8.2 The World Communicates

**Contextual Outline**
Humans are social animals and have successfully communicated through the spoken word, and then, as the use of written codes developed, through increasingly sophisticated graphic symbols. The use of a hard copy medium to transfer information in coded form meant that communication was able to cross greater distances with improved accuracy of information transfer. A messenger was required to carry the information in hard copy form and this carrier could have been a vehicle or person. There was, however, still a time limit and several days were needed to get hard copy information from one side of the world to the other.

The discovery of electricity and then the electromagnetic spectrum has led to the rapid increase in the number of communication devices throughout the twentieth century. The carrier of the information is no longer a vehicle or person — rather, an increasing range of energy waves is used to transfer the message. The delay in relaying signals around the world is determined only by the speed of the wave, and the speed and efficiency of the coding and decoding devices at the departure and arrival points of the message. The time between sending and receiving messages through telecommunications networks is measured in fractions of a second allowing almost instantaneous delivery of messages, in spoken and coded forms, around the world.

This module increases students’ understanding of the nature, practice, application and uses of physics and current issues, research and developments in physics.

**Assumed Knowledge**

Domain: knowledge and understanding:

Refer to the Science Stages 4–5 Syllabus for the following:
5.6.1a identify waves as carriers of energy
5.6.1b qualitatively describe features of waves including frequency, wavelength and speed
5.6.1c give examples of different types of radiation that make up the electromagnetic spectrum and identify some of their uses
5.6.4a distinguish between the absorption, reflection, refraction and scattering of light and identify everyday situations where each occurs
5.9.1b identify that some types of electromagnetic radiation are used to provide information about the universe
5.12c describe some everyday uses and effects of electromagnetic radiation, including applications in communication technology.
Skills

During this module teaching/learning activities should allow time to reflect on the relationships between the processes involved in the evolution of the Universe, the formation of stars and solar systems and the effects of solar and terrestrial processes on the Earth. Emphasis must be placed on the evidence for the processes and the effects that such processes have on the Earth’s atmosphere. Skill development relies on teacher input to model skills that students may need further assistance in refining. The skill development in this program focuses on:

- Accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet;
- Developing skills in selection of appropriate media to present information;
- Identify examples of the interconnectedness of ideas or scientific principles;
- Using models, including mathematical ones, to explain phenomena and/or make predictions;
- Analysing information to identify examples of interconnected ideas or scientific principles;
- Summarising and collating information from a range of sources;
- Assess the reliability of first-hand and secondary information and data by considering information from various sources, and
- Assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals.

Values and Attitudes

This module aims to assist students to develop positive attitudes about themselves and positive values about learning and towards the environment. In addition the module will help students to value ethical behaviour in the assessment of ideas and the views of others. In particular this module aims to develop in students:

- a desire for critical evaluation of the consequences of the application of physics;
- curiosity and critical thinking towards some of the big questions in science;
- a tolerance of uncertainty and an acceptance of the provisional and evolving status of scientific knowledge;
- be prepared to make informed judgements;
- to value and appreciate physics in becoming scientifically literate persons; and
- an ability to show flexibility and responsiveness to ideas and evidence as it arises.
Concept Map

Waves

Types of Waves

Properties of Waves

Graphing Waves

Superposition

The Wave Equation

Reflection & Refraction

Sound Waves

Echo

Terminology

Absorption

Amplitude & Frequency Modulation

Reflection

Snell’s Law

Critical angle

Refractive Index

Total Internal Reflection

Use of E.M. in Technology

Use of E.M. in Technology

Devices based on E.M. Technology

Global Positioning Systems

Compact Disc and Digital Versatile Disc Technology

Fibre Optic and Copper Cable Technologies (The Internet)
## The World Communicates Module Plan

