Heat transfer and the measurement of heat

Lesson plan and teacher's notes · Form 2 Physics · 1 period of 40 minutes

School	(write school name)	**Teacher**	(write name)
Date	(date)	**Class**	Form 2
Subject	Physics	**Enrolment**	Boys ___ Girls ___ Total ___
Time	40 minutes	**Topic**	Heat transfer and the measurement of heat

Learners describe conduction, convection and radiation, explain why metals conduct and plastics insulate, explain how dark and light surfaces treat radiation, explain a convection current, and define heat capacity, specific heat capacity and latent heat. Examples come from a charcoal brazier, a nshima pot, a refrigerator and a car trip with hot food.

Specific outcomes

By the end of the lesson, learners should be able to:

1. Describe conduction, convection and radiation
2. Explain why metals are good conductors and plastics are insulators
3. Explain how dark and light surfaces absorb or reflect radiation
4. Explain how a convection current forms
5. Define heat capacity, specific heat capacity and latent heat

Prior knowledge

- Particles in solids, liquids and gases
- Temperature and the idea of hot and cold
- Multiplying whole numbers

Teaching and learning materials

- a metal spoon and a plastic spoon
- a basin of hot water
- a black and a white piece of cloth or paper
- chalk and board
- exercise books

References

Ministry of Education (CDC) Form 2 Physics syllabus and module; 25Schools learners' note: Heat transfer and the measurement of heat.

Lesson development

Stage and time	Teacher activities	Learner activities
Introduction 5 min	Ask why a metal spoon in a nshima pot gets hot and why a brazier warms your hands. Tell learners that heat moves in three ways.	Suggest reasons and copy the lesson title.
Development: conduction and radiation 12 min	Put the metal spoon and the plastic spoon in hot water and compare them. Teach conduction, good conductors, insulators and why saucepan handles are wood or plastic. Teach radiation, absorbers and reflectors.	Record which spoon heats quickly, and sort dark and light surfaces into absorbers and reflectors.
Development: convection and keeping things hot or 10 min	Draw the convection current above a fire and in a refrigerator. Explain how each material in the car trip food box reduces heat loss.	Draw the convection loop and say what each material in the food box does.
Development: measuring heat 10 min	Teach heat capacity, specific heat capacity and latent heat of fusion and vaporisation. Work the 4200 J example for 2 kg and 3 °C step by step.	Copy the definitions and work a similar calculation.
Conclusion 3 min	Ask for the three ways heat is transferred and one use of each. Set the homework.	Answer orally and copy the homework.

Teacher's content notes

Read these before the lesson. They are what you need to know, not what to copy onto the board.

Conduction

Hold a metal spoon and a plastic spoon in hot water. The metal spoon quickly becomes too hot to hold, but the plastic one does not. A metal is a good conductor of heat. Its particles vibrate vigorously and pass kinetic energy on quickly to the next particles, and so to your hand. Plastic is a poor conductor, called an insulator, so energy moves through it very slowly. This is why saucepans have wooden or plastic handles: they are poor conductors, so heat does not reach the hand and burns are avoided.

Convection

Heat is also carried by moving air or liquid. Air above a fire is heated and rises. It then spreads out, cools and sinks back down towards the fire, forming a continuous loop called a convection current. The same idea keeps a refrigerator cold. Cold air near the cooling coils is denser and sinks, while warmer air rises. This flow keeps the temperature low and even throughout the fridge.

Radiation and keeping things hot or cold

Heat from the sun reaches us by radiation, in the form of infrared rays. Dark, dull or black surfaces are good absorbers of radiation, and light, shiny surfaces are good reflectors, so they stay cooler. Good absorbers of radiation are also good emitters. This is why people prefer to wear light clothes on a hot day, and why shiny aluminium foil is used to reflect heat. A family can wrap hot food in aluminium foil and put it in a cardboard box lined with old newspapers and cotton cloth for a long car trip. Each material stops a different kind of heat transfer.

Measuring heat

Heat capacity is the heat energy needed to change the temperature of a substance by 1 °C or 1 K. Specific heat capacity is the heat energy needed to change the temperature of 1 kg of the substance by 1 °C or 1 K. Latent heat is the heat energy needed to change the state of a substance without any change in temperature. The specific latent heat of fusion is the energy needed to change 1 kg of a substance from solid to liquid, for example ice to water, without changing its temperature. The specific latent heat of vaporisation is the energy needed to change 1 kg of a substance from liquid to gas

