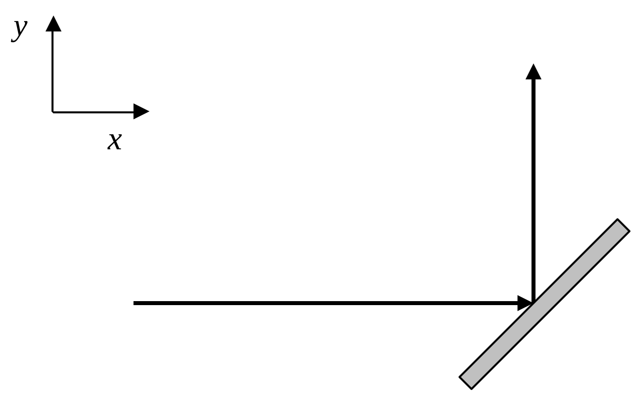
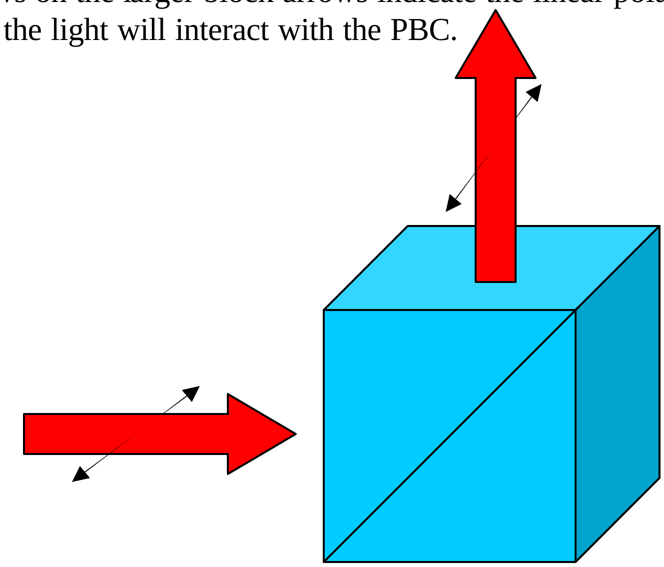
Physics 345 Pre-Lab 8 Polarization

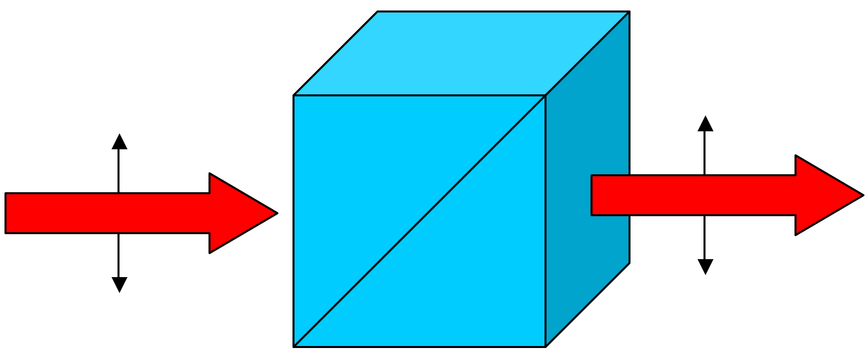
1. A linearly polarized laser beam reflects off an ideal metallic mirror as shown below. The electric field of the laser beam oscillates in the $\pm\hat{z}$ direction before the laser beam interacts with the mirror. Describe the laser beam's polarization after the mirror. HINT: You do NOT have to use Fresnel Coefficients.
2. A linearly polarized laser beam reflects off an ideal metallic mirror as shown below. The electric field of the laser beam oscillates in the $\pm\hat{y}$ direction before the laser beam interacts with the mirror. Describe the laser beam's polarization after the mirror. HINT: You do NOT have to use Fresnel Coefficients.
3. A linearly polarized laser beam reflects off an ideal metallic mirror as shown below. The electric field of the laser beam oscillates in the $\pm\frac{1}{\sqrt{2}}(\hat{y}+\hat{z})$ direction before the laser beam interacts with the mirror. Describe the laser beam's polarization after the mirror. HINT: You do NOT have to use Fresnel Coefficients.



