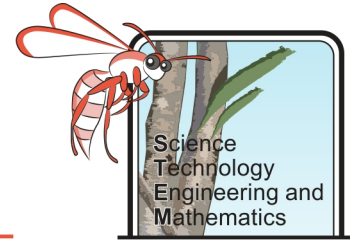
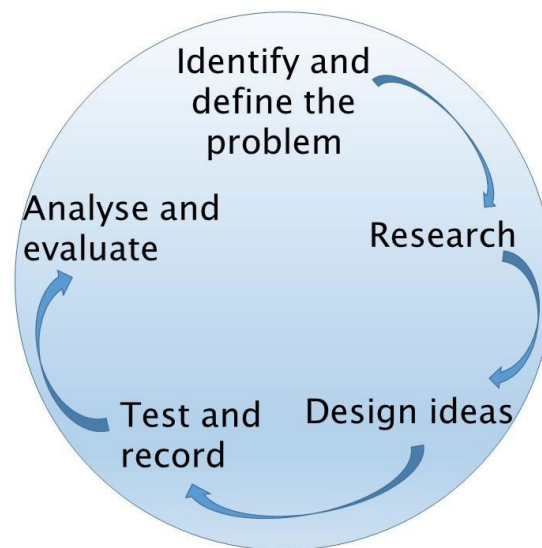


Monitoring a Volcano – Student Workbook



The Challenge

Indonesia is one of Australia's closest neighbours and a frequent tourist destination for Australians. It is also a country which is impacted by volcanic eruptions, which can be very dangerous. To ensure that locals and tourists are safe it is vital that volcanoes are closely monitored so that people can be evacuated from the area, if necessary. Your role is to decide which techniques you will use to monitor a volcano.



Background Information

Indonesia is often described as a tropical paradise. It has rich fertile soils which promote the growth of tropical plants. These rich soils get a lot of their minerals from volcanic ash, so farmland tends to be nearer volcanoes.

People that live near active volcanoes must be cautious as they can emit poisonous gases and eject hot ash and lava. Volcanic eruptions can also cause landslides and small earthquakes.

One of the most famous volcanic eruptions in Indonesia was the 1883 eruption of Krakatoa. The sound of this eruption was so great it could be heard nearly 5,000 km away, and reportedly burst the eardrums of sailors 64 kilometres away (Winchester, 2003). The eruption spewed so much ash and sulphur into the air that it has been linked to global cooling, and weather patterns changing for the following five years (Bradley, 1988).

Monitoring a Volcano – Student Workbook

Science
Technology
Engineering and
Mathematics

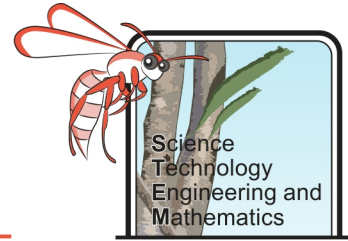


Figure 1. This map shows some of Indonesia's most active volcanoes.

In 2018/19 Mt Agung on Bali received a lot of attention, with a few small eruptions. These eruptions caused disruption to air travel and thousands were evacuated from the surrounding area to ensure they were safe. A previous eruption in 1993 resulted in landslides and lava flows which led to nearly 2,000 deaths (Wikipedia, 2019)

Luckily, volcanic eruptions tend to have many warning signs. These signs include increased seismicity (small earthquakes, caused by movement of magma below ground), increased temperature below the surface of the volcano, emission of gases and bulging/growth of the volcano. Monitoring of these signs is key to a good warning system which ensures the safety of people living nearby.

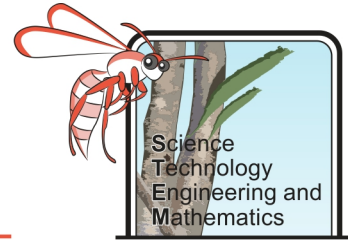
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Background Research

1. When did the largest eruption in recorded history occur? What was the name of the volcano?
2. What do the terms active, dormant and extinct mean when it comes to volcanoes?
3. How many volcanoes have been active in the past month in Indonesia?
4. What is the difference between a stratovolcano and a shield volcano?
5. What type of volcanoes are typically found in Indonesia, stratovolcanoes or shield volcanoes?
6. Describe at least three different ways of monitoring a volcano.

