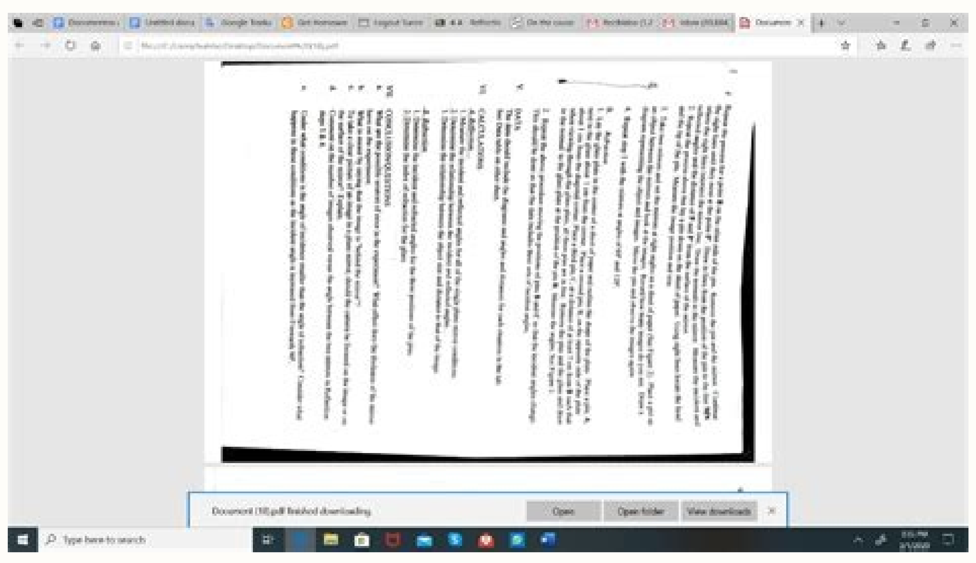
Reflection and refraction lab report

How many drops of water will my penny hold?

My Hypothesis:	Vocabulary: surface tension

Take your time and use a pipette to drop water onto a penny, one drop at a time. Count each drop as you go. When the water spills over stop counting and record your results.

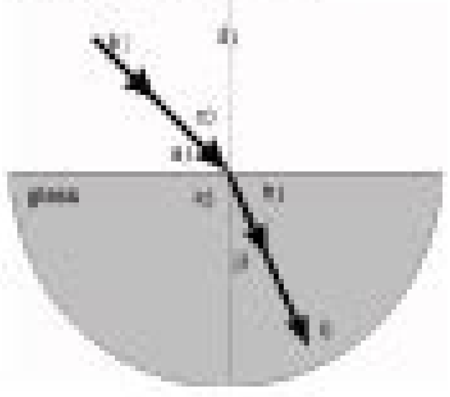
Number of Drops My Penny Held?	My Hypothesis	Difference between my actual results and my hypothesis?



L10 Refraction of Light Activity
– From Air (Less Dense) to Water (More Dense)

A Bird Can't Fly on One Wing (Scottish or Irish proverb – Exact origins lost to time.)
In science, theory must always balance with observation.

How, exactly, is light refracted when it passes from air into an optically denser medium, like water or glass?



Pre Lab
1) Relate each letter in the diagram to one of the following optical terms:
   ___ angle of incidence (∠i)
   ___ normal
   ___ refracted ray
   ___ incident ray
   ___ angle of refraction (∠R)

Materials
- Ray box (single slit) or Laser Level
- Semi-circular container
- Polar co-ordinate graph paper with semi-circular water container outline (attached below).

Procedure
1) Fill the semi-circular container with water; place it on the polar co-ordinate paper.
2) Direct a single incident ray of light at the semicircular along the 70° angle marked on the protractor.
3) Make sure that the ray passes through the centre of the flat surface. Measure the angle of refraction and record it in the table to the right.
4) Repeat the procedure for angles of incidence of 60°, 50°, 40°, 30°, 20°, 10°, and 0°, recording your observations in the table.