Physics 345 Lab 8 Polarization

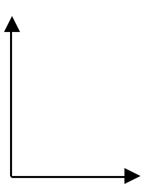
For much of this investigation you will use the semiconductor laser. Semiconductor lasers have a non-circular beam cross-section (its shaped like a football). To begin this experiment, you must first determine the polarization of the laser beam. An easy way to accomplish this is through the use of a Polarizing Beamsplitting Cube (PBC). The small arrows on the larger block arrows indicate the linear polarization of the electric field and how the light will interact with the PBC.



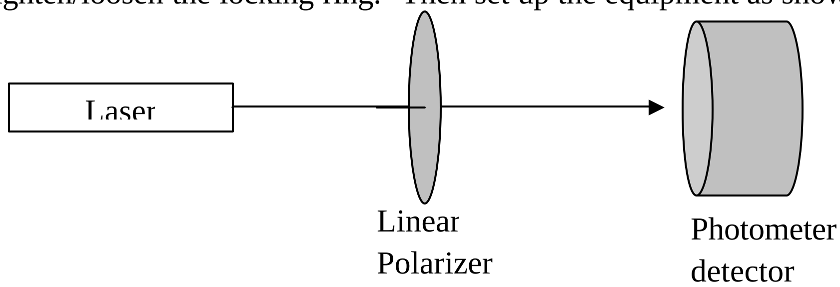


Use the PBC to determine the polarization of your laser beam. As always when using lasers, make sure the beam is traveling parallel with the optical table top at all times and you terminate the laser beam so that it does not travel off the optics table. Put the PBC on a prism holder. One of the frosted sides of the PBC should rest on the prism holder to protect the clear optical surfaces. Next, rotate the laser inside its mount so that the laser beam is polarized as the top PBC diagram (shown above). **When rotating the laser make sure you don't touch the shiny metal ring in the front.** Measure the ratio of the laser light power transmitted through the PBC and the laser light reflected by the PBC. Draw a sketch of the laser beam cross-section below.

Vertical

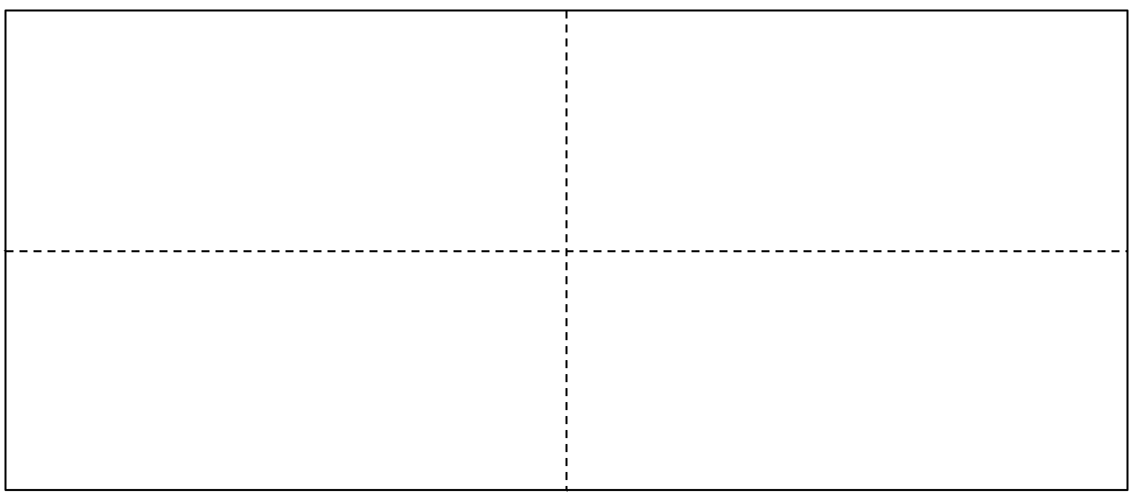


Put a linear polarizer in a plate rotator. Make sure you use the spanner wrench to tighten/loosen the locking ring. Then set up the equipment as shown below.



