Earth and Space Science 2.5

Externally assessed
4 credits

Demonstrate understanding of the causes of extreme Earth events in New Zealand

For Earth and Space Science 2.5, you are required to demonstrate understanding of extreme Earth events as they apply to New Zealand.

This topic requires you to know the characteristics of volcanic eruptions, earthquakes and tsunamis. You are also required to explain the causes of extreme Earth events in terms of relevant processes that occur in the geosphere, hydrosphere, biosphere and/or atmosphere.

Unit 1 –The Earth system, geosphere and plate tectonics

New Zealand is susceptible to dramatic Earth events because of the country's unique geology and its place in the middle of vast oceans. Earthquakes, volcanoes and tsunamis can all bring about devastation with very little warning.

Earthquakes can occur anywhere in New Zealand, although some parts of the country, especially Northland, experience earthquakes less frequently than other parts.

Auckland, Taranaki and the Taupo Volcanic Zone, extending from White Island to Ruapehu, are the areas that have active or dormant volcanoes. The Taupo area also has extensive geothermal areas.

All New Zealand's long coastline is susceptible to tsunamis, which can be caused by earthquakes, underwater volcanic eruptions, landslides into water, or submarine avalanches.

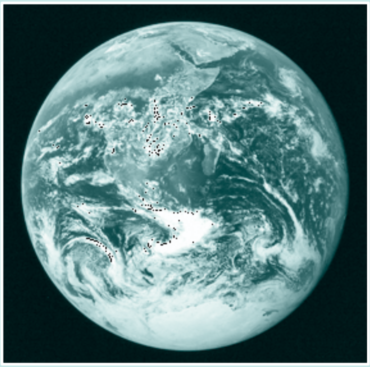
Gravity

Gravity is fundamentally important and pulls everything towards the centre of the Earth. Although it is often taken for granted, gravity affects and is an integral part of all processes that cause extreme Earth events. For example, anything that falls, such as ash from a volcano, sediment in an underwater avalanche, a subducting tectonic plate, or land after an earthquake shake, falls because of gravity.

AS 91191

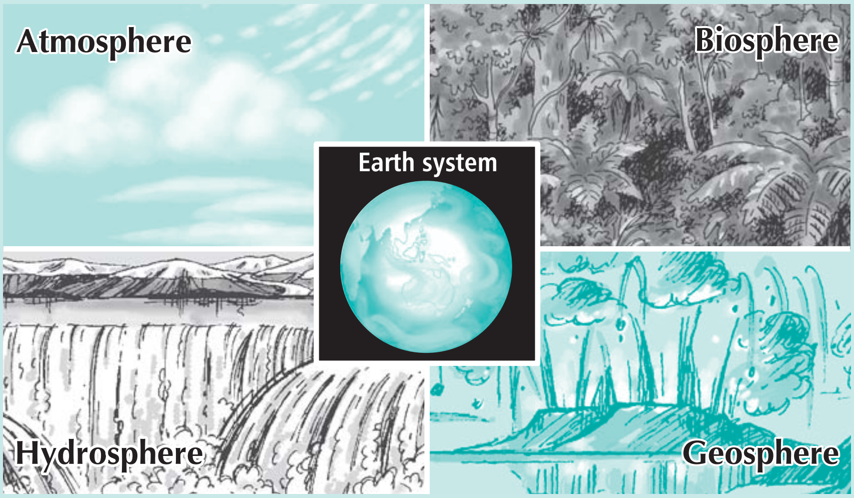
The Earth system

If we view planet Earth from space we see a beautiful blue and white ball that has liquid water at the surface and can support life. From that viewpoint it is easy to see that the atmosphere, land, water and living things are all part of one big Earth system.



The Earth system can be divided into four interdependent spheres:

- The **atmosphere** – air that extends up from the Earth's surface for about 100 kilometres. The lower part, the troposphere, has clouds and the weather.
- The **geosphere** (also called the lithosphere) – the land, which includes all minerals, rocks, sediments, and soil (the non-living components).
- The **hydrosphere** – contains all Earth's solid, liquid and gaseous water, e.g. as the ocean, rivers, and glaciers.
- The **biosphere** – all living organisms, wherever they live.

