Activity: Reasons for the seasons on Earth

Background information

The Earth orbits the Sun in a slightly elliptical path. This means that sometimes the Earth is slightly closer to the Sun than other times, but this does not explain why we have seasons. If this was the case, then the Northern and Southern Hemispheres would experience the same seasons at the same time of the year. This does not happen. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere (and vice-versa,) and when it is autumn in the Northern Hemisphere it is spring in the Southern Hemisphere (and vice-versa). The two hemispheres experience opposite seasons. However, near the equator there is little seasonal change.

Seasonal changes are mainly caused by the Earth's tilt. As the Earth travels around the Sun, it remains tilted (23.5 degrees) and pointing in the same direction. Sometimes the top half of the Earth is pointing towards the Sun while at other times it points away. During our summer, the Southern Hemisphere is tilted towards the Sun. Therefore, light from the Sun is more intense and is more effective at heating the ground than during winter when the Sun's rays are spread over a greater surface area. The Sun is also in the sky longer during summer allowing more time for warming and less time for cooling the Earth. Halfway between the times when the Earth is pointing towards or away from the Sun, both hemispheres get almost equal amounts of sunlight. These times are what we call spring and autumn.

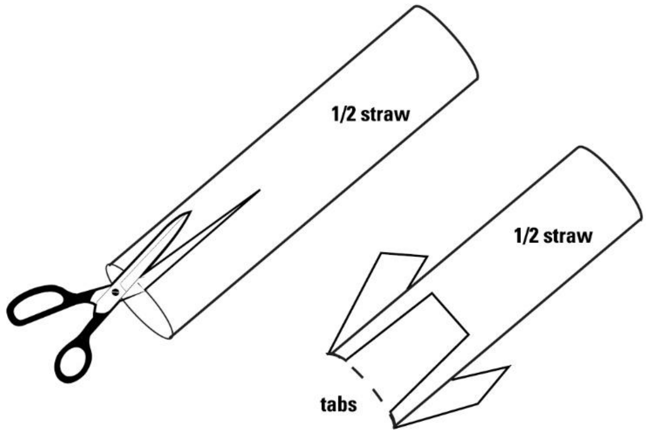
The following activity simulates how the Earth orbits the Sun with its North Pole always tilted at 23.5 degrees. It should be noted that the tilt of the Earth is the reason that the north and south hemispheres experience opposite seasons.

What you need

- balloon
- felt tipped pen
- straw
- sticky tape

What you do

1. Blow up a balloon to a diameter of approximately 25 cm. This will represent the Earth.
2. With a felt tipped pen, mark the North Pole, South Pole, the position of Australia, Europe and the Equator.
3. Cut the straw in half.
4. Make three cuts on one end of the straw forming tabs. (See diagram)



5. Stick this straw onto the balloon at the North Pole to represent an imaginary axis.
6. Repeat steps 4 and 5 to represent an imaginary axis at the South Pole.
7. Choose a light source in the classroom that will represent the Sun.
8. Circle the light source with the model, keeping the axis at the North Pole slightly tilted as it circles all the way around the light. Make sure that the North Pole always points at the same pointing the 'sky' (Polaris – the Pole Star).
9. Notice that sometimes the top half of the Earth is pointing towards the Sun and sometimes it is pointing away.
10. Model and discuss what would happen if the Earth circled the Sun straight up and down with no tilt.

Optional

- Identify the positions when it is summer, winter, autumn and spring in Australia. Discuss the tilt in the Earth's axis and the angle of the Sun's rays for each season.
- Identify the positions when it is summer, winter, autumn and spring in Europe. Discuss the tilt in the Earth's axis and the angle of the Sun's rays for each season.