Module Length: 7 weeks

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Time</th>
<th>Concept</th>
<th>Resources</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The wave model can be used to explain how current technologies transfer information.</td>
<td>1</td>
<td>1. describe the energy transformations required in one of the following: – mobile telephone – fax/modem – radio and television</td>
<td>UP: p251-253 Spotlight I: pp.2-12 Contexts I: pp.115 Humphrey’s Set 51</td>
<td>1. (Exp 1) Perform a first-hand investigation to observe and gather information about the transmission of waves in: – slinky springs – water waves – ropes or use appropriate computer simulations 2. (Exp 1) Present diagrammatic information about transverse and longitudinal waves, direction of particle movement and the direction of propagation.</td>
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<td></td>
<td>2</td>
<td>2. describe waves as a transfer of energy disturbance that may occur in one, two or three dimensions, depending on the nature of the wave and the medium</td>
<td>UP: 251-255 277-281 Spotlight I: pp.2-12 Contexts I: pp.115-121</td>
<td>3. (Exp 2) Perform a first-hand investigation to gather information about the frequency and amplitude of waves using an oscilloscope or electronic data-logging equipment</td>
</tr>
<tr>
<td>1½</td>
<td>3. identify that mechanical waves require a medium for propagation while electromagnetic waves do not</td>
<td></td>
<td>4. (Exp 2) Present and analyse information from displacement-time graphs for transverse wave motion</td>
<td></td>
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<tr>
<td>1½</td>
<td>5. describe the relationship between particle motion and the direction of energy propagation in transverse and longitudinal waves</td>
<td>Spotlight I: pp.2-12 Contexts I: pp.115-129</td>
<td></td>
<td></td>
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<tr>
<td>1</td>
<td>6. quantify the relationship between velocity, frequency and wavelength for a wave: ( v = f\lambda )</td>
<td>UP: 253-260 Spotlight I: pp.2-12 Contexts I: pp.115-129 Dyett: 168-174</td>
<td>6. (Act 4) Solve problems and analyse information by applying the mathematical model of ( v = f\lambda ) to a range of situations</td>
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<tr>
<td>Focus Area</td>
<td>Time</td>
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<td>Resources</td>
<td>Practical</td>
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<tr>
<td>2. Features of a wave model can be used to account for the properties of sound.</td>
<td>1</td>
<td>1. identify that sound waves are vibrations or oscillations of particles in a medium</td>
<td>UP: 277-281&lt;br&gt;Spotlight I: pp.2-12&lt;br&gt;Contexts I: pp.137-143</td>
<td>1. (Exp 5) Perform a first-hand investigation and gather information to analyse sound waves from a variety of sources using the Cathode Ray Oscilloscope (CRO) or an alternate computer technology</td>
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<tr>
<td></td>
<td>1</td>
<td>2. relate compressions and rarefactions of sound waves to the crests and troughs of transverse waves used to represent them.</td>
<td>Spotlight I: pp.2-12&lt;br&gt;Contexts I: pp.137-143</td>
<td>2. (Exp 6) Perform a first-hand investigation, gather, process and present information using a CRO or computer to demonstrate the principle of superposition for two waves travelling in the same medium</td>
</tr>
<tr>
<td></td>
<td>½</td>
<td>3. explain qualitatively that pitch is related to frequency and volume to amplitude of sound waves</td>
<td>Spotlight I: pp.2-12&lt;br&gt;Contexts I: pp.137-150</td>
<td></td>
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<tr>
<td></td>
<td>½</td>
<td>4. explain an echo as a reflection of a sound wave</td>
<td>UP: 278-281</td>
<td></td>
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<tr>
<td></td>
<td>1</td>
<td>5. describe the principle of superposition in standing waves and compare the resulting waves to the original waves</td>
<td>Spotlight I: pp.2-12&lt;br&gt;Contexts I: pp.137-150&lt;br&gt;Humphrey Set 52&lt;br&gt;Dyett: 170-174</td>
<td>3. (Exp 6) Present graphical information, solve problems and analyse information involving superposition of sound waves</td>
</tr>
<tr>
<td>3. Recent technological developments have allowed greater use of the electromagnetic spectrum.</td>
<td>2</td>
<td>1. describe electromagnetic waves in terms of their speed in space and their lack of requirement of a medium for propagation. 2. identify the electromagnetic wavebands filtered out by the atmosphere, especially UV, X-rays and gamma rays.</td>
<td>NS: The Electromagnetic Link&lt;br&gt;Spotlight I: pp.34-44&lt;br&gt;Contexts I: pp.180-187</td>