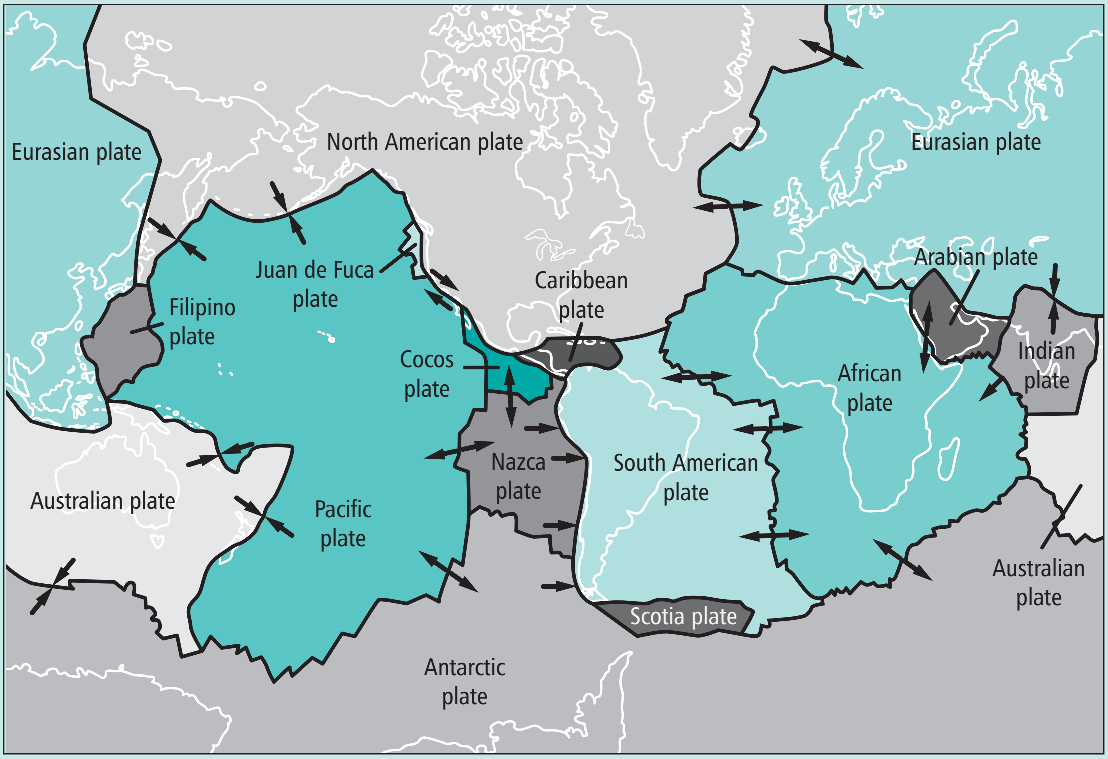


The four parts interact continuously. Often, a change in one sphere results in a change in one or more of the other spheres. Extreme Earth events are caused by the interaction of some or all of the atmosphere, hydrosphere, geosphere and biosphere. Such events are a result of changes in one or more of these spheres.

Examples of the interactions of the four spheres will be explained for each of volcanoes, earthquakes and tsunamis in the relevant following units.

Tectonic plates

The whole of Earth's crust and lithosphere is broken into a number of **tectonic plates**. Many potentially catastrophic extreme Earth events, such as earthquakes, volcanic eruptions, and tsunamis, are ultimately caused by tectonic plate movement. Movement also shapes the surface of the Earth, forming prominent land features such as mountain ranges and ocean basins. On the following map, the arrows show whether the plates are moving away from, moving towards, or sliding past each other.



Map showing Earth's tectonic plates

AS 91191

Earth and Space Science 2.6

Externally assessed
4 credits

Demonstrate understanding of stars and planetary systems

For Earth and Space Science 2.6 you explore stars and planetary systems, studying the different types and characteristics of stars and their life cycles, and the formation of planets and moons.

The main groups of stars are main sequence stars, white and black dwarfs, blue giants, red giants and supergiants, and brown dwarfs. The Hertzsprung-Russell diagram is an essential tool that explains the relationship between the mass, temperature, luminosity and colour of stars. Energy changes and the role of gravity are also examined.

A planetary system is one star, together with any orbiting planets and their moons. Generalised characteristics of planetary systems are explored using the specific characteristics of our Solar System. The stages in the formation of planets are studied, with particular reference to how distance away from the star affects the temperature and therefore the composition of different planets.

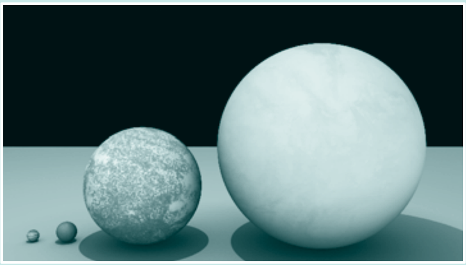
Moons can form in many ways. This is discussed using examples of moons from our Solar System.