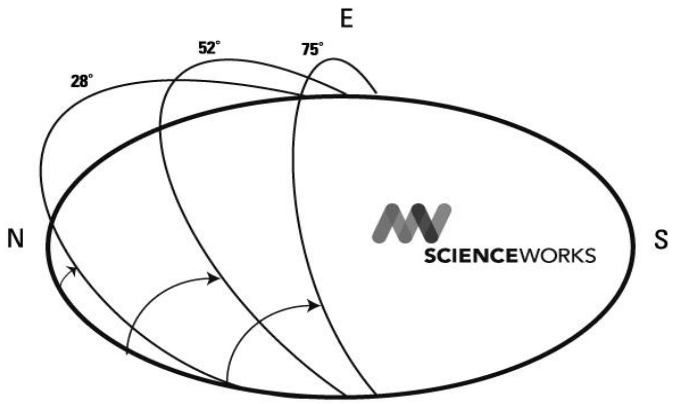
Activity: A Model showing the path of the Sun

The following activity represents the apparent path of the Sun on four special occasions of the year in the Southern Hemisphere.

- Path (a) – Summer Solstice (December 22), when the Southern Hemisphere has its longest day and shortest night of the year.
  The midday Sun is 90º above the horizon at the Tropic of Capricorn (23½ºs). Melbourne is ~15º further south, so the midday Sun in Melbourne is 90º – 15º = 75º above the horizon.

- Path (b) – Autumn and Spring Equinox (March 22 and September 23), when the length of day and night in the Southern Hemisphere is approximately equal.
  The midday Sun is 90º above the horizon at the Equator (0º). Melbourne is 38º further south, so the midday Sun in Melbourne is 90º – 38º = 52º above the horizon.

- Path (c) – Winter Solstice (June 22), when the Southern Hemisphere has its shortest day and longest night of the year.
  The midday Sun is 90º above the horizon at the Tropic of Cancer (23½ºN). Melbourne is ~ 62º further south, so the midday Sun in Melbourne is 90º – 62º = 28º above the horizon.



What you need

- A4 master copy of model
- cardboard
- glue
- protractor
- pipe cleaners
- sticky tape
- Stanley knife

