Calculating Power Questions: Extra Challenge

Give your answers to two decimal places. Show all your working out, including the equations you use. Don't forget to include the units for your answers.

Kinetic Energy Equation	Elastic Potential Energy Equation	Gravitational Potential Energy Equation	Power Equation
$E_k = \frac{1}{2}mv^2$	$E_e = \frac{1}{2}ke^2$	$E_p = mgh$	$P = E \div t$

Question 1

Maya picks up her school bag. The bag has a mass of 8.5kg. She lifts the bag to the height of her shoulders at 1.35m in 0.4s.

Gravitational field strength is 9.8N/kg.

Find the power that Maya lifts the bag with.

_____ kw

Question 2

Victoria draws back her bow 0.85m, ready to fire an arrow. The spring constant of the bow elastic is 800N/m. She draws the bow back in 0.2s.

Find the power that Victoria pulls the bow back with.

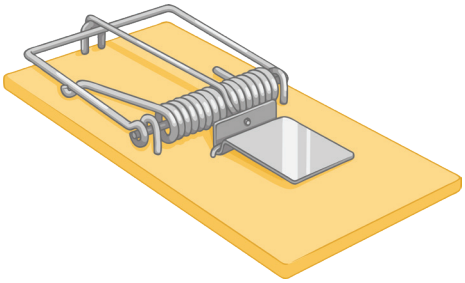
_____ kw

Question 3

A dodgem with a mass of 4500kg travels at a speed of 2.2m/s. The dodgem car runs for 3 minutes.

Find the power of the dodgem car.

_____ kw



More Challenge

A mouse trap takes 12 milliseconds to snap shut. The arm travels 30cm. The mass of the trap arm is 25g.

Find the power of the mouse trap.

_____ kw

Calculating Power Questions: Extra Challenge Answers

$E_p = mgh$

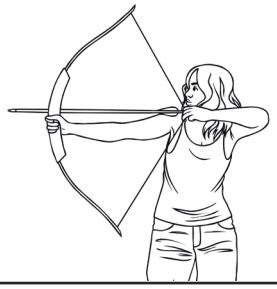
$E_p = 8.5 \times 9.8 \times 1.35$

$E_p = 112.455J$

$P = E \div t$

$P = 112.455 \div 0.4$

$P = 281.14W$ or $0.28kW$



$E_e = \frac{1}{2}ke^2$

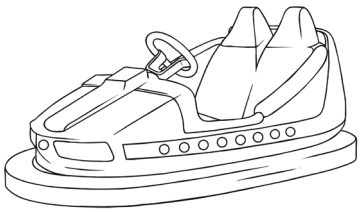
$E_e = 0.5 \times 800 \times 0.85^2$

$E_e = 289J$

$P = E \div t$

$P = 289 \div 0.2$

$P = 1445W$ or $1.445kW$



$E_k = \frac{1}{2}mv^2$

$E_k = 0.5 \times 4500 \times 2.2^2$

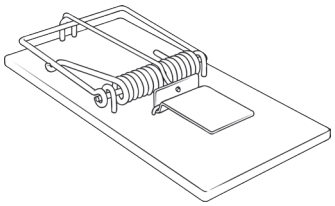
$E_k = 10\ 890J$

$P = E \div t$

$P = 10\ 890 \div (3 \times 60)$

$P = 10\ 890 \div 180$

$P = 60.5W$ or $0.061kW$



using speed = distance ÷ time:

$v = (30 \div 100) \div (12 \div 1000)$

$v = 25m/s$

$E_k = \frac{1}{2}mv^2$

$E_k = 0.5 \times 0.025 \times 25^2$

$E_k = 7.8125J$

$P = E \div t$

$P = 7.8125 \div 0.012$

$P = 651.04W$ or $0.65kW$

Efficiency Calculations Word Problems

$$\textbf{efficiency} = \frac{\text{useful output energy (J)}}{\text{total input energy (J)}} \times 100$$

Use the equation above to solve each question. Give your answer to two decimal places where it is not a whole number answer.

1. Joe is making toast for his breakfast. The toaster uses 500J energy to brown the bread. A total of 750J energy is input to the toaster. Calculate the percentage efficiency of the toaster.

2. Amaan is drying his PE kit ready for tomorrow. The dryer has a total input of 1300J energy. 650J energy is used to dry the clothes. Calculate the percentage efficiency of the tumble dryer.

3. The total input energy of Maja's hair straighteners is 1600J. 1200J are transferred usefully as heat energy. Calculate the percentage efficiency of the hair straighteners.

Don't forget to check the units carefully.