Unit 1 – General introduction to stars

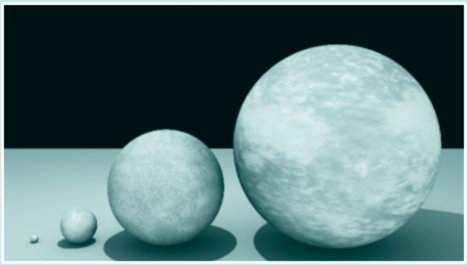
Characteristics of stars

A **star** is a massive, luminous (giving out light) ball of heated gas held together by gravity. Stars vary greatly in size. The mass of stars is an important measurement. **One solar mass** is the mass of the Sun. This is written as $1M_{sun}$. Stars with a greater mass may be as big as 30 M_{sun}. Stars with a smaller mass may be as small as 0.1 M_{sun}. The illustration shows some comparative sizes.

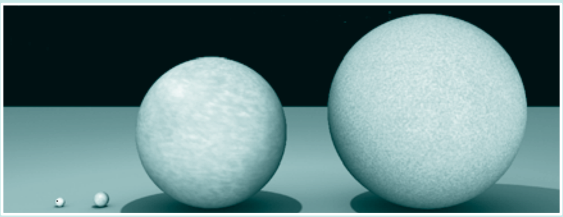
Jupiter < Wolf 359 < Sun < Sirius



Sirius < Pollux < Arcturus < Aldebaran



Aldebaran < Rigel < Antares < Betelgeuse

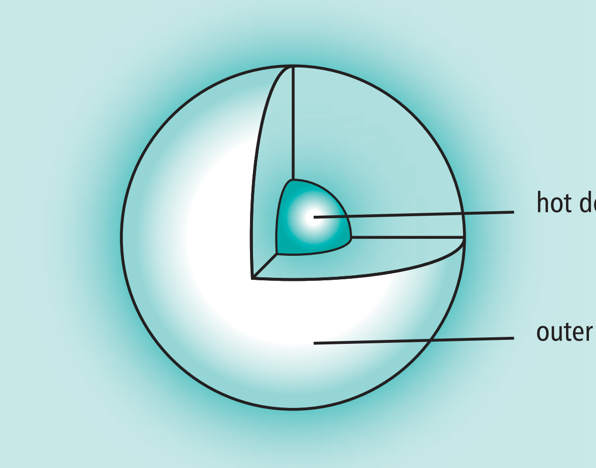


AS 91192

General structure of a star

A star has two main sections:

- a very hot, dense core (where nuclear fusion occurs), which keeps on contracting for most of the star's life; the core's temperature and density continue to increase
- an outer gaseous shell made of hydrogen and helium gas; the shell helps move heat from the core to the surface of the star, from where energy, as heat and light, is released into space.



Nuclear fusion

A star's heat and light are generated by **nuclear fusion**. Nuclear fusion is a nuclear reaction in which two or more atomic nuclei join or 'fuse', to form a single heavier nucleus with the release of a vast amount of energy. (Nuclear fusion is not the same as 'burning', although sometimes the word 'burning' is used when 'fusing' is what is meant.)

The main types of stars

Main sequence stars

These are the stars we commonly see in the sky. Most stars, including the Sun, are **main sequence** stars, converting hydrogen to helium by nuclear fusion with the release of vast amounts of energy. They are in the most stable part of their life cycle.

The size of main sequence stars ranges from red dwarfs to blue giants, depending on the mass of the star. Once stars run out of hydrogen, they become another type of star.

Giants and supergiants

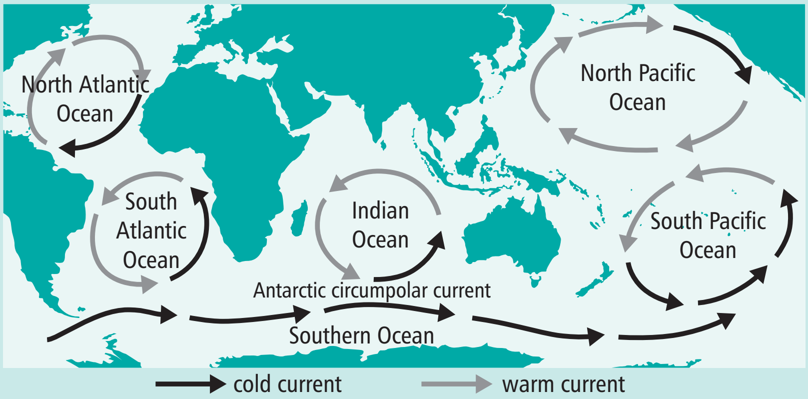
When stars have used all their hydrogen supply they stop being main sequence stars. The core of the star contracts and heats up as the outer layers expand, cool and redden, forming giant and supergiant stars. There are three types.

