input-energy model gives 6000 J after both conversions. The supplied diagram shows equal 200 J useful work completed in 2 s or 4 s at 100 W or 50 W. It makes no claim about input efficiency.

Hoist: $P=12000/30=400$ W. Separate motor: $t=E/P=9000/75=120$ s. Different device: $0.20 \text{ kW}=200$ W; $0.50 \text{ minutes}=30$ s; input $E=Pt=200 \times 30=6000$ J. Match energy and power labels: an input calculation does not establish the useful output.

If pupils are still stuck

Use the matching Say/Ask/Expect coaching and named fresh retry within its replacement time. If still insecure, help label input/useful quantities and complete the two conversion steps before choosing the equation. Record the exact remaining problem for the usual teacher. Keep D for next lesson; do not extend today's lesson.

Turn to teacher page 2 for the timed run sheet. Keep this guide separate from the pupil booklet.

Run the lesson from this page

Power and rates of energy transfer

Print the complete 8-page pupil booklet, one per pupil, stapled in order. Double-sided printing is fine.

Read teacher page 1, then use the timed run sheet on page 2. Keep the 10-page teacher guide separate from pupil copies.

Pupils need pens, a ruler and a calculator. Reading, data and figures are supplied. No login, pupil devices or practical apparatus are required.

Min	Pupil page / Q	Read aloud / check	Next action and answer key
0-5	1 / 1-3	Start from memory: rate definition, energy per second and minutes.	If insecure A uses first 2 reading minutes. Answers: teacher page 3. Coaching: page 7.
5-15	2 / reading	Read the rate/units rules, models and equal-work diagram.	Check A if used. Distinguish work W from watt W.
15-20	3 / 4	Choose a letter and justify useful work and both powers; stop.	If insecure B replaces 5-6. Answers: teacher page 3. Coaching: page 8.
20-30	4 / 5-8	Calculate useful powers, input energy and required time.	If B used complete 7-8 only; leave 5-6 blank. Answers: teacher page 4.
30-33	5 / 9	Calculate input energy independently, then check the label.	If insecure C replaces 10-11. Answers: teacher page 4. Coaching: page 9.
33-45	6-7 / 10-15	Use given 1200 J and 72 J useful work; match input/useful quantities.	If C used complete 12-15; leave 10-11 blank. Answers: teacher page 5.
45-55	8 / 16	Share practice keys; correct and explain a calculation or comparison.	Keep independent exit answers hidden. Answers: teacher page 5.
55-60	8 / 17	Cover earlier work; complete separate tests independently.	Collect all booklets. D is next lesson only. Answers: teacher page 6. Coaching: page 10.

Estimated 60 minutes: practice 10 minutes, a 3-minute mid-check and 12 minutes. A uses reading time; B replaces 5-6; C replaces 10-11; D is next lesson only. Timings not classroom-trialled.

Entry and hinge - pupil pages 1 and 3

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

1. **(pupil p1)** Power is the rate of energy transfer or doing work: energy transferred/work done per unit time.
2. **(pupil p1)** 300 J in each second. Not 300 J/s^2 or a total energy independent of time.
3. **(pupil p1)** $1.5 \times 60 = 90 \text{ s}$.
4. **(pupil p3)** B: each does 900 J useful work. A has mean useful power $900/3 = 300 \text{ W}$; B has $900/6 = 150 \text{ W}$. Same work in half the time gives twice the power.

Try again A - pupil page 1

Only if directed. Use the first 2 reading minutes, then continue on page 2.

(a) 240 J. (b) $0.25 \times 60 = 15 \text{ s}$. (c) Energy transferred/work done per unit time; it is a rate.

Try again B - pupil page 3

Only if directed. Complete B instead of questions 5-6 on page 4; then answer 7-8.

A: $600/4 = 150 \text{ W}$. B: $600/8 = 75 \text{ W}$. Both do 600 J useful work; A has twice the useful power because it takes half the time.

Power practice and conversion check

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

5. (pupil p4) $P=W/t=600/4.0=150$ W useful output power.

6. (pupil p4) $P=W/t=7200/30=240$ W useful output power.

7. (pupil p4) 0.50 kW= 500 W; 2.0 minutes= 120 s. Input energy $E=Pt=500 \times 120=60000$ J. This is not automatically useful lifting energy.

8. (pupil p4) $t=W/P=4500/150=30$ s.

9. (pupil p5) 0.15 kW= 150 W; 2.0 minutes= 120 s. Input $E=150 \times 120=18000$ J. The data describe total input; some energy may increase thermal stores or have other unwanted transfers. Useful lifting output is not specified, so do not relabel the input as useful.

