

Bending light: refraction, critical angle and lenses

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab

Name: _____ Date: _____ Class: _____

How can you find the refractive index of a glass block using only pins, paper and a protractor? In this lab you trace rays through a block, measure the angles of incidence and refraction, and use the results to calculate n .

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** IGCSE 3.2

Aim

To measure the refractive index of a rectangular glass or acrylic block by tracing a ray through it and to test that $\sin i \div \sin r$ stays constant.

Equipment

- Rectangular glass or acrylic block
- Four pins
- Sheet of plain A4 paper on a corkboard or thick cardboard
- Protractor and sharp pencil
- Ruler
- Calculator

Safety

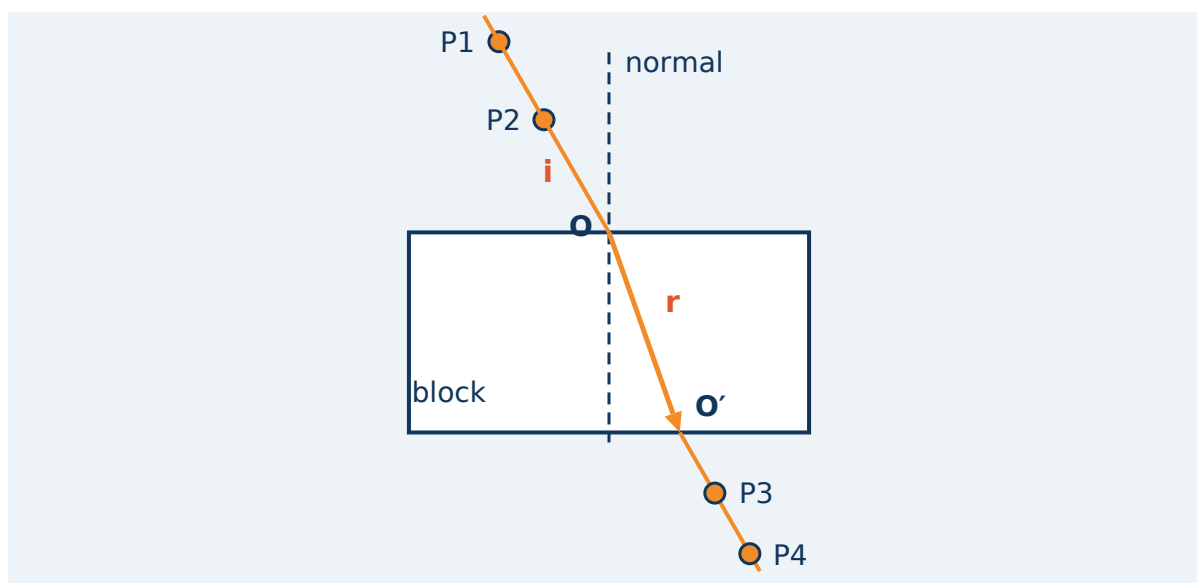
Safety

Pins are sharp. Push them in carefully into the board and never hold a pin pointing at your hand or face. Put the block down away from the table edge.

Method

1. Place the block on the paper and draw round it. Remove it, mark point O on the top edge and draw the normal there.
2. Use the protractor to draw a line from O at $i = 15^\circ$, then replace the block in its outline.
3. Push pins P1 and P2 upright on the line, about 8 cm apart.
4. Look through the block from the opposite side and place P3 and P4 so that all four pins appear in one straight line.

5. Remove the block and pins. Draw a line through P3 and P4 to the bottom edge, meeting it at O', and join O to O'.
6. Measure the angle r between OO' and the normal inside the block.
7. Repeat for $i = 20^\circ, 30^\circ, 40^\circ, 50^\circ, 60^\circ$ and 70° .



Top view. Sight along P1 and P2 through the block, then place P3 and P4 so all four pins line up.

Results

Sample measurements from a glass block (angles to the nearest degree):

$i (^{\circ})$	$r (^{\circ})$	$\sin i$	$\sin r$	$\sin i \div \sin r$
15	10	0.259	0.174	1.49
20	13	0.342	0.225	1.52
30	19	0.500	0.326	1.54
40	25	0.643	0.423	1.52
50	31	0.766	0.515	1.49
60	35	0.866	0.574	1.51
70	39	0.940	0.629	1.49

Analysis questions

Question 1 Plot the graph

Plot $\sin i$ (y-axis) against $\sin r$ (x-axis) for the sample data and draw a line of best fit through the origin.

Question 2 Gradient

Determine the gradient of your line and state what it represents.

Question 3 Mean value

Calculate the mean of the last column of the table and compare it with the gradient.

Question 4 Critical angle

Use your refractive index to predict the critical angle of the block.

Question 5 Sources of error

Suggest two sources of error in locating the pins and in reading r .

Question 6 Why a wide spacing

Explain why P1 and P2 should be far apart rather than close together.

Question 7 Improvement

Suggest one improvement that would give a more precise value of n .