

GCSE Physics

Heat Transfer

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Heat Transfer' activity which supports OCR GCSE Physics.



The Activity:

This resource comprises of 3 tasks.

Learning outcomes:

- To be able to recall the three main types of heat transfer
- To describe the processes in terms of particle models or in terms of energy transfer
- To apply their knowledge to real life applications



This activity offers an opportunity for English skills development.



This activity offers an opportunity for maths skills development.

Associated materials:

'Heat Transfer' Lesson Element learner activity sheet.

Introduction

These activities are designed as examples that can be used to demonstrate the different forms of heat energy transfer. You could split up the activities and use them after each section has been taught, or use them as a consolidation exercise at the end of the taught segment. Learners are expected to have a basic understanding of conduction and convection from Key Stage 3 but will need to develop their knowledge of radiation. They will need to be able to apply their knowledge of how energy transfers take place.

Learners often find it difficult to differentiate between the terms heat and temperature. A consistent misconception often based on earlier teaching is thinking that energy is a property of an object or system, which can be given a numerical value and they often see it as a substance that can be 'moved'. When considering the process of convection learners also need to be aware that heat itself cannot rise but it is actually particles with energy, and density changes that cause a change in temperature.

Task 1 Conduction demonstration

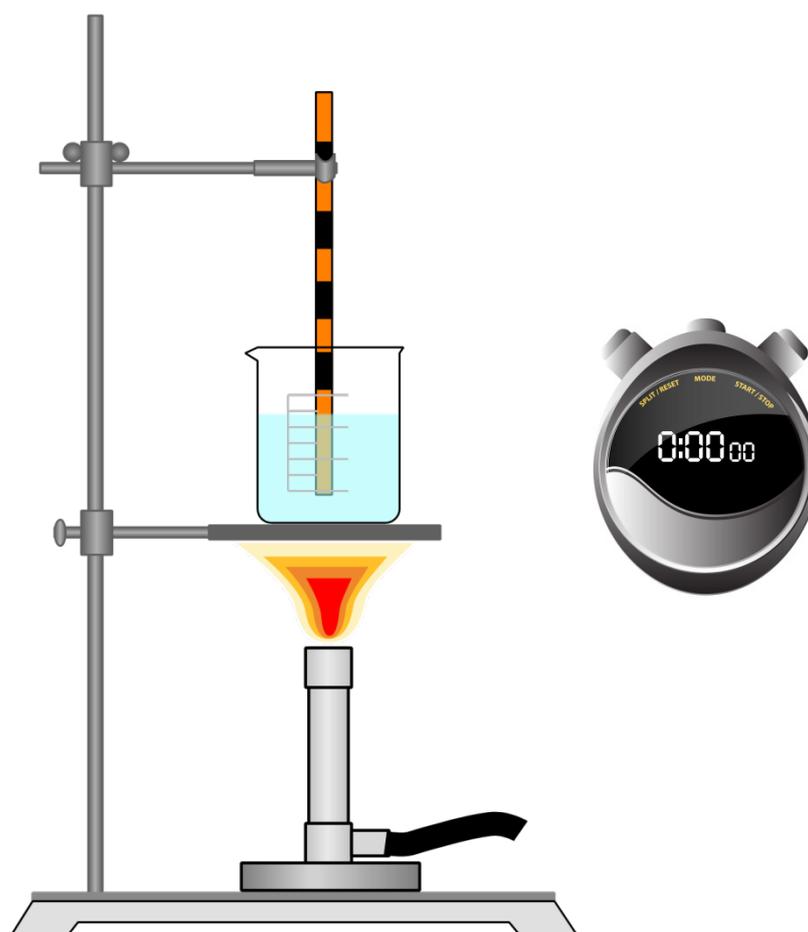
This demonstration should show how energy is transferred through different materials. It may be a good experiment to allow for discussion of the process of conduction with reference to the particle model.

Apparatus:

- Copper or brass rods – one completely coated with thermochromic paint and another with stripes of paint which are 1cm apart, with a minimum of 5 stripes
- Thermochromic paint
- Bunsen burner or heat source
- Clampstand
- Stopwatch

Method:

1. Coat a metal rod with thermochromic paint.
2. Heat one end (gently in a Bunsen burner or other heat source) and watch the colour change along the bar.
3. Now place into a beaker with ice and show the reverse transfer of energy from the rod. Discussion of the process of conduction can take place at this point with reference to movement of particles and what causes temperature change.