- **Red giants**: Form when Sun-sized stars run out of hydrogen.
- **Supergiants**: The largest known type of star – form when massive stars run out of hydrogen. They eventually become supernovae.
- **Blue giants** and **blue supergiants**: Massive blue stars close to running out, or that have just run out, of hydrogen. They also become supernovae.

AS 91192

Surface ocean currents are also affected by:

- the **Coriolis effect** (the force on moving objects caused by the Earth's rotation), which makes the currents in the northern hemisphere move to the right, and in the southern hemisphere move to the left
- Earth's continents – currents change direction when they encounter large land masses.



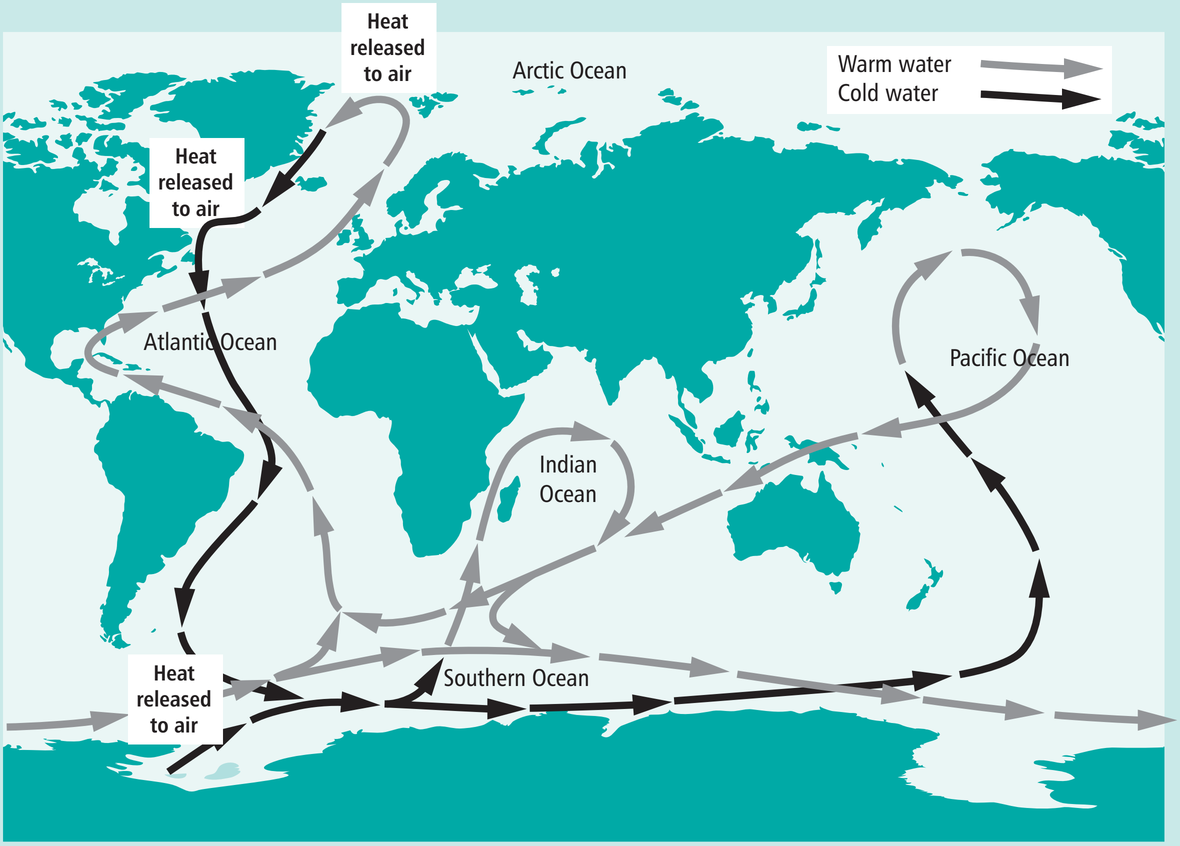
Deep ocean currents

Deep ocean currents, known as the 'global conveyor belt' carry warm and cold water around the globe, driven by density differences in the water. Warm water is less dense and lighter than cold water. Salt water is also dense and sinks, while fresh water is less dense and rises. A combination of temperature and salinity determines the ocean's density, so this circulation is known as **thermohaline** circulation.

