Lesson Title: UV Resin Lens Challenge

Lesson Overview

Activity Time: 2-3 60 min classes

Lesson Plan Summary: In this lesson, students will be introduced to the basics of microscopy, the concept of magnification, and learn and apply the lens and magnification equations. Students will engage in hands-on creation and experimentation with lenses of different sizes.

Student Understandings

Learning Objectives:

Students will know:

- The basic principles of microscopy, including the history and importance of lenses in scientific research and everyday applications.
- Key terms related to lenses and magnification, such as convex lens, focal point, focal length, and magnification.
- The lens equation and magnification equation and how they relate to the optical properties of lenses.

Students will be able to:

- Construct convex lenses using UV resin and accurately measure and calculate their magnification and focal length.
- Apply the lens equation (1/f=1/do+1/di)(1/f = 1/do + 1/di)(1/f=1/do+1/di) and the magnification equation (M=hi/ho=−di/do)(M = hi / ho = -di / do)(M=hi/ho=−di/do) to analyze lens performance.
- Compare the optical properties of handmade lenses to those of commercial microscope lenses.
- Reflect on and improve the design and performance of their lenses through iterative prototyping.
- Present and explain their findings, including calculations, observations, and design improvements, clearly and effectively.

Materials

Material	Description	Quantity
UV resin	UV fast curing resin for crafts	1 bottle per group
UV flashlights	365 nm UV light flashlight	1 per group
Ruler	Ruler with metric units	1 per group
Velcro Cable Tie	250 mm x 12 mm Velcro Cable Ties	1 per group
Phone attachment	Click here for STL files for 3D printing phone attachments	1 per group
Lens holders	Each group should have a 3 mm, 6 mm, 9 mm, and 12 mm diameter lens holder. Click here for SVG files for laser cutting lens holders	1 set per group
Lens bed	Click here for SVG files for laser cutting lens holders	1 per group
Polypropylene base	Click here for SVG files for laser cutting lens holders	1 per group
Lens stickers	Each group should have a 3 mm, 6 mm, 9 mm, and 12 mm diameter lens sticker. Click here for vector files for vinyl cutting lens stickers	1 set per group
Phone with camera	Students are to use their personal devices	1 per group
Pin	Safety pin or sewing pin	1 per group
Forceps	Metal or plastic forceps	1 per group
Student Handout 1.1	UV resin lens challenge lab	1 per student

Teacher Preparation

UV Resin Lens Kit Preparation:

1. 3D Print the Phone Attachment

Download: Download the phone_attachment.stl file.
Material: Use PLA
Slicer Settings:
Layer height: 0.3 mm
Wall line count: 3
Infill: 25%
Supports: Not required
Adhesion: Skirt
Orientation: The model is designed to print vertically. Rotate the model to the correct orientation before starting the print.
Attachment: After printing, secure the phone attachment to your phone using a 12 mm wide Velcro cable tie.

2. Laser Cut the Polypropylene Base, Lens Holder, and Lens Bed

Download Files:
Polypropylene base: PPbase.svg
Lens holder: lensholder.svg
Lens bed: lensbed.svg
Use a laser cutter to cut each component following the downloaded file specifications.

3. Cut the Lens Stickers

Download File: lenssticker.svg
Use either a vinyl cutter or a laser cutter to cut the lens stickers based on the provided file.

Procedure

Engage: Understanding microscopy - history, lens principles, and key equations.

1. Ask students, “What do you know about the role of microscopes in scientific research and everyday life?”
    - Discuss how microscopes are used in various fields such as biology, medicine, and materials science.
    - Explore examples of discoveries or everyday applications that rely on microscopy.

2. Provide each student with a magnifying glass and ask them to observe various small objects, such as text on a page or fine details on a leaf. Ask students, “Can you explain how a convex lens helps magnify objects?”
    - Encourage students to describe their observations and understanding of how the lens bends light to make objects appear larger.
    - Discuss any experiences they might have had using magnifying glasses or other optical devices.

3. Ask students, “Why do you think the shape of a convex lens is important for its function?”
    - Explore the relationship between the lens's curvature and its ability to focus light.
    - Discuss how the shape affects the focal length and the clarity of the image produced.

