Rotations & Orbits
(Black Holes & Foucault Pendulum)

Science – Earth and Beyond

Primary Module - Years 4-7

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ABSTRACT

Black holes in reality are a region of space that has so much mass that there is no way to escape its gravitational pull. Our Black Hole exhibit at the GDC allows you to explore planetary orbits of the type you see in the solar system. You can create orbits of planets and comets. You can measure the time of different orbits – circles and very eccentric ellipses. You can also observe your orbiting bodies 'disappearing down the plug hole', because of the long neck which simulates a black hole. A solar system model would curve to a gentle valley in the middle (occupied by the Sun) instead of having a steep neck.

The AIGO (Research Centre) is an essential component in a global telescope which is linked to detectors around the world to detect gravity waves.

The Foucault pendulum at the GDC will enable students to witness first-hand the rotation of the Earth. The movement, can be observed during the duration of the visit

Some interesting facts about the Foucault Pendulum:

1. A Foucault Pendulum will always work best at the North or South Pole where the motion is pure rotation.
2. At the Equator a Foucault Pendulum will not work at all, because its motion direction is exactly at right angles to the Earth's spin.
3. At Gingin, theory tells us that the pendulum should complete one rotation every 24 hours.

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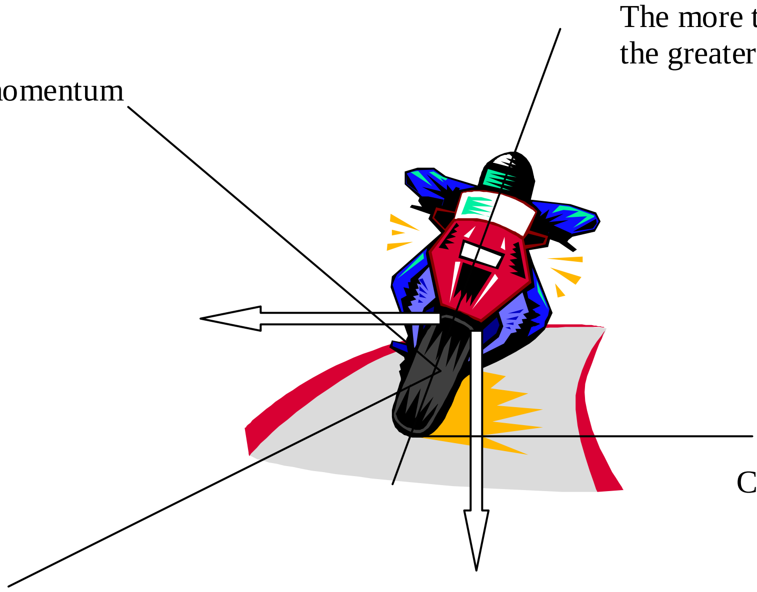
Background Information

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

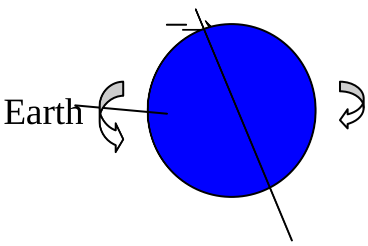
The world is full of things which move in circles - spinning tops, whirling fans, propellers, yet forces only act in straight lines. This circular motion has a lot to answer for!! Every part of a spinning object is constantly changing its direction of motion. An accelerating force pushes or pulls the object in a straight line while the centripetal force pulls into the centre. This centripetal force may be gravity or the spokes of a bicycle. If this force stops then there is nothing pulling the object inwards and it will fly off in a straight line. This is why you are thrown to one side of the car as it speeds around a bend - you are still trying to travel in a straight line.



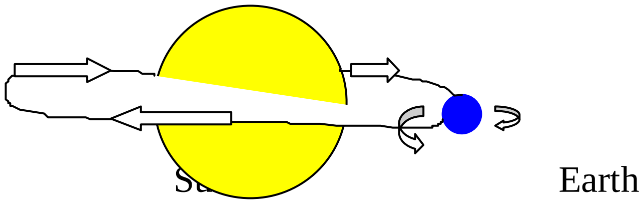
Suppose you are standing on the surface of a planet. You throw a rock straight up into the air. It will rise for a while, but eventually, due to the planet's gravity will make it start to fall again. If you threw the rock hard enough, you could make it escape the planet's gravity and it would keep rising forever.

The orbits of the planets have the same physics as cornering cars and Earth's satellites. These orbits are close to circles. We characterize orbits by distance from the sun and eccentricity (how out of round they are). The period is the time taken to complete one orbit, which on Earth we call one year. The rotation period of the Earth, about it's own axis, is approximately 24 hours while the revolution period about the Sun is 365.26 days. If the Sun was turned into a Black Hole the orbits of the planets would remain unchanged.