The next practical activity can either be demonstrated or undertaken as a class practical

4. Securely clamp the rod painted with stripes of thermochromic paint. Place the end of the rod into a beaker of water. Heat the water using a Bunsen burner or other heat source and measure the time for the paint to go clear at each centimetre interval. A simple graph of the results could be plotted.

As an extension of this task:

If you want to show the differences conductivity in metals, then paint stripes on different metal rods and collect the same data as in step 4. Copper will give a steeper graph, because it conducts heat better. You may want to question learners about the properties of materials that would make them better conductors.

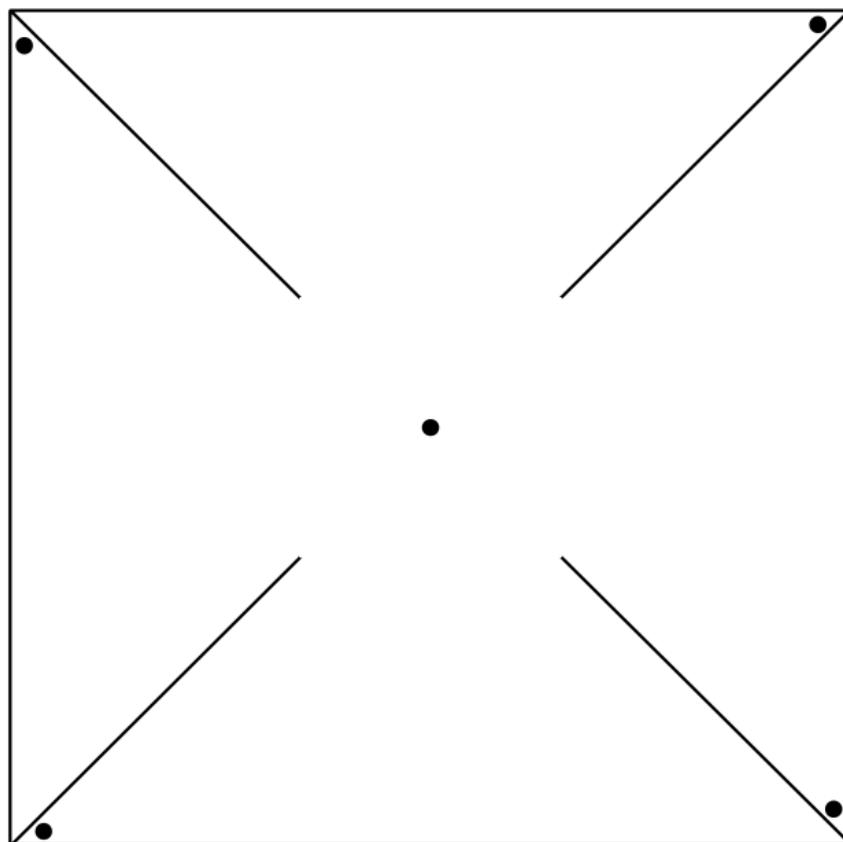
Task 2 Convection Windmill Activity

Apparatus:

- Paper
- Scissors
- Split pins or drawing pins
- Straw/lolly stick
- Heat source (maybe tealights)

Paper windmills can be used to demonstrate this principle. Learners can use the template, on the task sheet, to make paper windmills or can make them even bigger. They should cut along the solid lines and make holes where the black dots are, to attach the corners to the central hole with a split pin or a normal drawing pin. Learners need to be careful not to hurt themselves. This split pin should then be attached to a straw. If this is attached too tightly the windmill will not turn, which it should do if blown upon.

If they now hold it above a heat source, high enough that it cannot catch fire, they should see that it turns. This can be the start of a discussion about the process of convection.