Questions to ask during the lesson

Question	Expected answer
On a cold evening in Lusaka a family sits by a charcoal brazier, feels the sun earlier in the day and sees a metal spoon heat up in a pot. (a) Name the three ways in which heat is transferred. (b) Say which way heats a metal spoon in a pot. (c) Say which way brings heat from the sun.	(a) Conduction, convection and radiation. (b) Conduction. (c) Radiation.
A cook chooses between a plastic spoon and a metal spoon for stirring hot food. (a) Say which spoon is better. (b) Say why. (c) Say why saucepans have wooden or plastic handles.	(a) The plastic spoon. (b) Plastic is a poor conductor (an insulator), so heat passes through it very slowly. (c) They are poor conductors, so heat does not reach the hand and burns are avoided.
A learner watches smoke rise above a fire, spread out and sink back down towards it. (a) Name the loop that forms. (b) Say what happens to the air above the fire. (c) Say how the same idea keeps a refrigerator cold.	(a) A convection current. (b) It is heated and rises, then spreads out, cools and sinks. (c) Cold air near the cooling coils is denser and sinks while warmer air rises, which keeps the temperature low and even.
A learner reads that heat capacity and specific heat capacity are different quantities. (a) Say what the difference is. (b) Define latent heat. (c) Say what happens to the temperature of ice at 0 °C as it melts.	(a) Heat capacity is for a whole substance and specific heat capacity is for 1 kg of it. (b) The heat energy needed to change the state of a substance without any change in temperature. (c) It stays constant.

Worked examples for the board

Example 1: heat for 2 kg and 3 °C

A substance needs 4200 J to raise the temperature of 1 kg by 1 °C. How much heat does 2 kg need to rise by 3 °C? 4200 J is needed for 1 kg to rise by 1 °C. For 2 kg, the heat doubles: 4200 × 2 = 8400 J for 1 °C. For a rise of 3 °C, the heat triples: 8400 × 3 = 25 200 J. So 2 kg needs 25 200 J.

Example 2: the spoon test

A metal spoon and a plastic spoon are held in hot water. The metal spoon quickly becomes too hot to hold, but the plastic one does not. A metal is a good conductor, so its particles vibrate vigorously and pass kinetic energy on quickly. Plastic is a poor conductor, an insulator, so energy moves through it very slowly.

Example 3: wrapped hot food

A family wraps hot food in aluminium foil and puts it in a cardboard box lined with old newspapers and cotton cloth for a long car trip. Shiny aluminium foil is used to reflect heat. Each material stops a different kind of heat transfer, so the food stays hot for longer.

Board plan

Write the title and key words. Left: conduction with the spoon example. Centre: the convection current drawn above a fire with arrows. Right: radiation and the heat measurement definitions with the 4200 J working.

Way	How heat moves	Example from the lesson
Conduction	Particles pass on energy through a material	A metal spoon in a hot pot
Convection	A heated liquid or gas rises while cooler fluid sinks	Air above a fire; the inside of a refrigerator
Radiation	Infrared rays, which do not need a material to travel through	Heat from the sun

Three ways heat is transferred

Mistakes to expect

Learners often think	Put it right
Plastic is a good conductor of heat.	Plastic is a poor conductor, called an insulator, so energy moves through it very slowly. This is why saucepans have wooden or plastic handles.
Light, shiny surfaces absorb the most radiation.	Dark, dull or black surfaces are good absorbers of radiation, and light, shiny surfaces are good reflectors, so they stay cooler.
Heat capacity and specific heat capacity are the same thing.	Heat capacity is for a whole substance, and specific heat capacity is for 1 kg of it.

The temperature of ice keeps rising while it melts.	The temperature stays constant at 0 °C while it melts. The heat used is latent heat, in this case the latent heat of fusion.

Differentiation

Learners who struggle

Give learners a table with the three ways of heat transfer and ask them to fill in an example from home for each. For the calculation, write the steps on the board: for 1 kg and 1 °C, then for the mass, then for the rise in temperature.

Learners who finish early

Ask learners who finish early to explain why a refrigerator keeps its temperature low and even, using a convection current, and to explain why a light surface stays cooler than a dark one in the sun.

Hearing or visual impairment

For learners with hearing impairment, write each key word on the board and show the spoon test. For learners with visual impairment, let them feel the dark and light cloth after standing in the sun, and describe each diagram aloud, including the direction of the arrows.

No projector, no printing

Use any two spoons of different materials and a cup of hot water. Use any dark and light cloth for radiation. Draw the convection current and the food box on the board.

If time is short

Teach conduction, convection and radiation with the spoon, the fire and the black bag. Leave keeping things hot or cold and the measurement of heat for the next lesson.

Evaluation

Question or task	A correct answer shows
A learner at a school in Luangwa notices on a hot afternoon that a black school bag left in the sun is much hotter than a white one. (a) Name the heat transfer process that brings heat from the sun. (b) Explain why the black bag becomes hotter. (c) Suggest what colour of cloth is best to wear on a hot day.	(a) Radiation. (b) Dark, dull surfaces are good absorbers of radiation, while light surfaces reflect it. (c) Light or white cloth, because it reflects more radiation and stays cooler.
A learner in Lusaka puts 200 g of ice at 0 °C into a metal cup and heats it. The ice melts and then the water warms up. (a) Name the heat concept for melting the ice without a change in temperature. (b) Say what happens to the temperature while the ice melts. (c) Say what the energy needed to change 1 kg of a solid to a liquid is called.	(a) Latent heat, the latent heat of fusion. (b) It stays constant. (c) The specific latent heat of fusion.