<td>1. (Exp 7) Plan, choose equipment or resources for and perform a first-hand investigation and gather information to model the inverse square law for light intensity and distance from the source</td>
</tr>
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<td></td>
<td>2</td>
<td></td>
<td></td>
<td>2. (Act 8) Analyse information to identify the waves involved in the transfer of energy that occur during the use of one of the following: mobile phone, television, radar</td>
</tr>
<tr>
<td></td>
<td>½</td>
<td>3. identify methods for the detection of various wave bands in the electromagnetic spectrum</td>
<td>Spotlight I: pp.34-44&lt;br&gt;Contexts I: pp.188-191</td>
<td>3. (Act 9) Analyse information to identify the electromagnetic spectrum range utilised in modern communication technologies.</td>
</tr>
</tbody>
</table>
### Focus Area | Time | Concept | Resources | Practical
--- | --- | --- | --- | ---
½ | 4. | explain that the relationship between the intensity of electromagnetic radiation and distance from a source is an example of the inverse square law \( I \propto \frac{1}{d^2} \) | Spotlight I: pp.34-44
 |  |  | Contexts I: pp.188-191 |  |
1 | 5. | outline how the modulation of amplitude or frequency of visible light, microwaves and/or radio waves can be used to transmit information | Spotlight I: pp.34-44
 |  |  | Contexts I: pp.192-196 |  |
½ | 6. | discuss problems produced by the limited range of the electromagnetic spectrum available for communication purposes. | Spotlight I: pp.34-44
 |  |  | Contexts I: pp.188-191 |  |
2 | 1. | describe and apply the law of reflection and explain the effect of reflection from a plane surface on waves | Spotlight I: pp.44-61
 |  |  | Contexts I: pp.162-169 | 1. (Exp 10) Perform first-hand investigations and gather information to observe the path of light rays and construct diagrams indicating both the direction of travel of the light rays and a wave front |
1 | 2. | describe ways in which applications of reflection of light, radio waves and microwaves have assisted in information transfer | Spotlight I: pp.44-61
 |  |  | Contexts I: pp.115 | 2. (Exp 11) Present information using ray diagrams to show the path of waves reflected from:
 |  |  |  | – plane surfaces
 |  |  |  | – concave surfaces
 |  |  |  | – convex surface
 |  |  |  | – the ionosphere |
2 | 3. | describe one application of reflection for each of the following:
 |  |  | – plane surfaces
 |  |  | – concave surfaces
 |  |  | – convex surfaces
 |  |  | – radio waves and being reflected by the ionosphere | Spotlight I: pp.44-61
 |  |  | Contexts I: pp.115 | 3. (Exp 12) Perform an investigation and gather information to graph the angle of incidence and refraction for light encountering a medium change showing the relationship between these angles |
½ | 4. | explain that refraction is related to the velocities of a wave in different media and outline how this may result in the bending of a wavefront. | Spotlight I: pp.44-61
 |  |  | Contexts I: pp.170-179 |  |
½ | 5. | define refractive index in terms of changes in the velocity of a wave in passing from one medium to another | Spotlight I: pp.44-61
 |  |  | Contexts I: pp.170-179 |  |
½ | 6. | define Snell’s Law: \( \frac{v}{v} = \frac{\sin i}{\sin r} \) | Spotlight I: pp.2-12
 |  |  | Contexts I: pp.115
<p>|  |  | Dyett: 191-195 | 4. (Exp 12) Perform a first-hand investigation and gather information to calculate the refractive index of glass or perspex. |</p>
<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Time</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>7. identify the conditions necessary for total internal reflection with reference to the critical angle</td>
<td>Spotlight I: pp.2-12 Contexts I: pp.115</td>
<td>5. (Exp 12) Solve problems and analyse information using Snell’s Law</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>8. outline how total internal reflection is used in optical fibres</td>
<td>NS: Fibre Optics Spotlight I: pp.2-12 Contexts I: pp.115</td>
<td></td>
</tr>
<tr>
<td>½</td>
<td></td>
<td>1. identify types of communication data that are stored or transmitted in digital form</td>
<td>NS: Information NS: Making Lasers Work Spotlight I: pp.2-12 Contexts I: pp.115</td>
<td>1. (Act 13) Identify data sources, gather, process and present information from secondary sources to identify areas of current research and use the available evidence to discuss some of the underlying physical principles used in one application of physics related to waves, such as: – Global Positioning System – CD technology – the Internet (digital process)</td>
</tr>
<tr>
<td>5.Electromagnetic waves have potential for future communication technologies and data storage technologies</td>
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</table>
Preliminary Physics C3: The World Communicates Experiment 1: Transmission of Waves