The thermohaline current travels around the planet with a force 16 times greater than all the world's rivers combined, moving very slowly – only a few centimetres per second. It is responsible for the mixing of large amounts of water from all the oceans, and for the distribution of heat and nutrients.

At the Earth's poles, large volumes of dense, cold, salt water sink to the ocean floor and warm water flows in to take its place, establishing a current. The new warm water then cools, sinks and the cycle continues.

The global conveyor belt moves heat from the equator to northern and southern regions and moves cold water from the poles to the equator, as shown in the following diagram.



AS 91193

Ans. p. 277

Questions: Heat transfer in the hydrosphere

1. a. In what way is water unusual on Earth?

   b. How is heat energy transferred within the hydrologic cycle?

2. a. What does 'specific heat capacity' mean?

   b. Water has a high specific heat capacity. Explain what this means in terms of the oceans' ability to store heat energy.

3. a. Describe the two processes that account for surface ocean currents.

   b. Describe the direction of surface ocean currents around the Earth.

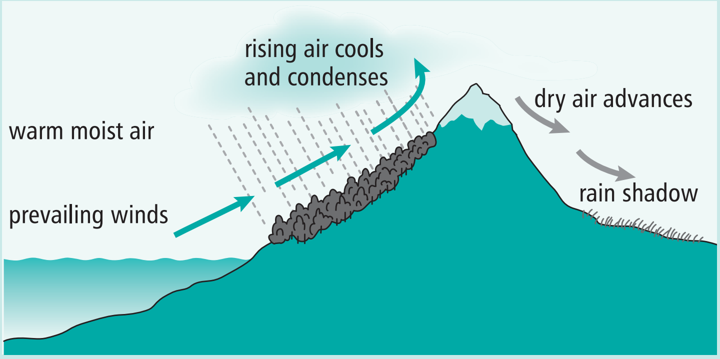
   c. Name two other factors that affect surface ocean currents and describe their effect.

4. a. What two factors affect the density of ocean water, and how?

   b. Describe the characteristics of the thermohaline current.

5. Explain how heat energy from the Sun relates to the flow of heat energy in the hydrosphere.

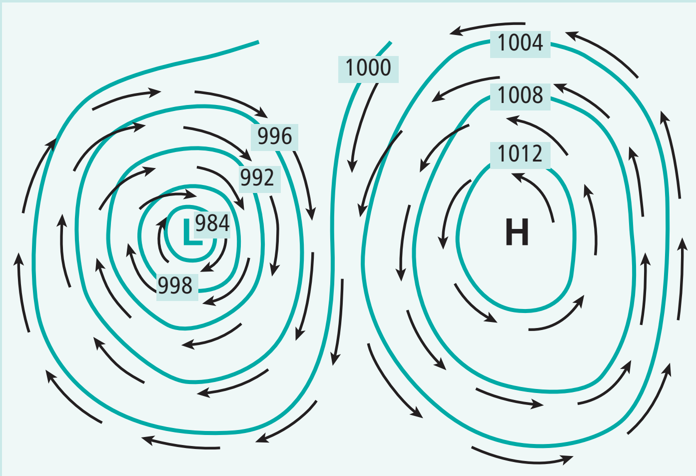
In New Zealand, rain falls on the windward side of the mountain ranges, which is the west coast of both islands, with very little rain falling on the downwind, eastern side of the mountains.



Areas of high and low pressure

Because of uneven solar heating of regions of the Earth, temperature differences occur, which cause areas of high and low pressure to develop. The horizontal transport of heat by wind from the equator to the poles is strongly influenced by the Earth's rotation (the Coriolis effect), which prevents the wind from flowing directly from high-pressure to low-pressure areas, instead causing the wind to flow around centres of high and low pressure.

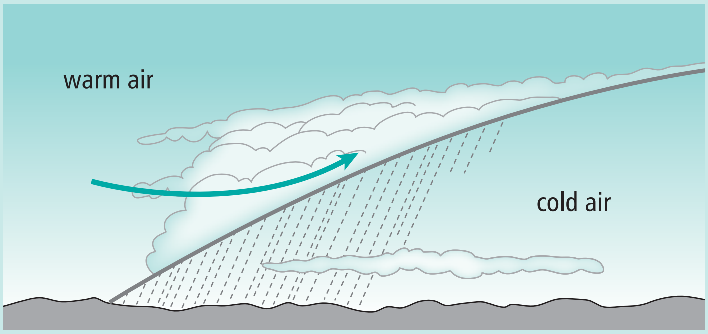
The following diagram shows how the wind flows in the southern hemisphere; in the northern hemisphere the wind flows in the opposite direction.



