

Student's Name:

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Lab day & time: __________
Date: _____

Intensity and Polarization of Light (E9) – Data Sheets and Procedure

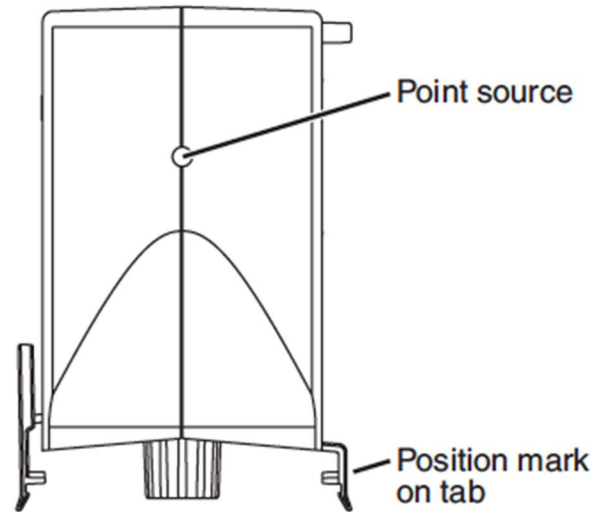
Write all results on the data sheets in ink.

Activity 1: Variation of Incandescent Light Intensity with Distance. (1.5 p.)

In this activity, you are going to measure the light intensity from a point source as a function of distance. Before you start collecting data, check the connections and the initial settings.

- Reduce the brightness of the monitor to 20%. To change the brightness, use buttons located on the front of the monitor.
- Make sure that the data interface is turned on.
- The rotary motion sensor should be connected to the DIGITAL CHANNEL #1 (the yellow plug) and #2 (black plug).
- The light sensor should be connected to the ANALOG CHANNEL A.

- 1.1. Download files for experiment E9 from Brightspace.
- 1.2. Find the document “E9, Activity 1” and open it. The application “Capstone” should open with configuration ready for Activity 1.
- 1.3. Attach the PASCO light source to the optics bench. Make sure that the small circular opening is facing the light sensor.



- 1.4. Attach the light sensor to the optics bench. Set the gain of the light sensor to “100” (use the slide on the top of the light sensor). Rotate the filter in front of the light sensor ("Aperture Bracket for Light Sensor") so that the open circular aperture is in front of the light sensor.
- 1.5. With the **light source turned off**, measure the light intensity. This is just the “background” light I_B coming from other sources. You will need to subtract that value

from all measurements. In this experiment, we use arbitrary units of the light intensity specified as a percentage of the maximum range.

$$I_B = \text{_____} (\%) \quad \text{Gain}_B = \text{_____} \quad I_B/\text{Gain}_B = \text{_____}$$

- 1.6. **Turn the light source on.** Measure the light intensity as a function of distance between the point light source and the light sensor. **When the reading is above 90%**, change the gain setting to a lower number, i.e., reduce the gain. **When the reading drops below 10%**, change the gain to a higher number, i.e., increase the gain. You need to set the distance manually and then click on the “Record” button. Remember that the halogen bulb is located inside the black plastic enclosure of the light source. You should measure the distance r using the bulb position mark located at the base of the light source and labeled: "POINT SOURCE". It should be about 3.0 cm from the outer surface of the light source case.