Monitoring a Volcano – Student Workbook



Designing a Tiltmeter

Background Information

One sign that a volcano is close to erupting is that it begins to grow and bulge. A way of measuring this can be using a tiltmeter. This instrument shows how much deformation is occurring.

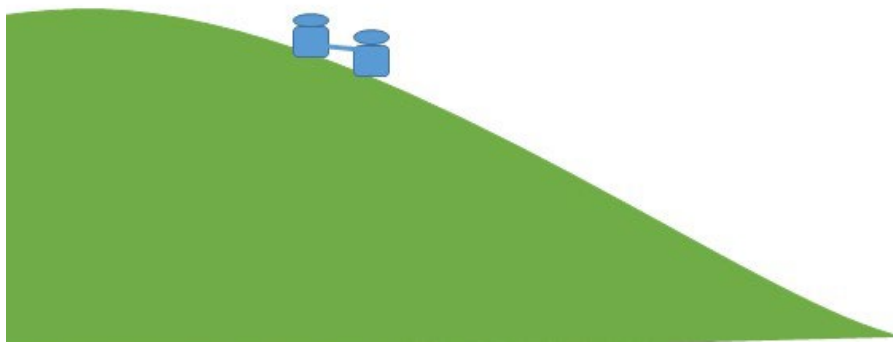


Figure 2. In ancient Rome tiltmeters were used which were made of one vessel with water in it placed above another empty vessel, they are connected with a pipe. If the volcano starts to swell the water will start to pass from the top vessel into the empty vessel.

Objective

To design and make a tiltmeter which could be used to indicate the growth or bulging of a volcano.

Materials

What materials will you need to make your tiltmeter?

Design

Draw a labelled diagram to show how you will build your tiltmeter.

Testing and Analysis

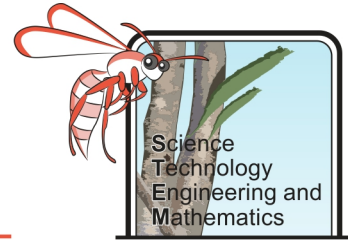
Place your tiltmeter on a tray/ board and slowly raise one end.

1. Does your tiltmeter work? What happens?
2. If this device was placed on the side of a volcano would it assist you to determine if it was growing or bulging? How?

Evaluation

1. After testing your tiltmeter discuss the pros and cons of your design.
2. How could you improve your design?

Monitoring a Volcano – Student Workbook



Detecting Seismic Waves

Background

Before a volcanic eruption occurs there are usually lots of small earthquakes in the area. This is caused by the magma moving around below the surface. The earthquakes are measured using a seismometer to produce a seismograph, which shows how much energy the earthquake waves have.

Explain, with the use of a diagram, how a basic seismometer works.

Objective

To make a model seismometer and evaluate how useful it is.

Materials

What materials will you need to create your model?

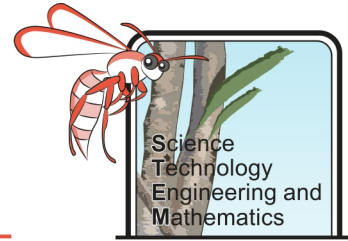
Method

Draw a labelled diagram to show how you will make your seismometer.

Evaluation

1. After testing your seismometer discuss the pros and cons of your design.
2. How could you improve your design?

Monitoring a Volcano – Student Workbook



Materials for Monitoring

Background

One way to monitor a volcano is to sample the gases coming out of it. If there is an obvious change in the volume and type of gas being released this can indicate that the volcano may erupt soon. However, this can be a dangerous job as a lot of the gases are bad for your health and it can also be very hot and steamy. It is important that volcanologists collecting this gas are properly dressed to protect themselves.

Objective

To test the properties of different materials to design a safe outfit to protect yourself from the gas, heat and steam.

Test 1 – Heat Protection

A volcanologist can get very hot testing the gases being released from a volcano. It is important that they wear clothing that provides insulation/protection from this heat.

Method

Write out a step-by-step method of how you can test different materials to see how effective they are at protecting someone/something from heat. Show your method to your teacher and gain their approval before you conduct the investigation.

Equipment

What equipment will you need for the investigation?

Results and Analysis

1. Which materials were the most effective and least effective at protecting someone from heat?
2. Which would be best for the creation of a suit for a volcanologist?