Aim: 1. To observe and gather information about the transmission of waves in slinky springs, water waves and ropes.
2. Present diagrammatic information about transverse and longitudinal waves, direction of particle movement and the direction of propagation.

Outcomes Assessed
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using symbols and formulae to express relationships and using appropriate units for physical quantities (13.1d)
- using a variety of pictorial representations to show relationships and present information clearly and succinctly (13.1e)

Materials
- Slinky springs
- Water trough
- Glass slabs
- Rope (thin and thick, joined)
- Ruler

Method
For each of the situations below, generate a single pulse rather than a continuous wave.
If possible, measure the wavelength of each wave and record it.

Set up the following diagrams:

For the water trough, use a ruler to generate waves perpendicular to the glass slab and then use a point source such as your finger.

Push the slinky in the same direction as its axis.

Draw the resultant waves, observing closely the
(i) wavelength of each reflected or refracted wave.
(ii) amplitude of each reflected or refracted wave.
(iii) phase of each reflected or refracted wave.

Discussion
Physics – Preliminary – Module 8.2 The World Communicates Teaching Program

1. What does the density of a medium to a wave mean?
2. What happens to wave when they hit the boundary of a medium?
**Preliminary Physics C3: The World Communicates Experiment 2: Relationship between frequency, amplitude and velocity of waves**

**Aim:**
1. To gather information about the frequency, amplitude and velocity of waves using an oscilloscope and electronic data-logging equipment.
2. Present diagrammatic information from displacement-time graphs for transverse wave motion.

**Outcomes Assessed**
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using symbols and formulae to express relationships and using appropriate units for physical quantities (13.1d)
- using a variety of pictorial representations to show relationships and present information clearly and succinctly (13.1e)
- selecting and drawing appropriate graphs to convey information and relationships clearly and accurately
- identifying situations where use of a curve of best fit is appropriate to present graphical information

**Method A – Without fancy equipment:**
1. Obtain a long length (minimum one metre) of coil/rope and a metre rule.
2. While one member of the group holds the rope down firmly on the ground, a second member pulls the rope such that it is just taut.
3. The third member measures the length of the rope with the metre rule.
4. The second member now moves the rope back and forth slowly until the rope displays a half-wave (length) pattern. Maintain the motion with a constant hand movement.
5. The third member times how long it takes for the second member to make 20 consecutive back-and-forth motions and records this time.
6. Steps 4 & 5 are repeated to produce full-wave, one-and-a-half waves, double-waves, etc. until the table is filled out.
7. Observe what happens to the wave when
   (a) a small amount of energy is put into making the wave.
   (b) a large amount of energy is put into making the wave.

**Method B – With fancy equipment**

Your teacher will demonstrate how to measure the frequency and amplitude of a sound wave using a CRO.

**Results**

<table>
<thead>
<tr>
<th>Shape of wave</th>
<th>Wavelength (m)</th>
<th>Time for 20 revolutions</th>
<th>Period</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

**Observations:**

**Discussion**
Physics – Preliminary – Module 8.2 The World Communicates Teaching Program

1. The quantity given by wavelength $\lambda$ frequency is called the **velocity** of the wave. The expression above is called the **wave equation**.
   (a) What would its units be?
   (b) What do your results tell you about the velocity of a wave?