Angle of Incidence (∠i)	Water Angle of Refraction (∠R) in Water
70°	
60°	
50°	
40°	
30°	
20°	
10°	
0°	

Analysis Questions: (Circle any Bold choices)

1) When light travels from air into water with an angle of incidence of 0° (along the normal), what happens to it?

law of reflection state that the angle of incidence (i) and the angle of reflection (r) are equal. The experiment demonstrated specular reflection because it involved the use of smooth surfaces to demonstrated the behavior of light waves. The experiment aided in confirming the three laws of reflection (Strong 8), which include:

- The normal to the reflection, reflected ray and incident ray lie on the same plane.
- The angle between the reflected ray and the normal must be equal to the angle between the incident ray and the normal.
- The incident ray and reflected ray lie on the opposite sides of the normal.

The confirmation of the laws of reflection involved tracing the line of the incident ray and the reflected ray.

The refraction experiment involved the observation of how light waves behave as they travel through air and water. Generally, the incident ray is partially reflected and refracted. Theoretically, the concept of refraction is explained Snell's law, which states that the ratio of the sines of the angle of reflection and the angle of reflection are equivalent to the ratio produced by the phase velocities in the two media in which the wave travels (Dekker 168).

The change in the direction as light travels from one medium to the next was observed when the straight pencil observed in water appeared bent at the water surface. The pencil was placed in a slanted position because refraction cannot occur if the angle of incidence is zero degrees. The pencil appeared slant as shown in Fig 2 because the light rays bend as they pass from air into water. The speed and wavelength of the light rays changed while the frequency was constant. When the bent rays reach the eye, they are interpreted as straight lines of sight. The straight lines of sight interpreted by the eye intersect at a position that is higher than the actual origin the rays. Thus, the water appears shallow and pencil much higher than its original depth. The behavior of light in different media is explained by the refractive index.

Cabrillo College
Physics 10L

Name________________

LAB 12
Reflection and Refraction

Read Hewitt Chapters 28 and 29

What to learn and explore – *Please read this!*

When light rays reflect off a mirror surface or refract through a lens, they change their direction of travel, thus fooling our eye/brain combination into thinking they came from someplace different than their true source. We call the true source of light the **object** and the place our brain thinks the light came from the **image**.

The images we see in mirrors and with a magnifying glass are called "virtual" images, since they can only be seen by looking "through" a lens or mirror. They look very real, but the light isn't really there where the image seems to be. Other images can be projected onto a surface—these are called "real" images—but they are sometimes difficult to see without the help of a screen. We will meet both types of images in this lab.

We can create images where we want them by varying the curvature of the mirror or lens. We describe the mirror or lens by its "focal length," and you will find that more strongly curved surfaces result in shorter focal lengths. The focal length is the distance from the lens or mirror to the spot where a group of parallel rays of light come together.

Terms to know:

Reflection: light rays bounce off a surface: specular (light rays stay together in a beam, as in mirror reflection) or diffuse (light rays scatter randomly, as off a white sheet of paper)
Refraction: light rays bend at the boundary when they enter or exit a material
Virtual image: where your brain thinks the image is located in a mirror or through a lens
Real image: where light rays converge to form an image that can project onto a screen
Focal length: the distance from a lens or mirror where parallel incoming rays come together

What to use

Concave, convex, and plane mirrors, lots of lenses, optical bench, light ray box, protractors and straight edges, scratch paper, lasers, transparent water containers, optical illusion banks, fiber optics demos.

What to do

Experiment with the equipment provided to help answer the questions I have asked below and other questions of your own.

Mandatory Comments

Please use this space for comments and suggestions for improving this lab. Thank you.

Reflection refraction and total internal reflection lab report. What is the meaning of reflection and refraction. Reflection and refraction lab report conclusion. Reflection and refraction lab report discussion. What is reflection and what is refraction. Reflection and refraction with the ray box lab report. Reflection and refraction lab report edgenuity. Reflection and refraction lab report answers.