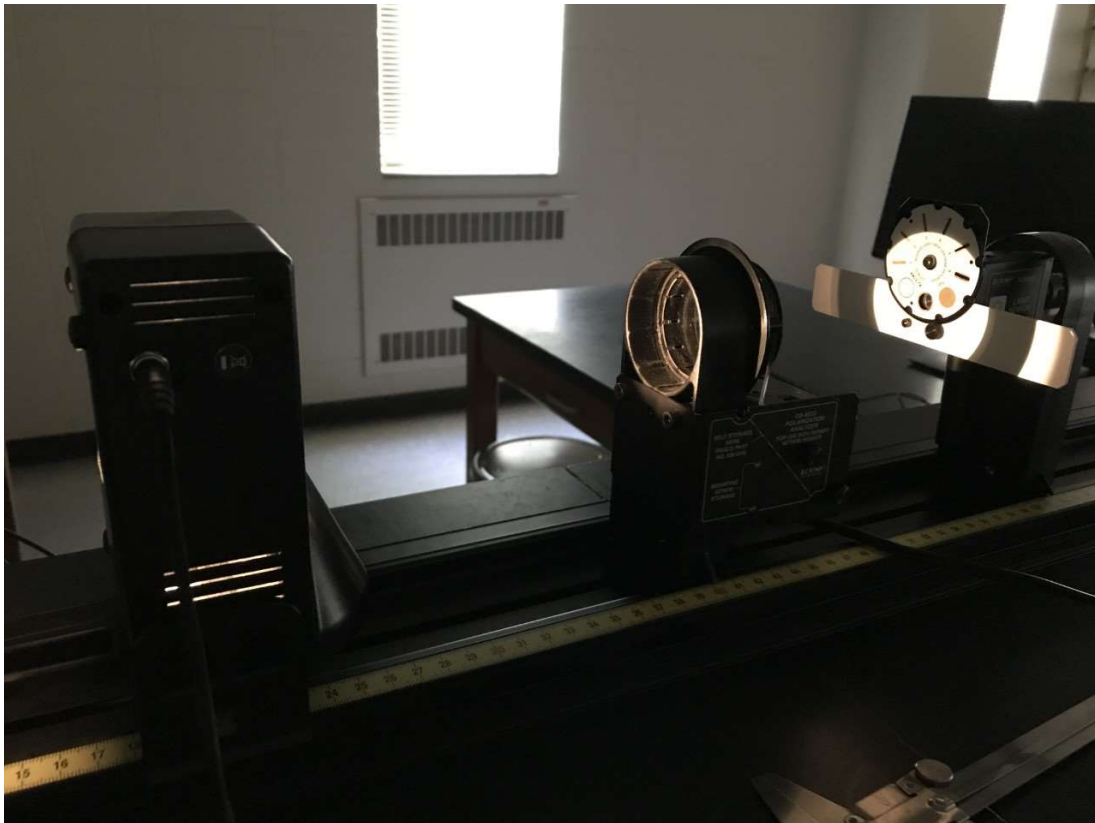
r (m)	$1/r^2$ (m^{-2})	Gain factor	I (%) / Gain	$I/\text{Gain} - I_B/\text{Gain}_B$ (%)
0.15				
0.20				
0.25				
0.30				
0.40				
0.50				
0.60				
0.80				

- 1.7. Prepare a graph showing the light intensity ($I/\text{Gain} - I_B/\text{Gain}_B$) from the point source as a function of $1/r^2$. According to equation (1), you should get a linear dependence. Try to fit a straight line to your data. The y-intercept of that fit should be close to zero. **Print** this graph and include it in your lab report.
- 1.8. Exit **Capstone**. **Do not save any changes!**


*Activity 2: Detection of Polarization.**(0.5 p.)*

In this activity, we are going to use the incandescent light source and detect if the light emitted by the incandescent lamp is polarized or not. Keep the fixed distance between the lamp and the sensor: $r = 0.35$ m.

- 2.1. We will use **only one polarizer** - the one with the rotary motion sensor attached to it (called polarization analyzer).
- 2.2. Make sure that **the polarizer is set to angle equal to zero**. A small knob at the bottom of the polarizer indicates the angle. The rotary motion sensor always uses the first data point to define zero. Therefore, **it is important to always start measurements with polarizers set to zero position**. Otherwise, the recorded angle would be incorrect. Setting the polarizer's angle to zero ($\theta = 0^\circ$) means that the light going through is **polarized vertically**.
- 2.3. Find the document “E9, Activities 2-3” and open it. You should see a graph of the light intensity I (using arbitrary units - % of the maximum range) versus the angle θ between the vertical and the polarization direction of the polarizer. Two small digital displays present the numerical values of the light intensity and the angle.





2.4. Set the gain of the light sensor to "100". Click on the  button. Initially, you won't see any data. **Gently rotate the polarizer slowly clockwise** (i.e., to increase the angle from zero to a positive value). After you reach the angle $\theta = 180^\circ$, the data acquisition will be complete. The computer will plot the light intensity as a function of the rotation angle θ . **Print** this graph and include in the lab report. If computer does not start collecting data when you move the sensor, then try reversing direction of the motion.

