Vacuums and Space

Science Strand: Energy and Change/Earth and beyond

Primary Module
Year 4-7

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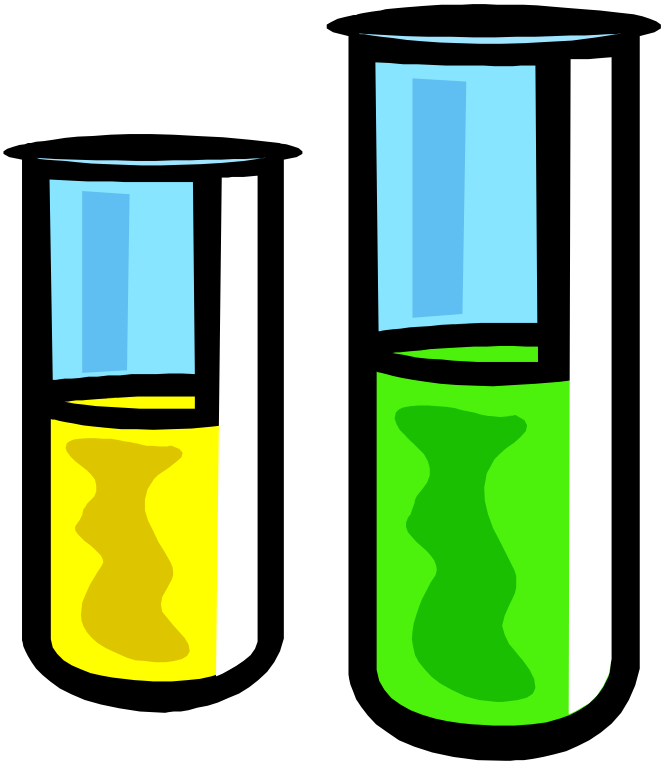
Abstract

What is a vacuum and what is space? At the GDC students will be able to explore the concept of vacuums and space and gain an understanding of questions raised during discussion.

The various experiments conducted at the centre will demonstrate to the students that some things do exist in a vacuum – light, heat, anything else?? They will investigate the effect of a vacuum on free falling objects and compare to free falling objects outside a vacuum. The students will examine the curved space model and the breathing mirrors.



BACKGROUND INFORMATION

These sheets are for teachers to use prior to their visits to the GDC. They can be used as information sheets for the students to access or as general background information.

According to the Macquarie Dictionary a vacuum is described as - ' a space, entirely void of matter; blank emptiness, nothingness, void, voidness'.

Some people think that gravity is due to the pressure of the air, or the rotation of the Earth. Yet it is gravity, which pulls the Earth in its orbit around the Sun and which pulls satellites around the Earth. As a vacuum is just an empty space with nothing in it, it can't possibly be the opposite to gravity.

For many years scientists thought there could be no such thing as a vacuum, a space with nothing in it, not even a gas. Aristotle insisted that a vacuum could not exist anywhere in the universe. But in 1644 Torricelli created a vacuum very simply. He filled a long tube with water, put in a stopper and held it upright in a bowl of water (the long tube must be more than 10 metres long!). At once the water level dropped in the tube, leaving a space between the water and the stopper. Torricelli concluded that this must be a vacuum. Torricelli believed that the water only fell so far down the tube because it was held up by the weight of all the air in the atmosphere pressing down on the water in the dish.
Late in the 19th century it was realised that this, so called, vacuum still contained heat

But what else can we say about nothing? Quite a lot. If you search the net you will find many mentions of this topic. The concept of an absolute void is challenging and a difficult one to understand. There seems to be no gravity in space because everything falls at the same speed – space shuttle, astronaut and all. It would be the same if it were a vacuum or not. Vacuum is empty space but is it really empty – it can have light in it and magnetic fields – but no gas.

The most common household item that uses the principle of a vacuum is the vacuum flask. By placing a vacuum between the hot/cold liquid and the outside air, the loss of heat or cold is stopped - no convection or conduction through the vacuum. A vacuum flask consists of a double- walled glass container with a vacuum between the walls (stopping heat energy transfer by conduction and convection) and the shiny surfaces (minimizing transfer by radiation.)

ASSESSMENT

Overarching Learning Outcomes - Curriculum Framework

There are opportunities to assess students in the following outcomes when taking part in this program:

OLO 7 Students understand and appreciate the physical, biological and technological world and have the knowledge and skills to make decisions in relation to it.

OLO 5 Students describe and reason about patterns, structures and relationships in order to understand, interpret, justify and make predications.

OLO 6 Students visualise consequences, think laterally, recognise potential and are prepared to test options.

