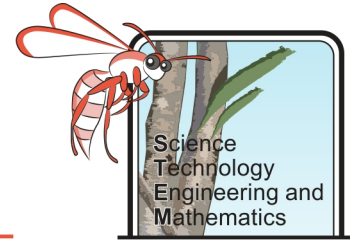# Monitoring a Volcano – Student Workbook

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.
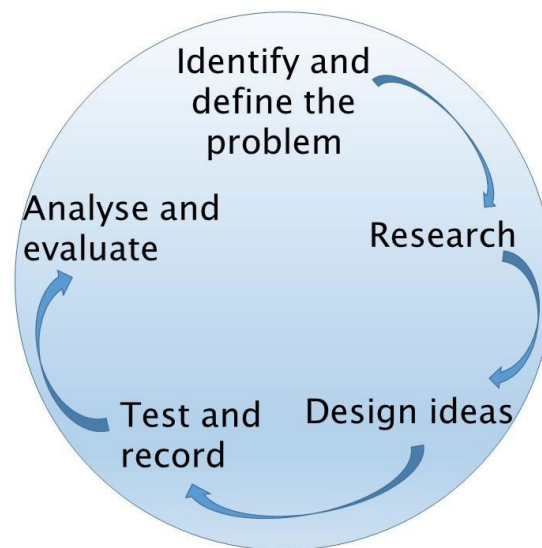
Background Information

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).
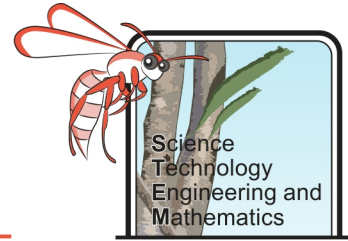
Monitoring a Volcano – Student Workbook

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.

Monitoring a Volcano – Student Workbook

Background Research

1. When did the largest eruption in recorded history occur? What was the name of the volcano?

   _____

   _____

   Suggested website: https://www.britannica.com/place/Mount-Tambora

2. What do the terms active, dormant and extinct mean when it comes to volcanoes?

   _____

   _____

   Suggested website: https://www.volcanodiscovery.com/volcanoes/faq/active_erupting.html

3. How many volcanoes have been active in the past month in Indonesia?

   _____

   _____

   Suggested website: https://earthquakes.volcanodiscovery.com/

4. What is the difference between a stratovolcano and a shield volcano?

   _____

   _____

   Suggested website: http://www.geo.cornell.edu/hawaii/220/PRI/PRI_PT_volcanoes.html

5. What type of volcanoes are typically found in Indonesia, stratovolcanoes or shield volcanoes?

   _____

   _____

   Suggested website: https://earthquakes.volcanodiscovery.com/
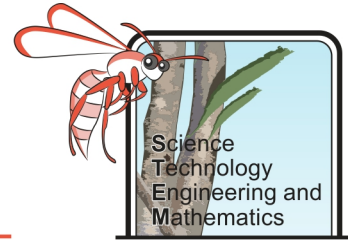
6. Describe at least three different ways of monitoring a volcano.

_____

_____

_____

_____

_____

_____

Suggested websites: https://www.bbc.co.uk/bitesize/guides/z8p9j6f/revision/5

https://opentextbc.ca/geology/chapter/4-5-monitoring-volcanoes-and-predicting-eruptions/
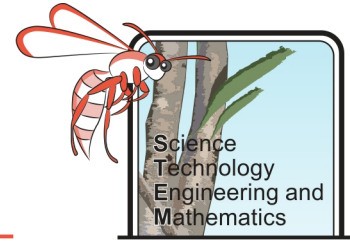
Designing a Tiltmeter

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.
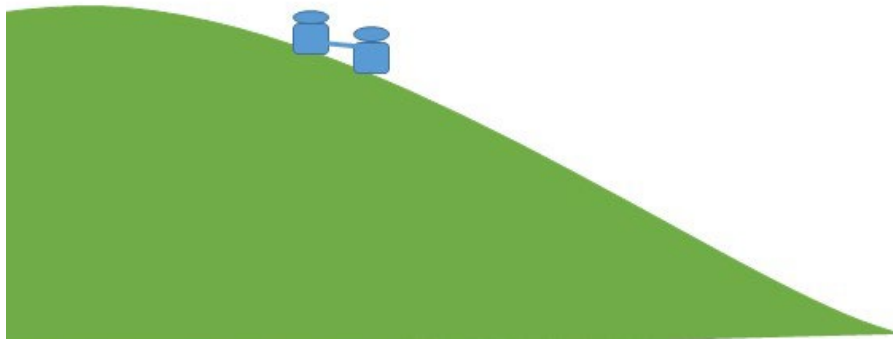

Figure 2. In ancient Rome tiltmeters were used which were made of one vessel with water in it placed above another empty vessel, they are connected with a pipe. If the volcano starts to swell the water will start to pass from the top vessel into the empty vessel.