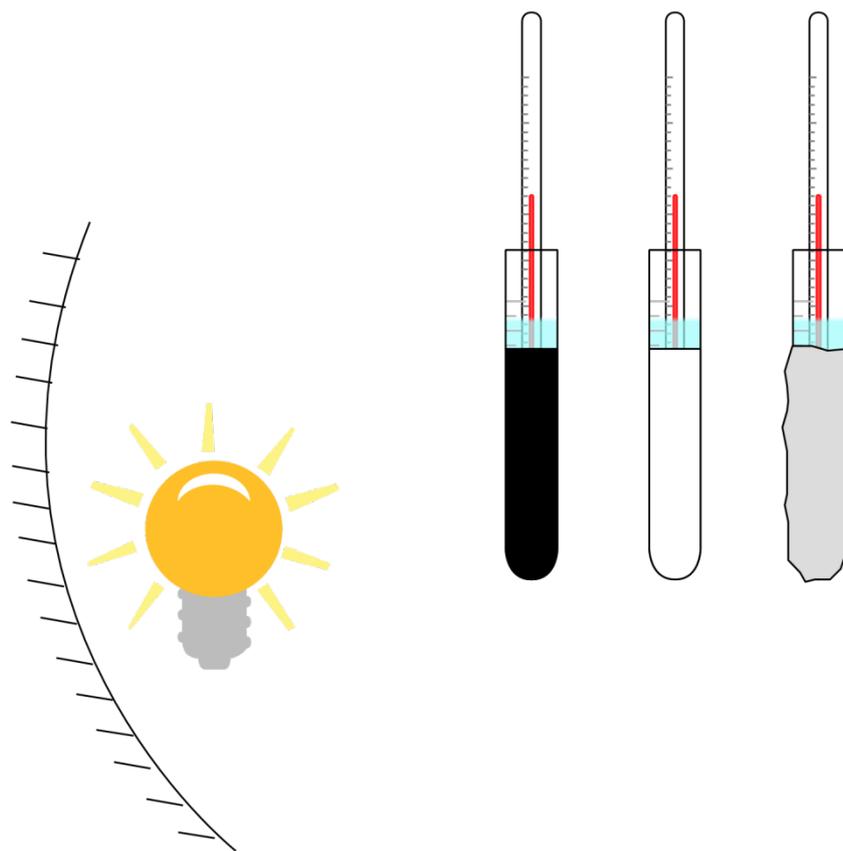


Task 3 Radiation

This simple demonstration can be used to demonstrate how colour and surface can have an effect on the transfer of energy through infra-red radiation.

Apparatus:

- 3 test tubes painted black, white and one covered in foil
- Thermometers in each tube
- Test tube rack
- 250W light bulb and power source
- Large concave mirror



Set the apparatus up as shown with 10ml of water in each tube. The tubes should be 5-10cm from the light bulb. Measure the start temperature and then leave them in full exposure of the reflected rays and take the temperature every 5 minutes for 15 minutes. This doesn't lend itself to a graph, but can be used as a comparison to show how different colours absorb heat at different rates.

You should be able to show that the test tube painted black has a greater ability to absorb, so the water temperature rises at a faster rate. White is not a good absorber of infra-red rays, while the shiny surface is a good reflector so neither allow for a great rise in temperature.

Discussion around this demonstration could include the function of the mirror and what this tells us about how infra-red radiation differs from conduction and convection. Learners could suggest improvements that could be made to this experiment.

Extension activity:

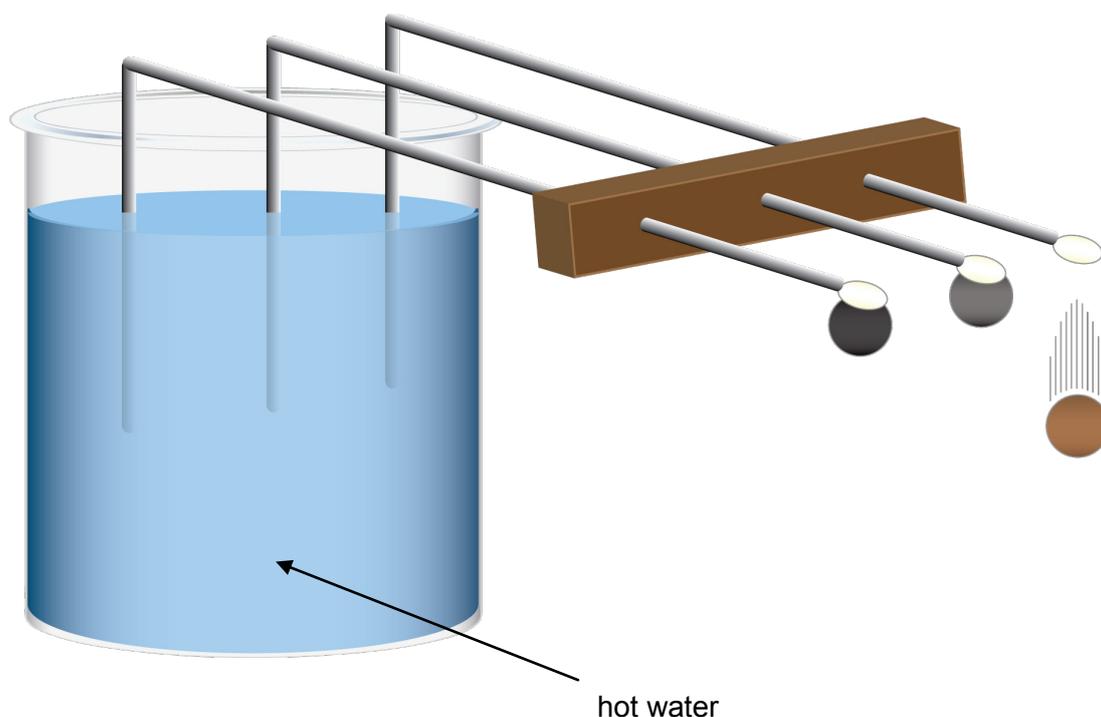
Learners could now be asked to discuss what would happen if a piece of ice was to be placed on a steel block painted black and a wooden block painted black and justify their answer.