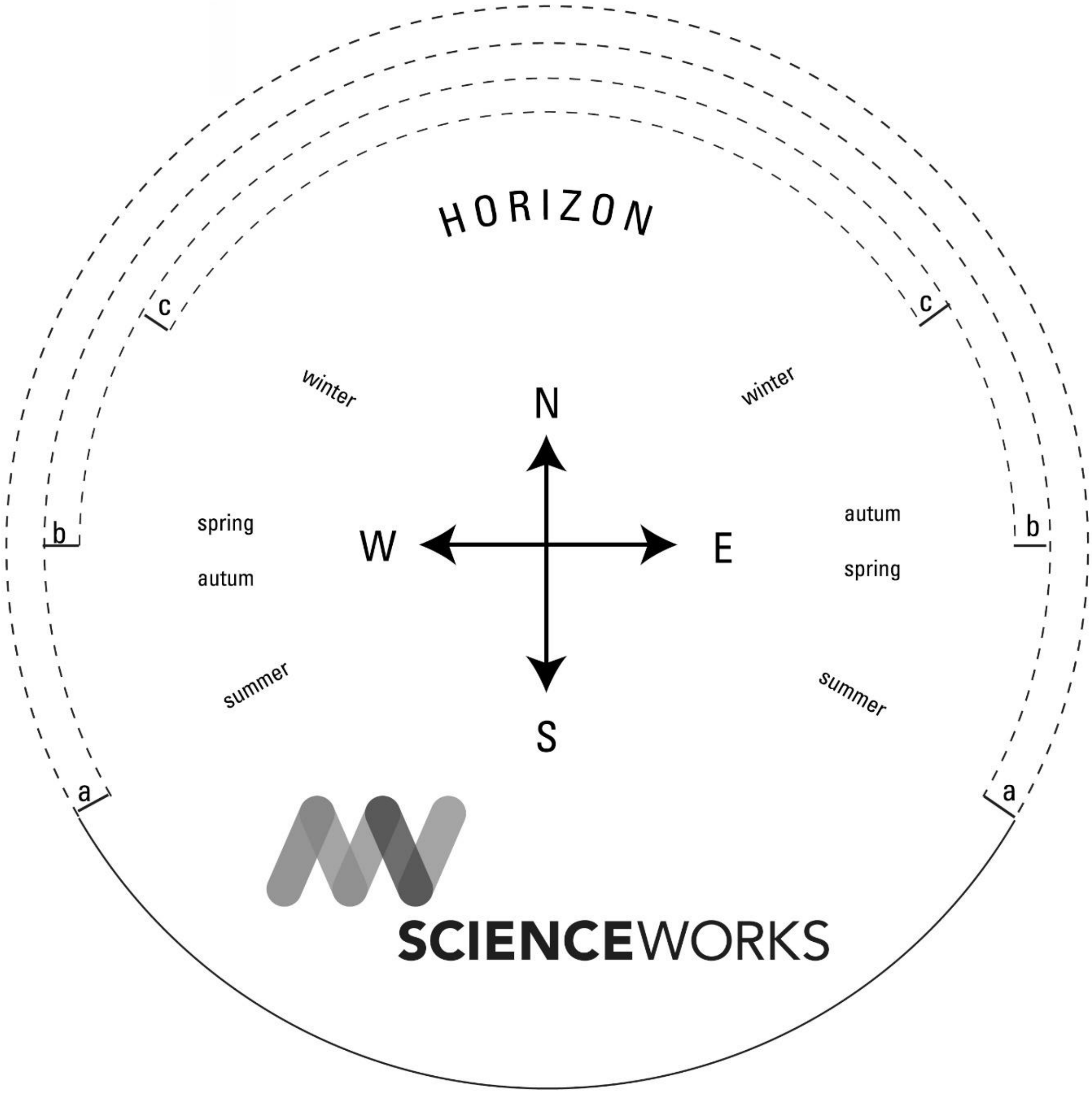
What to do

1. Glue the A4 sheet onto cardboard.
2. Carefully cut out the model along the dotted lines outlining paths (a), (b) and (c) using a stanley knife.
3. Fold the ends of path (c) along the thick black lines so that its midpoint becomes tilted at an angle that approximates 28 degrees above horizontal. You may want to use a protractor to measure the angle.
4. Fold the ends of path (b) along the thick black lines so that its midpoint becomes tilted at an angle that approximates 52 degrees above horizontal. You may want to use a protractor to measure the angle.
5. Fold the ends of path (a) along the thick black lines so that its midpoint becomes tilted at an angle of approximately 75 degrees above horizontal. You will need to wrap sticky-tape around the ends of this path so that it is supported at this angle.
6. You may want to glue pipe cleaners onto each path to hold it in place.

Optional

7. Students can decorate the horizon by adding grass, houses and trees.

A model showing the path of the sun



Activity: Some days are really longer than others

Background information

The shortest day of the year, the Winter Solstice, is around June 22 in the Southern Hemisphere. This day has the least amount of daylight hours. The Sun rises in the north-east, stays low in the sky and sets in the north-west. The longest day of the year, the Summer Solstice, is around December 22 in the Southern Hemisphere. This day has the greatest amount of daylight hours. The Sun rises in the south-east, moves high into the sky, then sets in the south-west.

The seasons in the Southern Hemisphere are:

- Summer: December, January and February
- Autumn: March, April and May
- Winter: June, July and August
- Spring: September, October and November

You can view a current colour map of the Earth showing the day and night regions at http://www.fourmilab.ch/earthview/vplanet.html

What you need

- pen and paper
- sunrise and sunset times (for Melbourne), you can get these from here: https://www.timeanddate.com/sun/australia/melbourne

What to do

1. Calculate the day length, in hours and minutes, of the Summer Solstice and the Winter Solstice.
2. Now do the same for the days of the Equinoxes.
3. Calculate day length for some other days.
4. Discuss the path of the Sun at different times of the year.

