Heat changes everything

PTV learning outcomes

- Students understand why their actions are important to being safe on and around public transport
- Students are aware of the opportunities for using public transport

Duration

Sequences are intended to be delivered in 2–4 lessons.

Overview

In this learning sequence, students explore a simple particle model for matter, heat energy and thermal expansion. They apply their learning to the context of expansion and contraction of rail lines and investigate ways that this is mitigated in real situations involving rail lines. They subsequently explain this to young users of public transport through the design of a poster or information sheet, or through a social messaging campaign designed for digital platforms used by young people.

Teachers will find useful background information about the particle model and thermal expansion at https://www.sciencelearn.org.nz/resources/750-heat-energy.

Curriculum alignment

Science Levels 7–8

VCSSU104

Energy appears in different forms including movement (kinetic energy), heat, light, chemical energy and potential energy; devices can change energy from one form to another

VCSSU096

The properties of the different states of matter can be explained in terms of the motion and arrangement of particles

VICTORIA State Government | Department of Transport and Planning

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Engage

Open a discussion with the students by asking why trains slow down on hot days. Establish what the students already know about rail travel during extreme weather. Are you aware of any changes to the availability of train services on very hot days? What causes these issues? Should your behaviour change around trains and trams? Should you be more alert for line malfunctions?

Teachers could also show the students online information provided by both V/Line and Metro Trains that relates specifically to speed restrictions put in place for trains in very hot weather – information about temperature, the effect of extreme heat and subsequent speed limits is included at:

- https://www.vline.com.au/Timetables/heat
- http://www.metrotrains.com.au/hot-weather/

Explore

Students explore what happens when train lines get hot. The particle model role-play activity explores the particle model for matter, how particles behave in solids, liquids and gases, and how heat energy affects particles in these states. The important aspect for exploration of the effect of heat on train lines is the section that focuses on solid expansion. If students have participated in this role play before, focus on solid expansion in this instance.

Arrange students in small groups, around five or six is best. They will need lots of space and possibly somewhere away from other classes, so outside on a netball court, or inside a gym would work well. Depending on student numbers, and if teachers prefer, the students could take turns during the parts of the role play – as observers or as participants.

Particle model role play part 1

Explain that students will be taking the roles of matter as solids, liquids and gases.

As a solid, students share rulers to act as molecular bonds. 3 students can hold one ruler – hands on either end of the ruler and one in the middle. So 1 ruler between 3 students, with each student holding different rulers in each hand. The students will be in a bunch and so now ask them to move so that their arms are fixed by their sides. They are not permitted to move their arms and are tightly packed. They jiggle slightly, because particles are always jiggling and active. No shoving or violent behaviour please.

Then as a liquid they keep holding the rulers but move their arms, which allows them to move more freely and flow like a liquid, and they jiggle a bit more. They also take up more space. No shoving or violent behaviour please.

As a gas, they no longer hold the rulers, and can run around and bounce off walls and each other (carefully!). No shoving or violent behaviour please, no hitting each other with rulers.

Ask the students to practise transitioning between the three forms of matter – still jiggling! They could respond to teacher directions as they transition.

Ask students: Which state do you feel has the most energy? And which takes up the most space?

Explain

Explain that heat is a form of energy, which causes the particles to jiggle more.

Particle model role play part 2

Ask students to start as a solid, holding one ruler between 3 students. Tell them that you're applying heat to their solid form. What will be their response? They should jiggle a little more, and a little more, as the temperature rises.

They will get to a point where (1) they can see that their 'solid' is taking up more space. Stop them here and discuss this. Then apply 'heat' again so they are jiggling more, and they get to point (2) where they can no longer maintain the elbow linking.

Explain that this is like ice melting – going from solid to liquid, and so now they can hold hands and jiggle as they move from solid to liquid.

This can be practised back and forth, applying heat and removing it as they transition between different states of matter, responding to teacher directions.

Demonstrate or discuss the action that students may have observed at home, of placing a jar with a screw top lid that won't budge under hot running water. Why is this done? What is happening to the particles in the lid as they are exposed to the heat of the water? And to the particles in the jar?

Elaborate

But what does this all mean for train lines?

Particle model role play part 3

As a class, ask the students to role play a train line. Discuss with them what a rail line model might look like at a particle level – guide the discussion around the material of a train line (solid), the shape (long and thin) and to the idea of the whole class linking arms tightly in a grid of around 3 x 10 so they are a long thin line. (Explain that there are actually millions and millions of particles in a real train line though!)

Now when we apply 'heat', as they jiggle more and more their nice straight line will begin to buckle and/ or get longer. When this happens, stop them so they can observe the shape of their train line. Now tell them you are removing heat – it's getting colder! What happens to the train line now?

How can we stop the buckling?

Explain that there are a number of ways rail lines are designed to stop buckling and warping when they are heated (and cooled). One of these is to anchor them to sleepers.

Provide students with the instructions for the Rail Line student activity. And provide them with the materials they will need. Students can work individually or in pairs.

Students can share the results of this activity with the whole class. The experiment models the role of sleepers that tie the rail line down to keep it in the correct shape. If the weather gets too hot or cold, or if the sleepers aren't tying the line down firmly enough, the train line can still buckle slightly.

Divide the class into small groups and ask each group to research online to investigate one of the following aspects of designing and maintaining rail lines that help mitigate the thermal expansion and contraction of the line. Also provide each group with the Track Structure and Maintenance handout, which provides further information specific to the Victorian rail networks. Each group may only need to refer to one section of the handout, depending on their task.

- Continuous rail versus jointed track (including gaps in footpaths, and expansion joints in road bridges)
- Sleepers, anchors and ballast – what are they and how do they work together?
- Trains slowing down – why slow down, and at what temperatures?
- Track maintenance – what is done in Australia and overseas to help keep rail lines in working order, especially in extreme weather?
- Rail stressing and stress-free temperatures – what are they and how do they help? (Note that this concept is quite advanced, and may be better suited to students with a firm grasp of the underlying concepts.)

Ask each group to report back to the class, and explain that this information will be useful for the final activity.

Evaluate

In small groups students discuss the effects of travelling by train on hot days. What should be considered in regard to planning a ***safe*** journey on a very hot day? What ***extra safety steps*** do you need to take around trains and train lines in hot weather?

Ask students to design a poster, information sheet, web page or social messaging campaign for platforms used by young people. The target audience is students from their own local community who may need to travel by train on very hot summer days.

Things to consider:

- Explain why trains slow down for ***safety*** on hot days
- Explain how well-engineered and well-maintained tracks and monitoring work together to keep trains running ***safely*** in all conditions including hot weather
- Suggest what to take when travelling on hot days: consider especially information to help travellers stay cool and hydrated
- Provide useful ***safety tips*** for hot weather, including being ***aware of hazards***, where to find travel and weather information and warnings and what to do in case of an emergency
- Give examples of how much extra time may be needed for train travel in your area on hot days, and how to find out more information, including travel alerts.

Make sure that, in whatever format is chosen, the message is as helpful, clear and informative as it can be, especially in promoting ***safe*** behaviours.