Suggested answer:

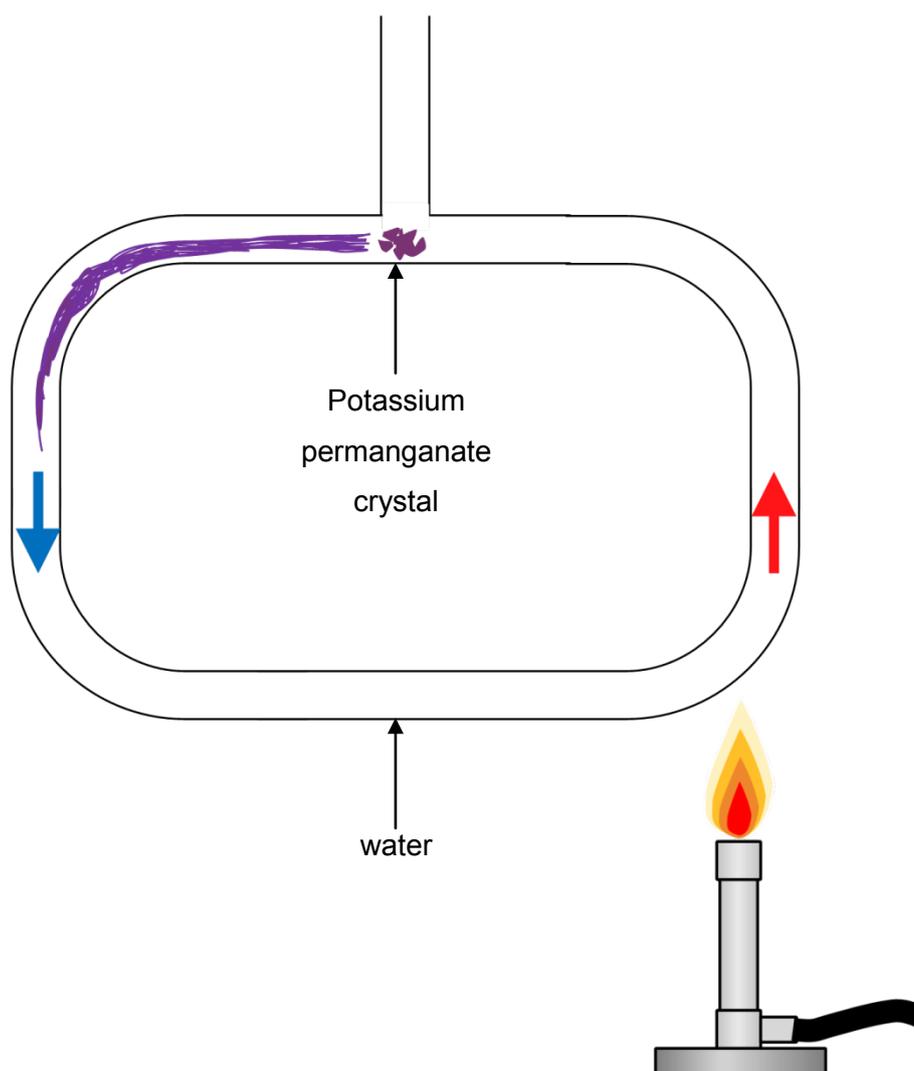
The ice would melt at a faster rate on the steel block. Although both would be good absorbers, wood is an insulator and would not be able to transfer its energy to the ice as quickly as the steel.

