**Waves & Thermodynamics**

**Practicals**

**Some of the practicals contained in this document may be of use to teachers and students in Module 3.**

* **The Oscilloscope**
* **Light Practical – using Optics Kits**
* **Refractive Index – using Optics Kits**
* **Sound Reflection & Absorption**
* **Video on Conduction, Convection & Radiation -**[**From Khan Academy**](https://www.khanacademy.org/science/physics/thermodynamics/specific-heat-and-heat-transfer/v/thermal-conduction-convection-and-radiation)

OSCILLOSCOPE PRACTICAL

1. **Students write a report to present the results of each of the sections below.**
2. **Explain briefly how an oscilloscope works and what it is used for. Include the meaning of the y and x axes (wave amplitude & period respectively).**
3. **Check that oscilloscope time scale is set to “normal” rather than 5X magnification. These buttons are found in the time scale control area of the oscilloscope.**
4. **Attach the oscilloscope probe to a microphone and demonstrate the following:**
	* **A wave of single frequency (use a tuning fork) produces a sine wave on the oscilloscope. Initial oscilloscope settings – Time = 0.5 to 2.0 ms/div & Volts = 50 mV/div and adjust from there.**
	* **Whistling a single frequency produces a sine wave trace.**
	* **Singing a song, speaking and clicking one’s fingers together produce more complex waveforms.**
	* **The louder the sound, the higher the amplitude (vertical axis value) of the waveform.**
	* **The higher the pitch of the sound, the closer together the waves seem to pack along the x-axis. That is, the higher the pitch, the lower the period and the higher the frequency of the waveform.**
	* **Measure the period of the signal from a 320 Hz tuning fork and thereby calculate the frequency. Use time = 1 or 2 ms/div (with variable sensitivity set to maximum) and volts = 10 mV/div.**
	* **Demonstrate the production of beats using two identical tuning forks, with a small amount of blue tack added to one prong of one of the forks to produce a slightly lower frequency. Show what the waveform looks like by using the microphone to receive the signal. For example, using the tuning forks & resonance boxes marked “Bob A” & “Bob B”, oscilloscope settings of time = 5 ms/div and volts = 20 mV/div should show good beat patterns on the oscilloscope screen.**
5. **Attach the probe to the low output terminals of an audio frequency signal generator. Select sine wave & microphone on. Demonstrate what a signal generator does. Measure the frequency of a particular signal using the oscilloscope. (eg Set the signal generator on 400 Hz & measure the period of the wave produced. From this calculate the frequency. Use time = 1 ms/div.) Also demonstrate once more that as you increase the frequency of the input signal, the horizontal spacing between crests on the screen decreases – that is, the period of the wave decreases.**
6. **Attach the wave generator to input A of the oscilloscope and the AC terminals of a power pack set to 2 or 4 volts to input B. Display both signals on the oscilloscope at once using the A & B display buttons. Adjust the signal from the signal generator until its frequency is almost identical to the signal from the power pack. Then display the two waveforms added together using the A+B button. Observe the oscilloscope trace vary with time in the usual beat fashion. (Settings: 2V AC power pack signal – Volts = 2 V/div & time = 5 ms/div; 50-60 Hz approx wave generator signal – Volts = 50 mV/div & time = 5 ms/div.)**
7. **OPTIONAL: Attach an oscilloscope probe to the exposed wires of an earphone jack that is receiving an AM signal from a radio – preferably receiving speech rather than music. Get a student to check that the wave pattern on the oscilloscope seems to match the voice pattern from the earphones. Point out the carrier wave and the amplitude modulated signal on the oscilloscope.**

This prac should take 1 to 1.5 periods but addresses several sections of the syllabus: 8.2.1 dots 4 & 5 & 8.2.2 dots 1 & 3 and can then be used by the students as a possible jumping off point for 8.2.2 dot 2.