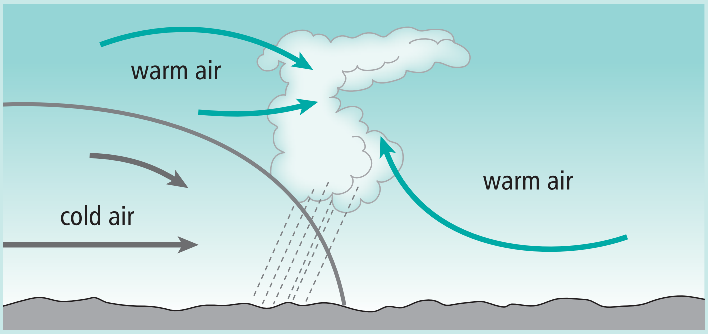
The direction in which wind flows is influenced by the Earth's rotation

Fronts

A front marks the boundary between two air masses. A **cold front** is the leading edge of a cold air mass. Cold fronts push in underneath warm air ahead of them, forcing the warm air upwards, producing cloud and areas of rain; the cloud band can be between 50 and 400 km wide. As the front passes, rain clears, leaving occasional showers; air temperature drops; air pressure rises; and the wind changes direction.

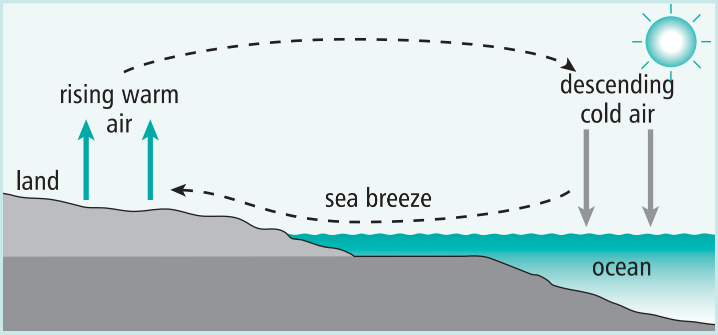


A **warm front** is the leading edge of a warm air mass. As a warm front advances, warm air rises over a zone of retreating cold air, making a cloud bank that rises upwards, often bringing steady rain; the cloud bank can be 500 to 1 000 km wide. As the front passes over a region, rain becomes patchy but **humidity** (amount of moisture in the air) remains high; air temperatures may rise a little; and the wind changes direction.

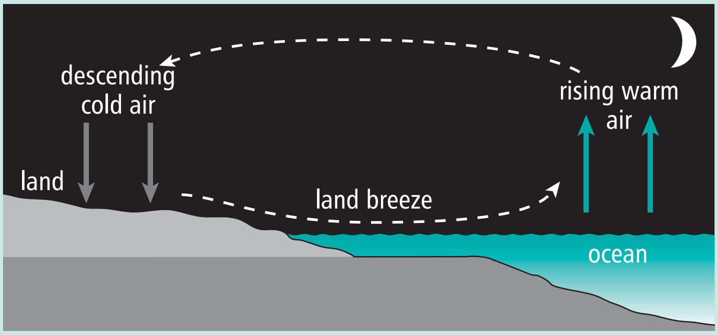


Land and sea breezes

Due to water's high specific heat capacity compared with that of land, water in the oceans warms very slowly in comparison with the adjacent land, so the air above the land during the day is warmer than the air above the ocean. This warmer, less dense air rises due to buoyancy forces, with the cooler, more dense air from above the ocean moving in to take its place. The movement is a **sea breeze**.



At night the land cools far more quickly than the ocean, so air above the ocean is warmer than above the land. The warmer air above the ocean rises due to buoyancy, while the cooler, more dense air above the land is drawn towards the sea to takes it place; this movement is a **land breeze**.



Ans. p. 278

Questions: Weather

1. a. Define the term 'weather'.

b. Name four processes involved in the creation of weather.

c. In which part of the atmosphere does all Earth's weather occur?

2. a. Explain how the uneven heating of the Earth by the Sun results in weather.

b. Explain the difference between vertical heat transport and horizontal heat transport.

3. a. Explain the heat transport mode called 'moist convection'.

ANSWERS

Achievement Standard 91187 (Earth and Space Science 2.1)

Introduction to Earth and Space Science investigations (page 2)

1. Meteorology, geology, environmental science, astronomy, marine science (any three)

2. Outliers are 2.2 and 3.4

3. Field-trip or environmental investigations have many variables that cannot be controlled, so a single variable cannot be changed whilst controlling the rest – as you must for a fair test.