If you are taking a general biology course or AP Biology, at some point you will have to do biology lab experiments. This means that you will also have to complete biology lab reports. The purpose of writing a lab report is to determine how well you performed your experiment, how much you understood about what happened during the experimentation process, and how well you can convey that information in an organized fashion. A good lab report format includes six main sections: TitleIntroductionMaterials and MethodsResultsConclusionReferences Keep in mind that individual instructors may have a specific format that they require you to follow. Please be sure to consult your teacher about the specifics of what to include in your lab report. Title: The title states the focus of your experiment. The title should be to the point, descriptive, accurate, and concise (ten words or less). If your instructor requires a separate title page, include the title followed by the name(s) of the project participant(s), class title, date, and instructors name. If a title page is required, consult your instructor about the specific format for the page. Introduction: The introduction of a lab report states the purpose of your experiment. Your hypothesis should be included in the introduction, as well as a brief statement about how you intend to test your hypothesis. To be sure that you have a good understanding of your experiment, some educators suggest writing the introduction after you have completed the methods and materials, results, and conclusion sections of your lab report. Methods and Materials: This section of your lab report involves producing a written description of the materials used and the methods involved in performing your experiment. You should not just record a list of materials, but indicate when and how they were used during the process of completing your experiment. The information you include should not be overly detailed but should include enough detail so that someone else could perform the experiment by following your instructions. Results: The results section should include all tabulated data from observations during your experiment. This includes charts, tables, graphs, and any other illustrations of data you have collected. You should also include a written summary of the information in your charts, tables, and/or other illustrations. Any patterns or trends observed in your experiment or indicated in your illustrations should be noted as well. Discussion and Conclusion: This section is where you summarize what happened in your experiment. You will want to fully discuss and interpret the information. What did you learn? What were your results? Was your hypothesis correct, why or why not? Were there any errors? If there is anything about your experiment that you think could be improved upon, provide suggestions for doing so. Citation/References: All references used should be included at the end of your lab report. That includes any books, articles, lab manuals, etc. that you used when writing your report. Example APA citation formats for referencing materials from different sources are listed below. BookName of author or authors (last name, first initial, middle initial)Year of publicationTitle of bookEdition (if more than one)Place where published (city, state) followed by a colonPublisher nameFor example: Smith, J. B. (2005). Science of Life. 2nd Edition. New York, NY: Thompson Brooks.JournalName of author or authors (last name, first initial, middle initial)Year of publicationArticle titleJournal titleVolume followed by issue number (issue number is in parenthesis)Page numbersFor example: Jones, R. B. & Collins, K. (2002). Creatures of the desert. National Geographic. 101(3), 235-248. Your instructor may require that you follow a specific citation format. Be sure to consult your teacher concerning the citation format that you should follow. Some instructors also require that you include an abstract in your lab report. An abstract is a concise summary of your experiment. It should include information about the purpose of the experiment, the problem being addressed, the methods used for solving the problem, overall results from the experiment, and the conclusion drawn from your experiment. The abstract typically comes at the beginning of the lab report, after the title, but should not be composed until your written report is completed. View a sample lab report template. Remember that lab reports are individual assignments. You may have a lab partner, but the work that you do and report on should be your own. Since you may see this material again on an exam, it is best that you know it for yourself. Always give credit where credit is due on your report. You don't want to plagiarize the work of others. That means you should properly acknowledge the statements or ideas of others in your report. Geometric optics is one of the oldest branches of physics, dealing with the laws of refraction and reflection. The law of reflection was known to the ancient Greeks who made measurements that supported this law. The law of