Science Major Learning Outcomes - Curriculum Framework

Working Scientifically

1. **Investigating** - students investigate to answer questions about the natural and technological world. They use the skills of scientific investigation, reflection and analysis to prepare a plan for their investigation; to collect, process and interpret data; to communicate their conclusions.
2. **Communicating Scientifically:** Students communicate scientific understandings to different audiences for a range of purposes.
3. **Applying Science in Daily Life:** students apply and evaluate scientific knowledge, skills and understandings across a range of contexts.
4. **Using science in Society:** Students understand that science is a human activity which influences all people as part of their daily lives.

Understanding Concepts

1. **Earth and Beyond:** Students understand the physical world around them and its impact on the way we live.
2. **Energy and Change:** Students understand the scientific concept of energy and explain that energy is vital to our existence and quality of life.

Progress Maps

The following will enable teachers to have a clear picture about the achievements required of students to demonstrate an outcome.

Investigating Scientifically:

Students investigate to answer questions about the natural and technological world, using reflection and analysis to prepare a plan; to collect, process and interpret data; to communicate conclusions; and to evaluate their plan, procedures and findings.

Planning: Students plan for investigations, to test ideas about the natural and technological world.

Conducting: Students collect and record a variety of information relevant to their investigations

Processing Data: Students translate and analyse information to find patterns and draw conclusions to extend their understandings

Evaluating: Students reflect on an investigation, evaluate the process and generate further ideas

Investigating Scientifically: Students investigate to answer questions about the natural and technological world, using reflection and analysis to prepare a plan; to collect and interpret data; to communicate conclusions; and to evaluate their plan, procedure and findings.

Student Outcome Statement	**Level 2**	**Level 3**	**Level 4**
Planning- plan investigations to test ideas about the natural and technological world	Identifies, given a focus question, some of the variables to be considered	Plans for investigations, shows some awareness of the for fair testing and makes simple predictions based on personal experience	Identifies the variables to be changed, the variables to be measured and at least one variable to be controlled
Conducting - collect and record a variety of information relevant to their investigations	Observes, classifies, describes and makes simple non-standard measurements and limited records of data	Uses simple equipment in a consistent manner; records data in simple tables, diagrams or observations	Uses equipment appropriately; recognises the need for safety equipment and precautions; takes care with data collection to ensure accuracy
Processing Data - translate and analyse information to find patterns and draw conclusions to extend their understandings	Makes comparisons between objects and events observed	Displays numerical data as tables or bar graphs, and identifies patterns in data; summarises the data	Calculates averages from repeated trials; plots data as line graphs where appropriate; makes conclusions which summarise, explains patterns in data
Evaluating Data - reflect on an investigation, evaluate process, generate ideas	Comments on what happened and can determine if what happened was expected	Identifies difficulties experienced in conducting the experiment	Makes general suggestions for improving the investigation

Energy and Change:

Students understand the scientific concept of energy and explain that energy is vital to our existence and to the quality of life

Student Outcome statement	**Level 2** Understands ways that energy is transferred and that people use different types of energy for different purposes	**Level 3** Understands patterns of energy use and some types of energy transfer	**Level 4** Understands that energy interacts differently with different substances and this can affect the use and transfer of energy
Students understand the scientific concept of energy, give examples of energy sources and describe patterns of energy around the home and in the community	Students can: describe how another person uses energy in their daily life	Students can: describe a pattern of energy use at home or school	Students can: compare different sources of energy available in the community
Students understand that energy can be converted from one form into another, and that change involves transfer of energy.	Students can: describe a way that energy is transferred	Students can : relate the transfer of energy to the carrier of that energy	Students can: compare different ways of enabling or impeding energy

Earth and Beyond Students understand how the physical environment on Earth and its position in the universe impact on the way we live.

Student Outcome Statements	**Level 2** Understands how changes in the observable environment including the sky, influence life	**Level 3** Understands changes, patterns in different environments and space, and relates them to resource use	**Level 4** Understands processes that help explain to predict interactions and changes in physical systems and environments
Students know that the sustainability of life depends on the quality of the air availability of water &materials from the ground, and they use these resources wisely	Students can: note changes in the local environment which influence daily life	Students can: describe how resource use changes the physical environment	Students can; describe ways information is gathered about the Earth and its resources
Students understand that the Earth is composed of materials that are altered by forces within and on its surface	Students can describe a change that occurs in the local environment	Make connections between changes in the physical environment and processes	Students describe the interactions between changes in the atmosphere and the interior of the Earth
Students understand the relationship between the earth, our Solar system and the universe is dynamic	Students record changes in the features of the day and night sky	Students relate changes on earth to patterns of nearby astronomical bodies	Students compare components of our universe