4. Steven has bought a new drill for work. The total input energy is 1.8kJ. The useful output energy is 800J. Calculate the percentage efficiency of the drill.

5. Ali has bought new speakers for his car. The output of the speakers is 550J. The total energy input is 0.85kJ. Calculate the percentage efficiency.

Rearrange the equation to change the subject.

6. Julia has bought a new freezer. The efficiency rating is E. The sticker states that the freezer uses a total energy input of 855kJ per year. It also states that it has an efficiency of 55%. Calculate the useful energy output of the freezer.

7. Huang's microwave is 65% efficient. It has a total input energy of 1.1kJ. Calculate the useful output energy, giving your answer in joules.

8. Rupert has a remote-controlled car. It is 35% efficient, transferring 90J of the total energy into useful kinetic energy. Calculate the total energy input, giving your answer in joules.

9. Susie is using a solar calculator. It is 75% efficient, transferring 12J of the total energy into useful output energy. Calculate the total energy input, giving your answer in joules.

Extension

Horace is installing a new wind turbine on his farm. The efficiency of the wind turbine is stated as 60%. The turbine requires a total input energy of 2.4kJ/hour.

a. Calculate the useful output energy of the turbine, per hour.

b. Calculate the wasted output energy of the turbine.

c. What type of energy might the wasted transfers be?

d. If the turbine runs for 16 hours in a day, calculate the total energy input to the turbine for that day.

Efficiency Calculations Word Problems Answers

Use the equation above to solve each question. Give your answer to two decimal places where it is not a whole number answer.

1. **(500 ÷ 750) × 100 = 66.67%**

2. **(650 ÷ 1300) × 100 = 50%**

3. **(1200 ÷ 1600) × 100 = 75%**

4. **Convert kJ into J: 1.8 × 1000 = 1800**
   (800 ÷ 1800) × 100 = 44.44%

5. **Convert kJ into J: 0.85 × 1000 = 850**
   (550 ÷ 850) × 100 = 64.71%

6. **useful output energy = (efficiency × total input energy) ÷ 100**
   (855 × 55) ÷ 100 = 470.25kJ/year (or 470 250J/year)

7. **Convert kJ into J: 1.1 × 1000 = 1100**
   useful output energy = (efficiency × total input energy) ÷ 100
   (1100 × 65) ÷ 100 = 715J

8. **total input energy = (useful output energy ÷ efficiency) × 100**
   (90 ÷ 35) × 100 = 257.14J

9. **total input energy = (useful output energy ÷ efficiency) × 100**
   (12 ÷ 75) × 100 = 16J

Extension

Horace is installing a new wind turbine on his farm. The efficiency of the wind turbine is stated as 60%. The turbine requires a total input energy of 2.4kJ/hour.

a. **useful output energy = (efficiency × total input energy) ÷ 100**
   (2.4 × 60) ÷ 100 = 1.44kJ or 1440J

b. **wasted output energy = total input energy – useful output energy**
   2.4 – 1.44 = 0.96kJ or 960J

c. **sound or heat (thermal)**

d. **2.4 × 16 = 38.4kJ or 38 400J**

Efficiency Calculations

$$\textbf{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100$$

Using a calculator, complete the table below to calculate the efficiency of the following appliances

Appliance	Useful Energy Output (J)	Total Energy Supplied (J)	% Efficiency
toaster	520	800	
hair straighteners	960	1200	
electric heater		1800	45
microwave		1200	35
hairdryer	250		25
tumble dryer	500		40
food processor	450	600	
cd player		350	80

Extension

Rearrange the equation above to make...

a. **useful output energy** the subject:

b. **total input energy** the subject:

Efficiency Calculations Answers

Appliance	Useful Energy Output (J)	Total Energy Supplied (J)	% Efficiency
toaster	520	800	**65**
hair straighteners	960	1200	**80**
electric heater	**810**	1800	45
microwave	**420**	1200	35
hairdryer	250	**1000**	25
tumble dryer	500	**1250**	40
food processor	450	600	**75**
cd player	**280**	350	80

Extension

Rearrange the equation above to make...

a. **useful output energy** the subject:
(efficiency × total input energy) ÷ 100

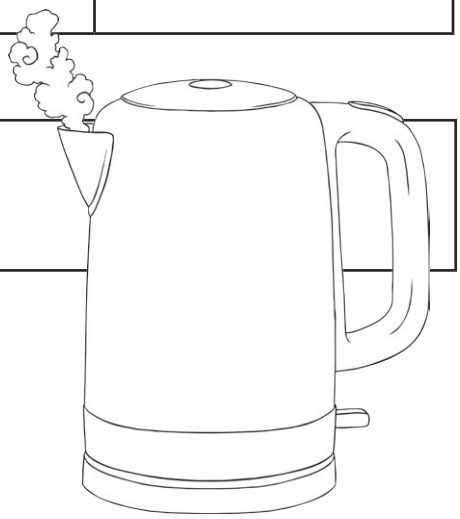
b. **total input energy** the subject:
(useful output energy ÷ efficiency) × 100