2. Is the velocity of a particular wave constant in a medium? Justify your answer.

3. Can a wave accelerate?

4. Do Humphrey’s Set 14.
**Preliminary Physics C3: The World Communicates Experiment 3: Relationship between frequency and wavelength**

**Aim:** To plan, choose equipment for and perform a first-hand investigation to gather information to identify the relationship between frequency and wavelength of a sound wave travelling at constant velocity.

**Outcomes Assessed**

- demonstrate the use of the terms 'dependent' and 'independent' to describe variables involved in the investigation (11.2a)
- identify variables that needed to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control (11.2b)
- design investigations that allow valid and reliable data and information to be collected (11.2c)
- describe and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or the repetition of procedures is appropriate (11.2d)
- predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary (11.2e)
- identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation (11.3a)
- carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards (11.3b)
- identifying technology that would be used during investigation determining its suitability and effectiveness for its potential role in the procedure or investigation (11.3c)
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)

You must devise a method using equipment listed below and/or any other equipment you bring in; by:

**Equipment Available**

- Stop watches
- Ropes, slinky coils, water trough
- Metre rulers
- Any other equipment that is reasonable (arrange with your teacher beforehand)

You should consider the following points:

- Does the experiment satisfy the aim above?
- The safety of the experiment. Any safety notes need to be explicit.
- Design your own result table. Have you repeated the experiment several times to validate the results and to calculate a mean?
- Did you show your working?
- What are some possible sources of error? How could these errors be minimised or eliminated?
**Preliminary Physics C3: The World Communicates Activity 4: The Wave Equation**

Aim: To solve problems and analyse information by applying the mathematical model of \( v = f \lambda \) to a range of situations

Outcomes Assessed
- use models, including mathematical ones, to explain phenomena and/or make predictions (14.1f)
- identifying and explaining the nature of a problem (14.2a)

Do Humphrey’s Set 51

**Preliminary Physics C3: The World Communicates Experiment 5: Sound Waves**

Aim: To gather information and analyse sound waves from a variety of sources using the Cathode Ray Oscilloscope (CRO) or an alternate computer technology

Outcomes Assessed
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors (12.2a)
- measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate (12.2b)

Method
Your teacher will demonstrate the following:

1. Tuning forks of different frequencies
2. Various musical instruments
3. Voice (normal / singing)
4. Other sound-generating events

Discussion
1. Find the meanings of the following terms:
   (a) superposition
   (b) Fourier transform
2. How are musical notes different to “normal” sounds?
3. What is your range of hearing? How does this compare to other animals?
4. How does the cochlea (in the inner ear) work?
Preliminary Physics C3: The World Communicates Experiment 6: Superposition

Aim: 1. To gather, process and present information using a CRO or computer to demonstrate the principle of superposition for two waves travelling in the same medium.
   2. To present graphical information, solve problems and analyse information involving superposition of sound waves

Outcomes Assessed
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors (12.2a)
- measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate (12.2b)
- assess the accuracy of any measurements and calculations and the relative importance of the data and information gathered (12.4a)
- identify and apply appropriate mathematical formulae and concepts (12.4b)
- using symbols and formulae to express relationships and using appropriate units for physical quantities (13.1d)
- using a variety of pictorial representations to show relationships and present information clearly and succinctly (13.1e)
- selecting and drawing appropriate graphs to convey information and relationships clearly and accurately (13.1f)
- identify trends, patterns and relationships as well as contradictions in data and information (14.1a)
- identify and explain how data supports or refutes a hypothesis, a prediction or a proposed solution to a problem (14.1c)
- use models, including mathematical ones, to explain phenomena and/or make predictions (14.1f)

Part A: Computer Simulation
In this experiment, we will be using the program “Travelling Waves” by Barenger Software. (version 2)