Try again C - pupil page 5

Only if directed. Complete C instead of questions 10-11 on page 6. Then answer 12-15.

250 W and 180 s; input $E=250 \times 180=45000$ J. Useful output is not given; input energy alone does not establish how much serves the intended task.

Hoist and display-lift comparisons

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

10. (pupil p6) $P_{\text{useful}} = 1200/8.0 = 150 \text{ W}$. Use useful energy, not total input energy.

11. (pupil p6) $P_{\text{useful}} = 1200/12 = 100 \text{ W}$.

12. (pupil p6) Both do the same useful work, 1200 J, lifting the same mass through the same height. A has greater useful power because it completes this work in less time, not because it does more work.

13. (pupil p6) A: $2000/8.0 = 250 \text{ W}$ input. B: $1500/12 = 125 \text{ W}$ input. These use total input energy and differ from useful output powers.

14. (pupil p7) 1.5 minutes = 90 s. Mean useful power = $72/90 = 0.80 \text{ W}$. This is maintained note practice Q4(b), with Q4(a)'s 72 J supplied.

15. (pupil p7) Useful energy is unchanged at 72 J. Half the time is 45 s, so useful power = $72/45 = 1.6 \text{ W}$, twice 0.80 W. No claim about input energy or efficiency follows. Maintained note practice Q4(c).

16. (pupil p8) Accept an explained correction, not a copied number. All-correct: $P = E/t$; the same useful energy can be transferred in less time at greater power. Compare both energy and time; input/useful labels must be matched.

Independent exit and next-lesson follow-up

Match the pupil number. Accept equivalent correct wording. Keep this guide separate from pupils.

17. (pupil p8) (a) 240 W and 90 s; input energy= $240 \times 90 = 21600$ J. (b) Useful power= $840/7 = 120$ W. (c) Useful energy remains 840 J; useful power= $840/3.5 = 240$ W, double because the same work is done in half the time. Keep the separate input test distinct from the lifts.

Try again D - next lesson - pupil page 8

Leave this today. Your usual teacher may direct it next lesson.

(a) 180 W and 150 s; input E= 27000 J. (b) Useful power= $600/5 = 120$ W. (c) Same useful energy 600 J; useful power= $600/2.5 = 240$ W, twice as great because time halves.

Collect and follow up

Collect every named booklet with working/corrections. Record who needs support with conversions, rearrangement, input/useful labels or rate-versus-amount comparisons, and who needs Try again D.

Source provenance - for the usual teacher

Pupil question	Original worksheet part / page
1	WS-16 Q1(a) / source p1
2	WS-16 Q1(b) / source p1
5	WS-16 Q1(c) / source p1
6	WS-16 Q1(d) / source p2
7	WS-16 Q1(e) / source p2
8	WS-16 Q1(f) / source p2
10	WS-16 Q2(b) / source p2
11	WS-16 Q2(c) / source p3
12	WS-16 Q2(d) / source p3
13	WS-16 Q2(e) / source p3

Selected practice is reformatted from the maintained PhysicsUK worksheet. Required context is included; unassigned parts are omitted.

Source worksheet | Maintained solutions | Revision notes

Worksheet Q2(a) result 1200 J and note practice Q4(a) result 72 J are supplied as givens. Pupil 14-15 retain note practice Q4(b,c), with complete display-lift context. The maintained comparison SVG is rendered unchanged for print. Worksheet efficiency parts and its Higher replacement instruction are excluded.

Check 1: Entry

Questions 1-2, Question 3

Look for: Q1 rate of energy transfer/work per time; Q2 300 J each second; Q3 90 s.

If secure: Continue to page 2 reading/models.

If: Defines power as energy, or gives 300 J/s² or 300 W as the energy amount.

Likely issue: Power and an energy amount per stated interval are confused.

Say: Power tells you energy transferred each second. A 300 W useful output means 300 joules usefully transferred in one second; power itself is a rate.

Ask: For question 2, how much useful energy is transferred in one second, and which unit measures that amount?

Expect: 300 J in one second; energy amount is in joules.

Next: Use page 2's rate/units rules, then complete Try again A on page 1 in the first 2 reading minutes.

Pupil page 2, power and 1 W=1 J/s rows.

If: Gives 1.5 s or 150 s for question 3.

Likely issue: Minute-to-second conversion is insecure.

Say: One minute has 60 seconds, so multiply a number of minutes by 60, not 100.

Ask: For question 3, what is 1.5×60?

Expect: 90 s.

Next: Use page 2's rate/units rules, then complete Try again A on page 1 in the first 2 reading minutes.

Pupil page 2, convert-first row.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 2: Hinge

Question 4

Look for: B: both 900 J; A useful power 300 W, B 150 W, with same-work/half-time reason.