Efficiency Calculations

$$\textbf{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100$$

Using a calculator, complete the table below to calculate the efficiency of the following appliances

Appliance	Useful Energy Output (J)	Total Energy Supplied (J)	% Efficiency
kettle	90	100	
television	70	150	
light bulb	20	100	
drill	550	1,500	
radio		700	50
electric fan	147		70



Extension

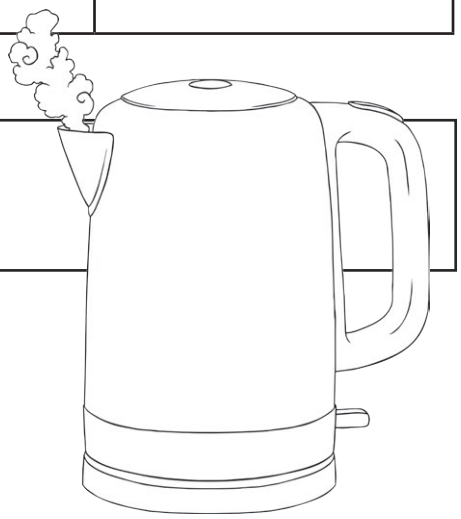
Can you rearrange the formula to complete the last two examples?

Answers

$$\textbf{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100$$

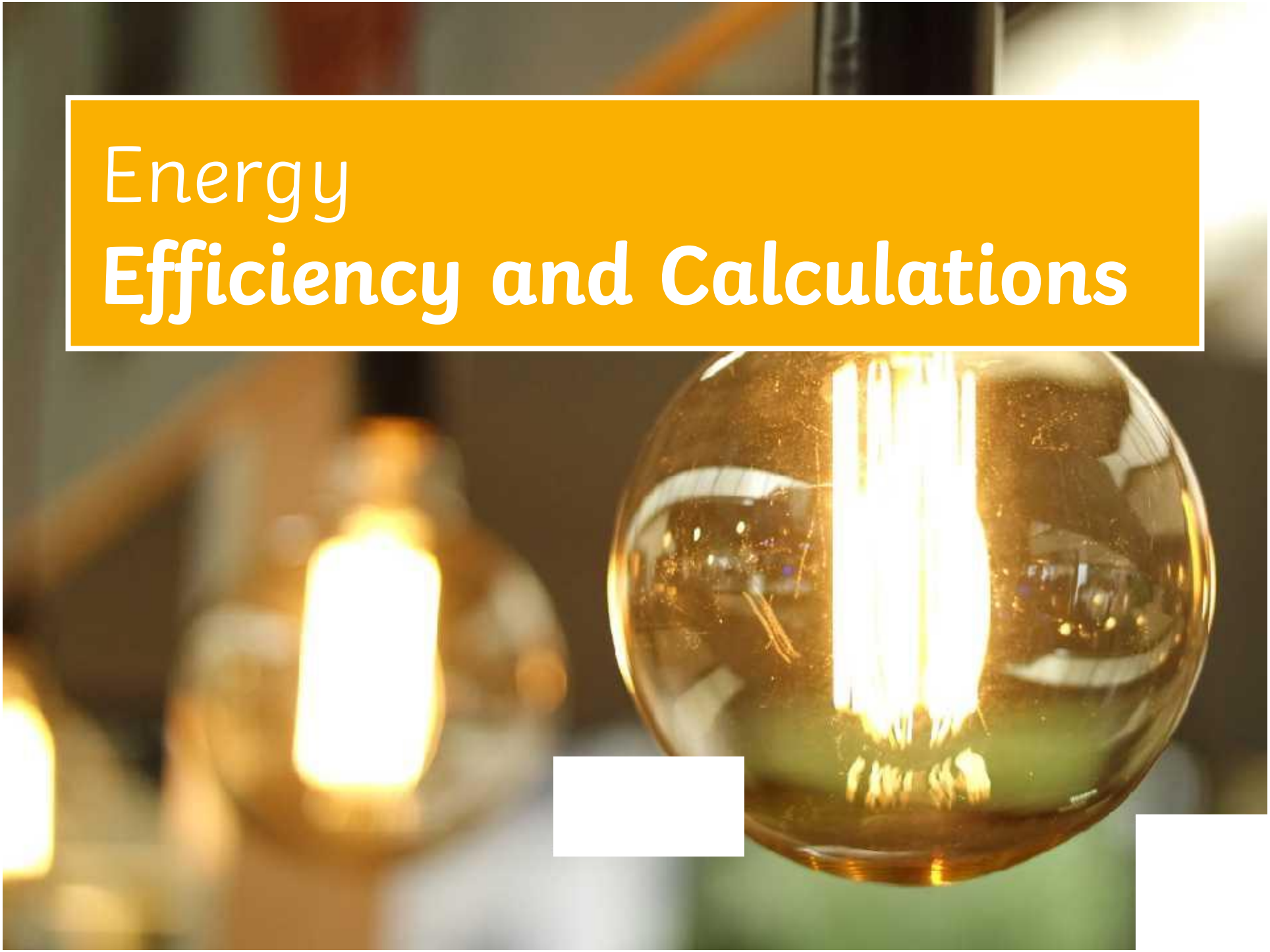
Using a calculator, complete the table below to calculate the efficiency of the following appliances