Rotation period:
One rotation = 24 hours

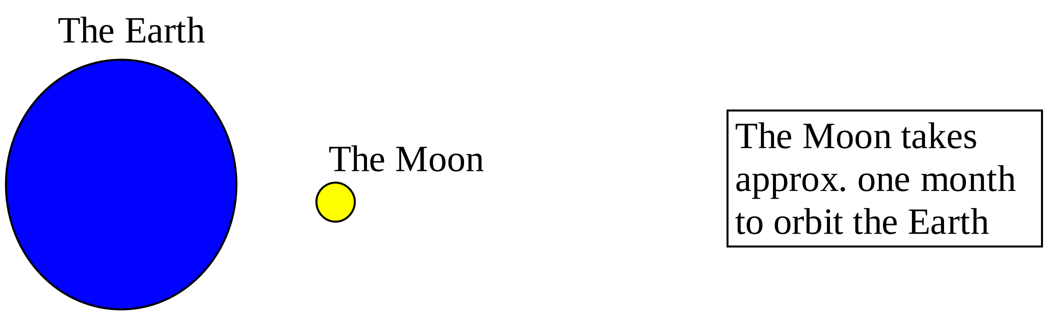


Orbit period:
One revolution = 365.26 days



You also have a regular body rhythm - a circadian rhythm has a dominant period of day. Jet lag is a phenomenon we experience when our circadian rhythm is out of sync. with the place we are visiting. Our circadian rhythm tunes into the Earth's pattern of night, day and seasons. We measure the passing of time in many different ways - years, months, weeks, days, hours, minutes and seconds. Many living things also have a pattern of action and rest. Many flowers open up by day and close at night. Migrating birds, have a circadian rhythm, that tell them when to migrate and when to return home.

The pattern of day and night is the result of the Earth's rotation. The phases of the Moon result from the orbit of the moon around the Earth, which takes approximately a month. Depending on which side of the Earth the moon is on (relative to the Sun) we can see different amounts of its daylight side.

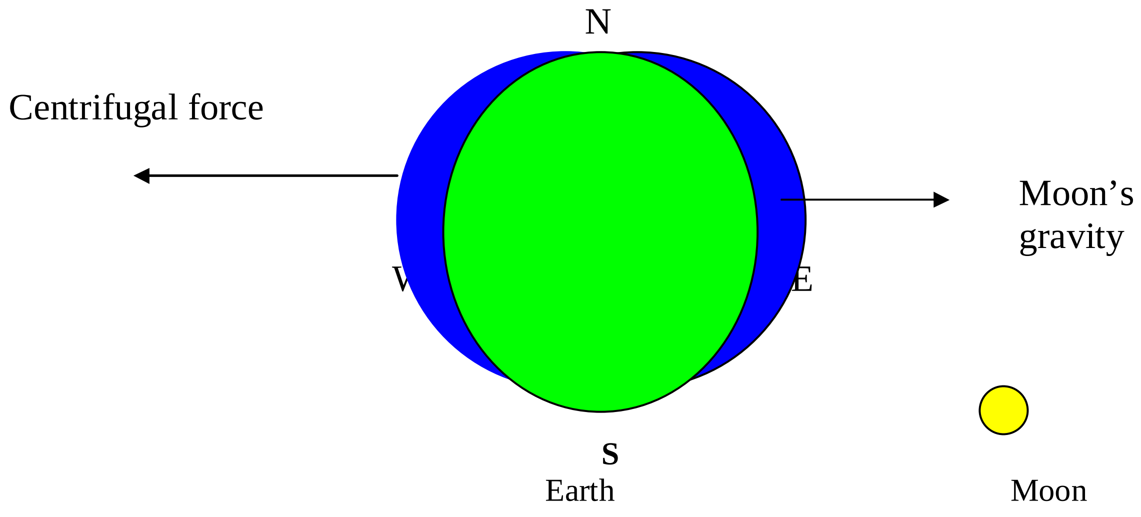


The axis of the Earth's rotation is tilted at 23.5° to the plane of orbit, and this produces temperature variations we associate with the seasons. In the temperate and polar zones this means four seasons - spring, summer, autumn and winter. Near the Equator the temperatures variation is too small and the seasons are better-described wet and a dry season. At the poles they have six months of day and six months of night.

The axial tilts of the other planets cause all sorts of strange phenomena - no seasons at all, planets moving backwards, days that last longer than the planets year, sidereal days lasting 2/3 as long as their year, planets moving on their side to experience extreme seasons and planets with moons that orbit retrograde.
A sidereal day is 23 hours 56 minutes while a solar day is 24 hours.
For more information on planetary orbits go to:
http://users.ethi.com/~brentt/tourist/ptllts.htm

Tides are caused by the gravity of the Moon's and to a lesser degree the sun. The gravitational pull at the Earth's surface is stronger at the near side and weaker at the far side. The earth-moon appears to spin about a certain point, just like a pair of dancers or ice skaters spinning about each other. In the Earth-moon case it is one fat skater spinning with a small thin one. However both of them experience an outward force; and the outward force causes the water to bulge up on the opposite side from the moon as well.This variation causes the water to 'heap up' producing a tidal bulge. This force pulls on the water in the oceans causing a tidal bulge. These tidal bulges move from east to west around the Earth.