Objective

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

Materials

- 2 paper cups
- A straw cut in half
- Plasticine
- Hole punch or scissors
- Ruler
- Pencil
- A tray
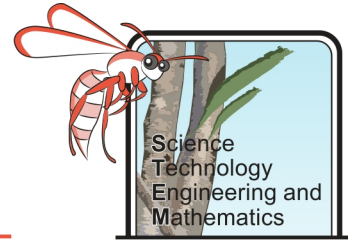
## Monitoring a Volcano – Student Workbook

Method

1. Use the ruler to measure five centimetres from the bottom of each cup and mark with a pencil.
2. Use the hole punch or scissors to carefully make a hole at that mark (just smaller than the circumference of the straw).
3. Push the straw through the hole and connect the two cups together. Use the plasticine to ensure there is no space around the straw and it is very secure.
4. Pour water into one of the cups to just below the level of the straw.
5. Place the cups in a tray and tilt it slowly (so the cup with water in it is higher than the empty cup). Observe what happens.

Results and Analysis

1. What happened as you tilted the tray?

   _____

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?

   _____

   _____
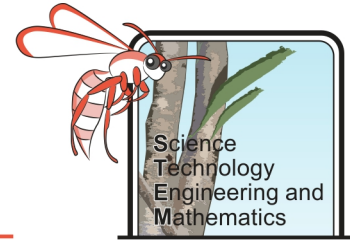
# Detecting Seismic Waves

Background

Before volcanic eruptions occur 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 graph, which shows how much energy the earthquake waves have.

In ancient China, a device was created that looked something like a large vase with dragons on the side. Inside there was a pendulum, which would move in the direction of the seismic (earthquake) waves. When the pendulum moved it made a ball release from the mouth of the dragon which was facing the direction the wave was travelling. This allowed people to know where to send help.

Figure 3. The ball would be released from the mouth of the dragon in to the frog's mouth to indicate which direction the seismic wave was moving.

Monitoring a Volcano – Student Workbook
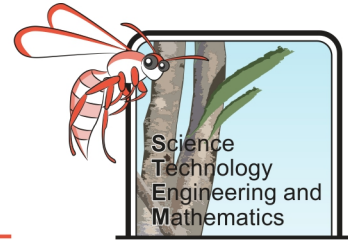
Objective

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

Materials

- Cardboard box
- Paper cup
- Scissors
- A felt tip pen
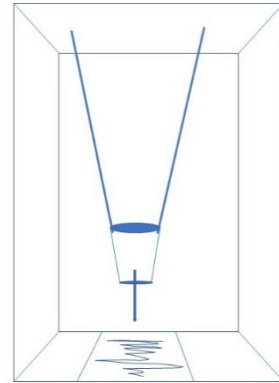- Marbles
- Strong string
- Narrow piece of paper

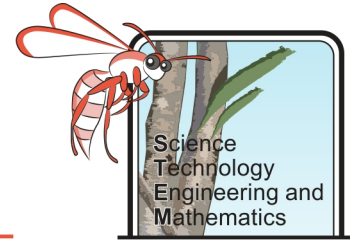*Figure 4. Box with suspended cup creating a seismometer*

Method

1. Carefully make a small hole in the centre of the base of the cup, and two holes near the top on the sides opposite one another.
2. Push the pen part way through the hole in the centre and loop the string through the holes in the sides of the cup.
3. Make two holes in the top of the cardboard box, and push the string through them, tying them together so that the cup is hanging with the pen just touching the bottom of the box.
4. Add some marbles to the cup to keep it weighted down.
5. Carefully make a slit in the bottom of the box (near where it meets the side the pen is hanging toward), big enough to pull the paper through.
6. Create an earthquake by shaking the box from side to side while someone else slowly pulls the paper through the slit.

