Refractive Index Using Hollow Cell and Percent Light Transmission Measurement:
Lab Worksheet Example Answers

Part 1. Refractive Index Using Hollow Cell
See the theoretical data below, based from Snell's law, using n=1.33 for water and n=1.47 for glycerin.

Table 1. Angle of refraction (θ_2) vs. changing angle of incidence (θ_1).

For water:

θ_1	θ_2	sin θ_1	sin θ_2
0°	0	0.0000	0.0000
5°	7	0.0872	0.1219
10°	13	0.1736	0.2250
15°	20	0.2588	0.3420
20°	27	0.3420	0.4540
25°	34	0.4226	0.5592
30°	42	0.5000	0.6691
35°	50	0.5736	0.7660
40°	59	0.6428	0.8572
45°	70	0.7071	0.9397
50°	start of TIR		

For glycerin:

θ_1	θ_2	sin θ_1	sin θ_2
0°	0	0.0000	0.0000
5°	7	0.0872	0.1219
10°	15	0.1736	0.2588
15°	22	0.2588	0.3746
20°	30	0.3420	0.5000
25°	38	0.4226	0.6157
30°	47	0.5000	0.7314
35°	57	0.5736	0.8387
40°	71	0.6428	0.9455
45°	start of TIR	0.0000	0.0000
50°			

TIR = total internal reflection

Plot Your Data
Plot your data in terms of sin θ_2 vs. sin θ_1. Label your graph. Determine the slope, which is your average refractive index. (Note: n_{air} = 1.00)
The answer graphs were plotted in Excel. The equation showing the slope corresponds to the refractive index of the liquid.

Determining the refractive index of water.

$$y = 1.3322x - 0.0006$$

(x-axis: sin θ_1, y-axis: sin θ_2)

Determining the refractive index of glycerin.

$$y = 1.4684x - 0.0022$$

(x-axis: sin θ_1, y-axis: sin θ_2)
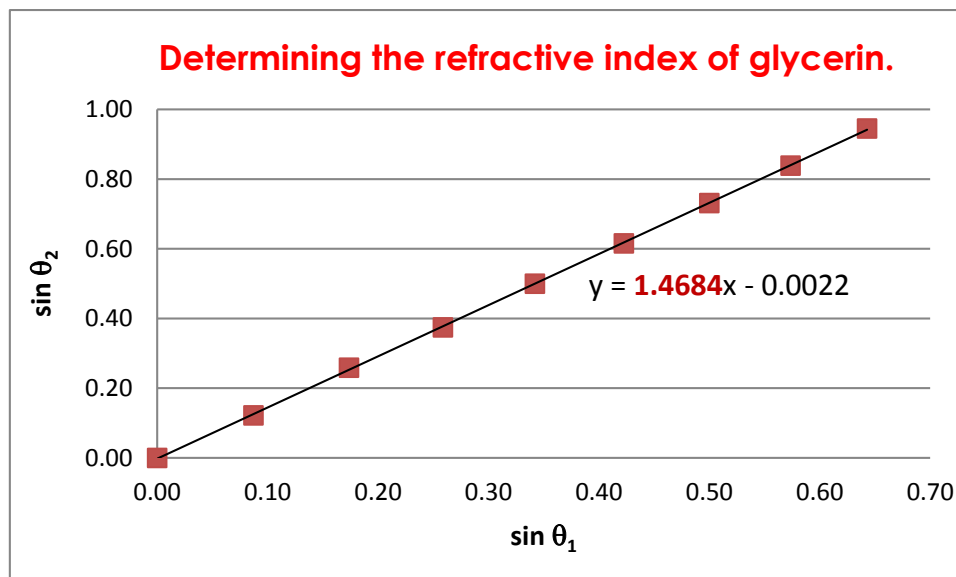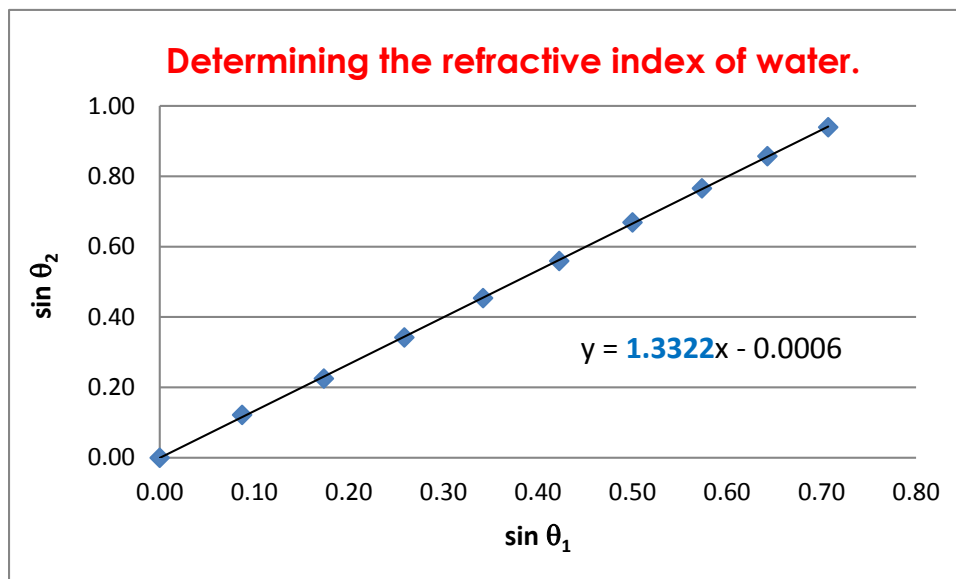
Analysis Questions

