SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Heat Transfer Part 3 **Grade 7 – Heat in the Environment**

Lesson Plan

Assessment	AFL, experiment, worksheet
Cross-curricular	

Big Ideas

- Heat is a form of energy that can be transformed and transferred. These processes can be explained using the particle theory of matter.
- There are many sources of heat.

Learning Goals

- To be able to explain that water expands when it is heated.
- To understand that convection drives currents in water.

Specific Expectations:

2.2 investigate the effects of heating and cooling on the volume of a solid, a liquid, and a gas
2.4 use scientific inquiry/experimentation skills to investigate heat transfer through conduction, convection, and radiation
2.5 use appropriate science and technology vocabulary
3.5 explain how heat is transmitted through convection, and describe natural processes that depend on convection

Description:

This is the **third** lesson in a five-lesson unit on heat. The framework for the unit is to look at the heat transfer from solar energy on Earth. In this lesson we focus on the effects of heat on water.

Materials/Resources:

Heat Transfer Part 3 Visuals, Reference Images, Experiment Worksheet
Water Expansion: Flask with stopper and a hole to fit straw or clear tube. **Alternative**: Stiff plastic water bottle, with hole drilled in lid that fits a straw (see image)
-Playdough or silicone (to tightly seal the hole with the straw in it)
-Straw (clear if possible)
Convection Trick: Four glass jars or bottles that are the SAME. Good options: baby food jars
-Two playing cards or thin stiff pieces of plastic
Convection Experiment: Clear plastic basins (e.g. Tupperware like containers, clear flower pot saucers) for each student group
-Food colouring (one colour per group)
-Styrofoam cups (two or three per student group)
-Source of very hot water (tea kettle, hot tap water as backup only)
-Optional: Ice cubes & cold water

Safety Notes

Caution working with hot water

Introduction

Setting up today's lesson

- Yesterday students learned about convection in a gas.
- Discussion question;
- **What can you remember?**
    - Heat rises, leading to convection currents around candles (e.g.)
    - Hot gas has a lower density than cold gas
    - Convection drives air currents near lakes (for example) and around the world. Air that rises in the hottest regions of the world flows away from the equator and cools at altitude. It then comes back down further North and South etc.
- Today we will look at how heat affects a liquid – water.
- Discussion questions:
    - **Does water expand when it's heated?**
    - **Do you think convection can happen in water?**

Water Expansion (Demo)

For this experiment we want to see if water expands when it is heated. We can heat water in a bottle and tightly seal in a straw through which excess water can rise and spill. If we place the bottle near a heat source we will be able to see if the water indeed rises through the straw – i.e. if it expands. See reference image link.

- Set up experiment (fill bottle with water, insert straw, and tightly seal around the hole in the lid (leave straw opening open!)
- Show students the bottle full of water and that there is no water in the straw.
- We will place this under a heat source. What do you think will happen? Why?
    - If water expands as it's heated it will have nowhere to go but up the straw…
- HINT: Add some dark food colouring to the water in order to make it heat up faster.

Action

Convection in Water

In this experiment students place a dish of cold water over a cup filled with hot water. They drop in a bit of food colouring to see the currents in the water. They should easily observe that above the hot spot the currents flow up and on the edges of their dish the water will flow down – convection currents.

- Students should work in groups (two is ideal) if the class is bigger.
- Preheat enough water to fill a Styrofoam cup for each team.
- Instructions:
    - Fill clear container with cold water.
    - Fill one of the Styrofoam cups with hot water almost to the brim.
    - Carefully place the full water container onto the full cup and another cup beside it to support it evenly (see reference images link).
    - Release one drop of food colouring on the far side of the hot water (release close to water surface). Observe what happens.
        - Food colouring will drop and slowly disperse.
    - Now release one drop of food colouring right above where the hot water cup is located. Observe what happens again.

        - After initially dropping to the bottom you should see a lot of the food colour rising again and then flowing AWAY from the hot spot along the surface in any direction.
        - If you wait a while you may see places where the food colouring starts turning down again and flows back toward the hot spot.
        - Does this look like convection? (Yes!)
    - If you want to see it again, fill the container with fresh water!
- Time permitting: Fill an empty cup with ice and water to create a cold spot on the other side of the basin. Note that since the cold will not rise it will work best if the water level really is right to the brim and makes contact with the container once you place it on the cup.
- Students complete the Heat Transfer Part 3 Experiment worksheet. (See Link)

Consolidation/Extension

Convection Trick

This is a fun little demonstration to show how water mixes only if the hot water is initially below the cold water. Make sure to do this in a tray or something else that will catch any unexpected spills!

- We have seen convection happening in our experiments. Let me finish with a little "magic" that exploits the same physics!
- Fill two jars/bottles with hot water, and two with cold water – TO THE BRIM. Add food colour to mark the hot and cold water (e.g. red and blue)
- Place a playing card (or similar) one cold bottle and one warm bottle opening.
- Here comes the trick:
    - Hold on to the card and flip the bottles, then place them on top of another jar, so that you end up with one setup of hot on the bottom, cold on top, and one setup that is the reverse.
    - Now CAREFULLY pull out the cards between the bottles and leave them stacked on top of each other (do the one with the hot water on top first). You should get some very colourful and interesting results!
        - Does it mix? (one setup will, while the other one doesn't)
        - Can we explain these results?

Discussion (with slides)

- **Slide 2:** We can see that the flow of currents is similar in air and water (as we saw in our experiments as well)
- **Slide 3:** Let's define a new term: fluids. Convection happens in fluids.
- **Slide 4:** The largest convection current on Earth is the global conveyor belt.
- **Slide 5:** This is what happens where the water sinks down (Eastern Canada)
- **Slide 6:** And this is how water comes back to the surface (Western Canada)
    - The Ocean conditions around Canada in fact are dominated by this large CONVECTION flow!