Rotate the linear polarizer to minimize the transmitted laser beam power. We will call this 0° and we will keep this definition throughout the rest of the investigation. NOTE: This designation more than likely does not agree with the values on the rotation stage.

Predict how the power of the transmitted light will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. polarizer's angle.

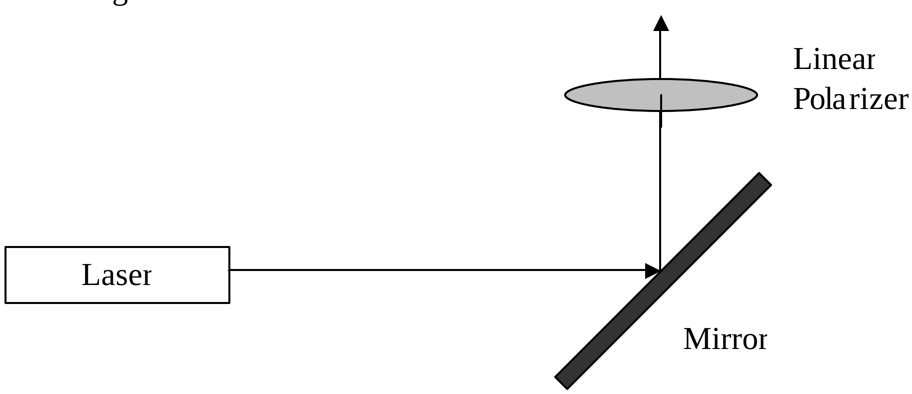


Explain your reasoning for the above sketch:

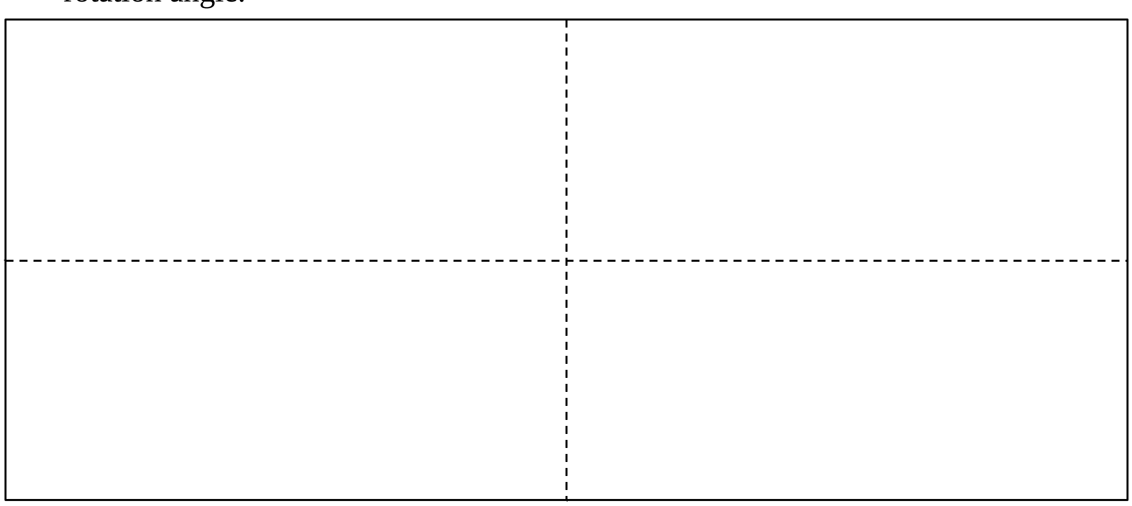
Now rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

$\theta = 0°$		$\theta = 120°$		$\theta = 240°$	
$\theta = 15°$		$\theta = 135°$		$\theta = 255°$	
$\theta = 30°$		$\theta = 150°$		$\theta = 270°$	
$\theta = 45°$		$\theta = 165°$		$\theta = 285°$	
$\theta = 60°$		$\theta = 180°$		$\theta = 300°$	
$\theta = 75°$		$\theta = 195°$		$\theta = 315°$	
$\theta = 90°$		$\theta = 210°$		$\theta = 330°$	
$\theta = 105°$		$\theta = 225°$		$\theta = 345°$	

Make sure you turn your linear polarizer back to 0° before proceeding. Now consider the following circumstance.