Results and Analysis

1. Stick your resulting seismograph (paper with lines drawn into it below.
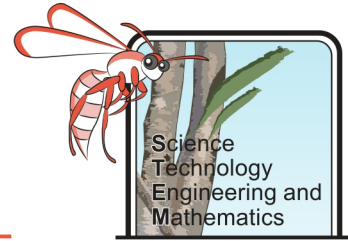
2. Repeat this activity but this time ask the person shaking the box (creating earthquake waves) to be gentle. Stick the resulting seismograph here.

3. Repeat the activity for a third time, with the person generating earthquake waves moving the box very rapidly. Stick the resulting seismograph here.

4. What did you notice about the differences in the seismographs from your first, second and third trials? What does this tell you about the recording of earthquakes?

_____

_____

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.

Equipment

- 4 samples of different types of material (about 10 x 30 cm in size)
- 4 measuring beakers
- 4 thermometers or temperature probes
- 4 elastic bands

Method

1. Wrap a beaker with each material using the elastic band to secure it.
2. Pour 100mL of hot water into each beaker and record the starting temperature.
3. Every minute record the new temperature into the table (up to 10 minutes).
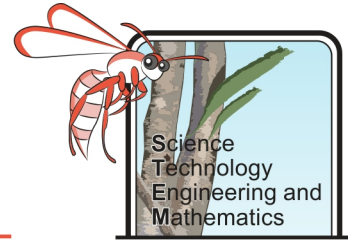
Results and Analysis

Time (m)	Material A	Material B	Material C	Material D
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

1. Which material kept the water warmest for longest?

   _____

2. Which would be best for the creation of a suit for a volcanologist? (Hint: materials that kept the water warmer didn't allow the heat to escape into the surrounding environment. If a volcanologist was wearing that material it may stop the heat moving from the surrounding environment to them).
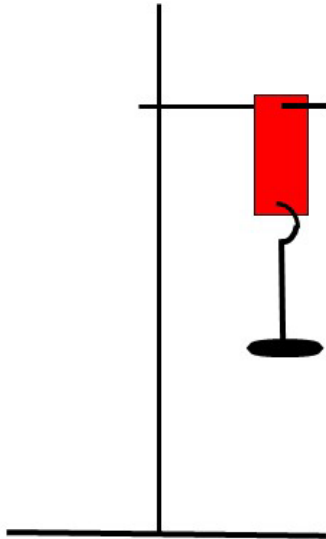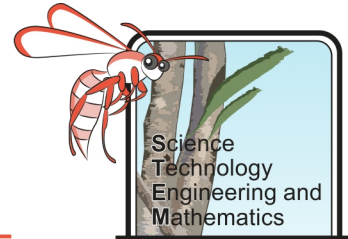
   _____

   _____

Figure 5. Testing how strong the material is by adding weights to it.

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.

Equipment

- The material used in test 1
- Retort stand, boss head and clamp
- Hole punch
- Slotted masses or other weights

Method

1. Use a hole punch to make a hole in each end of one of the materials.
2. Attach one end of the material to a clamp stand.
3. Measure where the bottom of the material is (relative to the table) – the height.
4. Attach the hook stand for the slotted mass to the other end of the material and measure where the bottom of the material is again.
5. Add slotted masses onto the hook, one at a time, until the material tears or you cannot add any more masses. Make sure to measure where the bottom of the material is for each.
6. Repeat steps 1-5 for each material.

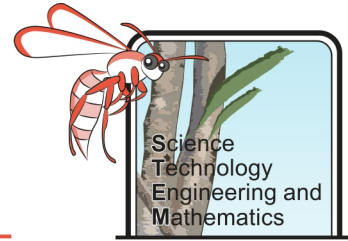Science
Technology
Engineering and
Mathematics
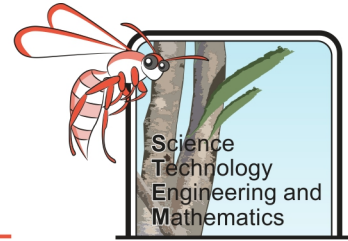
Results and Analysis

Material A

Weight added (g)	Height (length from bottom of material to table in cm)
0	

Material B

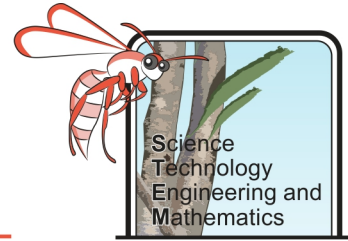| Weight added (g)	Height (length from bottom of material to table in cm)
0	

Material C

Weight added (g)	Height (length from bottom of material to table in cm)
0	

Material D

Weight added (g)	Height (length from bottom of material to table in cm)
0	

1. Which material held the most weight before tearing?

    _____

2. Which material held the least weight before tearing?

    _____

3. Which material stretched the most?

    _____

4. Which material would you recommend for use in a volcanologist's suit? Explain your answer.

    _____

    _____

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.

