Light Through Filters

Model how filter angle changes transmitted light

HS-PSII-9.6 "Develop graphical and mathematical representations that describe the relationship between the angle between two polarizing filters and the intensity of light passed through the filters from an unpolarized light source and apply those..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the two equations and circle the phrases that name the graph's axes. These marks will help you connect the calculation to the graph.

Turning Down the Light

1. A camera faces sunlight reflected from a window. Sunlight arriving at the first polarizing filter is treated as unpolarized: its electric fields vibrate in many directions. An ideal first filter transmits half the incident intensity and leaves light polarized along its transmission axis. Rotating a second filter changes how much of that light gets through.

2. Let I_{in} be the intensity before the first filter, and let θ be the angle between the two transmission axes. After the first filter, $I_1 = I_{in}/2$. After the second, Malus's law gives $I_{out} = I_1 \cos^2(\theta)$. To model both filters, substitute $I_{in}/2$ for I_1. Use degree mode when calculating angles in degrees.

3. The table records the intensity after both ideal filters for an unpolarized source with an incident intensity of 120 units. Plotting angle on the horizontal axis and transmitted intensity on the vertical axis gives a curve, not a straight line. Each plotted value comes from the same equation, so you can predict values between the listed angles.

LIGHT PASSING THROUGH TWO FILTERS

Angle between axes (degrees)	Intensity after both filters (units)
0	60
30	45
60	15
90	0

2 ANSWER WITH EVIDENCE

Use the passage

1. At 30°, what fraction of the original 120 units passes through both filters? Show your ratio.

2. Use the equations to predict the intensity after both filters at 45° for this 120-unit source. Show your calculation.

3. If the angle changes from 30° to 60°, by how many units does the intensity fall? What is the percent decrease?

4. A student says doubling the angle from 30° to 60° halves the intensity. Use the table to test the claim, then name the part of the equation that accounts for the result.

3 YOUR TURN

Your own words

On the grid, graph the predicted intensity after both ideal filters for an unpolarized 80-unit source at 0°, 30°, 45°, 60°, and 90°. Label both axes, draw a smooth curve through the points, then show one calculation and write one sentence describing how intensity changes.



ANSWER KEY

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HIGH SCHOOL · HS-PSII-9.6

PART 1 · READ AND MARK

Underline the two equations and circle the phrases that name the graph's axes. These marks will help you connect the calculation to the graph. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	At 30°, what fraction of the original 120 units passes through both filters? Show your ratio.	**45/120 = 3/8 of the incident intensity.**
2	Use the equations to predict the intensity after both filters at 45° for this 120-unit source. Show your calculation.	**$I_{out} = (120/2)\cos^2(45°) = 60(0.5) = 30$ units.**
3	If the angle changes from 30° to 60°, by how many units does the intensity fall? What is the percent decrease?	**It falls by 45 − 15 = 30 units. The decrease is 30/45 × 100% ≈ 66.7%.**
4	A student says doubling the angle from 30° to 60° halves the intensity. Use the table to test the claim, then name the part of the equation that accounts for the result.	**The claim is false: intensity changes from 45 to 15 units, or to one-third of its earlier value. The $\cos^2(\theta)$ factor accounts for the change.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Graph: horizontal axis, angle between axes (degrees), 0 to 90; vertical axis, intensity after both filters (units), 0 to 40. Plot (0, 40), (30, 30), (45, 20), (60, 10), and (90, 0), then connect them with a smooth decreasing curve. Calculation: $I_{out} = (80/2)\cos^2(30°) = 30$ units. As the angle increases from 0° to 90°, the transmitted intensity decreases to zero.

Accept equivalent fractions and reasonable rounding of the percent decrease. For the graph, accept a smooth curve consistent with the plotted points, not straight segments as a model of the relationship.