4. **a.** Fair test

b. Fair test, because Emma is changing only one variable, the salt concentration.

c. No. Emma needs to do at least three repeats for each of the five salt concentrations. In addition, using only one seed per concentration is too small a sample, because the seed might not be viable (might not grow), so Emma needs to use at least 10 seeds at each salt concentration.

5. **a.** 0.998 g L^{-1} 0.954 is an outlier so is not included in the calculation

b. 89.5 seconds 84 is an outlier so is not included in the calculation

c. 38 °C 37.75 rounded

6. **a.** Fair test, because they are changing only the soil composition.

b. Measuring cups / beakers

c. The depth and diameter of the container the substrate is held in / the size of the weight used / shape of weight used / volume of water (any two)

Planning fair-test investigations (page 6)

1. The aim describes what you want to find out.

2. **a.** A controlled variable is a factor you keep the same.

b. The independent variable is what you change.

c. The dependent variable is what you measure.

3. Independent variable: angle between Sun and Earth; Dependent variable: temperature inside the cone of black paper; Controlled variable: use the same cone for each angle between Sun and Earth.

4. A method needs to be trialled to try to ensure the values for the independent variable give clearly different results (i.e. the values are a valid range), and therefore a trend can be established.

5. All other variables must be kept the same so you know any changes in what is being measured are due only to the changing independent variable.

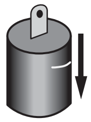
6. **a.** Claire should not use these values because they are too close together, so a clear trend would not be established. The numbers might overlap when the method is repeated.

b. 0, 20, 40, 60 degrees Celsius (or four other values with a reasonable spread)

c. These temperatures should give clearly different results when the density is measured, so there will be no overlap between results and a trend can be seen.

7. The arrow represents where the ruler could be placed.

Start the stopwatch when the weight is placed on the soil. Stop the stopwatch when the weight sinks to the point indicated by the horizontal line on the weight.



Collecting data for fair-test investigations (page 9)

1. **a.** 3.2 cm; **b.** 4.2 cm; **c.** 5.3 cm; **d.** 6.0 cm

2. **a.** An extreme value, different from other values collected.

b. The value between the median and the highest value (when values are ordered from lowest to highest)

c. The value between the median and the lowest value (when values are ordered from lowest to highest)

d. The middle value (when values are ordered from lowest to highest)

e. The sum of all values divided by the number of values.

3.

Type of substrate	Distance (cm) Trial 1	Distance (cm) Trial 2	Distance (cm) Trial 3	Distance (cm) Trial 4	Distance (cm) Trial 5	Distance (cm) Trial 6
MC	3.2	4.0	4.7	4.3	4.5	
GS	3.5	3.2	3.2	3.3	3.4	
Sa	9.5	5.3	5.0	5.0	5.1	
Si	6.2	6.0	6.2	6.0	5.9	6.0

4.

Type of substrate	Median	Upper quartile	Lower quartile	Inter-quartile range	1.5 × inter-quartile range
MC	4.3	4.5	4.0	0.5	0.8
GS	3.3	3.4	3.2	0.2	0.3
Sa	5.1	5.3	5.0	0.3	0.5
Si	6.0	6.2	6.0	0.2	0.3

5. **a.** 50 mL of water, because all the values are very different from each other so you cannot say which is the most accurate.

b. 9.6 is an outlier because it is very different from the other two values. The upper quartile is 8.7 and lower quartile is 8.2 so the inter-quartile range is 0.5. The mild outlier is $1.5 \times 0.5 = 0.8$. The value 9.6 is greater than the upper quartile plus the mild outlier value.

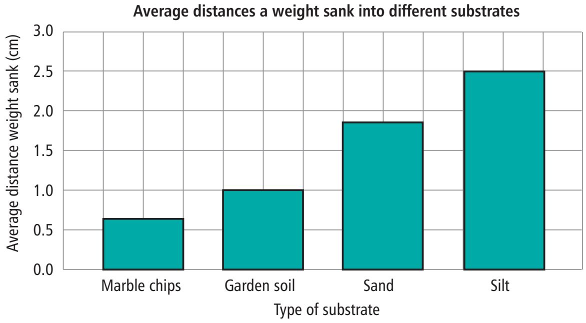
c. When the ice-cream container is filled, it might contain different amounts of substrate each time. Finn should mark the container to ensure it is filled to the same level for each repeat.

He needs to make sure the rate of moving the container stays the same, e.g. two movements per second.