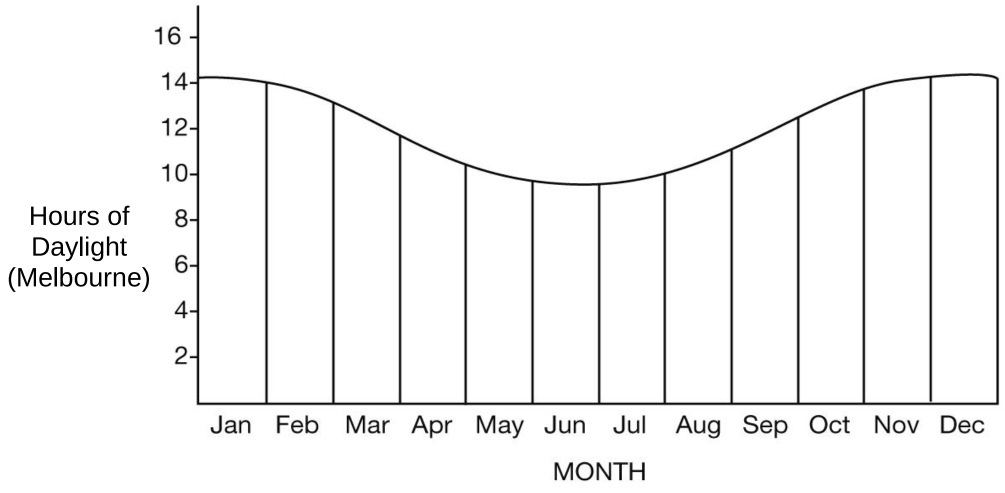
Optional

- Calculate day length every fortnight for the year and draw a bar graph using this information (Day length versus fortnight, primary students).
- Calculate day length for every day of the year and graph this information using Excel (Day length versus day, secondary students).

Questions

1. Describe the shape of the graph.
2. How many weeks are there where the day length:
    (i) is less than 12 hours?
    (ii) is more than 12 hours?
3. Does the graph correspond with the longest day being around December 22, and the shortest being around June 22?

Some days are really longer than others



Questions

1. Colour in the different sections of the graph showing the different seasons in a year.
2. Describe the shape of the graph.
3. How does the amount of daylight in a day change from winter to summer?
4. Cross out the wrong word in bold in the following sentences:
   (i) During summer, the days are longer, and the nights are **longer/shorter.**
   (ii) During winter, the days are shorter, and the nights are **longer/shorter.**

Activity: The angle of light makes a difference (A)

Background information

When combined with the Earth's motion around the Sun, the tilt of the Earth (23.5 degrees) causes the seasons. There are two factors that work together to make summer hot and winter cool. Firstly, during the southern summer the Southern Hemisphere is tilted towards the Sun. Therefore light from the Sun is more intense and is more effective at heating the ground than during winter when the Sun's rays are more spread out. Secondly, in summer the Sun travels a longer path across the sky. It rises in the south-east and sets in the south-west. This means that the Sun is in the sky longer and therefore has more time to heat the ground (and the ground has less time at night to cool down).

Approximate dates of the equinoxes and solstices in Melbourne

Autumn Equinox	March 22	Sun lies on the celestial equator – rises due east and sets due west	day and night are equal in length	Maximum altitude of the Sun at midday: 52 degrees
Winter Solstice	June 22	Sun is furthest north – rises in the north-east and sets in the north-west	shortest day, longest night	Maximum altitude of the Sun at midday: 28 degrees
Spring Equinox	September 23	Sun lies on the celestial equator – rises due east and sets due west	day and night are equal in length	Maximum altitude of the Sun at midday: 52 degrees
Summer Solstice	December 22	Sun is furthest south – rises in the south-east and sets in the south-west	longest day, shortest night	Maximum altitude of the Sun at midday: 75 degrees

The following activity deals with the first effect that causes the seasons, the intensity of sunlight.

As the Earth orbits the Sun, the angle of sunlight varies. This is modelled in the activity using a torch and graph paper. Students will see that moving the torch at different angles changes the surface area of the beam. Furthermore, since the same amount of light is given off by the torch, an increase in surface area causes a decrease in intensity.

In order to complete this activity a grasp of measuring surface area is required. Surface area is the amount of two-dimensional space an object takes up. One way of measuring it is by counting squares on graph paper. If the units are 1cm x 1cm, then the unit of the surface area measured is centimetres squared or cm2. Older students can use graph paper to calculate surface area in cm2. To simplify the measurement of surface area for the younger students, the surface area can be measured by counting how many squares a certain space takes up.

Extension information

Seasons at the Equator and the Poles

The intensity of sunlight varies according to where you are on Earth. The Sun is almost always directly overhead at the Equator. This means that light from the Sun covers a small surface area. At other places further north or south of the Equator, the angle of the Sun decreases, spreading the sunlight over a larger surface area. The light also travels a greater distance through the atmosphere and more of the light is absorbed or reflected before it reaches the ground. Places further north or south of the Equator do not experience temperatures as hot as places closer to the Equator. Note that the Sun is always up for about 12 hours at the Equator so generally the year is divided into the wet season and the dry season (rather than summer and winter).