2.5. Do you see any clear angular dependence when you rotate the polarizer?

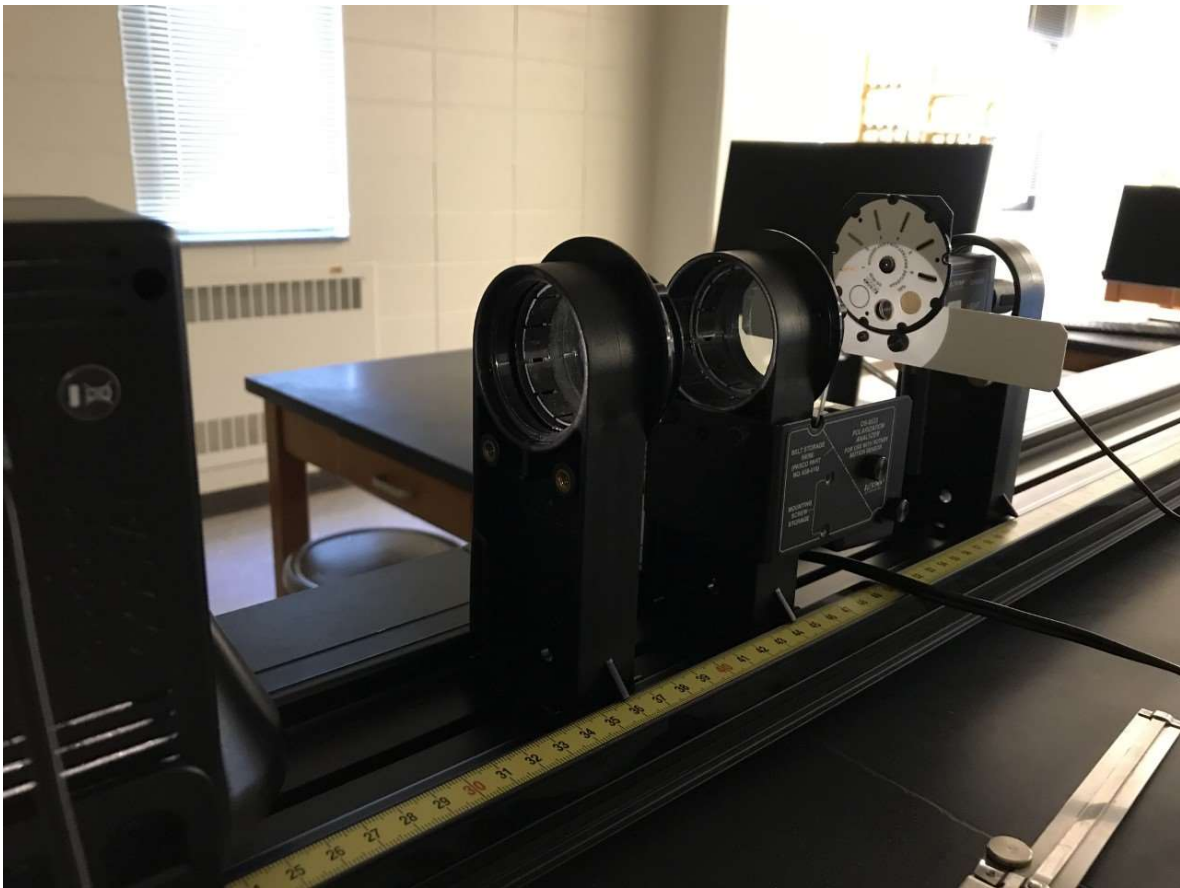
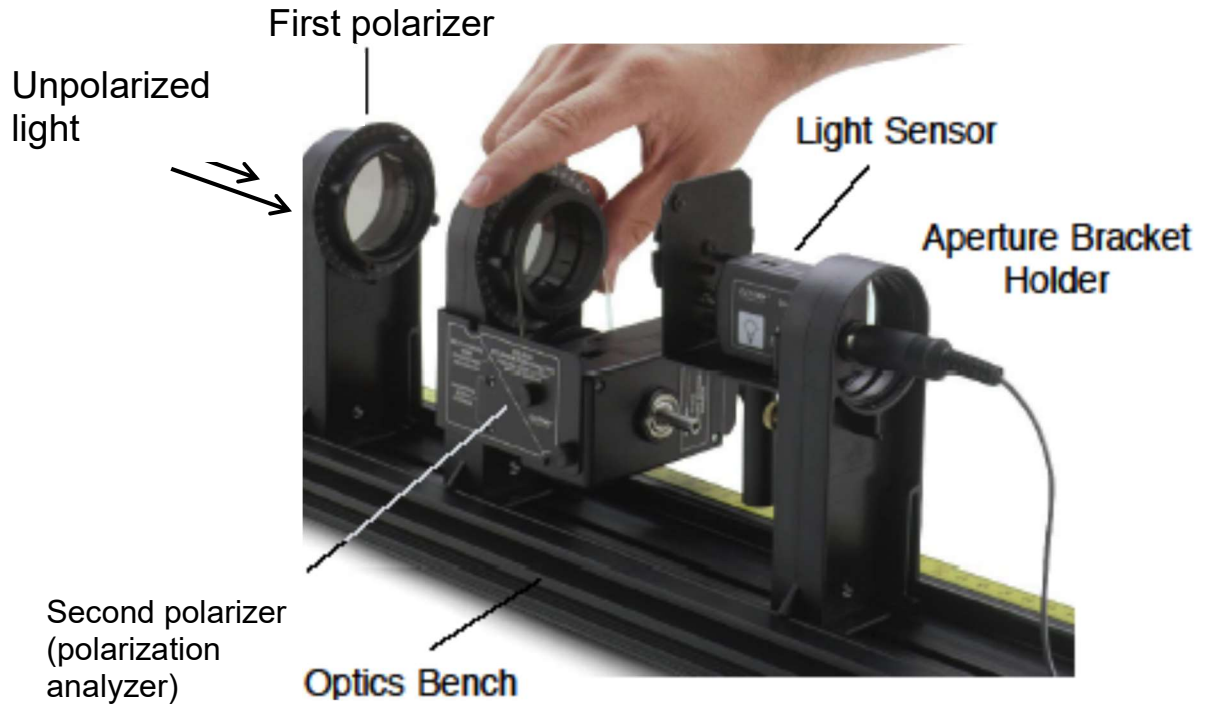
2.6. Is the light coming from an incandescent bulb polarized?