1. Set the following parameters on the program:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Source Waveform</th>
<th>Frequency</th>
<th>Attenuation</th>
<th>Show Waves</th>
<th>Load Reflection</th>
<th>Wave Speed (under Start button)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting</td>
<td>Sine Wave</td>
<td>centred</td>
<td>none</td>
<td>Forward</td>
<td>1 (o/c)</td>
<td>fast</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reflected</td>
<td></td>
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</tr>
</tbody>
</table>

2. Press “Start” and wait until the wave reflects.
3. When the wave has sufficiently reflected, press “Pause” and draw the waveform into your results.
4. Repeat the simulation for a square wave (all other settings are the same).

Part B: Using the CRO
Your teacher will demonstrate the superposition of waves using a CRO and a signal generator.

Discussion
1. If two waves cancel each other out, what happens to the energy?
2. Another name for superposition is constructive and destructive interference. Research some devices that make use of superposition / interference and how they employ this idea in technology.
3. Do Humphrey’s Set 52
**Preliminary Physics C3: The World Communicates Experiment 7: The Intensity Law**

**Aim:** Plan, choose equipment or resources for and perform a first-hand investigation and gather information to observe the inverse square law for light intensity and distance from the source.

**Outcomes Assessed**
- demonstrate the use of the terms ‘dependent’ and ‘independent’ to describe variables involved in the investigation (11.2a)
- identify variables that needed to be kept constant, develop strategies to ensure that these variables are kept constant, and demonstrate the use of a control (11.2b)
- design investigations that allow valid and reliable data and information to be collected (11.2c)
- describe and trial procedures to undertake investigations and explain why a procedure, a sequence of procedures or the repetition of procedures is appropriate (11.2d)
- predict possible issues that may arise during the course of an investigation and identify strategies to address these issues if necessary (11.2e)
- identifying and/or setting up the most appropriate equipment or combination of equipment needed to undertake the investigation (11.3a)
- carrying out a risk assessment of intended experimental procedures and identifying and addressing potential hazards (11.3b)
- identifying technology that would be used during investigation determining its suitability and effectiveness for its potential role in the procedure or investigation (11.3c)
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)

You must devise a method using equipment listed below and/or any other equipment you bring in.

**Equipment Available**
- Power supplies and leads
- Light globes and holders
- One digital camera, software and several notebook computers
- Tape measure / metre rulers
- Any equipment that is reasonable (arrange with your teacher beforehand)

You should consider the following points:
- Does the experiment satisfy the aim above?
- The safety of the experiment. Any safety notes need to be explicit.
- Design your own result table. Have you repeated the experiment several times to validate the results and to calculate a mean?
- Did you show your working?
- What are some possible sources of error? How could these errors be minimised or eliminated?
Preliminary Physics C3: The World Communicates Activity 8: Electronic Communication

Aim: To analyse information and use available evidence to identify the waves involved in the transfer of energy that occur during the use of one of the following: mobile phones, television, radar

Outcomes Assessed
- identify trends, patterns and relationships as well as contradictions in data and information (14.1a)
- identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem (14.1c)
- use models, including mathematical ones, to explain phenomena and/or make predictions (14.1f)
- design and produce creative solutions to problems (14.3a)
- propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas (14.3b)
- apply critical thinking in the consideration of predictions, hypotheses and the results of investigations (14.3c)
- Formulate cause and effect relationships (14.3d)

Write a 400 word report explaining the energy transfers and type of wave used in all three devices listed above.

Preliminary Physics C3: The World Communicates Activity 9: EM Use in Communication

Aim: To analyse information to identify the electromagnetic spectrum range utilised in modern communication technologies.