Keeping the same definition of 0° (regardless of whether it will now minimize the light in this set up), predict the shape of a plot of the transmitted laser beam power vs. rotation angle.

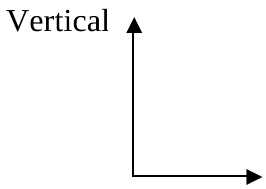


Explain your reasoning for the above sketch:

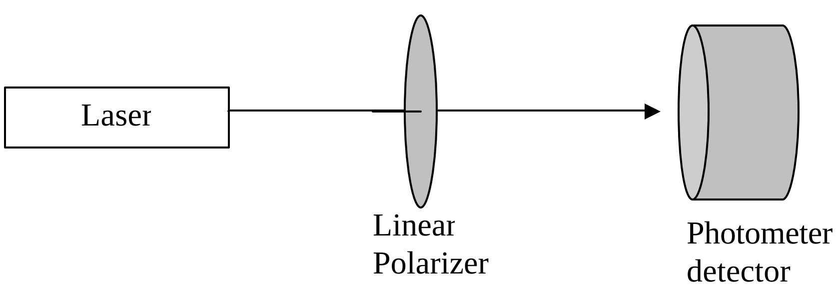
Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

Rotate the laser inside its mount so that the laser beam is polarized as the bottom PBC diagram on page 2 above. Measure the ratio of the laser light power transmitted through the PBC and the laser light reflected by the PBC. Draw a sketch of the laser beam cross-section below.



Then set up the equipment as shown below.



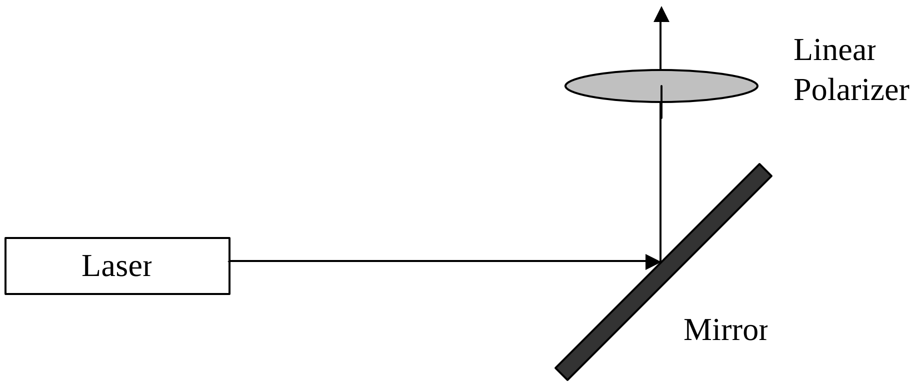
Using the same 0° angle for the linear polarizer as you used on page 3, predict how the power of the transmitted light will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. polarizer's angle.

Explain your reasoning for the above sketch:

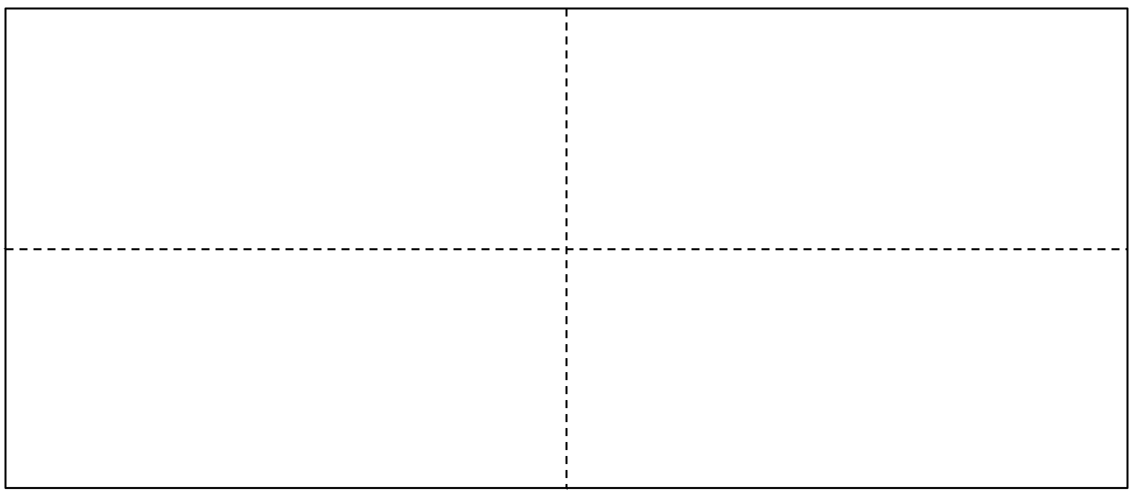
Now rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

Now consider the following circumstance.



Keeping the same definition of 0° (regardless of whether it will now minimize the light in this set up), predict the shape of a plot of the transmitted laser beam power vs. rotation angle.

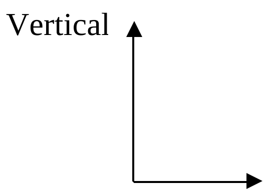


Explain your reasoning for the above sketch:

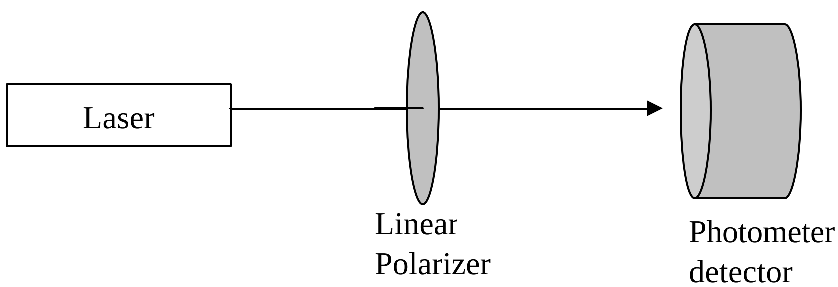
Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

$\theta = 0°$		$\theta = 120°$		$\theta = 240°$	
$\theta = 15°$		$\theta = 135°$		$\theta = 255°$	
$\theta = 30°$		$\theta = 150°$		$\theta = 270°$	
$\theta = 45°$		$\theta = 165°$		$\theta = 285°$	
$\theta = 60°$		$\theta = 180°$		$\theta = 300°$	
$\theta = 75°$		$\theta = 195°$		$\theta = 315°$	
$\theta = 90°$		$\theta = 210°$		$\theta = 330°$	
$\theta = 105°$		$\theta = 225°$		$\theta = 345°$	