So all around us we can see the effects of the Earth's rotation and revolution.



Newton's Laws gave scientists a clear and detailed understanding of the way force and motion were related and a way of analysing them mathematically. Coupled with Newton's insights into the nature of gravity, they seemed to account for every movement in the universe, large or small, from the vibration of the tiniest atoms to the movements of the planets and stars. Today we know that Newton's Laws are only an approximation. To understand the vibration of atoms you have to use Quantum Mechanics, while for the motion of the stars Einstein's General Theory of Relativity is required. One application of Newton's Laws is the Foucault Pendulum. Using the 5 storey high Foucault's Pendulum at the GDC students can actually monitor the rotation of the Earth during their visit.

The Foucault pendulum is named after the French physicist Jean Foucault who in 1851 used such a pendulum to demonstrate the rotation of the Earth. He showed an early interest in mechanical toys, studied medicine, but shifted to physical sciences at the Paris Observatory. His demonstrations were the first satisfactory demonstration of the Earth's rotation using laboratory apparatus rather than astronomical observations.

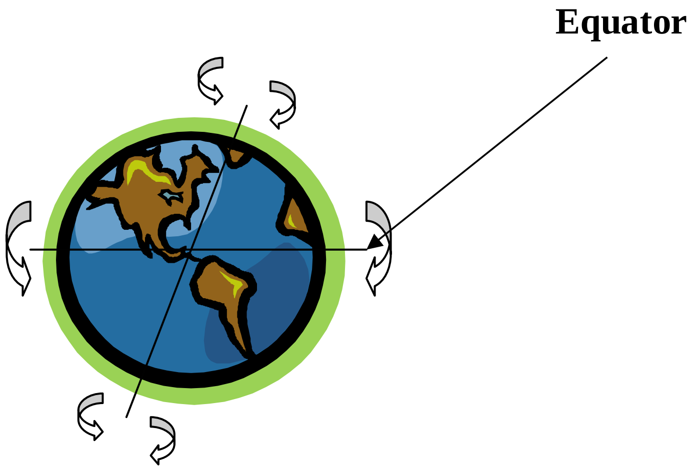
If you start a Foucault pendulum swinging in one direction you will notice, after a few hours that it's direction of swing has changed. From our perspective we presume that the base of the pendulum, which is the solid Earth is completely stable and we assume it is the pendulum that moves. In reality the pendulum is hung so perfectly that it does not now about the Earth's rotation. So while it appears that the pendulum changes its path during the day it is actually the floor that is moving. The fascination of the Foucault pendulum is that it in fact measures the true rotation of the Earth in space..

The circumference of the Earth at the Equator is 40 000kms. The earth completes one rotation in approximately 24 hours. Therefore, if you were to hang above the surface of the Earth at the Equator without moving, you would see 40 000kms pass by in 24 hours, at the speed of over 1,700km per hour.

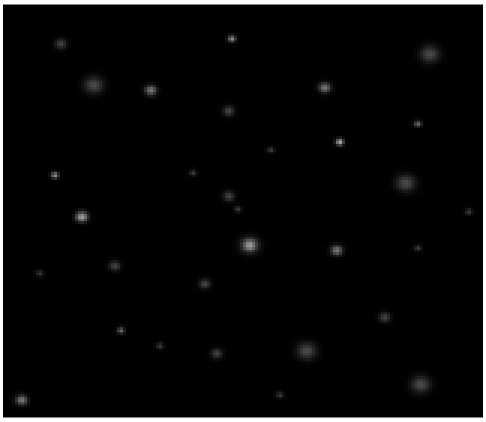
The earth rotates once in just under a day (23 hours, 56 minutes, 04.09053 seconds). This is called a sidereal period – which means the period relative to the stars. The sidereal period is not
exactly a day because by the time the Earth has rotated once, it has also moved a little in its revolution around the Sun, so it has to keep rotating for another 4

minutes before the Sun seems to be back in the same place in the sky that it was exactly one day ago.

An object at the Earth's Equator will travel once around the Earth's circumference (40 075.036 km) each sidereal day. So if you divide that distance by the time taken you will get the speed that the Earth is travelling. An object at one of the poles has hardly any speed due to the earth's rotation. (A spot on a rod, one centimetre in circumference, stuck vertically in the ice exactly at the pole would have a speed of one centimetre a day!) A person on the earth's Equator will travel once around the earth's circumference (40 000km) each sidereal day. However a person standing near the South or north Poles will travel in a much smaller circle; their speed will be much less even though they make one revolution each sidereal day.