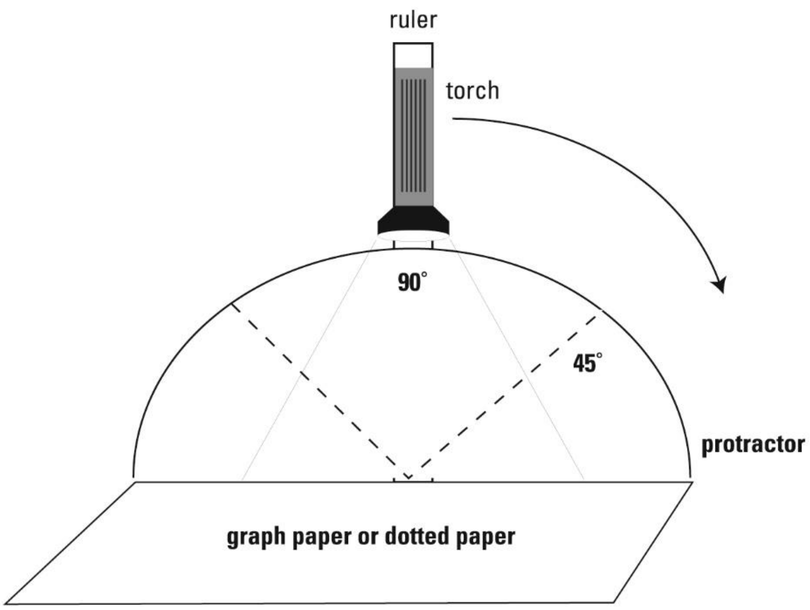
The seasons are more extreme at the Poles. The North and South Poles experience (almost) 6 months of continuous daylight followed by (almost) 6 months of darkness. The Sun does not come up at the poles during the whole of winter. At the South Pole, winter begins on March 22 and ends on September 23. The Sun peeps up on September 23 and summer begins. At the North Pole the opposite happens.