Evaluation

1. How fair was your test?
2. How could you improve your investigation?

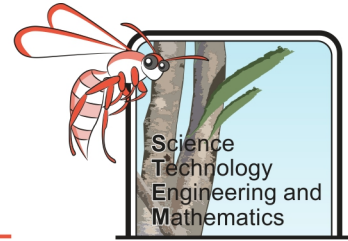
Test 2 - Strength of Materials

Volcanoes often have very jagged and rocky surfaces, it is important that the material being worn by a volcanologist does not rip easily.

Method

With the aid of a diagram, write a step-by-step method of how you can test the strength of different materials.

Monitoring a Volcano – Student Workbook



Equipment

What equipment do you need for the investigation?

Results and Analysis

1. Which material was the strongest?
2. Which would be best for the creation of a suit for a volcanologist?

Evaluation

1. How fair was your test?
2. How could you improve your investigation?

Test 3 – Permeability

A volcanologist will be exposed to lots of gas so it is important that, that gas does not pass through their suit. If the material is too permeable it will allow gas and water to pass through it easily.

Method

With the aid of a diagram, write a step-by-step method of how you can test the permeability of different materials. Show this to your teacher and gain their approval before conducting the investigation.

Equipment

What equipment will you need for the investigation?

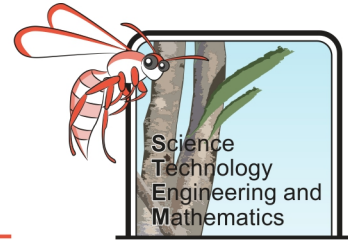
Results and Analysis

1. Which material allowed the least water to pass through?
2. Which material allowed the most water to pass through?
3. Which material would be most appropriate for use in a volcanologist's suit? Explain your answer.

Evaluation

1. How fair was your test?
2. How could you improve your investigation?

Monitoring a Volcano – Student Workbook



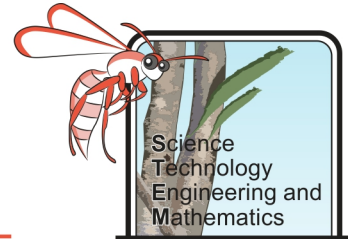
Further Testing

Are there any further tests you would like to conduct? If so, write a method for these investigations and show them to your teacher to gain approval before conducting them.

Designing the Suit

Considering what you have found about the different materials, design a suit which would be used for testing gases on a volcano. On your design add annotations stating which type of fabric you are using and why. You may even want to use different fabrics for different sections of the body.

Monitoring a Volcano – Student Workbook



Displaying the Temperature

Background

Thermal images use infrared radiation to show how hot something is. Below is a thermal image of a wolf. You can see by the scale red is used for hotter object and blue to purple for cooler objects. Can you also spot where the wolf had been lying on the ground?