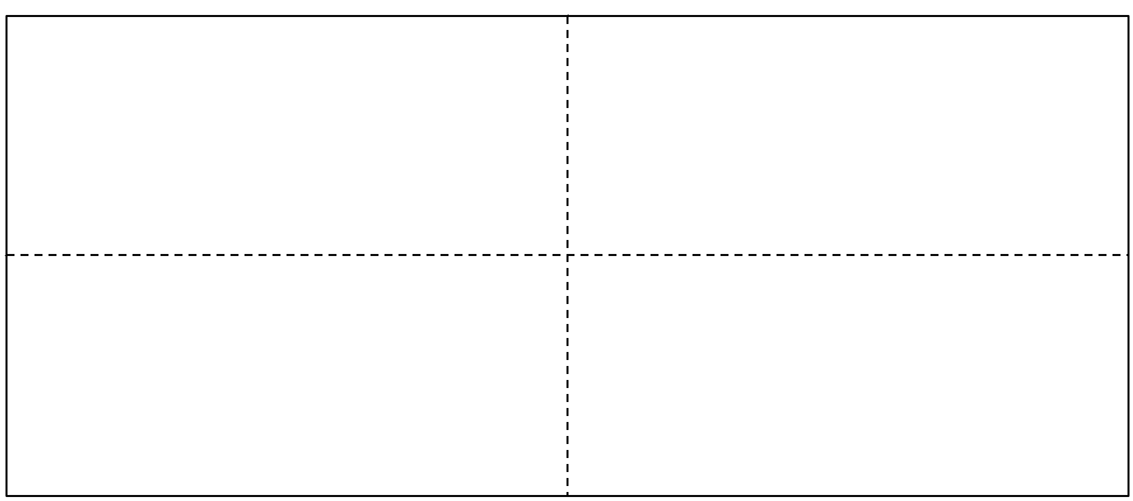
Next, rotate the laser inside its mount so that half the laser beam power is transmitted through the PBC and the other half is reflected by the PBC . Measure the ratio of the laser light power transmitted through the PBC and the laser light reflected by the PBC. Draw a sketch of the laser beam cross-section below.



Then set up the equipment as shown below.



Using the same 0° angle for the linear polarizer as you used on page 3, predict how the power of the transmitted light will change as a function of the linear polarizer's angle. That is, make a plot of the transmitted laser beam power vs. polarizer's angle.

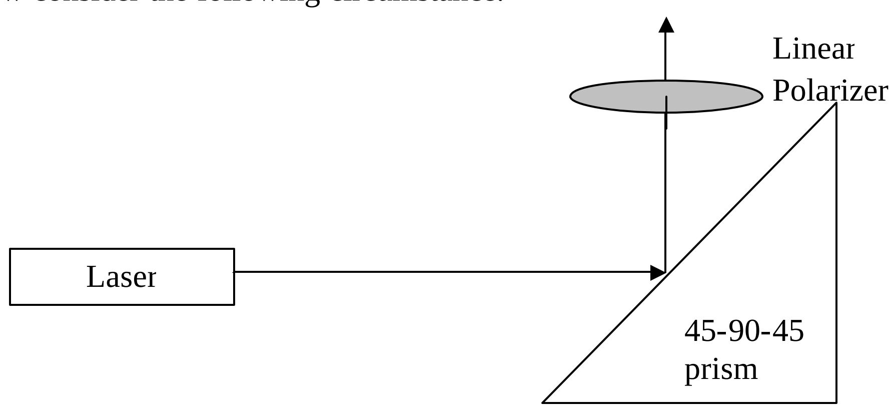


Explain your reasoning for the above sketch:

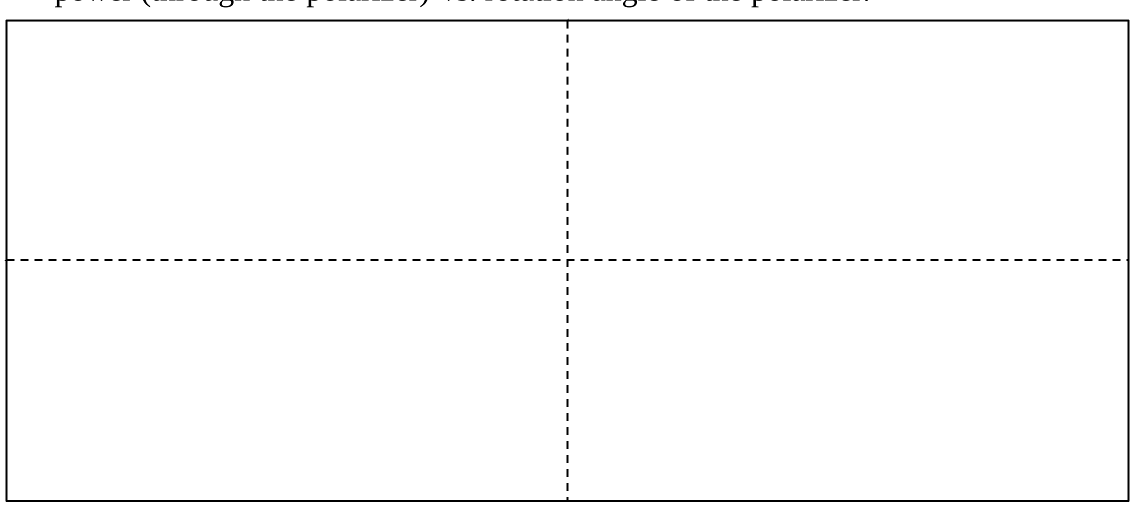
Now rotate the linear polarizer by iterations of 15° until you rotate 360°. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