Equipment

- The material used in tests 1 and 2
- 4 beakers
- 4 pipettes or droppers
- 1 container of water
- 4 elastic bands
- Measuring cylinder
- Stopwatch
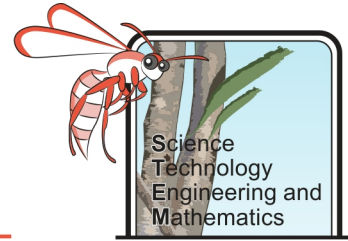
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Method

1. Stretch each material so that it is tight along the top of a beaker.
2. Use an elastic band to hold it in place.
3. Using a pipette add 10 drops of water to the top of the material and start your stopwatch.
4. After one minute take the material off the beaker and measure the water in it.

Results and Analysis

| Material	Water collected after 1 minute (mL)
A	
B	
C	
D	

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 in a suit for a volcanologist? Explain your answer.

_____

_____

Designing the Suit

Considering what you have found out 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.
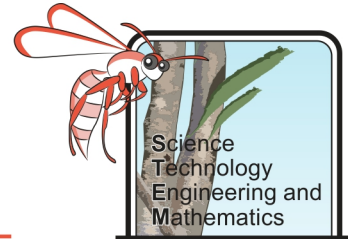
Displaying the Temperature

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?
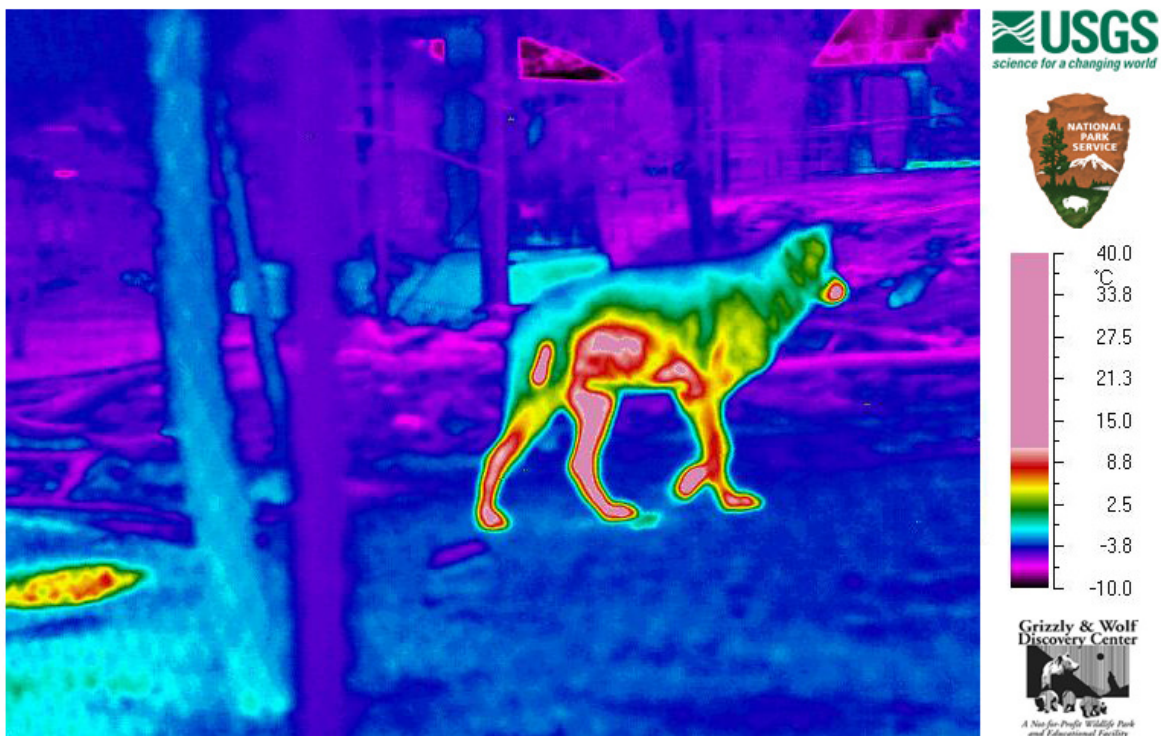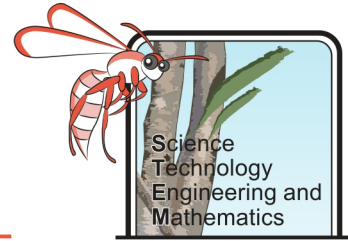