refraction, however, was not formulated mathematically until almost 1500 years later. Image formation by lenses and mirrors is explained by these two laws. Lenses and mirrors are the basic components of many common optical devices such as cameras, telescopes, eyeglasses, binoculars and microscopes. In geometric optics light is represented as rays coming from a light source. When these rays encounter a mirror, lens, or prism, for example, they bend or change direction. In this experiment, you will examine how light rays behave due to reflection and refraction in plane surfaces. When light is incident on a surface, some of the light is reflected back while some of it is transmitted or absorbed. A plane mirror is a highly polished surface with minimal absorption or refraction of light. Nearly all of the light is reflected back. There are numerous rays coming from a single source. However, when analyzing the behavior of light using the ray model, we use just one, two, or three rays to show the path of the rays and image formation. These are known as ray diagrams. To understand reflection using the ray model, we need to first define certain terms. The incident ray is a ray from the light source incident on the plane mirror. The angle of incidence is the angle between the incident ray and the normal (perpendicular) at the point of incidence. The reflected ray is the path of the ray after reflection by the surface. The angle of reflection is the angle between the reflected ray and the normal at the point of incidence (see Fig. 1). Arrows indicate the path of light rays. Figure 1: Reflection in a plane mirror The Law of Reflection for a plane mirror states that the angle of incidence equals the angle of reflection. The Law of Reflection is true at every point on the mirror. When light is incident on the boundary between two optical media such as air and glass, some of it is reflected at the boundary, and some of it passes through and is refracted (bent), as shown in Fig. 2. Figure 2: Reflection and refraction of light at air-glass and glass-air boundaries When light propagates from one medium into another, the ray bends toward or away from the normal in the second medium. Which way and how much it bends depends on the optical density of the material or medium defined by the refractive index n of the medium. A perfect vacuum has an index of refraction of 1.00. Air, because of its low density, has an index of refraction close to 1.00 and will be approximated as 1.00 in this lab. A typical index of refraction for glass is 1.5, but the value varies considerably with the type of glass. When light goes from a rarer medium into a denser medium it will bend toward the normal. The angle of refraction in the second medium will be less than the angle of incidence in the first medium. On the other hand, when light goes from a denser medium into a rarer medium it will bend away from the normal. In Fig. 2, light is traveling from air into glass and then emerges back into air. Here and therefore the refracted ray bends toward the normal. This refracted ray now goes from glass (denser medium) into air (rarer medium) and therefore it bends away from the normal. The angle between the refracted ray and the normal line is referred to as the angle of refraction. The law of refraction is given by Snell's Law, which stated mathematically is (2) where the subscripts refer to the two media. In the case of refraction at the second boundary, Snell's Law can be written as (3) If equals as in Fig. 2, then will equal and Eq. (3) is essentially the same as Eq. (2). Also note that the emergent ray is parallel to the incident ray but shifted laterally to the right. Unless a surface is highly polished, some of the light incident on a surface will be reflected and some part of it will be refracted. In Fig. 3 the incident ray is reflected off the front and back surfaces of the glass plate. The separation distance between the two reflected rays will depend on the thickness of the slab t and the angle of incidence. Figure 3: Sketch showing path of rays through glass plate Figure 4: Sketch showing geometry of the setup Fig. 4 shows part of the glass plate and the geometry needed to derive a relationship between d and t. Angle ABD = CBD = ADB is a right triangle and, therefore, we have The reflected and incident angles are equal and, therefore, we have angle CAE = 90 – $\theta 1$. From this it follows that in the right triangle AEC, angle ACE = which gives us (5) Combining Eq. (4) and Eq. (5), we get (6) tan $\theta 2$ = = . The objective of this experiment is to study the path of light rays due to reflection and refraction at plane surfaces and to verify the Law of Reflection in a plane mirror and Snell's Law of Refraction. Glass plate Laser Optic bench Vernier caliper Angular translator Rotational stage Please print the worksheet for this lab. You will need this sheet to record your data. Description of Apparatus: Laser We will use a HeNe laser with a wavelength of 632.8 nm. The power output of the laser is less than 1 mW so it cannot be used to burn holes in