If secure: Continue to 5-8.

If: A: faster means more useful work.

Likely issue: A rate has been mistaken for total transferred energy.

Say: The useful work is explicitly the same in both tests. A finishes that amount sooner, which raises its power, not the stated total work.

Ask: In question 4, how many joules does each machine transfer usefully?

Expect: 900 J each. The difference is time, not useful work.

Next: Use page 2's rate model/comparison, then complete Try again B on page 3 instead of 5-6; complete 7-8.
Pupil page 2, comparison figure.

If: C: gives greater power to the slower machine.

Likely issue: The inverse dependence on time has been reversed.

Say: For the same energy amount, divide by each machine's time. A shorter time gives more joules each second.

Ask: For question 4, what are $900/3$ and $900/6$?

Expect: 300 W for A and 150 W for B.

Next: Use page 2's rate model/comparison, then complete Try again B on page 3 instead of 5-6; complete 7-8.
Pupil page 2, $P=E/t$ model.

If: D, or B without working.

Likely issue: Energy may have been multiplied by time or the answer guessed.

Say: Power is energy per second, so divide energy by time. Multiplying joules by seconds does not give watts. A correct letter needs the two powers and useful-work comparison.

Ask: Which operation gives J/s for question 4? Show both calculations.

Expect: $900/3=300$ W and $900/6=150$ W; both useful work amounts remain 900 J.

Next: Use page 2's rate model/comparison, then complete Try again B on page 3 instead of 5-6; complete 7-8.
Pupil page 2, power/units rows.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 3: Mid Practice

Question 9

Look for: 150 W; 120 s; input energy 18000 J; useful output not established.

If secure: Continue to 10-15 with matched input/useful labels.

If: Gives 0.30 J, 300 J or 18 J, or labels energy in W.

Likely issue: One or both conversions or the energy equation are wrong.

Say: Energy is power multiplied by time in seconds. Convert kW to W and minutes to seconds separately before multiplying.

Ask: For question 9, what are 0.15 kW in W, 2 minutes in s, and their product?

Expect: 150 W, 120 s, then input energy 18000 J.

Next: Use page 2's conversions and matching labels, then complete Try again C on page 5 instead of 10-11; complete 12-15.

Pupil page 2, conversion model and $E=Pt$.

If: Calls all 18000 J useful lifting output.

Likely issue: Total input has been relabelled as useful output without evidence.

Say: The power label is input, so the product is input energy. Some input may warm the motor or surroundings; no useful output amount is specified.

Ask: In question 9, does the stated power describe input or useful output? What amount is actually known?

Expect: Input; only total input energy, 18000 J, is established.

Next: Use page 2's conversions and matching labels, then complete Try again C on page 5 instead of 10-11; complete 12-15.

Pupil page 2, useful-or-input rule.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Check 4: Exit

Question 17

Look for: Q17: input 21600 J; useful 120 W; second lift same 840 J and useful 240 W, double.

If secure: Record secure conversion, equation choice, matched labels and rate comparison.

If: Wrong input energy or useful power, especially missing either SI conversion.

Likely issue: Units or equation choice still needs follow-up.

Say: Identify the unknown first. For input energy convert power/time then multiply. For useful power divide useful work by its time. Keep the independent test labels separate.

Ask: For question 17, what are 0.24×1000 , 1.5×60 , and $840/7$?

Expect: 240 W, 90 s, and useful power 120 W. Input energy is 21600 J.

Next: Next lesson revisit the relevant page 2 rules, then complete Try again D independently on page 8.

Pupil page 2, conversions and models.

If: Changes useful work in the faster lift, halves power or mixes input and useful data.

Likely issue: Rate versus amount or matched quantities remains insecure.

Say: The useful work is fixed at 840 J. Halving the time doubles its rate. Do not combine the separate input test with a lifting-output calculation.

Ask: For question 17(c), what stays 840 J, and what is $840/3.5$?

Expect: Useful energy stays 840 J; useful power is 240 W, twice 120 W.

Next: Next lesson revisit the relevant page 2 rules, then complete Try again D independently on page 8.

Pupil page 2, comparison figure and labels.

If the retry remains insecure, use the support guidance on teacher page 1 and record the precise difficulty for the usual teacher.

Specification and review

AQA 8463: 4.1.1.4 | AQA 8464: 6.1.1.4. Both courses and tiers: $P=E/t=W/t$, $E=Pt$ and $t=E/P$; rate versus amount, SI conversions and matching input/useful labels. GPE results supplied; no efficiency calculation or Higher-only improvement task.

PhysicsUK original cover lesson. Reviewed 2026-11-01. Timings estimated.