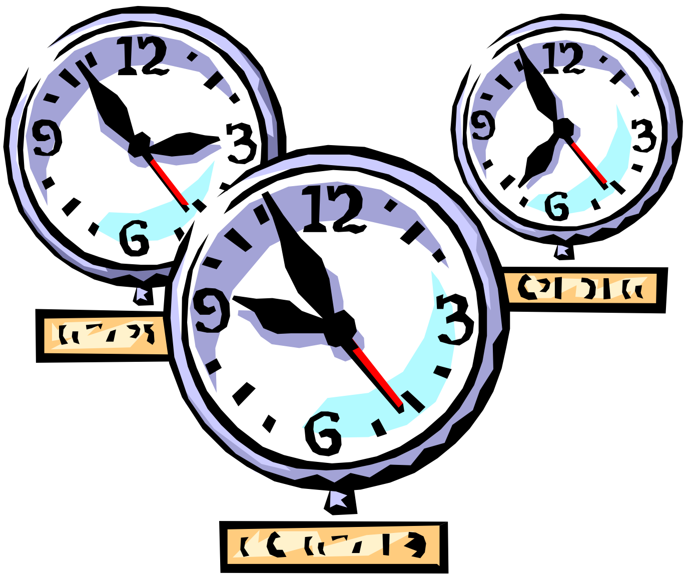


The earth is doing a lot more than rotating, although that is certainly the motion we notice most, because day follows night as a result. We also orbit the Sun once a year and we notice that through the changing seasons, due to the tilt of the Earth's axis of rotation. The circumference of the earth's orbit is 940 million kilometres. So the Earth's speed of revolution is 30kms/s a 100 times faster than a jet plane. We are also moving with the Sun around the centre of our **galaxy.** This speed is even faster, about 230 km/s.



While students are aware that day and night occur they may not understand that these changes happen because the earth rotates every 24 hours. Day occurs when our side of the Earth faces away from the Sun. As the day progresses, the Sun appears to follow a path from its rising in the east to its setting in the West. Although less obvious to the students, the stars also follow a daily path. Like the Sun they rise in the east and set in the West

We can tell the time of day by the position of the Sun in the sky. During the night the sun is below the horizon – the line where the sky seems to meet the earth. The Sun appears above the horizon at the beginning of the day. When the Sun reaches its highest point in the sky it is the middle of the day. As the Earth spins, the Sun reaches its highest point in the sky over different countries at different times. So the time by the clock is different in different parts of the world.



Assessment

Overarching Major Learning Outcomes

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

Investigating Scientifically:

1. **Planning -** Plans for investigations, showing some awareness for the need of fair testing; makes simple predictions based on personal experience.
2. **Conducting -** Uses simple equipment in a consistent manner; records data in simple tables, diagrams and graphs.
3. **Processing Data -** Displays numerical data as tables or bar graphs, identifies patterns in data and summarises the data.
4. **Evaluating -** Identifies difficulties experienced in conducting the evaluation.

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

Students typically in Years 4-7 will be performing at Levels 2-4. The following examples demonstrate outcomes for Level 2, 3 & 4

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

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

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 and explain patterns in data
Evaluating Data - reflect on an investigation, evaluate the process and 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 use around the home and in the community	Students can: describe how another person uses energy in their daily life and are aware of common types of energy	Students can: describe a pattern of energy use at home or school; classify objects as sources or receivers of energy	Students can: compare different sources of energy available in the community
Students understand that energy can be converted from one form to another, and that change involves the transfer of energy.	Students can: describe a way that energy is transferred and understands that energy moves from one thing to another	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

	Level 2 Understands how some changes in the observable environment including the sky, influence life	**Level 3** Understands changes and patterns in different environments and space, and relates them to resource use	**Level 4** Understands processes that can help explain and predict interactions and changes in physical systems and environments
Sustainability of life and wise resource use	Students can: note changes in the local environment which influence daily life	Students describe how resource use changes the physical environment	Students can; describe ways information is gathered about the Earth and its resources
Earth forces and materials	Students can identify different materials in their environment and understand the uses; can describe a change in the environment	Students can make connections between changes in the physical environment and physical processes	Students describe the interactions between changes in the atmosphere and the interior of the Earth

The relationship between the earth, our Solar system and the universe	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

Pre Visit Activities

The following activities and information will give students the opportunity to develop some understanding of the topic prior to their visit to the GDC.