pieces of paper. However, it is sufficiently bright that it might cause eye damage if you stare into it. Caution: DO NOT STARE INTO THE LASER OR ITS REFLECTION. It is common practice to remove rings, watches, and other shiny objects to prevent inadvertent reflections. The laser is more stable after it has warmed up for a few minutes, so keep it turned on until you complete your experiment. It's a good idea, though, to close the shutter when the laser beam is not in use. Description of Apparatus: Optical Bench The optical bench has a scale along one edge—this edge should be facing you. The back edge of the bench is raised slightly and should be used to align everything placed on the bench. All of the optical equipment (laser, component carriers, angular translator) have metal strips attached to them and will, therefore, stick to the magnetized surface of the bench. Fig. 5 shows a photo of the optic bench. Figure 5: Optic bench Description of Apparatus: Angular Translator The angular translator is used to align optical components to within one degree. The top surface rotates so that an object can be moved through a certain angle. The translator also has a "stage holder" that rotates around the outside of the translator. This "stage holder" will be used to hold a scale. The photos below show two views of the translator and the stage holder. Figure 6: Side and top views of the angular translator Alignment of Apparatus 1 Set up the laser at the right end of the optical bench and the rotational stage at the left end of the bench with the 0° mark toward the laser. Make sure both pieces of equipment are flush against the raised back edge of the bench. 2 Turn the rotational stage until the arrow indicates exactly 0°. 3 Position the glass plate on the stage so that the laser beam is reflected from the front surface of the plate straight back onto the face of the laser. The glass plate must be positioned so that its front surface is directly over the center point (pivoting point) of the stage. This assures us that the laser beam will always strike the glass plate at the same place as you rotate the stage (see Fig. 7). Figure 7: Side and top view of glass plate on rotating surface 4 Now if the rotational stage is turned, the angle between the laser beam and the normal to the glass plate will be the angle indicated by the arrow on the stage—this is the angle of incidence. Whenever the stage is set to 0° the laser beam should be reflected straight back onto the laser. Once the apparatus is aligned you should not change the position of the laser or the position of the glass plate on the rotational stage. Fig. 8 shows the glass plate rotated through an angle The red line indicates the path of the light from the laser and the green line shows the position of the normal to the plate. Figure 8: Photo showing rotation of glass plate 5 With the stage set to 0°, rotate the screen holder to 180°. 6 Place the screen on the screen holder and position the screen so that the laser beam passing through the glass plate strikes the screen at the center point on the scale. No further adjustment of the screen should be made after this initial positioning. Procedure A: Measurement of Angle of Reflection 7 Set the rotational stage to the desired angle of incidence as described in step 4 and record this value in Data Table 1 on the worksheet. 8 Now rotate the screen holder until the laser beam reflected from the front surface of the glass plate strikes the screen at the center point on the scale. 9 The angle of reflection is the angular position of the screen holder minus the angular position of the rotational stage. Measure and record the angle of reflection for reflections from the surface of the glass plate. 10 Repeat steps 7 through 9 by changing in increments of 10° on both sides of the laser beam. 11 Using Excel, plot the angle of reflection versus the angle of incidence See Appendix G. 12 Model your results as and use the linest function in Excel to determine m and b. See Appendix J. Checkpoint 1: Ask your TA to check your table values, graph, and calculations. Procedure B: Measurement of Index of Refraction 13 Measure the thickness t of the plate with the calipers and record it in Data Table 2 on the worksheet. 14 Where possible, use the same values for as you did for in Procedure A. Make sure to use angles of incidence on both sides of the laser beam. 15 Repeat steps 7 through 10, but this time record in Data Table 2. Recall that d is the distance between the two reflected rays. The two red dots on the scale that is mounted on the stage holder (see Fig. 9) correspond to the images of the two reflected rays. Figure 9: Photo showing the two reflected images on the scale 17 Using Excel, graph versus and determine the slope of the graph using the linest function. 18 From the slope, determine the index of refraction of the plate. 19 Calculate the percent error between the experimental value and the accepted value of Checkpoint 2: Ask your TA to check your table values, graph, and calculations.

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