

SNC2D/2P Light and Geometric Optics/Light and Applications of Optics

Student Activity: Refraction of Light—Disappearing Penny

Topics	Timing
refraction of light index of refraction	preparation: 10 min activity: 10 min

Specific Expectations

SNC2D

- A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research
- A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data
- A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions
- E3.4** explain the conditions required for partial reflection/refraction and for total internal reflection in lenses, and describe the reflection/refraction using labelled ray diagrams
- E3.7** identify the factors, in qualitative and quantitative terms, that affect the refraction of light as it passes from one medium to another

SNC2P

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- A1.5** conduct inquiries, controlling some variables, adapting or extending procedures as required, and using standard equipment and materials safely, accurately, and effectively, to collect observations and data
- A1.10** draw conclusions based on inquiry results and research findings, and justify their conclusions
- E3.4** describe qualitatively how visible light is refracted at the interface between two different media

Introduction

This demonstration serves as a superb introduction to the refraction of light. Students place a penny underneath a plastic cup. While viewing the penny through the side of the cup, they slowly fill the cup with water. The penny disappears from sight.

Materials

transparent plastic cup
penny

small opaque jar lid or plate
water in a small beaker or jug

Safety Considerations

None

Procedure

1. Organize your class into groups of 2 to 3 students.
2. **Predict/Explain**
Have each group place a penny on the desk and place the bottom of a transparent plastic cup over the penny. Cover the top of the plastic cup with a small opaque jar lid or plate. Ask each group to predict what will happen if the plate is tilted back and water is slowly added to the cup and the penny is viewed from the side of the cup.
3. Encourage all groups to provide a rationale for their prediction.
4. **Observe**
Provide time for students to record their observations.
5. Direct students to tilt the lid back and slowly pour water into the plastic cup. They should continue observing the penny from the side of the cup.
6. **Explain**
Ask the groups to reconvene, consider their observations, and revise their rationales if necessary. Challenge students to suggest a model to help explain their observations.

Disposal

No special concerns

What happens?

The penny is visible when there is no water in the cup but it disappears as water is added.

How does it work?

When there is no water in the cup, the light from the penny experiences very little refraction and we can see the light from the penny (Fig.1). When there is water in the cup, the light from the penny experiences refraction (bending) and reflection (total internal reflection, TIR) such the light it is not able to reach the observer's eyes (Fig.2). A small amount of refraction occurs as the light leaves the penny and travels through the bottom of the cup, then refraction occurs again as it enters the water. When refraction occurs at the side of the cup there is TIR because of the angle of incidence. The light ends up travelling at such an angle that we are unable to see the penny. A more complete explanation of this phenomenon is given in the STAO PowerPoint presentation listed in Additional Resources.

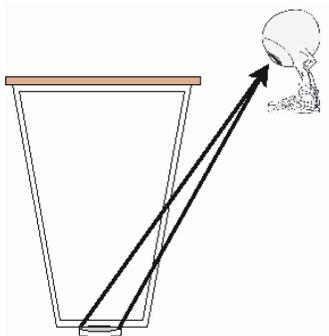


Fig.1 The penny is visible when there is no water in the cup.

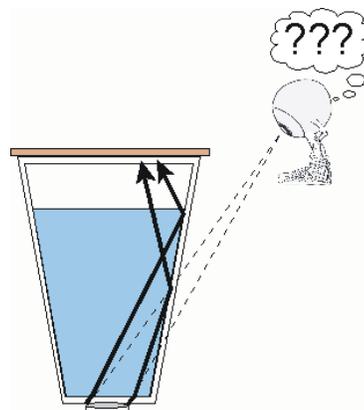


Fig.2 The penny becomes invisible when the cup is full of water. The dotted lines show the direction of the light rays from the penny if no glass cup or water was present.

Teaching Suggestions/Hints

1. The reason for placing the lid on top of the cup is to force the observer to view the penny from an appropriate angle: through the side of the cup.
2. This demonstration can be used as a powerful hook for the Light and Geometric Optics/ Light and Applications of Optics strands in the Grade 10 Science courses.
3. This is a great inquiry activity. However, because it involves total internal reflection (TIR), it should be treated more as review after the TIR concept is learned.

Next Steps

Make connections between this demonstration and other refraction phenomena.

Additional Resources

1. An additional explanation of the demonstration and related concepts - <http://www.stevespanglerscience.com/experiment/disappearing-money-sick-science>
2. Website showing this demonstration - <http://www.youtube.com/watch?v=7tUFmu-hcEc>
3. STAO PowerPoint presentation: Penny Under a Cup Take Two - <http://stao.ca/VLresources/2008/PennyUnderCupTwo.ppt>