Now consider the following circumstance.



Keeping the same definition of 0° (regardless of whether it will now minimize the light in this new set up), predict the shape of a plot of the transmitted laser beam power (through the polarizer) vs. rotation angle of the polarizer.

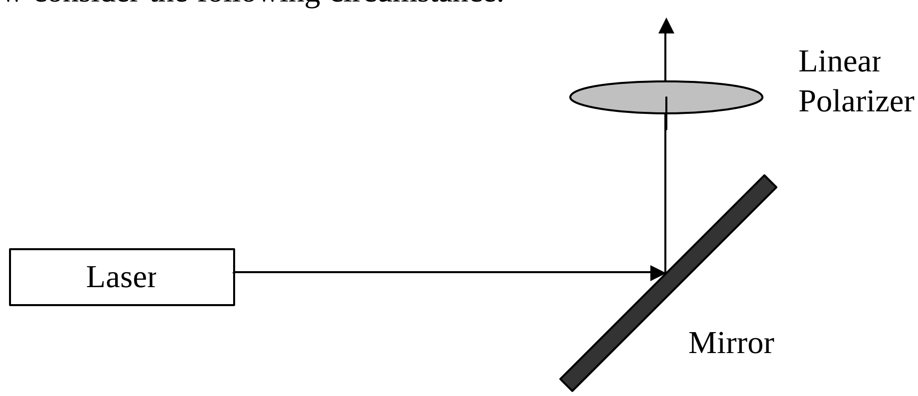


Explain your reasoning for the above sketch:

Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

θ = 0°		θ = 120°		θ = 240°	
θ = 15°		θ = 135°		θ = 255°	
θ = 30°		θ = 150°		θ = 270°	
θ = 45°		θ = 165°		θ = 285°	
θ = 60°		θ = 180°		θ = 300°	
θ = 75°		θ = 195°		θ = 315°	
θ = 90°		θ = 210°		θ = 330°	
θ = 105°		θ = 225°		θ = 345°	

Now consider the following circumstance.



Keeping the same definition of 0° (regardless of whether it will now minimize the light in this new set up), predict the shape of a plot of the transmitted laser beam power vs. rotation angle.

Explain your reasoning for the above sketch:

Now set up the above condition and test your predictions. Complete the table and then using Excel plot your results. Compare to your predictions. Resolve any differences.

$\theta = 0°$		$\theta = 120°$		$\theta = 240°$	
$\theta = 15°$		$\theta = 135°$		$\theta = 255°$	
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$\theta = 45°$		$\theta = 165°$		$\theta = 285°$	
$\theta = 60°$		$\theta = 180°$		$\theta = 300°$	
$\theta = 75°$		$\theta = 195°$		$\theta = 315°$	
$\theta = 90°$		$\theta = 210°$		$\theta = 330°$	
$\theta = 105°$		$\theta = 225°$		$\theta = 345°$	

Consider the following circumstance. Suppose you set up a complicated laser experiment with multiple mirrors. However, you want to maintain the laser beam's linear polarization throughout the optical path. What linear polarization (if any) will accomplish this?