LIGHT PRACTICAL

**AIM:**

**To study the reflection and refraction of an electromagnetic wave (light), using the standard school laboratory Optics Kit.**

**METHOD:**

1. **Using the light source and slit plate, observe the path of light rays and construct both a ray diagram and a wavefront diagram to indicate the direction of travel of the light.**
2. **Present information using ray diagrams to show the path of waves reflected from:**
	* **A plane surface**
	* **A concave surface**
	* **A convex surface**

**In each diagram clearly label the angle of incidence (i), the angle of reflection (r) and the normal to the surface.**

1. **Tabulate the data collected in part 2 above and comment on any similarity between the sizes of the angles of incidence and reflection.**
2. **Present information using ray diagrams to show the path of light as it moves from air into either a glass or perspex prism for five different angles of incidence ranging from 15o to 60o. Clearly label the angle of incidence (i), the angle of refraction (r) and the normal to the surface.**
3. **Tabulate the data collected in part 4 above, using separate columns for i, r, sin i, sin r and sin i/sin r.**
4. **Plot graphs (on graph paper) of:**
	* **Angle of incidence (vertical axis) v’s angle of refraction (horizontal axis)**
	* **Sin i (vertical axis) v’s sin r (horizontal axis)**
5. **For a given pair of media, the ratio sin i/sin r can be shown to be a constant called the relative refractive index of the material for light passing from medium 1 into medium 2. For light passing from air to glass (or perspex) the theoretical value of the relative refractive index is 1.5. From your sin i v’s sin r graph, calculate an experimental value for this relative refractive index. Compare the result with the theoretical value and propose an explanation for any difference.**
6. **Using the semi-circular perspex prism, observe the total internal reflection of light. Draw a ray diagram to record this observation and clearly label the critical angle (ic).**
7. **Given that the theoretical value for ic is given by:

  ,

where absolute refractive index of medium 1 (1.5 for glass & perspex), calculate the theoretical value for the critical angle of glass or perspex and compare this with the experimentally obtained value.**

**REFRACTIVE INDEX PRACTICAL**

**AIM:**

**To determine the refractive index of a material.**

METHOD:

1. **Using a standard school laboratory Optics Kit, set up a ray box with a single slit aperture. Connect it to a DC power supply set to 12V.**
2. **Place a rectangular perspex prism in the middle of a white sheet of A4 paper so that its long edge is parallel to the long edge of the paper.**
3. **Trace carefully around the prism to mark its position on the paper.**
4. **Remove the prism and at ONE point somewhere near the centre of the left hand side of the prism draw the normal to the side of the prism (using a protractor or set square).**
5. **From the point chosen in 4 above, draw three straight lines (representing rays of light) striking the side of the prism at angles of incidence of 30o, 45o and 60o. Clearly label the angles of incidence. These lines are going to be used to guide rays of light to strike the prism at those angles of incidence.**
6. **Shine a single ray of light striking the prism at an angle of incidence of 30o and clearly trace onto the paper the path of the refracted ray emerging on the other side of the prism. Repeat this for the other two angles.**
7. **Measure and label the angles of refraction for each of the angles of incidence. Tabulate these results in the table shown in the Results section.**
8. **Complete all entries in the table and the other details required in the Results section.**

RESULTS:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Angle of Incidence (o)** | **Angle of Refraction (o)** | **Sin i** | **Sin r** | **Refractive Index** |
| **30** |  |  |  |  |
| **45** |  |  |  |  |
| **60** |  |  |  |  |
|  |  |  |  **Average =** |

1. **Show how you calculated the refractive index of the prism from the 30o angle of incidence data.
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2. **Determine an average value for the refractive index of the prism by calculating an average of all three refractive index measurements in the table.
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3. **Suggest TWO methods for improving the reliability of this experiment.
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CONCLUSION:

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**AIM:**

**To investigate the extent to which various materials reflect and absorb sound.**

**METHOD:**

1. **Data on the reflection and absorption properties of different materials were examined to enable the selection of appropriate materials for this investigation. Data used was from Harding, J. et al (1996). “Physics Concepts & Applications VCE Units 3 & 4*"* Melbourne: Macmillan Education Australia Pty Ltd**
2. **Using the experimental set-up shown in Diagram No.1, a sound intensity meter was used to measure the intensity of sound of constant frequency, produced by an audio frequency generator, after the sound had travelled the length of cardboard tube A. The end of Tube A in contact with the audio generator was positioned so as to completely cover the speaker outlet in the back of the generator.**
3. **The sound intensity was then measured at the end of tube B, after the sound had been reflected from plane surfaces composed of various different materials. The plane surfaces were positioned so as to cover the opening at the intersection of Tube A with Tube B, as shown in the diagram.**
4. **The results were tabulated and analyzed qualitatively to determine the extent to which different materials reflect sound.**
5. **Using the experimental set-up shown in Diagram No.2, the intensity of sound of constant frequency was measured at a set distance from the audio generator, when no absorbing material was covering the speaker outlet.**
6. **Styrofoam cups containing various absorptive materials were then placed in turn to completely cover the speaker outlet. For each material the sound intensity was measured at the set distance from the generator.**
7. **The results were tabulated and analyzed qualitatively to determine the extent to which different materials absorb sound.**





RESULTS:

**Reflection of Sound from Various Materials:**

**Sound intensity at end of tube A (ie before reflection), I1 = 110 dB**

**Background sound intensity with audio generator off was very much lower than 110 dB and was neglected in this experiment.**

###### TABLE No.1: Sound Intensity Values – Reflection

|  |  |  |
| --- | --- | --- |
| TYPE OF MATERIAL | **REFLECTED SOUND INTENSITY, I2 (dB)** | DifferenceI1 – I2 (dB) |
| **Foam Rubber** | **104** | **6** |
| **Low pile Carpet** | **108** | **2** |
| **Felt** | **111** | **-1** |
| **Human Skin/Flesh** | **112** | **-2** |
| **Leather** | **110** | **0** |
| **Styrofoam** | **110** | **0** |
| **Thick pile of paper** | **111** | **-1** |
| **Thick cardboard** | **110** | **0** |
| **Hard plastic** | **110** | **0** |
| **Wood** | **110** | **0** |
| **Glass** | **110** | **0** |

**\* Note: Sound intensity at end of Tube B when no material was placed over opening at intersection of Tubes A and B = 104 dB.**

**Absorption of Sound by Various Materials:**

**Sound intensity at set distance from audio generator when no absorptive material was covering speaker outlet, I1 = 88 dB**

**Background sound intensity with audio generator off was very much lower than 88 dB and was neglected in this experiment.**

###### TABLE No.2: Sound Intensity Values – Absorption

|  |  |  |
| --- | --- | --- |
| TYPE OF MATERIAL | **SOUND INTENSITY AFTER ABSORPTION, I2 (dB)** | DifferenceI1 – I2 (dB) |
| **Foam Rubber** | **68** | **20** |
| **Paper Towels (crumpled into balls)** | **70** | **18** |
| **Styrofoam\*** | **75** | **13** |
| **Bubble Plastic (as used in packaging)** | **75** | **13** |
| **Woodchips (fine)\*** | **70** | **18** |

**\*Note: To avoid spillage several tissues were used to pack the end of cups containing these materials.**

**DISCUSSION:**

**To assist you in the writing of your discussion, consider the following questions:**

* **What do the data in Table No.1 suggest about the sound reflection properties of the materials used? Which is the best reflector? Which is the worst reflector?**
* **Is this what you expected? If not, why not?**
* **Were there any anomalies in the data? If so, how do you account for these?**
* **How do you explain the result mentioned in the “Note” at the bottom of Table No.1?**
* **What were some possible sources of error in this experiment?**
* **What suggestions can you make to improve the precision and accuracy of this experiment?**
* **Discuss the data in Table No.2 in a similar manner.**

CONCLUSION:

When you have written a brief Discussion section, complete this report by writing an appropriate Conclusion, under that heading.