Appliance	Useful Energy Output (J)	Total Energy Supplied (J)	% Efficiency
kettle	90	100	**90**
television	70	150	**47**
light bulb	20	100	**20**
drill	550	1,500	**37**
radio	**350**	700	50
electric fan	147	**210**	70

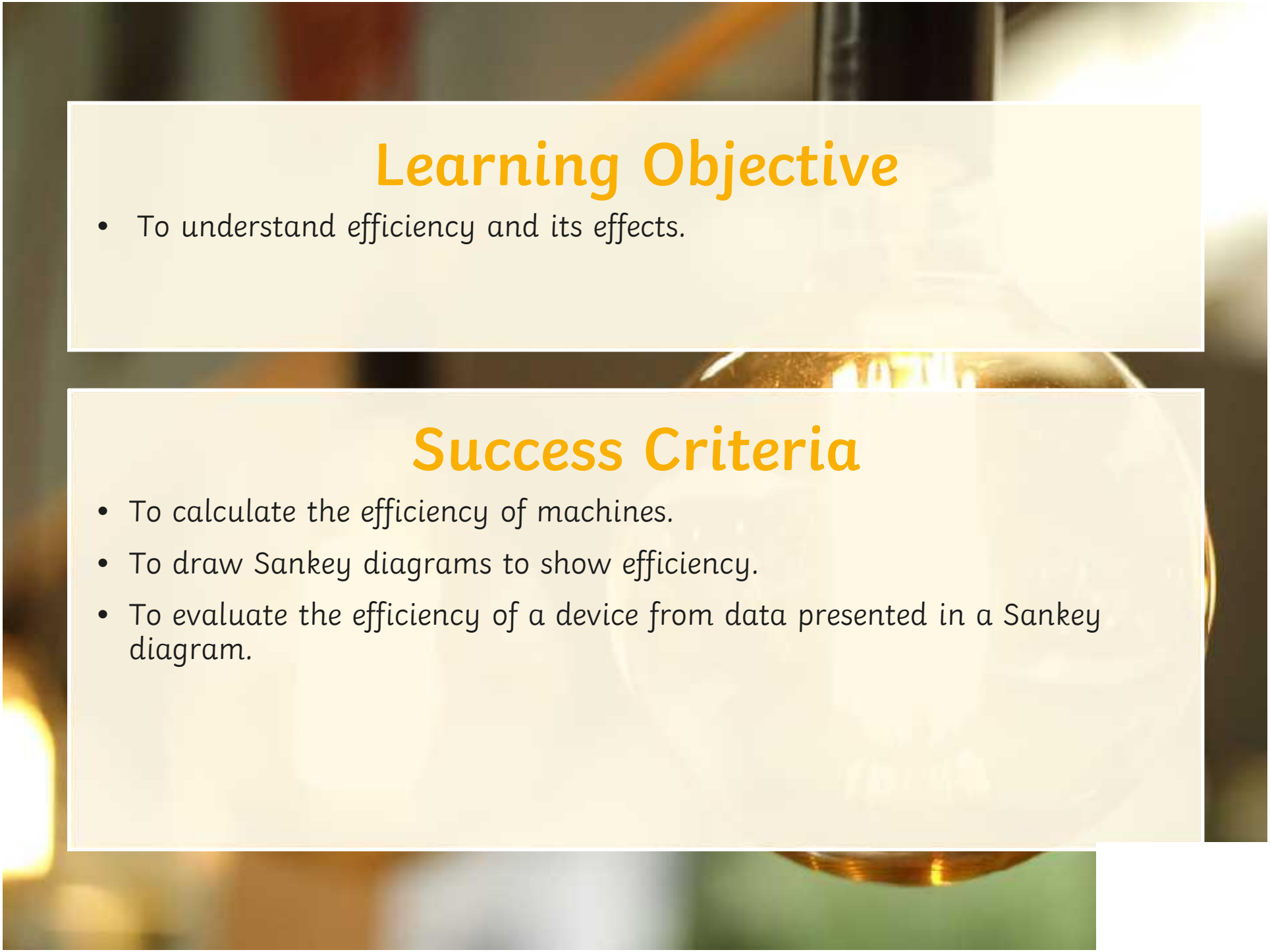


Extension

Can you rearrange the formula to complete the last two examples?