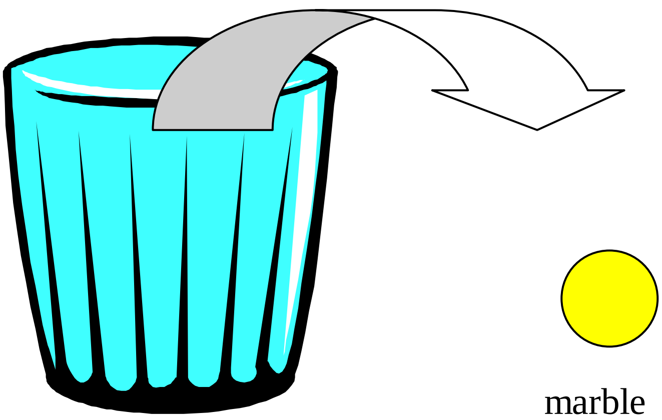
a) Brainstorm: Students search the Internet for information about tides, seasons, sidereal days, orbits of the earth and other planets, the revolutionary movement of the Earth around the Sun and record notes, (key words, main ideas) on recording sheet provided with this pack. Students can present this information as a powerpoint, poster, project or their own choice of presentation. ***Inspiration*** and ***Kidspiration*** could be used to collect information.

b) Try these simple experiments to demonstrate 'centrifugal force'.

1.Pick up the marble without using your hands!

Have students place a marble on the table and cover it with a clear glass jar. Start to rotate the glass and the marble will climb up the side of the jar. Why do you think this happens?

The spinning creates a centrifugal force, which pulls it outwards and upwards.



2. Tip the bucket up without losing a drop

Students are to fill a small bucket of water and take it outside and try spinning it round in a circle quite quickly. Students observe what happens. Centrifugal force will keep the water pressed to the bottom and sides of the bucket as it spins around. This means the water will not fall out of the bucket even when it is upside down.

3. Make a spin drier

This simple demonstration will show students what happens to water in a container when the container is spun horizontally.

Materials: You will need an eggbeater or hand drill, thin string, a yoghurt pot, water and food colouring.

What to do:

1. Make 3 small holes in the rim of the yoghurt pot and use the string to hang the pot from the turning point of the drill or beater.
2. Put about 3cm of water in the pot and add a few drops of food colouring.
3. Turn the handle of the drill or beater steadily so that the pot spins around and around. If you watch closely the water will be pulled up the sides of the pot by centrifugal force.

4. More things to do

Make holes in the sides of the yoghurt pot and put a very wet piece of cloth inside instead of the water. Spin the pot using the drill or beater. You will see the water in the cloth is thrown out of the pot by centrifugal force. This is how a spin drier in a washing machine works.

5. Cork on a string

A cork whirling on a string is kept moving in a circle by centripetal force, shown by tension in the string. Try this experiment with your students to show how this force varies with the speed of the cork to keep it in balance.

Materials: Students will need a hand drill and bit, string, a cork, cotton reel, wooden block or similar weight.

Method:

1. Ask an adult to drill a hole in the cork. Tie a loop in one end of the string. Thread the other end through the cork and then through the cotton reel.
2. Tie the string's free end to the weight, about 40-50cm from the cork. Make sure the string runs freely through the cork.
3. Hold the cotton reel. With the weight hanging down, twirl the cork around slowly at first, then faster and faster. As the cork spins

faster, you increase the centripetal force, which is causing the circular motion. You should see the increase in force by the way the weight rises. Pull in the string, pull the weight down, watch how the corks speed up.

6. Charting Shadows

This activity will assist students to understand:

- The Sun appears to move across the sky due to the rotation of the Earth on its axis
- The Sun's path for a certain day is determined by the location of the observer on the Earth

Students in this activity will follow the Sun's apparent movement across the sky by charting the shadows. The following method may be followed or the students can plan an investigation using the Planning Sheet

Materials: A thirty centimetre ruler, a metre ruler, large powdered milk tin full of sand or soil, large flat sheet of cardboard or paper (at least 60cm by 90cm), texta marker, directional compass.

Method:

1. Select a sunny day and allow time to make periodic measurements through the day.

2. Use the compass to determine North, South, East and West. Place the cardboard on the ground so the edges are aligned with the compass directions.

3. Place the tin with the ruler stuck in it in the middle of the cardboard. With chalk outline the cardboard in case it gets moved.

4. Mark the line and tip of the shadow cast by the ruler and record the time of observation. Get students to predict where the shadow will fall after a certain time interval, perhaps fifteen minutes or half an hour. Students can mark their predictions with a small stone or pop stick.

5. When the chosen interval has passed mark the new shadow position with a marker.

6. Throughout the course of the day, periodically record the movement of the shadow and mark the tip and line of the shadow.

7. After a day of recording, connect the shadow ends recorded near noontime with a line. At midday the sun is at it's highest and therefore corresponds to the shortest shadow.

Discuss observations of shadow length.

- How do the shadow length vary during the day?
- Why do the lengths change?
- Is there a pattern to where the shadows fall and their length?
- Is the Sun directly overhead at any time?
- When is the shadow the shortest?

