# Efficiency

4.1.2.2 · Energy · revision notes

Efficiency tells you how much of the energy supplied to a device is transferred usefully. You need to calculate it from energy or power values, as a decimal or a percentage, and rearrange the equation. Higher tier students must also describe ways to increase efficiency. Most questions are 2 to 3 mark calculations.

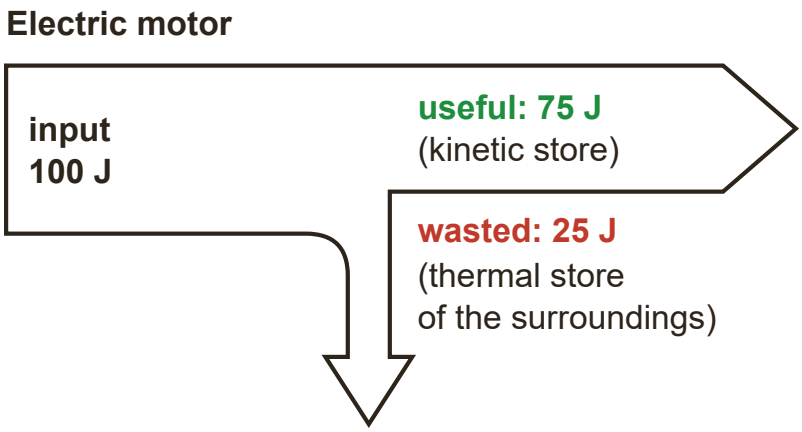
## Key facts

- efficiency = useful output energy transfer ÷ total input energy transfer
- percentage efficiency = efficiency × 100
- Efficiency has no unit and is never more than 1 (100%)
- Grade 7+ only Increase efficiency: lubricate, streamline, insulate, reduce resistance
- efficiency = useful power output ÷ total power input
- total input = useful output + wasted
- useful output = efficiency × total input

## Notes

### What efficiency means

- Energy supplied to a device is either transferred **usefully** (to the store you want) or **wasted** (dissipated, usually to the thermal store of the surroundings).
- total input energy = useful output energy + wasted energy




Sankey diagram: widths show the energy. Efficiency = 75 ÷ 100 = 0.75 (75%).

- **Efficiency** = useful output energy transfer ÷ total input energy transfer
- You can also use power: efficiency = useful power output ÷ total power input.
- Efficiency has no unit. Give it as a decimal (e.g. 0.35) or as a percentage (× 100, e.g. 35%).
- No real device is 100% efficient, because some energy is always dissipated. Efficiency can never be more than 1 (100%).

### Using the equation

- Both energies (or both powers) must be in the same unit, e.g. both in J or both in kJ.
- If you are given a percentage, divide it by 100 before you use it in the equation.
- To find the useful output: useful output = efficiency × total input.
- To find the input: total input = useful output ÷ efficiency.

### Increasing efficiency Grade 7+ only

- Reduce the wasted energy transfers, so more of the input energy is transferred usefully.
- Lubricate moving parts to reduce friction.
- Streamline vehicles to reduce air resistance.
- Thermally insulate devices that heat things (e.g. an oven), so less energy is dissipated to the surroundings.
- Use wires with a low resistance, and LED lamps instead of filament lamps, so less energy is wasted by heating.

## How to answer each type of question

### Calculate the efficiency

2 marks | Grade 4

1. Pick out the useful output and the total input.
2. Divide useful by total.
3. Give a decimal, or multiply by 100 for a percentage (with the % sign).

**Example.** An electric motor is supplied with 2400 J of energy. It transfers 1800 J of this energy usefully.
Calculate the efficiency of the motor.

**Model answer.**

efficiency = 1800 ÷ 2400 (1)
efficiency = 0.75 (or 75%) (1)

### Calculate the efficiency when you are given the wasted energy

3 marks | Grade 6

1. Find the useful energy: total input − wasted energy.
2. Divide the useful energy by the total input.
3. Convert to a percentage if the question asks.

**Example.** A filament lamp is supplied with 500 J of energy. 425 J of this energy is wasted heating the surroundings.
Calculate the efficiency of the lamp as a percentage.

**Model answer.**

useful output = 500 − 425 = 75 J (1)
efficiency = 75 ÷ 500 = 0.15 (1)
efficiency = 15% (1)

### Rearrange to find the input power

3 marks | Grade 5

1. Change a percentage to a decimal.
2. Write efficiency = useful ÷ total and substitute.
3. Rearrange: total input = useful output ÷ efficiency.

**Example.** An electric motor is 80% efficient. Its useful power output is 1.2 kW.
Calculate the total power input to the motor in watts.

**Model answer.**

0.80 = 1200 ÷ total power input (1)
total power input = 1200 ÷ 0.80 (1)
total power input = 1500 W (1)

**Describe how to increase efficiency** 2 to 4 marks **Grade 7**

1. Name the wasted energy transfer, e.g. friction heating the moving parts.
2. Give a change that reduces it, e.g. lubrication.
3. Explain the effect: less energy is dissipated, so more is transferred usefully.

**Example.** An electric motor gets hot when it is used.
Describe **two** ways the efficiency of the motor could be increased. Give a reason for each.

**Model answer.**

Lubricate the moving parts (bearings) (1), to reduce friction so less energy is dissipated by heating (1).

Use wires with a lower resistance in the motor (1), so less energy is dissipated by heating when there is a current in them (1).

## Don't lose marks

- Dividing the total input by the useful output.
- Putting the wasted energy on top instead of the useful energy.
- Using one value in J and the other in kJ.
- Giving efficiency a unit (such as J), or forgetting the % sign.
- Putting a percentage (e.g. 80) into the equation instead of the decimal (0.80).

## More tips

### Memory tricks

- 'Useful over total': the smaller number goes on top.
- Sense check: if your efficiency is more than 1 (or 100%), you have divided the wrong way round.
- Decimal to percentage: multiply by 100, so 0.35 becomes 35%.
- An electric heater is almost 100% efficient, because heating the room is its useful output.

### Exam technique

- Check whether the question wants a decimal or a percentage.
- Show the subtraction when you have to find the useful energy first; it can earn a mark on its own.
- For 'describe how to increase efficiency', link each change to the wasted transfer it reduces.

## What each grade needs

What you need to be able to do, from the first marks up to the top grade.

**Grade 3** **Identify useful and wasted energy transfers**
E.g. for a lamp, light is the useful output and heating the surroundings is wasted.

**Grade 4** **Calculate efficiency from energy values**

Divide the useful output energy by the total input energy.

Grade 5

### Give efficiency as a decimal or percentage

Multiply the decimal by 100 to get a percentage; efficiency is never more than 1 (100%).

Grade 5

### Calculate efficiency from power values

Divide the useful power output by the total power input.

Grade 5

### Rearrange to find the input or output

Useful output = efficiency × total input; total input = useful output ÷ efficiency.

Grade 6

### Find the wasted or useful energy

Wasted energy = total input − useful output, so useful output = total input − wasted energy.

Grade 7

### Describe ways to increase efficiency

Reduce the wasted transfers, e.g. lubricate moving parts, streamline, insulate.

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