Rubric example for portfolio assessment

Level 2	**Level 3**	**Level 4**
Uses pictures, words or numbers to record observations of vacuums	Chooses forms of data presentation that are appropriate for the types of data collected on vacuums	Ensures that data collection is accurate and takes multiple measurements to ensure accuracy of temperature of water
Student is able to comment on what happened in the investigations and to comment on whether what happened was expected	Students are able to pinpoint difficulties in conducting the investigation into vacuums and identify external factors which influenced the results.	Student is able to make suggestions on improving the investigation into vacuums
Student comments on how a vacuum works	Student describes how a vacuum works	Student is able to compare the vacuum and the jug and explains the differences

Pre-visit Activities

The following activities and information will give students the opportunity to develop some understandings prior to their visit to the GDC

PLEASE NOTE: ALL THE FOLLOWING TASKS NEED TEACHER SUPERVISION

1:

Students in this activity will be investigating how effective a vacuum flask is in keeping water hot. Students may follow the method below and the recording sheets that follow or the students can conduct their own investigation.

Materials: thermos flask, kettle for hot water, a jug with a similar capacity as the thermos flask, 2 thermometers, work sheet to record data and predictions.

Method:

1. Boil the kettle and fill the jug and thermos flask with the same quantities.
2. Have students predict what will happen to the temperature of the water in both containers. Record prediction on worksheet.
3. Using the thermometer check the temperature of the water in the jug and the flask every 5 minutes.
4. Have students discuss why they think the results read as they do. Have students record their ideas on the worksheet.

Test the insulation effect of different materials such as foam rubber, aluminium, plastic, newspaper and wool. Have different groups of students using different insulating materials. Record the student's results on the worksheet. Discuss results with students.

2:

Materials : a short, fat candle about 5cm high and 5cm. wide, a plate, a wide mouthed jar, measuring cup, tap water, matches

Method:

1. Put the plate on the table.
2. Pour enough water to cover the bottom of the plate.
3. Place the unlit candle in the middle of the plate.
4. Cover the candle with the jar. Have students record what happens on their worksheet.
5. Remove the jar and light the candle.
6. Watch the candle burn for a couple of minutes.
7. Place the jar carefully over the candle.
8. Students record what happens and give their explanation.

Explanation:

When the jar covered the candle, the candle heated up the air. Hot air expands and pushed some of the air in the jar. Oxygen is used up when anything burns. So when the candle used up oxygen inside the jar, the fire went out the air cooled down and contracted. At that point there is less air pressure inside the jar than outside and a vacuum is created. The outside air pushes the water into the jar until the weight of the water balances the difference in pressure between the inside and the outside.

Sometimes you may also see the effect of the candle heating the air. This causes a quick gush of air out of the bottle before the main process – the using up of the air – causes it to suck inwards.

After the candle has gone out the water continues to rise as the inside gas cools down.

With this experiment you can also see another interesting effect.(Use a wide mouthed jar for best effects)

After the candle has gone out the gas inside the jar has a lot of CO_2. This gas is heavier than air. If you now take this jar of CO_2 you can <u>pour it</u> over the burning candle and it will make the candle go out.

3. Research the following and present your findings in one of the following ways - a warning label to go on space craft's air lock doors; a letter to movie scriptwriter to give them correct information; a scene from a science fiction movie where one of the characters is set adrift without a space suit.

- What is a vacuum?
- What sort of pressure exists outside our bodies?
- How would a vacuum affect our bodies – long and short term?
- How tough is our skin and our other organs?

Student Name: _____ **Date: _____**

Task 1:

1. I predict that the:

2. Record your temperature results in the table below

Time in minutes	Temperature of water in Vacuum Flask (°C)	Temperature of water in Jug (°C)
5		
10		
15		
20		
25		
30		
35		
40		

3. What have you found out from your results?

4. Why do you think this has happened?

Time in minutes	Temperature of water in Vacuum Flask (°C)	Temperature of water in Jug wrapped in (°C)
5		
10		
15		
20		
25		
30		
35		
40		

5. What have you found out from your results?

6. Why do you think this has happened?

Task 2:

1. I predict that the _____ will _____ once the jar covers the unlit candle.

2. I predict that the _____ will _____ once the jar covers the lit candle.

3. What actually happened when the jar covered the unlit candle?

4. What actually happened when the jar covered the lit candle?

5. Can you explain why this happened when the jar covered the lit candle?

Alternative data collection sheet Task 1

Name: _____ Others in my group: _____
_____
_____

Plan and carry out your investigation using the following sections.

1. The problem: investigate what effect a vacuum has on the temperature of water

2. Prediction: What suggestions or predictions can you make that are relevant?

3. Background knowledge: What previous knowledge do you have that might be useful?

4. Linking predictions with theory: From what you already know, why do you think your prediction will happen?

5. What will you keep the same?

6. What will you measure?

7. Basic method: What will you do to test your predictions. Sketch the method you will use and list your materials and apparatus.