What you need

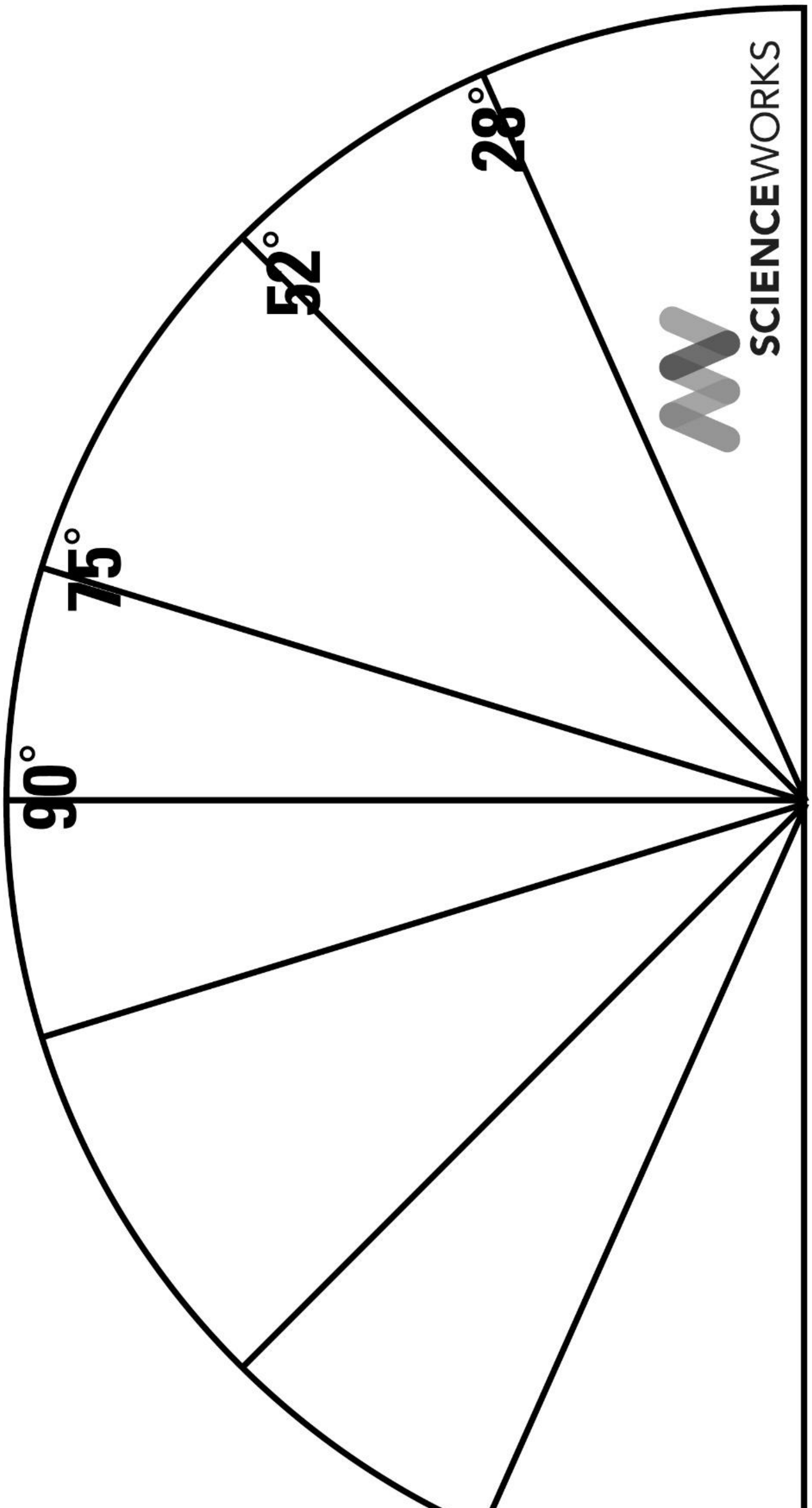
- A4 sheet of graph paper (or dotted paper)
- torch
- 30 cm ruler
- sticky tape
- cardboard protractor
- glue

What to do

1. Stick the outline of the protractor (provided) onto cardboard and cut it out when it is dry.
2. Lay a sheet of graph paper (or dotted paper) on a flat bench. Place the beam of the torch 15cm along the ruler and attach it with sticky tape. (Make sure that the torch can be easily switched on and off once it is fixed to the ruler.)
3. Stand the ruler, with torch attached, upright above the graph paper.
4. Switch the beam on. Count the squares (or dots) that the beam covers at this distance. Record this in the table provided. This angle represents the Sun's rays at midday at the Equator, when the Sun is directly overhead.
5. Keeping the torch at this distance, move the ruler (with the torch attached) and change the angle of the torch to 75 degrees. This angle represents the Sun's rays at midday on December 22 (Summer Solstice) in Melbourne.
6. Count the squares (or dots) that the beam covers now. Record this value in the table provided.
7. Change the angle to 28 degrees and again count and record the number of squares (or dots) the beam covers. This angle represents the Sun's rays at midday on June 22 (Winter Solstice) in Melbourne.


ruler
torch
90°
45°
protractor
graph paper or dotted paper

The protractor



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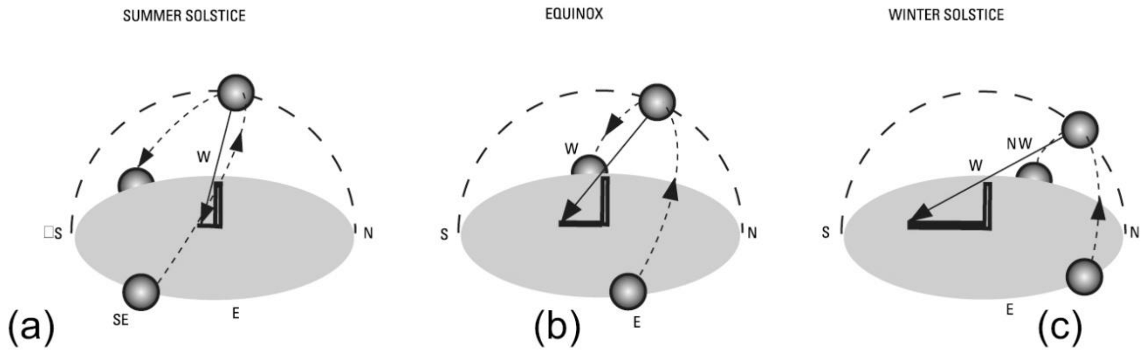
The angle of light makes a difference (B)