Supporting information:

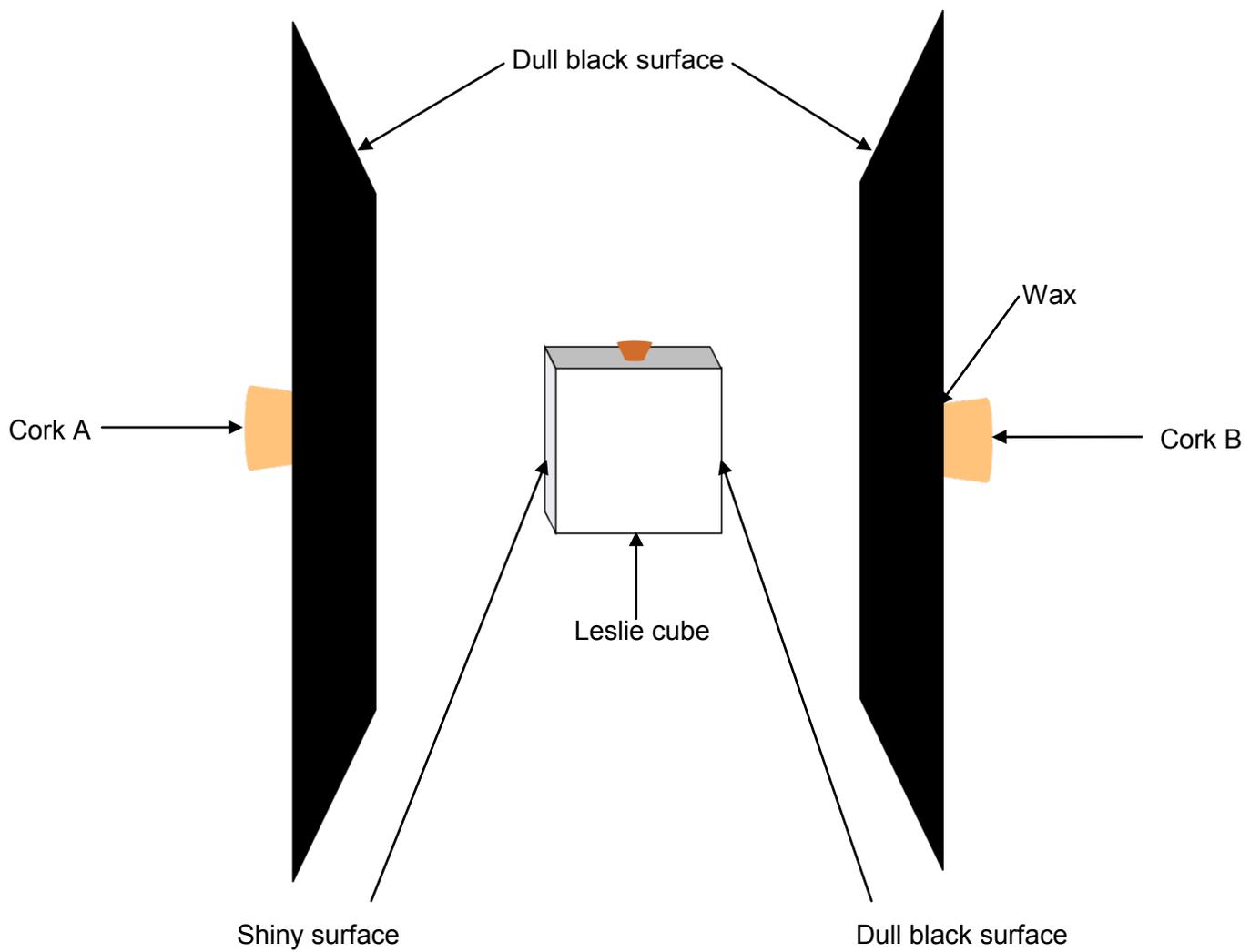
There are a range of standard experiments that can be done to demonstrate the three methods of heat transfer. Examples of these include using different metal rods with metal balls attached with wax that can be heated in water as shown below.



The following experiment is a very clear way of showing conduction, and can be adapted by placing potassium permanganate at the bottom of a beaker of water and watching the path of colour as the water is heated. Alternatively it is possible to do this experiment in a square or circular glass tube, where it may be clearer to see the effect. as the water is heated.



The Leslie cube experiment also demonstrates the effect of different colours on the rate of heating through radiation.



Learner activity sheet

Convection Windmill

Aim:

To construct a windmill which you can use to demonstrate how convection currents can be used to make things move.