Energy
Efficiency and Calculations



Learning Objective

- To understand efficiency and its effects.

Success Criteria

- To calculate the efficiency of machines.
- To draw Sankey diagrams to show efficiency.
- To evaluate the efficiency of a device from data presented in a Sankey diagram.

Starter: Efficiency

Which would you buy?
Why?
What does efficiency mean?

- 80W bulb.
- Lasts 1 500 hours.
- Only 50p each.

- Produces the same light as an 80W bulb, using only 20W.
- Lasts at least 12 000 hours.
- Only £2 each.

Efficiency

The efficiency of any device is the ratio of useful energy compared to the energy required to make the device work.

Efficiency can be calculated using the following equation:

$$\textbf{efficiency} = \frac{\text{useful output energy J}}{\text{total input energy J}}$$

To convert this to a percentage, multiply by 100.

Efficiency Calculation

A washing machine:

200J supplied as electrical energy.

100J transferred as sound and light.

100J as useful energy.

Using the equation:

$$\textbf{efficiency} = \frac{\text{useful output energy J}}{\text{total input energy J}} \times 100$$

$$\textbf{efficiency} = \frac{100}{200} \times 100 = 50\%$$

Your Turn: Efficiency Calculations

Using a calculator, complete the table below to calculate the efficiency of the following appliances.

Appliance	Useful Energy Output (J)	Total Energy Supplied (J)	% Efficiency
kettle	90	100	**90**
television	70	150	**47**
light bulb	20	100	**20**
drill	550	1 500	**37**
radio	**350**	700	50
electric fan	147	**210**	70

Extension

Can you rearrange the formula to complete the last two examples?

Missing Energy: Thinking Activity

In pairs you have two minutes to answer these questions.

What do you notice about the efficiency of each appliance?
None of the appliances have 100% efficiency.

What do you think has happened to the missing input energy?
It has been transferred in a non-useful way, perhaps dissipated as heat to the surroundings, or as light, or as sound.

Can you think of a way of showing the missing energy?
Sankey diagrams

Missing Energy: Can You Spot the Wasted Energy?

light bulb
(useful)
Electrical energy → light
→ thermal (wasted)

electric drill
electrical energy → kinetic (useful)
→ heat (wasted)
→ sound (wasted)

Quick Assessment: Energy Transfers

On white boards, fill in the following blanks:

mains operated radio

input energy:
_____ 100J

_____ (useful)
_____J

_____
(wasted)
40J

_____
(wasted)
40J

Extension:
Can you calculate the efficiency?

Sankey Diagrams

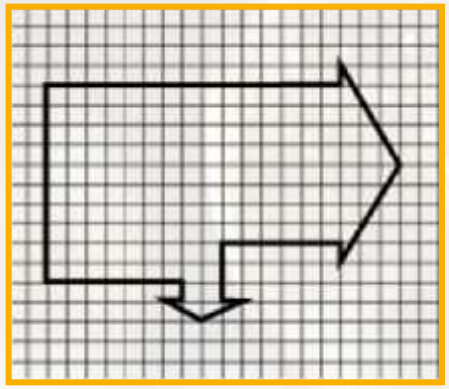
battery-operated torch

Energy diagrams can also be shown as Sankey diagrams.