Figure 6. infrared image of wolf (USGS, 2019)

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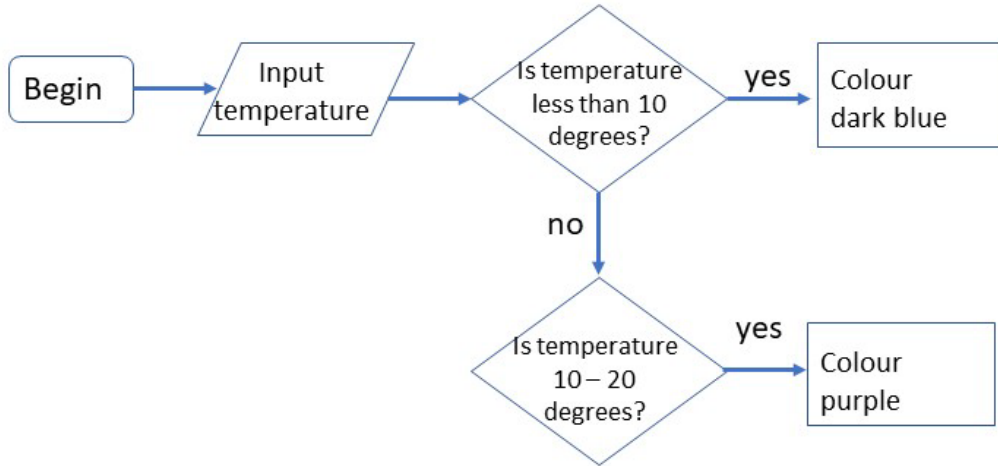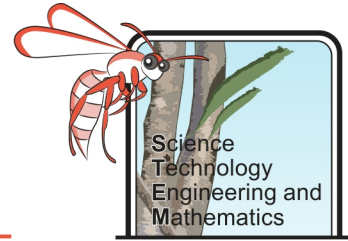
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| Symbol	Function
	Terminator This represents a start or end point
	Flowline This shows the direction of the data flow
	Data This represents the input or output of data
	Process This indicates one or more instructions or things to do
	Decision This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

Temperature (°C)	Output Colour
Less than 10	Dark blue
10 – 20	Purple
20- 50	Pink
50 – 70	Orange
70- 90	Yellow
More than 90	White

Method and Results

1. Develop an algorithm to create an infrared picture of a volcanic eruption. Use the temperatures and their associated colours from the table above. The first two steps have been completed for you on the next page.
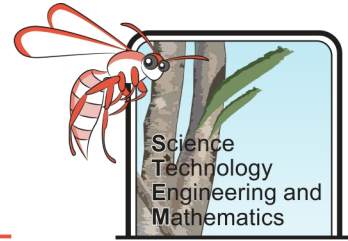
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Monitoring a Volcano - Decision Making

Background

Mt Agung on the Island of Bali has been relatively active in the recent past. The fact that the areas 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. Your job is to evaluate the different methods of monitoring and decide which ones you should be used. You will then present your decision either as a poster or as a presentation to the class.

Results and Analysis

Monitoring Technique	Pros	Cons
Gas sampling		
Tiltmeter		
Temperature measurement		
Groundwater sampling		
Seismometer		
GPS monitoring		

Monitoring a Volcano – Student Workbook
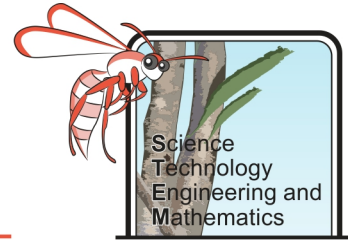
1. Which monitoring technique is the highest risk?

   _____

2. Which technique do you think will be most useful in predicting a future eruption?

   _____

3. Which monitoring techniques would you advise for use around Mt Agung? Explain your answer.

   _____

   _____

   _____

   _____

   _____

   _____

   _____