A cook stirs a pot of hot nshima with a metal spoon and a plastic spoon, and the metal spoon quickly becomes too hot to hold. (a) Name the process by which heat moves along the spoon. (b) Explain why the metal spoon becomes too hot. (c) Say why the plastic spoon is better for stirring.	(a) Conduction. (b) Metal is a good conductor, so its particles vibrate vigorously and pass kinetic energy on quickly. (c) Plastic is a poor conductor, an insulator, so heat passes through it very slowly.

Homework

A substance needs 4200 J to raise the temperature of 1 kg by 1 °C. A woman in a village heats 4 kg of this substance in a pot and the temperature rises by 2 °C. (a) Find the heat needed for 4 kg to rise by 1 °C. (b) Find the heat needed for a rise of 2 °C. (c) Name the quantity that 4200 J per kilogram per degree describes.

Extra practice with answers

Question	Answer
1. A girl leaves a black bag and a white bag in the sun at school, and the black bag becomes hotter. (a) Name the process that brings the heat from the sun. (b) Explain why the black bag becomes hotter. (c) Say what kind of surface is a good reflector.	(a) Radiation. (b) Dark, dull surfaces are good absorbers of radiation. (c) A light, shiny surface.
2. A substance needs 4200 J to raise the temperature of 1 kg by 1 °C, and a cook heats 3 kg of it by 2 °C in a pot in Lusaka. (a) Find the heat for 3 kg for 1 °C. (b) Find the heat for a rise of 2 °C. (c) Say what this 4200 J per kilogram per degree is an example of.	(a) 4200 × 3 = 12 600 J. (b) 12 600 × 2 = 25 200 J. (c) Specific heat capacity.
3. A substance needs 4200 J to raise the temperature of 1 kg by 1 °C, and a learner heats 2 kg of it by 5 °C in an experiment. (a) Find the heat for 2 kg for 1 °C. (b) Find the heat for a rise of 5 °C. (c) Say what happens to the heat needed if the mass doubles.	(a) 4200 × 2 = 8400 J. (b) 8400 × 5 = 42 000 J. (c) It doubles.
4. A learner puts ice at 0 °C in a cup and keeps heating it while it melts, and a pot of water at its boiling point turns to steam. (a) Name the heat needed to change ice to water without changing temperature. (b) Name the heat needed to change 1 kg of liquid to gas at its boiling point. (c) Say what h	(a) The latent heat of fusion (for 1 kg, the specific latent heat of fusion). (b) The specific latent heat of vaporisation. (c) The temperature does not change.
5. A learner looks at the inside of a refrigerator where cold air near the cooling coils sinks and warmer air rises. (a) Name the flow that forms. (b) Say why cold air near the coils sinks. (c) Say what this flow does to the temperature inside the fridge.	(a) A convection current. (b) It is denser. (c) It keeps the temperature low and even throughout the fridge.

Answers to the learners' check-yourself questions

1. Name the three ways in which heat is transferred.
   Conduction, convection and radiation.
2. Why is a plastic spoon better than a metal spoon for stirring hot food?
   Plastic is a poor conductor (an insulator), so heat passes through it very slowly.
3. What is a convection current?
   The continuous loop in which hot air or liquid rises, cools and sinks again.
4. What is the difference between heat capacity and specific heat capacity?
   Heat capacity is for a whole substance and specific heat capacity is for 1 kg of it.
5. What happens to the temperature of ice at 0 °C as it melts, and what is the heat called?
   It stays constant; the heat is latent heat (of fusion).
6. You are a learner at a school in Luangwa. On a hot afternoon you notice that a black school bag left in the sun is much hotter than a white one. (a) Which heat transfer process brings the heat from the sun? (b) Explain why the black bag becomes hotter. (c) Suggest what colour of cloth is best for a
   (a) Radiation. (b) Dark, dull surfaces are good absorbers of radiation, while light surfaces reflect it. (c) Light or white cloth, because it reflects more radiation and stays cooler.
7. A learner in Lusaka puts 200 g of ice at 0 °C into a metal cup, then heats it. The ice melts and then the water warms up. (a) Name the heat concept for melting the ice without a change in temperature. (b) Say why the temperature stays constant while it melts. (c) Say which concept is used for the he
   (a) Latent heat, the latent heat of fusion. (b) The heat energy is used to change the state of the substance, not to raise its temperature. (c) Specific heat capacity.

Teacher's reflection

What went well:

What I will change next time:

Learners who need follow-up: