Energy and efficiency

Specification references:

- P1.2.2 Efficiency
- MS 1a, 1b, 2a, 3b, 3c

Aims

In this exercise, students will consider the meaning of the term efficiency and apply it to circumstances where energy is usefully transferred and wasted. They will describe ways to increase efficiency and to reduce unwanted energy transfers. Students will also calculate the efficiency of a variety of machines based on the useful energy and power that is transferred compared with what is wasted.

Learning outcomes

After completing this activity, students should be able to:

- state the efficiency equations using both energy and power
- describe what the word efficiency means
- describe how to increase efficiency
- calculate efficiency using the equations
- $\text{efficiency} = \dfrac{\text{useful output energy transfer}}{\text{total input energy transfer}} \times 100\%$
- $\text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100\%$
- calculate energy and power values based on efficiency values.

Teaching notes

This activity can be deployed to diagnose students' understanding of the key material relating to the area of energy and efficiency. The questions are differentiated by their level of demand, with Question 1 focusing on grade 2 material, and subsequent questions allowing access to content and concepts that students will need to successfully address if they are to achieve grades 5 to 8. The demand of the questions increases as students go through the exercise. This sheet may be used for assessing and consolidating the main body of work covered in lessons, as extension material, as part of a plenary, or as part of homework and independent study.

Answers to questions

1 Missing values are shown in bold in the table below. Award 1 mark for each row completed correctly. (*4 marks*)

Device	Useful output energy in %	Wasted output energy in %	Order of efficiency
hairdryer	91	**9**	**2**
light bulb	2	98	5 (least efficient)
cell or battery	**88**	12	**3**
kettle	94	**6**	**1 (most efficient)**
microwave oven	**68**	32	**4**

2 **a** Use of efficiency $= \left(\frac{\text{useful energy output}}{\text{total energy input}} \div \right) \times 100\%$ (*1*), 450 J − 143 J to get useful energy output of 307 J (*1*), so efficiency $= \left(\frac{307}{450} \div \right) \times 100\% = 68\%$ (*1*) (*3 marks*)

b Useful power is 3 W (*1*), efficiency $= \left(\frac{3}{20} \div \right) \times 100 = 15\%$ (*1*) (*2 marks*)

c power input = current × voltage (*1*), giving a value of 2.5 A × 16 V = 40 W (*1*), Useful power of motor is 18 W (*1*), so efficiency is $\left(\frac{18}{40} \div \right) \times 100\% = 45\%$ (*1*) (*4 marks*)

3 **a** Efficiency of the filament bulb is 5% (*1*); efficiency of the fluorescent bulb is 15% (*1*). (*2 marks*)

b Filament bulb has lower efficiency / other bulb has higher efficiency (*1 mark*)

c More input energy / (a greater proportion) is transferred to useful light energy (*1*) and less is wasted as thermal energy (*1*). (*2 marks*)

4 Some energy is always lost to the surroundings (as heat). (*1 mark*)

5 Suggestions could include: convert more input energy into electrical energy, for example, via more efficient generators or transformers (*1*); use the waste heat energy in a useful way, for example, to heat homes, hospitals or businesses (*1*). (*2 marks*)

6 Missing values are shown in bold in the table below. Award 1 mark for each row correctly completed. Other devices can be suggested as well as those shown here. (*3 marks*)

Device	Efficiency in %	Input	Useful output
hairdryer / transformer	**96**	140 kJ	135 kJ
lamp	17	**264.7 J**	45 J
motor	36	12 MW	**4.32 MW**