Activity 3: Polarization by Absorption – Malus's Law.

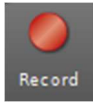
(1.5 p.)

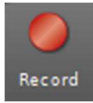
In this activity, you will use two polarizers and measure the light intensity as a function of the angle between the orientations of the two polarizers. The first polarizer polarizes the incident light, whereas the second polarizer allows detection and analysis of the polarized light.

- 3.1. **Add another polarizer** (the one without rotary motion sensor) between the light source and the polarizer that was already there (the one with the rotary motion sensor attached to it). This additional polarizer converts unpolarized light from the incandescent light source into linearly polarized light. Using the second polarizer (the one with the rotary motion sensor attached to it), you should analyze how the light intensity changes with rotation of the second polarizer. You should have the following items on the optics bench in this order: the incandescent light source, the first polarizer, and the second polarizer with the rotary motion sensor and the light sensor. Keep the fixed distance between the lamp and the sensor: $r = 0.35$ m.
- 3.2. Set the gain of the light sensor to "100".



- 3.3. Make sure that **both polarizers are set to angle equal to zero**. A small knob at the bottom of the polarizer indicates the angle. You should keep the first polarizer at zero and rotate the second polarizer (also called the polarization analyzer) to measure the angle between the polarization planes of the first and the second polarizers. The rotary motion sensor always uses the first data point to define zero. Therefore, **it is important to always start measurements with both polarizers set to zero position**. Otherwise, the recorded angle would be incorrect. Setting the polarizer's angle to zero ($\theta = 0^\circ$) means that the light going through is **polarized vertically**.
- 3.4. Check and make sure that “E9, Activities 2-3” is still open. You should see a graph of the light intensity I (using arbitrary units - % of the maximum range) versus the angle θ between the polarization planes of the first and the second polarizer. Two small digital displays present the numerical values of the light intensity and the angle.



- 3.5. Click on the  button. Initially, you won't see any data. **Gently rotate the second polarizer slowly clockwise** (i.e., to increase the angle from zero to a positive value). After you reach the angle $\theta = 180^\circ$, the data acquisition will be complete. The computer will plot the light intensity as a function of the rotation angle θ . If computer does not start collecting data when you move the sensor, then try reversing direction of the motion.
- 3.6. The computer should try to fit the intensity vs. angle θ function predicted by the Malus Law (Eq. (3)): the function: $I = I_0 \cos^2 \theta + I_1$. In Capstone, the function is called “Cosine Squared” and is described by the following formula.

$$I = A * \cos^2(B * \theta + \varphi) + C$$

The last equation is identical with the Malus Law if:

$$A = I_0 \quad \text{and} \quad B = 1 \quad \text{and} \quad C = I_1.$$

Parameter φ is called “phase” and it depends on the starting position. Parameter A is simply the amplitude of the light intensity I_0 . Parameter C should be equal to zero, but due to imperfect polarizers is often larger than zero.

- 3.7. Record the measured fitting parameters:

$$A = \underline{\hspace{2cm}} (^\circ) \quad B = \underline{\hspace{2cm}} (^\circ) \quad C = \underline{\hspace{2cm}} (^\circ)$$

$$\varphi = \underline{\hspace{2cm}}$$

- 3.8. **Print** this graph. Does your measurement agree with the law of Malus? Please, briefly **explain** why you think it does (or why you think that it doesn't) agree with the prediction of the law of Malus.

- 3.9. **Do not save any changes!**

Remove all polarizers from the optics bench.

Complete the lab report and return it to the lab TA.