Efficiency

6.1.2.2 · Physics · 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.

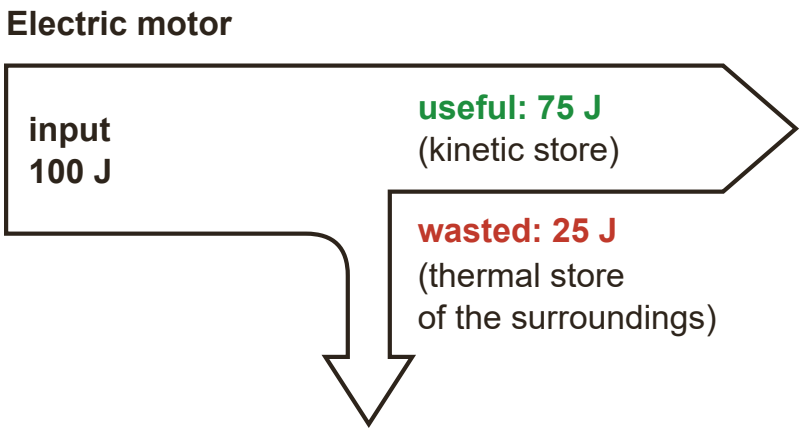
Key facts

- 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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