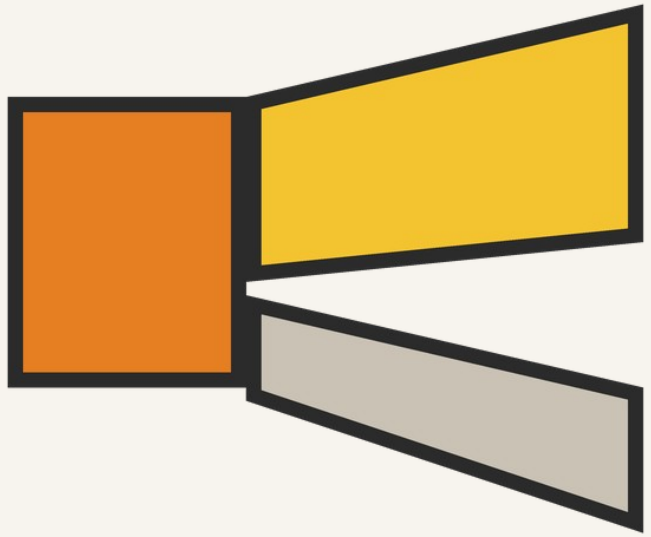
BOOKLET 2 · ENERGY AND EFFICIENCY

Efficiency

How much of what goes in actually does the job?



National 5 Engineering Science

LEARNING INTENTION

To calculate efficiency as a ratio and as a percentage, for both energy and power.

Daily Review

SHOW ME BOARDS

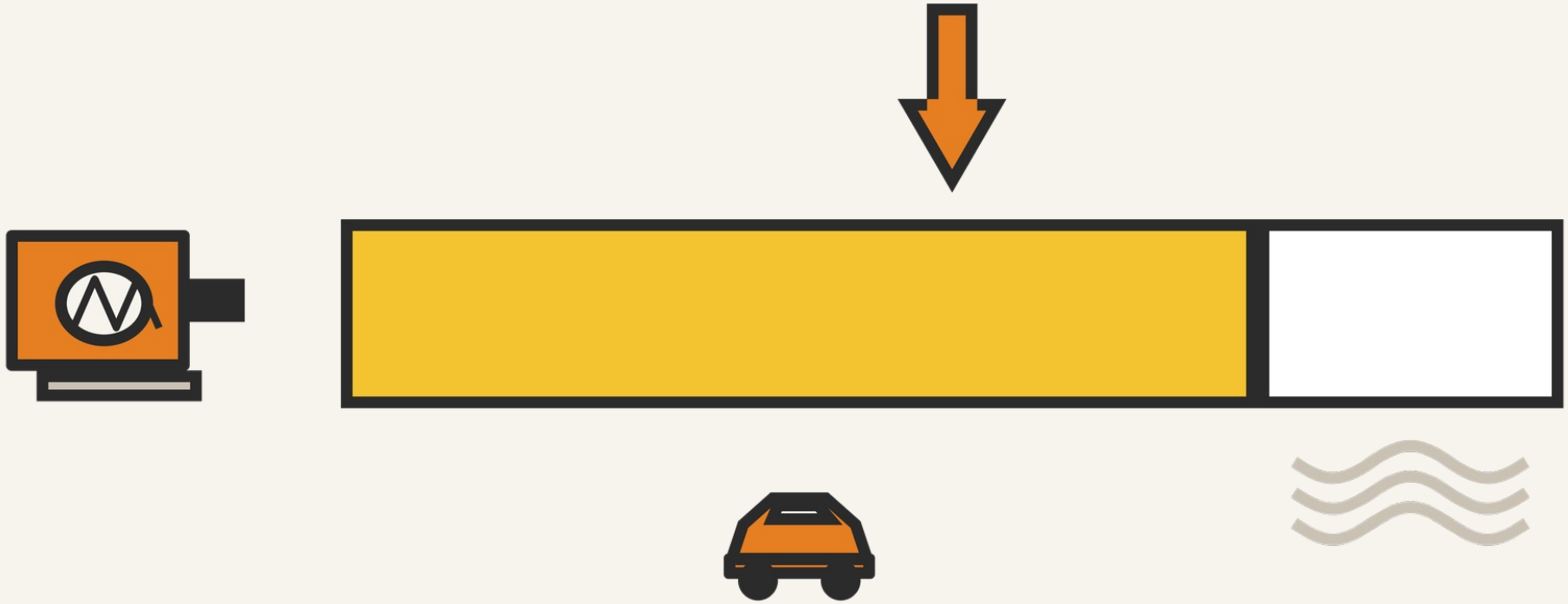
1. Write the formula for power.
2. A motor transfers 8 000 J in 20 s. Calculate the power.
3. Change 2 kW into watts.
4. State the law of conservation of energy.
5. A system takes in 700 J and wastes 100 J. How much is useful?

By the end of this lesson…

1. I can calculate the wasted energy from the input and the useful output.
2. I can state $\eta = E_{out} \div E_{in}$ and use it as a ratio.
3. I can calculate a percentage efficiency.
4. I can use the same formula with power values.
5. I can explain why no real system reaches 100 %.