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Information Recording sheet

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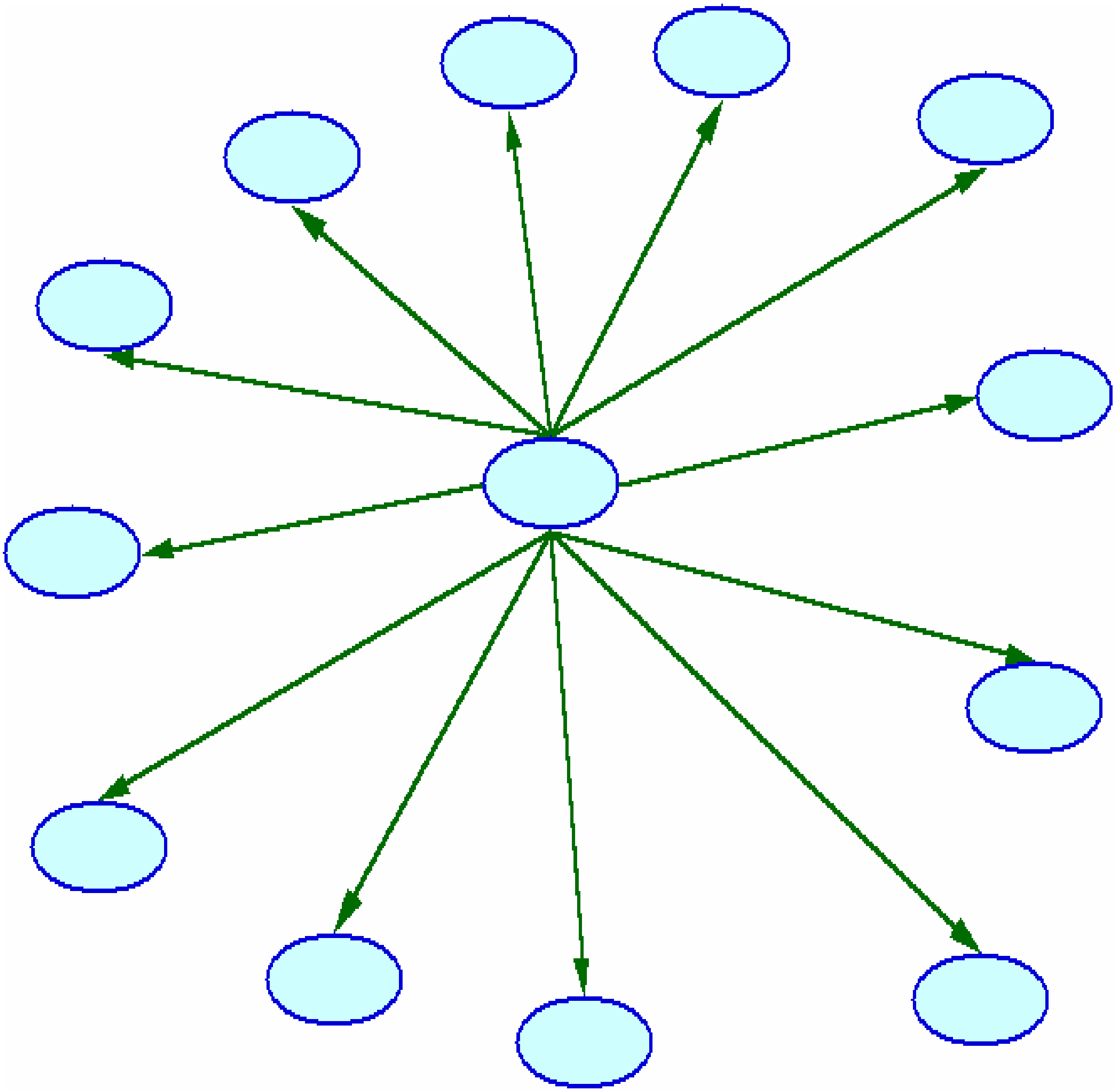
a) Brainstorm



Student Planning and Recording Sheet

Pre-visit Activities

Name: ____________________________

1. **<u>Pick up the marble without using your hands!</u>**

1.1 What is the task you have been set to do?

1.2 Prediction: What predictions can you make which are relevant?

1.3 From what you already know, why do you think your prediction will happen?

1.4 Basic Method: What will you do to test your prediction?

1.5 What materials will you need?

1.6 What happened?

1.7 Why did it happen?

2. Tip the bucket without losing a drop.

2.1 What is the task you have been set to do?

2.2 Prediction: What predictions can you make which are relevant?

2.3 From what you already know, why do you think your prediction will happen?

2.4 What will you do to test your prediction?

2.5 What materials will you need?

2.6 What happened?

2.7 Why did it happen?

3. Make a spin drier.

3.1 What task have you been set to do?

3.2 What predictions can you make which are relevant?

3.3 From what you already know, why do you think your prediction will happen?

3.4 What will you do to test your prediction?

3.5 What materials will you need?

3.6 What happened?

3.7 Why did it happen?

4. Cork on a string

4.1 What is the task that has been set for you to do?

4.2 What predictions can you make which are relevant?

4.3 From what ou already know, why do you think your prediction will happen?

4.4 What will you do to test your prediction?

4.5 What materials will you need?

4.6 What happened?

4.7 Why did it happen?

5. Charting Shadows

Plan and carry out your investigation using the following sections.