ANSWERS

Line and bar graphs (page 12)

1. Add up all the values in the group and divide them by the number of values there are.
2. a. X axis; b. Y axis.
3. There is no title, there are no units for volume, there is no description of the distance, the labels on the volume axis are not going up in equal amounts, there is no line of best fit (any three).
4. Averages are: marble chips, 0.6 cm; garden soil, 1.0 cm; sand, 1.9 cm; silt, 2.5 cm.
   a. centimetres / cm
   b. Type of substrate
   c. Average distance weight sank (cm)
   d. Average distances a weight sank into different substrates
5.



Planning pattern-seeking investigations (page 15)

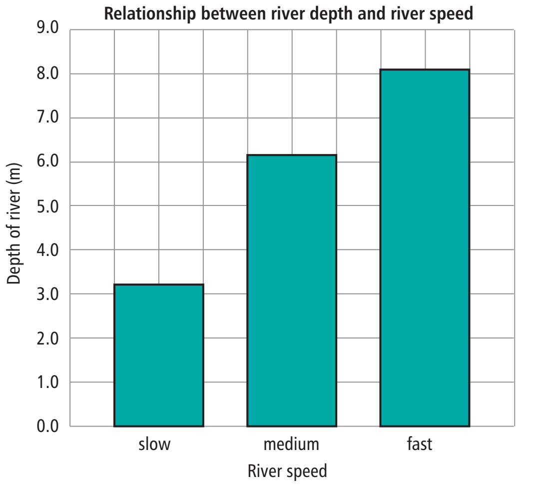
1. Pattern-seeking investigations are performed when variables cannot be controlled easily / for natural events.
2. A hypothesis describes what you think you will observe / will be the outcome in an investigation.
3. a. Time of day and the length of the shadow.
   b. Temperature of the river and distance from where the river meets the sea.
   c. The diameter of anemones and the diameter of rock pools, in order to calculate the pools' surface areas.
4. Pattern-seeking investigations are studying nature, where measurements are made of naturally occurring events that cannot be controlled.
5. The day on which the measurements were made; the time of day the measurements were made; the equipment used for measuring; the way the measurements were taken (e.g. the pool was measured from the edge, across the widest part).
6. They are valid because they show a trend – when there is more rainfall there is more sediment in the river.

Displaying data for pattern-seeking investigations (page 17)

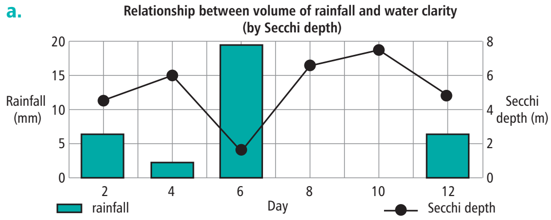
1. Line graph, histogram, bar chart (any two).
2. a.

Average depth (m)	3.2	6.2	8.1
Average speed (m/s)	2.0	3.5	5.0
Speed	Slow	Medium	Fast

   b.



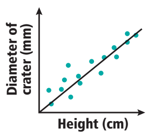
   c. As the depth of the river increases, so does its speed; therefore there is a positive correlation between the depth of the river and its speed.
3. a. The data can be clearly interpreted from the table, where the average speed is shown and the numbers can be easily compared.
   b. The volume of rainfall on the days prior to measurements could have caused the speed of the river to increase. It might also have changed the characteristics of the substrate, bringing more silt down from the hills.
4. a.



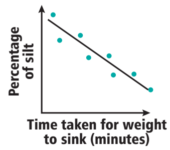
   b. The more rainfall there was, the less clear was the water.

Questions: Interpreting data (page 19)

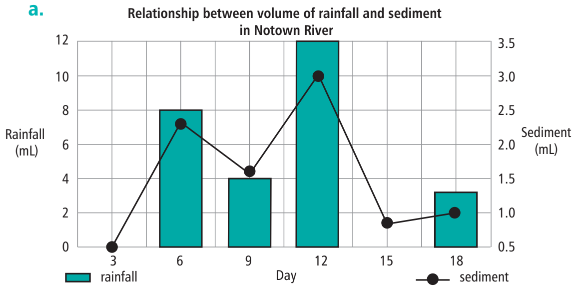
1. a. No 'line of best fit' can be drawn.
   b.



   c.



2. a. There was no relationship between pH and speed of the river.
   b. There was a positive correlation between the height from which a ball-bearing was dropped and the diameter of the crater formed.
   c. There was an inverse relationship between the percentage of silt in the soil and the time it took for a weight to sink in the soil.
3. a.



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