chemical energy 10J

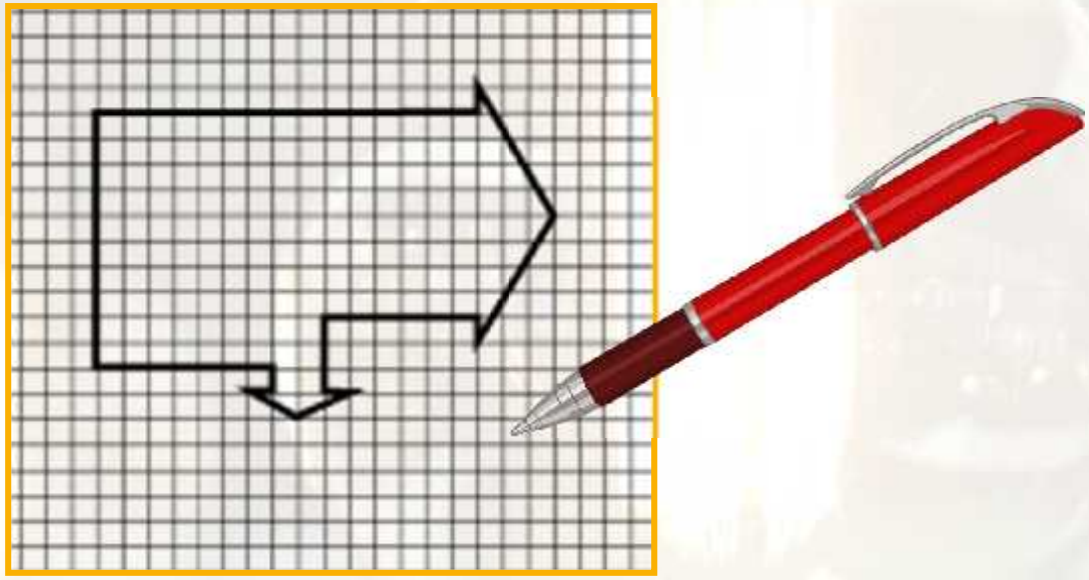
light (useful energy) 8J

thermal (wasted energy) 2J



Making a Sankey Diagram

Follow the instructions on the activity sheet to make your own Sankey diagram.

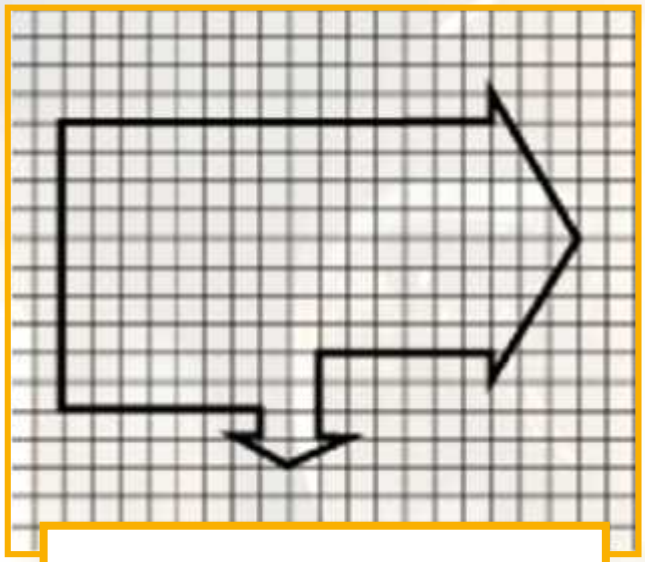


Scientific Sankey Diagrams

A more scientific way of drawing Sankey diagrams is on graph paper. You may see them like this in your exams.

Energy input (from the left of The diagram)

Width represents the amount of energy



Wasted or unwanted energy forms (vertical)

Useful energy output (to the right)

Length has no significance

Drawing Sankey Diagrams: Your Turn

Use graph paper to draw Sankey diagrams for the following appliances. Remember that width represents the amount of energy.

1. A radio uses 10J of electrical energy, 1J is transferred as sound energy, and 9J is wasted as heat

2. An electric fan produces 3J kinetic energy, 2J sound energy and 5J heat energy for every 10J electrical energy it is supplied with.

3. A radio produces 5J sound energy, while using 200J electrical energy, the rest is wasted as heat.

Extension:

4. A car engine which makes 150J kinetic energy, 50J sound energy and 800J heat energy from every 1 000J in the fuel.

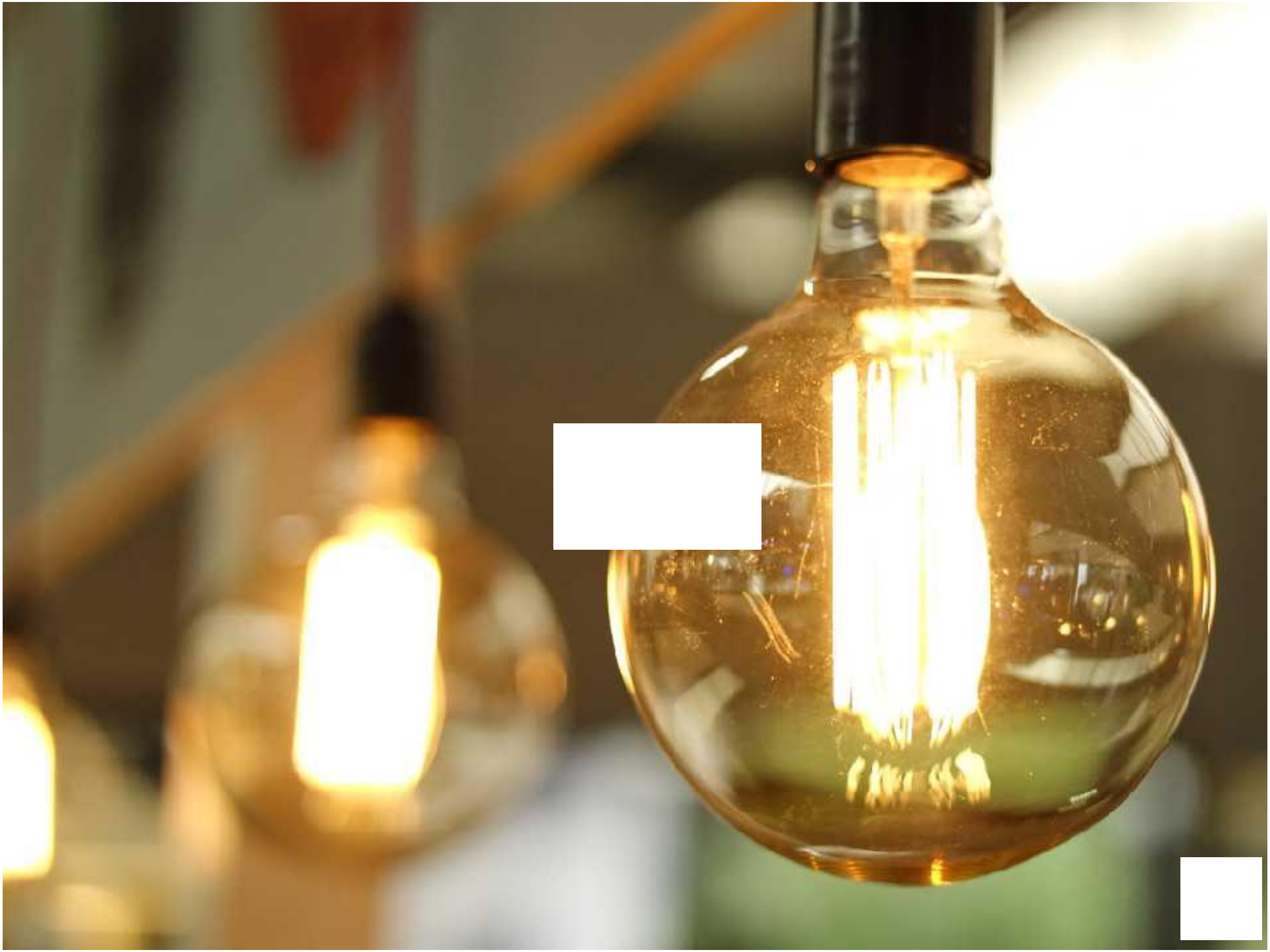
Three Things...

3

- you know now that you didn't at the start of the lesson;
- you have done well.

Home Work

Research and report how we can try to make machines more efficient.

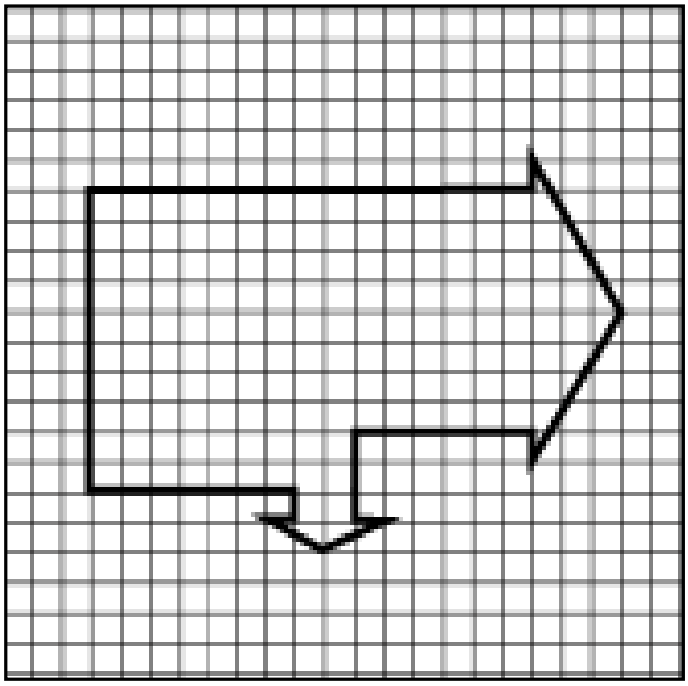


Making Sankey Diagrams

To make a Sankey diagram for a battery-operated torch, follow the instructions.

input energy (chemical)	useful output energy (light)	wasted output energy (thermal)
10J	8J	2J

1. Cut around the shape.
2. Label the following areas on your outline: input energy (10J), useful energy (8J) **and** wasted energy (2J).
3. Add the key 1 square = 1J.
4. Fold the wasted energy down.
5. Stick in your book.