1. What is the first and second medium?
   The first medium is the liquid (water/glycerin) and the second medium is air.

2. What line shape does sin θ_2 vs. sin θ_1 create? Describe the line or the curve that you produce.
   The shape is a diagonal line (linear). As the sin θ_1 is increasing, sin θ_2 is also increasing.

3. What is the average refractive index of your liquid?
   It depends on the sample; for water, n=1.33, and for glycerin, n=1.47.

4. At what angle did you start to observe total internal reflection?
   It depends on the sample; for water=50º and for glycerin=45º

5. What is the identity of your unknown liquid? Explain your answer.
   Either water or glycerin. Explanations will vary, depending on students' results and calculations.

6. If you change the configuration of your setup to that shown to the right, would there be any difference? Explain. ➔

   There would be no difference in the calculated refractive index of the sample, although you would need to switch the first and second media. In the drawn setup, the first medium is air and the second medium is the liquid, which is the opposite of the original setup.
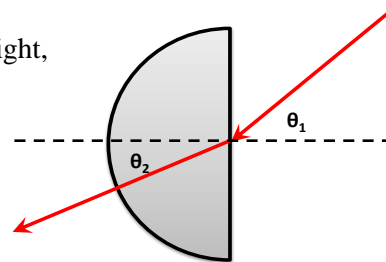
Part 2. Refractive Index Matching Using Percent Light Transmission Measurement

The values depend on the type of LED, laser and multimeter that are used, but expect the percent light intensity to be higher with liquid glycerin.
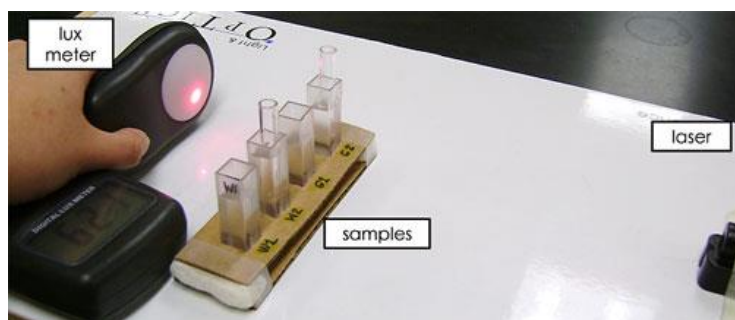
Table 2. Refractive index matching using % light transmission of particles on two different liquids.

Liquid	Light intensity (V)	$\%T = \dfrac{I}{I_o} x 100$
W1		With WATER (n=1.33):
W2		**Should be less than the %T with glycerin**
G1		With GLYCERIN (n=1.47)
G2		**Should be 100% or higher than the water %T.**

Analysis Questions

1. What is most likely the refractive index of the glass tube? Explain your answer.
   The refractive index is approximately 1.47. The %T calculated is higher when the glass tube is submerged on the glycerin liquid. As an additional observation, the glass tube is almost invisible when it is submerged in glycerin compared to when it is submerged in water.

2. Verify your results using a lux meter as the detector. (See the setup to the right ➔) A lux meter is a commercially available device used to determine light intensity. Did you get the same results as with the LED-multimeter detector? Describe what you observed.
   It depends on the meter that you are using and also the distance of the meter from the sample. But expect students to observe the same trend as with the LED-multimeter detector, that is, %T is higher with the glass tube submerged in glycerin.

Lab Reflection Questions

Write a paragraph answering the following questions. Your answer should have at least five sentences.
1. What is the purpose of this lab?
2. What are three things that you learned in this lab? (Write at least one sentence explaining each one.)
3. How does this lab connect to the real world?