Introduction

The angle at which light is directed can affect how much heat is felt. In the following activity, you will see how the brightness of the light changes when a torch shines on paper at different angles. At the Equator, the Sun is almost always at 90 degrees (at midday) all year round. In Melbourne, the Sun never reaches that high. The highest angle that the Sun reaches is 75 degrees at midday on December 22. In spring and autumn, the maximum altitude the Sun reaches is 52 degrees, and on June 22, the Sun reaches only about 28 degrees above the horizon.

Count how many dots or squares the light takes up at the different angles and record your values in the table below.



Angle of torch at a distance of 15 cm	Representing the Sun at midday	Surface area (number of dots or squares)
90 degrees	Equator	
75 degrees	Summer Solstice in Melbourne (December 22)	
52 degrees	Autumn/Spring Equinox in Melbourne	
28 degrees	Winter Solstice in Melbourne (June 22)	

Questions

1. How does the angle change the surface area (or amount of space) the beam takes up on the paper?

2. How does the activity demonstrate why it is easier to get sunburnt in summer than in winter?

Optional

3. Find out the altitude the Sun reaches at the North and South Pole during a year.

Activity: Seasons on other planets

Background information

The seasons on the planets of the Solar System are largely a reflection of the size of the difference between the maximum and minimum temperatures on each planet. This difference is caused by the combined influence of a number of factors:

1. **The distance of the planet from the Sun**
   If a planet is close to the Sun (eg. Mercury), the influence of the Sun's rays will be much greater than on planets far away (eg. dwarf planet Pluto). The Earth is quite close to the Sun, so the Sun has a large influence on temperatures on Earth.

2. **The rotation time of the planet**
   Planets that have a long rotation time (eg. Mercury) have a much longer daytime and night-time than planets with a short rotation time (eg. Jupiter). If the Sun is in the sky for a long time, that half of the planet will tend to become much hotter than if the Sun is in the sky for a short time. Similarly, long nights will cause much lower temperatures than short nights, as the half of the planet in darkness will have longer to cool down. The average daytime and night-time on Earth is quite short, so our rotation time has only limited influence on maximum and minimum temperatures.

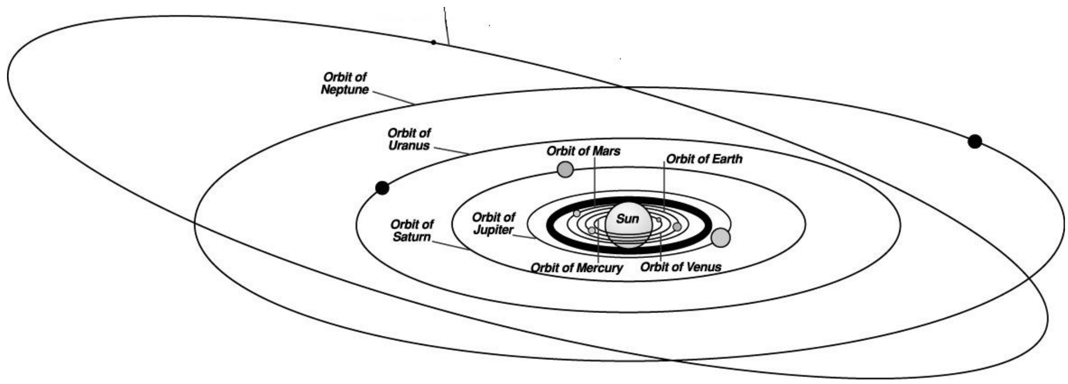
3. **The composition and density of the planet's atmosphere**
   Planets with dense atmospheres (eg. Venus) will have little variation in temperature, as the atmosphere moderates heat gain and loss. Temperatures on planets with no atmosphere, or a very thin atmosphere (eg. Mercury) are not subject to this moderating influence. The Earth's atmosphere is of medium density – it filters the Sun's heat that comes through to the surface during the day and helps to retain heat when the Sun goes down.