Outcomes Assessed
- justify inferences and conclusions (14.1b)
- identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem (14.1c)
- predict outcomes and generate plausible explanations related to the observations (14.1d)
- make and justify generalisations (14.1e)

1. Create a graph of depth of penetration into the atmosphere (in kms) on the Y-axis versus wavelength of light on the X-axis.
2. Identify wavelengths that are filtered out by the atmosphere.
3. Identify wavebands that are used by: civilian, military, scientific purposes.
Preliminary Physics C3: The World Communicates Experiment 10: Constructing Light Rays

Aim: To perform first-hand investigations and gather information to observe the path of light rays and construct diagrams indicating both the direction of travel of the light rays and a wave front

Outcomes Assessed
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using appropriate data collection techniques, employing appropriate technologies, including data loggers and sensors (12.2a)
- measuring, observing and recording results in accessible and recognisable forms, carrying out repeat trials as appropriate (12.2b)

Materials
Ray box kits
Power supply & leads

Method
1. Arrange the following diagrams using a single slit:

4. Carefully trace the path of the light rays and shape of the objects directly onto your prac book.
5. Draw wavefronts for the light rays (at right angles to the light rays)

Discussion
1. What happens to the light rays when they change media? What happens to the wavefronts?
2. Why do light rays travel in straight lines? Are there situations where light continually bends?
3. Why do we draw the normal to the surface in constructing wavefronts?
**Preliminary Physics C3: The World Communicates Experiment 11: Refraction**

**Aim:**
1. To present information using ray diagrams to show the path of waves reflected from plane surfaces, concave surfaces, convex surface, and the ionosphere.
2. To graph the angle of incidence and refraction for light encountering a medium change showing the relationship between these angles.

**Outcomes Assessed**
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using symbols and formulae to express relationships and using appropriate units for physical quantities (13.1d)
- using a variety of pictorial representations to show relationships and present information clearly and succinctly (13.1e)
- selecting and drawing appropriate graphs to convey information and relationships clearly and accurately (13.1f)

**Method**

**Part A: Reflection**
1. Place a sheet of paper underneath a plane mirror. Reflect a light ray from a ray box off the mirror as shown below. Measure the angles \(i\) and \(r\) and record them below (see figure 1). Repeat this for several values of \(i\) and \(r\).
2. Repeat the procedure for the curved mirror: figure 2 shows a **convex** mirror and figure 3 shows a **concave** mirror. Record your values of \(i\) and \(r\) for each case.

1. incoming ray
2. outgoing ray
3. outgoing ray
4. incoming ray
5. outgoing ray
Part B: Refraction

1. Use the same technique as you used previously to measure the angle of refraction as shown in figure 4. Repeat this for several values of i and r.

2. Using white light, qualitatively assess which colours are refracted by a triangular prism as shown in figure 5.

Results

<table>
<thead>
<tr>
<th>object</th>
<th>i</th>
<th>r</th>
<th>i</th>
<th>r</th>
<th>i</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>flat mirror</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>curved mirror</td>
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<td></td>
</tr>
</tbody>
</table>

Discussion

1. What rule can you deduce about reflection?
2. Does Snell's law hold true for the refraction you observed? Verify this.
3. What colour is refracted the least? The most?
4. Rainbows are caused by sunlight being refracted by water droplets in the air. What conditions must there be to form a rainbow? (use your common experience).
Preliminary Physics C3: The World Communicates Experiment 12: Refractive Index

Aim: 1. To perform a first-hand investigation and gather information to calculate the refractive index of glass or perspex.
   2. To solve problems and analyse information using Snell’s Law.

Outcomes Assessed
- carrying out the planned procedure, recognising where and when modifications are needed and analysing the effect of these adjustments (12.1a)
- identifying and using safe work practices during investigations (12.1d)
- using symbols and formulae to express relationships and using appropriate units for physical quantities (13.1d)
- using a variety of pictorial representations to show relationships and present information clearly and succinctly (13.1e)
- selecting and drawing appropriate graphs to convey information and relationships clearly and accurately (13.1f)
- identify trends, patterns and relationships as well as contradictions in data and information (14.1a)
- identify and explain how data supports or refutes an hypothesis, a prediction or a proposed solution to a problem (14.1c)
- use models, including mathematical ones, to explain phenomena and/or make predictions (14.1f)
- design and produce creative solutions to problems (14.3a)
- propose ideas that demonstrate coherence and logical progression and include correct use of scientific principles and ideas (14.3b)
- apply critical thinking in the consideration of predictions, hypotheses and the results of investigations (14.3c)
- formulate cause and effect relationships (14.3d)

Background Information

When light passes from air into glass it bends towards the normal. This is known as refraction. The index of refraction of a substance is defined as the ratio of the speed of light in a vacuum to its speed in that substance.