Can you make your own to show a lamp that uses 100J of electrical energy and transfers it into 60J light energy and 40J as wasted thermal energy.

Hint: what scale will you use? 1 square = ____ J

Remember the width of the arrows represents the amount of energy at each stage.

Sankey Diagrams

1. A radio uses 10J of electrical energy, 1J is transferred as sound energy, and 9J is wasted as heat.
2. An electric fan produces 3J kinetic energy, 2J sound energy and 5J heat energy for every 10J electrical energy it is supplied with.
3. A radio produces 5J sound energy, while using 200J electrical energy, the rest is wasted as heat.

Extension:

4. A car engine which makes 150J kinetic energy, 50J sound energy and 800J heat energy from every 1 000J in the fuel.

Key Points

1. For each of the questions identify the following:

Appliance	Total Input Energy (J)	Useful Energy (J)	Wasted Energy (J)
1			
2			
3			
4			

2. The input is on the left of your graph paper. The width of the box represents the number of joules. For example, 1 square = 1 joule.

3. The useful energy goes to the right of the graph paper.

4. The wasted energy is shown vertically.

Remember

The width represents the amount of energy.

The length has no significance.

Sankey Diagrams

1. A radio uses 10J of electrical energy, 1J is transferred as sound energy, and 9J is wasted as heat.
2. An electric fan produces 3J kinetic energy, 2J sound energy and 5J heat energy for every 10J electrical energy it is supplied with.
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Extension:

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Sankey Diagrams

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Energy
Efficiency and Calculations

Learning Objective:	• To understand efficiency and its effects.
Success Criteria:	• To calculate the efficiency of machines. • To draw Sankey diagrams to show efficiency. • To evaluate the efficiency of a device from data presented in a Sankey diagram.
Context:	This is the second lesson in the energy topic for key stage 3 physics.

Resources

Lesson Pack

glue

scissors

calculators

rulers

pencils

white boards and pens (if possible)

graph paper

erasers

Starter

Efficiency

Slide 3: Pupils are given data about a standard light bulb and an energy efficient light bulb. They are asked the following questions: Which would you buy? Why? What does efficiency mean?

It is worth spending some time asking pupils for answers, because not all will be aware of the particulars of lightbulbs!

Main Activities

Efficiency

Slides 4-5: A definition of efficiency is given, along with the equation required to calculate efficiency, and a worked example of a washing machine.

Using the Efficiency Calculations Activity Sheet, pupils practice calculating the efficiency of various devices. There is an extension question on the sheet where pupils are required to rearrange the formula. For this, they may require some guidance.

Slide 6 contains a copy of the questions, and the answers wipe in with a mouse click, so the work can be peer marked.

If possible, ensure that there are enough calculators for one per pupil.

Missing Energy

Slide 7 contains a short thinking activity, based on the work covered in lessons 1 and 2. Pupils are asked to think about why the devices are not 100% efficient, and they should notice that in energy transfers there are three important sections: energy input, useful energy and wasted energy.

Slide 8 contains a guided worked example followed by a quick assessment on slide 9.

Activity Sankey Diagrams:

Slides 10-11 illustrate the appearance of Sankey diagrams and guides pupils through the stages to produce their own. The

Making Sankey Diagrams Activity Sheet involves following a set of instructions to cut out and fold paper to produce a Sankey diagram for a battery-operated torch. The first example could be completed together as a class, and then the second example allows pupils to demonstrate their understanding of Sankey diagrams by creating their own.

Slides 12-13 cover the more scientific way of drawing Sankey diagrams using graph paper. Having mastered making their own diagrams, pupils are set a number of diagrams to draw using graph paper. Make the pupils aware that this is excellent exam practice! These tasks are also available on the **Sankey Diagram Tasks Activity Sheet**, should you wish to print and distribute them. There is also a **Sankey Diagram Tasks Help Sheet** for lower ability pupils who may require extra assistance.

Plenary

Three Things

The lesson is completed by asking pupils to name three things...

- they didn't know at the start of the lesson;
- they have done well.

Spend some time asking pupils for their answers to these questions, the responses can be very interesting and can inform future planning.

Home Work

Research and report how we can try to make machines more efficient.