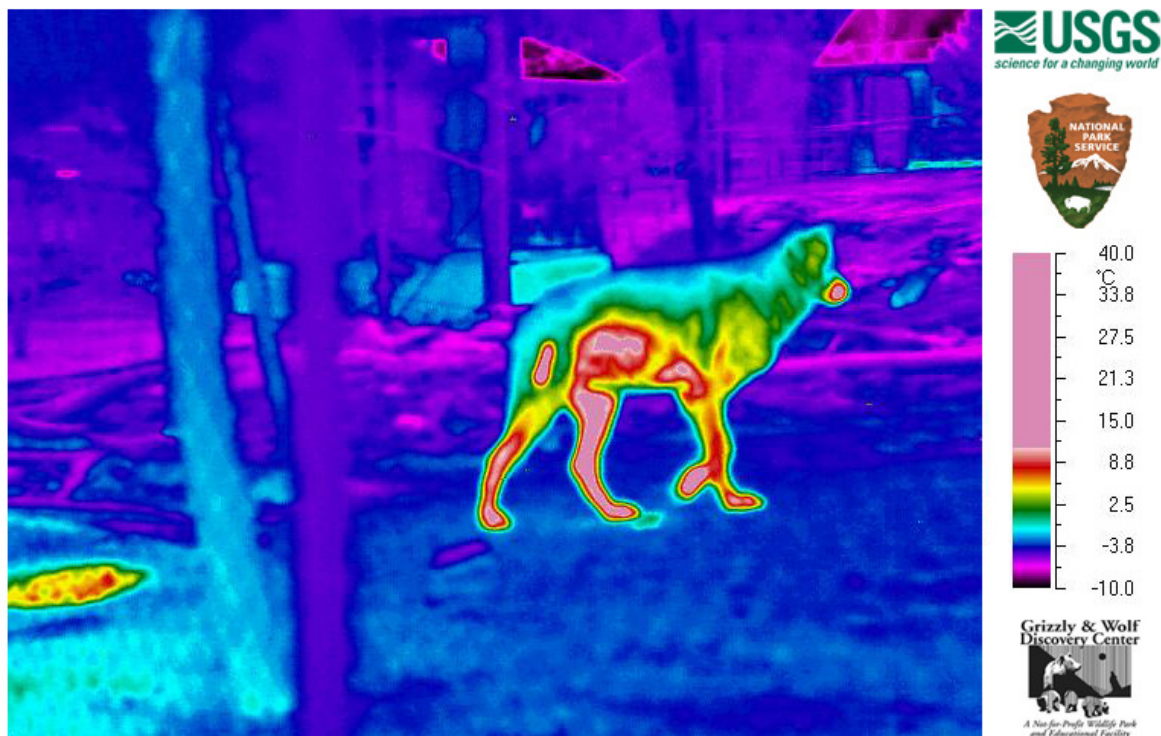


Figure 3. infrared image of wolf (USGS, 2019)

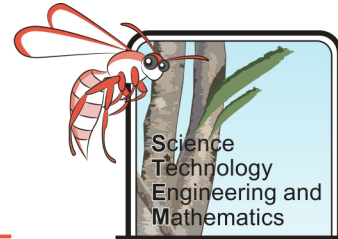
Objective






To design an algorithm that can be used to create temperature dependant images for an erupting volcano.

What is an algorithm?

An algorithm is a set of steps to solve a problem. Algorithms are represented in a flowchart using symbols to represent different instructions. Below is a table of common flowchart symbols.

Monitoring a Volcano – Student Workbook



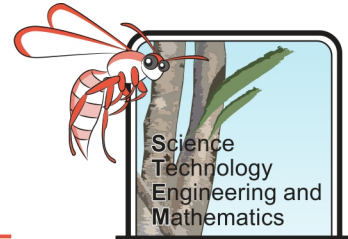
Symbol	Function
	Terminator This represents a start or end point
	Flowline This shows the direction of the data flow
	Data This represents the input or output of data
	Process This indicates one or more instruction or thing to do
	Decision This indicates a decision point between two or more paths

Temperature (°C)	Output Colour
Less than 10	Dark blue
10 – 30	
30-50	
50 - 70	
70-90	
More than 90	

Method and Results

1. Decide what colour you will use for each temperature range and complete the table.
2. Create an algorithm which will be used to create a temperature dependant picture - so each pixel will display the right colour for the temperature.

Monitoring a Volcano – Student Workbook



Monitoring a Volcano Decision Making

Background

Mt Agung on the Island of Bali has been relatively active in the recent past. The fact that the area is densely populated means that it could be very dangerous if it were to erupt without warning. It is vital, therefore, that it is well monitored so that evacuations can take place quickly.

Objective and Method

To decide which methods of monitoring Mt Agung you would use, explaining your decisions.

There are numerous methods used to monitor volcanoes. Some of them involve people going up the volcano to take measurements (making them high risk) and others can be done remotely, using satellites and other equipment. Some of them can be very costly to set up (below is a table of possible costs). Your job is to evaluate the different methods of monitoring and decide which ones you should be used. You have a budget of \$100,000. You will then present your decision either as a poster or as a presentation to the class.

Monitoring technique	Cost of installation	Cost of each measurement
Gas sampling	n/a	2,000
Tiltmeter	20,000	500
Temperature measurement	30,000	100
Groundwater sampling	n/a	3,000
Seismometer	40,000	n/a
GPS monitoring	50,000	n/a

Results and Analysis

Complete a table to compare the pros and cons of each of the listed monitoring techniques.

1. Fill in the table to calculate the cost of monitoring techniques you have chosen.

Type of monitoring	Cost of installation	Cost of each measurement	Number of measurements	Total cost

2. Which monitoring technique is the highest risk?
3. Which technique do you think will be most useful in predicting a future eruption?
4. Which monitoring techniques would you advise for use around Mt Agung? Explain your answer.