1. What investigation can you conduct to show the Sun's apparent movement in the sky?

2. What previous knowledge do you have which might be useful?

3. What suggestions or predictions can you make which are relevant?

4. From what you already know, why do you think your prediction will happen?

5. What is going to be your basic method to test your predictions? List your materials and apparatus.

6. What things are likely to have an effect on your investigation i.e. what are the variable factors?

7. What will you measure?

8. What will you change?

9. What will you keep the same?

10. Describe the method you actually used to carry out your investigation?

11. Can you draw up a suitable table for showing data?

12. Can you graph the data you collected?

13. Explain your results.

14. What conclusion have you come to?

Site Activity

Collection and Analysis of experimental data

During this activity you will determine the time taken for an object to revolve once around the black hole model and compare different revolutions.
You will be working at the Black Hole model and use balls to represent the planets.
You will be investigating planetary orbits.
You will also be working at the Foucault Pendulum site.

Task 1

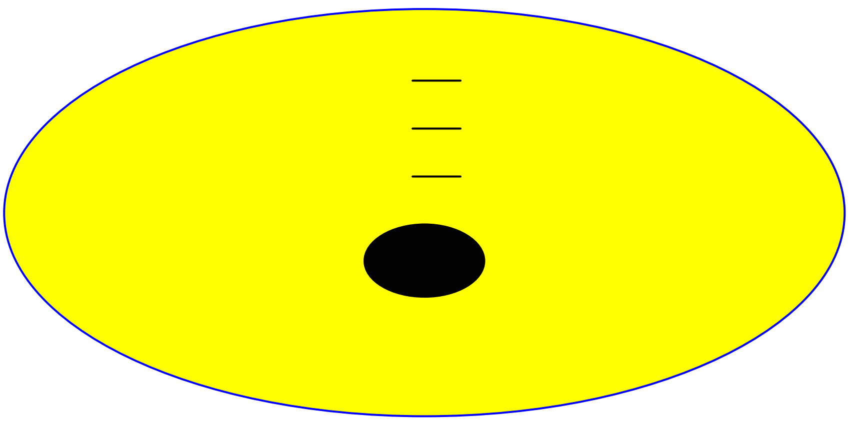
1. Practice rolling balls in nice circular orbits on the Black Hole model. It takes some practice.

2. Predict the time taken for your ball to complete one orbit of the black hole at the outer most point. Use the work sheet supplied to record your prediction.

3. Look at the markings along the inside of the Black Hole model which show different orbit sizes. You will observe that they are approximately 50cm apart. Predict what the time taken will be for the ball to complete a revolution if it is released at each of these markings.

4. Using the ball release it at each of the 50cm markings and measure the time taken for the ball to complete one revolution. Look carefully at the diagram to assist you in completing this experiment correctly.

5. Repeat the experiment several times and record your results



Task 2

1. **Predict** what will happen if you set the ball on a steeply elliptical route around the Black Hole model. Record your prediction on your work sheet.

2. Now do the experiment. Set the ball rolling in an ellipse around the black hole model. Observe what happens to the orbit and record some of the orbit using the video clip it with the digital camera. Record your findings on the work sheet.

3. Measure the time from the first roll to when the ball emerges from the bottom of the black hole. Compare the total time for a circular trajectory and for an elliptical trajectory.

Task 3:

To develop understanding of the earth's rotation by observing the Foucault pendulum over the period of the class visit and to construct a model Foucault pendulum using materials on site.

Materials: Work sheet to collect data, timer, digital camera.

Processes: Observe a demonstration of an experiment, collect data.

Procedure: Assemble at the Foucault pendulum site

1. Set the Pendulum swinging. Have students predict where they think the marker will be each half hour of their visit.

2. Using the recording sheets students observe periodically the movement of the pendulum bob and the rotation of the Earth and mark accordingly using the full scale model of Foucault's pendulum.