4. Discuss basic principles of how lenses work, focusing on convex lenses.
    - Introduce the lens equation:

$$1/f = 1/d_o + 1/d_i$$

    - Introduce the magnification equation:

$$M = h_i/h_o = -d_i/d_o$$

Explore: UV resin lens challenge - making convex lenses.

5. Assign students a partner to work with. Provide each group with the materials they will need to create their lenses. Students will follow the instructions in **Student Handout 1.1** to guide them through the procedure, documenting their measurements and calculations along the way.

6. To make the lenses, students will first place the polypropylene base onto the lens bed. They will start with the 12 mm diameter lens holder and remove the protective tape from both sides, then carefully attach the 12 mm diameter sticker to one side of the lens holder. Next, they will place the lens holder, sticker side down, on the polypropylene base in the lens bed at position #1. Students will carefully drip UV resin into the hole while holding the lens holder flat, continuing until a visible curved shape forms above the lens holder surface, being careful not to add too much resin to prevent spillage. They will then shine the UV flashlight on the resin for about 30 seconds or until it hardens. After flipping the lens holder over and placing it sticker side up at position #2, students will apply resin using the sticker as a guide to form an equivalent curved shape, hardening it with the UV flashlight for another 30 seconds. Once complete, they will remove the lens holder to reveal a biconvex lens with a curved bulge on both sides. This process is repeated for the 9 mm, 6 mm, and 3 mm lens holders, resulting in a collection of four different sizes of lenses.

7. To test their resin lenses, students will securely attach the lens to their phone camera. They will then open the camera and focus on the metric side of a ruler using the lens attachment, taking a photo of the focused lines. Students will measure and record the object distance (d_o) from the lens to the ruler.

8. Next, they will measure the height of the image (h_i) of the ruler lines in the photo and record the actual height (h_o) of those same lines directly on the physical ruler. *Repeat steps 7-8 for each lens.*

9. Students will then calculate the magnification of for each lens using the magnification equation:

$$M = h_i / h_o$$

10. Students will then calculate the image distance (d_i) for each lens by plugging the calculated magnification:

$$d_i = -M \cdot d_o$$

11. Finally, students will calculate the focal length for each lens by using the following lens equation:

$$1/f = 1/d_o + 1/d_i$$

Explain: Students share their findings.

12. For each group ask, "What is your highest magnification and shortest focal length lens?" Record their magnification and focal length on the board. Have students reflect and share how they calculated the magnification and focal length of their lenses. Ask students, "What might these numbers tell you about your lens?" Explain what the high magnification and short focal length indicate about the lens's ability to enlarge small objects and focus light sharply. Reflect on the effectiveness of the lens for detailed observation and how these properties contribute to its performance in microscopy.

13. Identify the group(s) with the highest performing lens and analyze the design features that led to their success. Ask the students, "What aspects of the design of the lens made it that way? Why would these aspects contribute to a good lens for microscopy?" Discuss specific design elements such as curvature, material quality, and precision in shaping the lens. Explain how these features contribute to high magnification and short focal length, and why they are beneficial for achieving clear and detailed microscopic images.

14. Discuss how the measured object distance (d_o) and image distance (d_i) were used to calculate the focal length (f). Explain the relationship between these distances and how they help in understanding the lens's optical properties.

15. Have students reflect on their process. Ask students, “What challenges did you encounter when measuring the object and image distances, and how did you overcome them?” Encourage students to share any difficulties faced during the measurement process and discuss strategies used to obtain accurate measurements and ensure reliable results.

Elaborate: Lens Improvement and Optimization

16. Students will design and prototype an improved version of their lens, focusing on refining key factors such as curvature, resin application techniques, and material adjustments. Teams will sketch their design ideas and discuss the changes they believe will enhance performance.

17. Once their new lenses are created, students will test them using the same procedure as the original lenses. They will measure magnification, focal length, and overall performance, documenting their findings for comparison.

18. Students will share their new lens designs and results with the class, discussing:
    - “What changes did you make to your lens design?”
    - “How did these changes affect the magnification and focal length?”
    - “Were your improvements successful? Why or why not?”

Optional Extension:

- **Image Competition**: Host a friendly competition to recognize the best images captured with the improved lenses. Create multiple award categories, such as:
    - *Most Creative Image*
    - *Clearest Image*
    - *Most Magnified Image*
    - *Best Overall Image*
- Have the class vote or invite guest judges (e.g., other teachers or staff) to select the winners.