Account for Every Joule

Some of the input does the job. The rest is wasted, usually as heat or sound.



the whole bar is the input · the yellow part is useful · the rest is wasted

Task 1 — Account for the Energy

Five systems. Work out the wasted energy in each.
Wasted = input − useful. Nothing more complicated than that.
Check every row: your three numbers must add up.

Booklet — “TASK: Account for the Energy”

Efficiency

Efficiency compares the useful output with the total input.

$$\eta = (E_{out} \div E_{in}) \times 100$$

η	E_{out}	E_{in}
efficiency (%)	useful output energy (J)	input energy (J)

Without the × 100 you get a ratio. The same formula works with power: $\eta = P_{out} \div P_{in}$.

Worked Example — Motor

An electric motor is supplied with 800 J of energy.

It produces 600 J of useful kinetic energy. Calculate the efficiency.

$E_{out} = 600\ J$

$E_{in} = 800\ J$

$\eta = ?$

$\eta = (E_{out} \div E_{in}) \times 100$

$\eta = (600 \div 800) \times 100$

$\eta = 75\ \%$

Watch Out — Over 100 %?

THE MISTAKE

- “800 ÷ 600 × 100 = 133 %”
- “The answer is 0.75, so I will write 0.75 %.”
- “A really good motor could reach 105 %.”

THE CORRECT ANSWER

- Useful on top, input underneath. Always that way round.
- 0.75 is the ratio. × 100 makes it 75 %.
- Impossible. The useful output is part of the input.

Show Me — Efficiency Basics

SHOW ME BOARDS

1. Which number goes on top — the useful output, or the input?
2. What is the unit of a percentage efficiency?
3. What is the highest efficiency any real system can reach?
4. Input 100 J, useful 40 J — what is the efficiency?
5. Why can no real system reach 100 %?

Show Me — Basics Again

SHOW ME BOARDS

EXTRA PRACTICE

1. What does η stand for?
2. What must you multiply by to turn a ratio into a percentage?
3. Input 200 J, useful 50 J — what is the efficiency?
4. A system is 100 % efficient. What is wrong with that claim?
5. Name the two forms wasted energy usually takes.

Show Me — Efficiency Calculations

SHOW ME BOARDS

1. Input 400 J, useful 300 J — calculate the percentage efficiency.
2. Input 500 W, useful 400 W — calculate the percentage efficiency.
3. Input 2 000 J, useful 1 500 J — calculate the percentage efficiency.
4. Input 250 W, useful 200 W — calculate the percentage efficiency.
5. Input 80 J, useful 20 J — calculate the percentage efficiency.

Show Me — More Calculations

SHOW ME BOARDS

EXTRA PRACTICE

1. Input 600 J, useful 540 J — calculate the percentage efficiency.
2. Input 1 000 W, useful 250 W — calculate the percentage efficiency.
3. Input 50 J, useful 45 J — calculate the percentage efficiency.
4. Input 3 000 J, useful 1 800 J — calculate the percentage efficiency.
5. Input 900 W, useful 720 W — calculate the percentage efficiency.

Task 2 — Efficiency

Three calculations in your jotter, SQA layout every time.
Q2 is in watts and Q3 is in kilowatts — the formula does not care.
3 marks each. The % sign is part of the answer.

Booklet — "TRY THIS: Efficiency"

Checkpoint

1. Write the formula for percentage efficiency.

2. Input 1 200 J, useful 900 J — calculate the percentage efficiency.

3. What + why: a motor is 75 % efficient. Where is the other 25 %?

Exam Practice — Past Papers

2021 Q10(b)(ii) — output energy from η = 0.72 (3)
2022 Q14(d) — input power from η = 0.85 (3)
SQP Q11(b) — $E_{out} = E_{in} \times \eta$, rearranged (3)
SQP Q17(b)(iii) — explain why less than 100 % (2)
2025 Q10(d) — E_k from η, then explain (5)

Find the relationship in the data booklet

LOOKING AHEAD

Energy Audits

An energy audit puts the whole picture in one diagram.

Plenary — Prove Your I Can… Statements

SHOW ME BOARDS

1. Write the formula for percentage efficiency.
2. Input 500 J, useful 250 J — calculate the efficiency.
3. Input 60 W, useful 48 W — calculate the efficiency.
4. What is the highest efficiency a real system can reach?
5. Where does the wasted energy usually end up?

Plenary — More Quick Checks

SHOW ME BOARDS

EXTRA PRACTICE

1. What does E_{out} stand for?
2. Input 200 J, useful 160 J — calculate the efficiency.
3. Turn a ratio of 0.45 into a percentage.
4. Input 40 W, useful 10 W — calculate the efficiency.
5. Why is efficiency never given a unit like joules?

Extension — If You Finish Early

1. A system is 30 % efficient and takes in 900 J. Find the useful output.

2. A pump is 80 % efficient and gives 400 J useful. Find the input energy.

3. What + why: which wastes more energy — a 90 % motor using 1 000 J, or a 40 % lamp using 100 J?

Extension — More Challenges

EXTRA PRACTICE

1. A system is 25 % efficient and takes in 480 J. Find the useful output.

2. A motor is 60 % efficient and wastes 800 J. Find the input energy.

3. What + why: why do engineers quote efficiency as a percentage rather than in joules?