4. **The axial tilt of the planet**
   If the axis of a planet has a moderate tilt (eg. Earth, Mars), or a large tilt (Uranus, Pluto) there will be a big seasonal variation in the length of day and night, especially at higher latitudes. For planets that are close to the Sun, this will cause a marked seasonal difference between temperatures in the two hemispheres.

   Earth's tilt of 23.5 degrees causes locations close to the poles to have around six months of daytime and six months of night-time. When the South Pole is tilted towards the Sun, it is the Southern summer with continuous daylight, and when the South Pole is tilted away from the Sun, it is the southern winter with continuous nighttime.

5. **The orbital eccentricity of the planet**
   The more elliptical the orbit of a planet, the more variation there will tend to be in temperature as the planet revolves around the Sun. When the planet's orbit takes it nearer the Sun, it will receive more heat than when it is further away. Mercury has a quite elliptical orbit, while Earth's orbit is almost circular.

Orbit of Pluto (dwarf planet)



Student activity

Study the background information about the factors influencing the seasons on other planets. You may wish to supplement your information with library and Internet research.

Write a short paragraph about the seasons on each of the planets (one paragraph per planet). Explain the influence of each factor on temperature variations and seasons for each planet, noting where a factor tends to moderate temperature differences and where it tends to increase temperature differences.

If time is short, the planets can be divided between class members (one planet per group) and the results shared when everyone is finished.

Notes about seasons on other planets

Teachers:
The notes below about seasons on each planet may be used to assist students who are finding the activity that follows difficult. It is suggested that students first try to use the background information without the benefit of the notes below.

- **Mercury** is the closest planet to the Sun. Its climate varies considerably throughout its year because it moves in a highly elliptical path. This means that at times it is much closer to the Sun than at other times. It does not have any atmosphere and has no protection from the Sun. During the day it gets really hot and during the night it gets really cold. Mercury has no tilt, so its seasons are caused by its highly elliptical path around the Sun.

- **Venus** is the second closest planet to the Sun. Its orbit does not cause the seasons because it is nearly circular. It has a tilt of only three degrees (in the opposite direction to the other planets) so temperatures across the planet do not vary much throughout a Venus year. The climate on this planet is always hot because it is relatively close to the Sun and has a thick atmosphere that keeps temperatures stable. You could say that Venus hardly has any seasons at all.

- **Mars** is the fourth closest planet to our Sun. This planet can be considered to have only two seasons (summer and winter) that vary greatly in temperature. The planet's elliptical path and its significant tilt produce the seasons. The fact that Mars has a very thin atmosphere also contributes to the extreme temperature variations.

- **Jupiter** has a tilt of only three degrees and has a very thick atmosphere (being one of the gas giants). Its path around the Sun is elliptical, so you might expect the temperature to vary along its orbit. However, it is very far from the Sun, so the temperature change is small. Jupiter is always very cold. The very thick atmosphere keeps the cold temperatures very stable. You could say that Jupiter does not have any seasons.

- **Saturn** is one of the gas giants. It has a tilt as well as an elliptical path around the Sun. However, since it is very far away from the Sun, it is always very cold and its thick atmosphere keeps it that way.

- **Uranus** has an elliptical orbit but is a long way from the Sun so it experiences extremely cold conditions all year round. It has a very thick atmosphere (being another of the gas giants) and so the temperature remains very cold throughout its year. It has a tilt of about 98 degrees, practically spinning on its side. Its daytime lasts for half of its year and night-time for the other half.

- **Neptune**'s orbit is nearly circular, and it has a tilt of about 28 degrees. However, Neptune is far away from the Sun, so temperatures are always extremely cold. Its atmosphere is very thick and keeps the climate icy cold.

- **Pluto** (a dwarf planet) is very far from the Sun so temperatures are always extremely cold. Even though its path around the Sun is very elliptical, and its atmosphere is extremely thin, the distance from the Sun makes it extremely cold all the time.