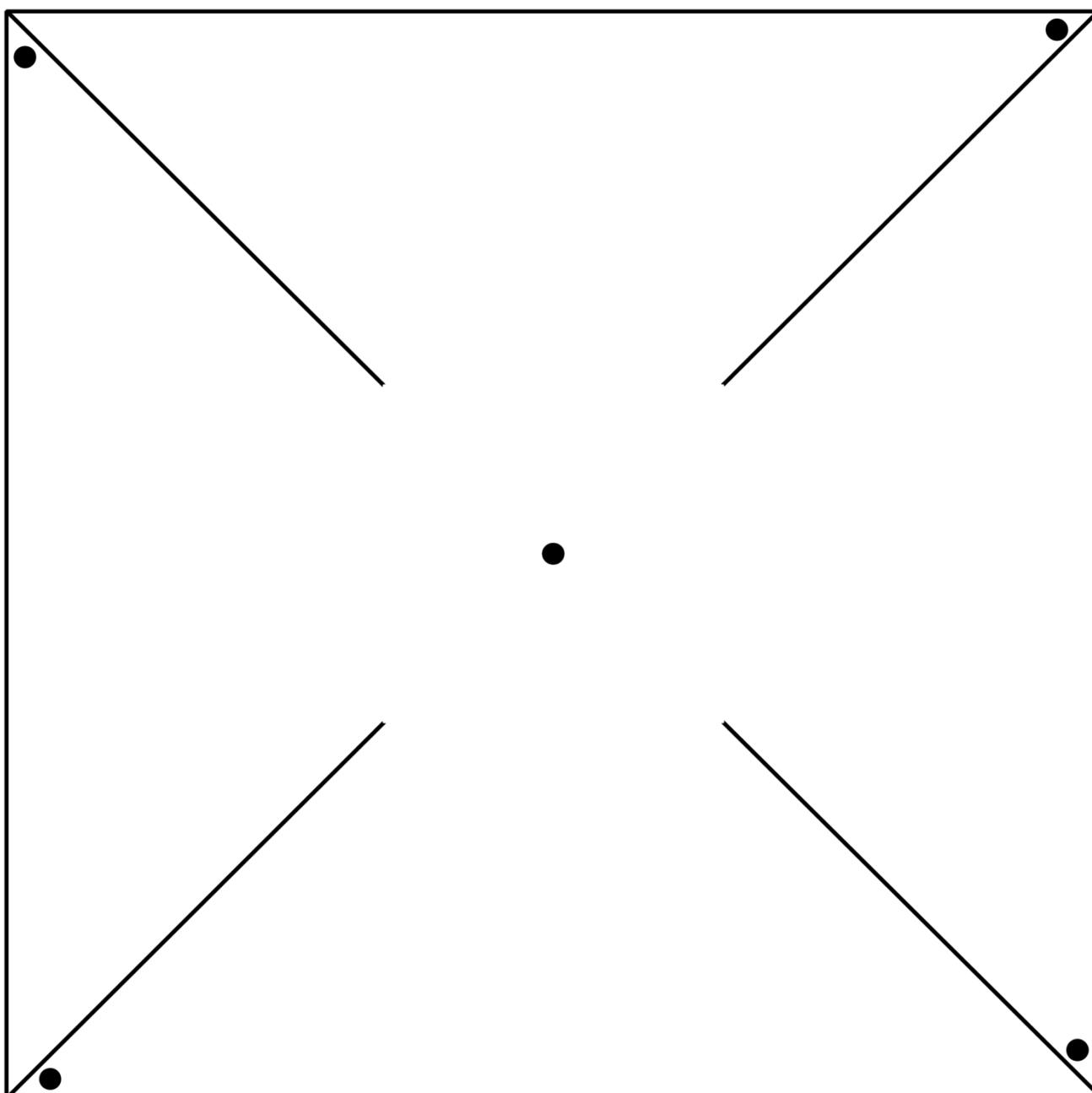


You will need:

- A pair of scissors
- A drawing pin or split pin
- A straw/lolly stick
- Tealight

Instructions:

1. Cut along the solid lines in the shape below
2. Use a drawing pin or split pin to carefully make a hole where there is a dot marked on the shape
3. Line up the holes so that you can place a pin through all of them and through the middle hole as shown above
4. Carefully push the pin into a straw/lolly stick
5. Blow on the windmill you have made, if it does not turn freely then you may want to loosen the pin
6. Now hold your windmill above a lit tealight. Make sure you do not hold it too close to the flame.
7. Using your knowledge of heat transfer, try to explain what makes the windmill spin.



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