STUDENT USE

Name: ___________________ Others in my group:

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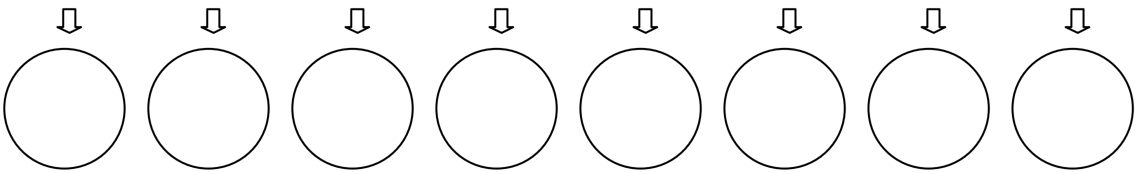
Task 3: Watch the Swing

Prediction - I predict that the pendulum will be in these positions at these times. The arrow indicates the starting point of the pendulum at the beginning of the session.



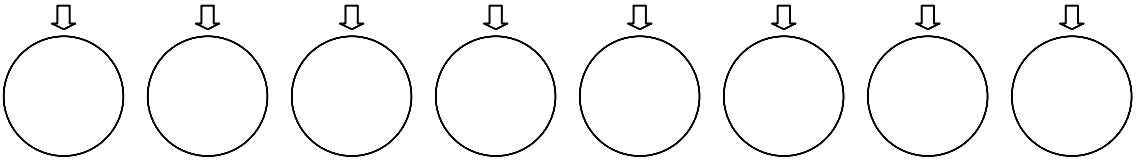
9.00am 9.30am 10.00am 10.30am 11.00am 11.30am 12.00pm 12.30pm

12.30pm 1.00pm 1.30pm 2.00pm 2.30pm 3.00pm 3.30pm 4.00pm

What to do?

1. Set the pendulum swinging.
2. Mark on the first circle below the time and position of the Pendulum.

3. Each half hour return and mark on the circles below the apparent movement of the Pendulum and the time.



9.00am	**9.30am**	**10.00am**	**10.30am**	**11.00am**	**11.30am**	**12.00pm**	**12.30pm**
12.30pm	**1.00pm**	**1.30pm**	**2.00pm**	**2.30pm**	**3.00pm**	**3.30pm**	**4.00pm**

4. How many degrees do you think the pendulum will move in a 24-hour period?

5. Do you think a pendulum of this type may appear to move differently at different parts of the Earth?

6. What did the Foucault's pendulum demonstrate to you?

7. What other phenomena, natural or other do you know that demonstrate the rotation of the Earth?

8. How could this experiment/demonstration be improved?

Investigation and Recording sheet

Name: ________________ Others in my Group __________________

____

Task 1

1.1 What are you going to investigate?

1.2 What previous knowledge do you have about orbits which might be useful?

1.3 What predictions can you make about the orbits, which are relevant?

1.4 From what you know already about orbits, why do you think your prediction will happen?

1.5 **Describe the method you actually used to carry out this activity?**
What is going to be your basic method to test your predictions?

1.6 What things are likely to have an effect on your investigation about orbits?

1.7 What will you change?

1.8 What will you keep the same?

1.9 What will you measure?

1.10 You can use the table below to record your **prediction** or draw up a suitable table for showing what you have predicted

Distance (cm)	**Time taken to complete one revolution (sec)**
0	
50	
100	
150	
200	

Table for predictions

1.11 Use the table below to record the **actual time** taken when the ball is released at the set measurements or draw up your own table

Distance	**Time taken to complete one revolution**
0 cm	
50 cm	
100 cm	
150 cm	
200 cm	

Table for actual results

1.12 Were your predictions close to the actual experiment times?

1.13 Is there a pattern to your results?

Task 2

2.1 What is the task you have been set?

2.2 Predictions: What predictions can you make which are relevant?

2.3 Linking prediction to theory: From what you already know, why do you think your prediction will happen?

2.4 Background knowledge: What previous knowledge do you have which might be useful?

2.5 What will I need?

2.6 What will I measure?

2.7 What is the best way to represent your results?

2.8 Analyse your data. What are your results telling you?

2.9 What happened?

2.10 Why did it happen?

2.11 What is your conclusion?

2.12 Did you have any questions that haven't been answered - jot them down below for discussion.

Post visit activities and follow up

1. Brainstorm any questions that the students may have after their visit to the centre. Use the video clip from the experiment to answer questions about orbits.

   Give students time for discussion and research to come up with answers.

2. Have them visit the following websites to search for answers:
   - http://www.eclipse.net/~cmmiller/BH/
   - http://worldalmanacforkids.com/explore/html
   - http://www.starclass.com.au/kids.html

3. Look in the library for books and videos which are also available on the topic of Black Holes

4. Students use the newspaper or Internet sites to collect data over a period of time, on the length of a day during the different seasons. Note what time the sun rises and sets. Discuss with students why the length of daylight differs from season to season.

5. Students keep a moon chart to monitor the phases of the moon. Discuss why the shape of the moon appears to change over the course of a month.

6. Students investigate the changes in the patterns of the tides over a period of time. Use Internet and newspapers to gain information. Elicit from students why the tides change and are the changes related to other phenomena that they have observed.