8. What will you change?

Carry out your activity and record your results in a suitable form in the sections below

9. How did you make it a fair test?

10. Describe the method you actually used to carry out this activity

Can you graph the data collected or draw up a table to show data obtained. Analyse the data under the following headings.

11. Explain your results.

13. Conclusion

ACTIVITY ON SITE

Students in this activity will determine the effect of a vacuum on a falling object. They can follow the method below or plan their own investigation

Activity 1 – Phtt!! There's nothing there at all

Materials: recording sheet, pencil, 2 stop watches and digital camera, model of the vacuum parachute, magnet, parachute and figurine.

Processes: compare the effects on falling objects inside and outside a vacuum. Record data.

Procedure:

1. Predict what will happen when you let the parachute inside the vacuum fall. Write your prediction down on the recording sheet.
2. Using the magnet and running it up the side of the container, bring the parachute and figurine to the top of the clear container.
3. Pull the magnet away and observe what happens. Write your observation on the worksheet.
4. Bring the figurine and parachute inside the vacuum to the top of the container.
5. Someone in your group hold the figurine and parachute outside the container.
6. Predict what will happen if you let both the parachutes go at the same time. Write your prediction down on your worksheet.
7. Allocate members of your group - to time the fall of the vacuum parachute, to time the fall of the parachute outside the container, and to take digital photos of the landings.
8. One member of your group to bring the vacuum parachute to the top of the container and one to hold the other parachute level with the top of the container.
9. On the count of three let both parachutes go. Observe what happens and record your observation on the worksheet.

PHTTTT! THERES NOTHING THERE AT ALL

Sheet 1 - Following the procedure

1. I predict that the parachute inside the container will _____ _____ when I let go.

2. The parachute:

3. I predict if we let both parachutes go at the same time they will:

4. The vacuum parachute took _____ seconds and the outside parachute took _____ seconds. I think this happened because:

5. The digital photo showed me that :

6. I think this happened to the parachutes because:

Reflection

7. How accurate were your predictions?

8. Why do you think the parachutes behaved in this way?

9. What did you learn from this experiment?

Activity 2: Space and Distance

Look at the two circles. Estimate what you think the distance is between them.
_____ cm.

Is this the shortest possible distance between these objects? _____
Are you sure?

When the page is flat the shortest distance is a straight line that you measure between the objects. Will the distance be shorter if you fold or bend the page?

Move to the hemispherical white board. Using the ruler and marker draw a triangle. Do you know how many degrees in a triangle? _____ °
Using the protractor measure the angles of the triangle - what do you find?
_____
_____
_____

Why do you think this is so?

_____
_____
_____

Set the car moving on the hemispherical whiteboard. Time it – perhaps give it 10 seconds to draw a line. If the line is not long enough then let it draw for 15 seconds. Measure the line.
The line drawn by the car is _____cm.

Now set the car moving on the large sheet of paper on the ground. Let it travel for the same amount of time as the first attempt. Now measure the line drawn. Compare the two measurements.

What do you find?

_____
_____
_____
_____
_____

Activity 3:
Find the sculptures that represent Newtonian and Einsteinian views of the Universe.
Describe each of the sculptures. Look for the differences and explain how they help you understand space.

Post visit activity and follow up
To determine further facts about vacuums and space

1. Discussion:

Brainstorm with students any questions which arose from their visit to the GDC. Allow students time to research, using the internet, to find answers to their questions.
If the answers can't be found students can email the GDC and pose questions to personnel at the centre.

2. Remove the air:

Materials:
You will need: 60 cc syringe, plain plastic sandwich bag, piece of sticky tape, 2 cable ties.

Method:

1. Try the syringe and see how it works.
2. Take a plastic bag and place the open end around the syringe. Leave a little air inside the bag, but not too much. Ensure that the plastic bag does not have any holes.
3. Tighten the plastic bag around the syringe by using the cable ties and secure with tape.
4. Observe how much air you have in the bag.
5. Move the piston of the syringe out as far as you can and observe what happens to the bag?

Conclusion:
As you move the piston of the syringe the air from the bag moves into the syringe and the pressure inside the bag drops.
Have students discuss the phenomena and come up with ideas of why this happened.
Discuss the relation of this phenomena to what happens in a space shuttle.

Look on the internet for related sites on vacuums.

3. Create a Mind Map

In your group make a mind map of all that you know about space and vacuums. A mind map maps all the ideas, feelings, symbols shapes etc. Be creative and use colour and drawings.
Mind maps are used to give you an overview of a large subject; gather and hold large amounts of data; lets you see the whole picture.