Since the amount of refraction depends on this index there is a relationship between the amount of bending and the refractive index. Snell's Law states this relationship which is

\[ n_1 \sin \theta_i = n_2 \sin \theta_r \]

where
- \( n_1 \) is the refractive index of air
- \( n_2 \) is the refractive index of the glass
- \( \theta_i \) is the angle of incidence
- \( \theta_r \) is the angle of refraction

Since the refractive index for air is very close to 1 we can write Snell's law for the air-glass situation as

\[ n = \frac{\sin \theta_i}{\sin \theta_r} \]

In this experiment you will use Snell's law to determine the refractive index of a glass.

Method
1. Place a sheet of styrofoam flat on the benchtop with a sheet of paper on it.
2. Place the rectangular slab centrally on the paper and accurately trace around it with a sharp pencil.
3. Use a single slit on the ray box and shine a ray through the slab at an oblique angle to the surface of the slab (as shown in the diagram).
4. Repeat this procedure for six different angles.
Results
Record the results in the table below:

<table>
<thead>
<tr>
<th>Incident angle $I$</th>
<th>Refracted angle $r$</th>
<th>$\sin I$</th>
<th>$\sin r$</th>
<th>$\sin I / \sin r$</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

Plot a graph of $\sin Q_I$ vs $\sin Q_r$, and draw the line of best fit.

Discussion

(1) What is the refractive index of the glass used in this experiment? Estimate the error associated with your measurement.

(2) The refractive indices of several types of glass are shown in the table below:

<table>
<thead>
<tr>
<th>Glass type</th>
<th>Zinc crown</th>
<th>Crown</th>
<th>Light flint</th>
<th>Heavy flint</th>
<th>Heaviest flint</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.I.</td>
<td>1.517</td>
<td>1.520</td>
<td>1.570</td>
<td>1.650</td>
<td>1.890</td>
</tr>
</tbody>
</table>

From this data suggest the type of glass used.

(3) Why does the ray emerging from the glass block come out parallel to the incident ray?

(4) Assuming you have a tin-walled rectangular container, briefly describe a technique suitable for determining the speed of light in various liquids. For this remember that $n = \sin Q_I / \sin Q_r = V_I / V_r$

(5) Do Humphrey’s Set 53
Preliminary Physics C3: The World Communicates Activity 13: Wave Technology

Aim: To identify data sources, gather, process and present information from secondary sources to identify areas of current research and use the available evidence to discuss some of the underlying physical principles used in one application of physics related to waves, such as Global Positioning System, petrological microscope, CD technology; or the Internet (digital process).

Outcomes Assessed
- accessing information from a range of resources, including popular scientific journals, digital technologies and the Internet (12.3a)
- practising efficient data collection techniques to identify useful information in secondary sources (12.3b)
- extracting information from numerical data in graphs and tables as well as written and spoken material in all its forms (12.3c)
- summarising and collating information from a range of resources (12.3d)
- identifying practising male and female Australian scientists, and the areas in which they are currently working and in formation about their research (12.3e)
- identify and apply appropriate mathematical formulae and concepts (12.4b)
- evaluate the validity of first-hand and secondary information and data in relation to the area of investigation (12.4d)
- assess the reliability of first-hand and secondary information and data by considering information from various sources (12.4e)
- assess the accuracy of scientific information presented in mass media by comparison with similar information presented in scientific journals (12.4f)
- selecting and using appropriate text types or combinations thereof, for oral and written presentations (13.1a)
- selecting and using appropriate methods to acknowledge sources of information (13.1c)

Write a 400 word report on this topic.