Refraction of light rays

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Today's main work

1 Answering questions from 'Refraction 3' sheet

Refraction III

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Take the refractive index of glass to be 1.50, and water to be 1.33.

1. Find the angle of refraction when...
   (a) ...a ray of light is travelling from air to glass at an angle of incidence of 40°.
   (b) ...a ray of light is travelling from glass to air at an angle of incidence of 20°.
2. A ray of light is incident on the surface of a glass block. The angle of incidence is 60°. Calculate the angle of refraction.
3. A ray of light is incident on a glass–water boundary. The angle of incidence is 50°. Calculate the angle of refraction.
4. A ray of light is incident on a flat surface of an ice block, at an angle of incidence of 24°. If the refractive index of ice is 1.31 , calculate
   (a) the angle of refraction of the ray,
   (b) the angle through which the ray is deviated upon entering the block.
5. Calculate the angle of refraction and the angle through which the ray is deviated when a light ray travels...
   (a) from air to water with an angle of incidence of 48°.
   (b) from water to glass at an angle of 24°.
6. *A narrow beam of white light strikes one face of an equilateral glass prism as shown in the diagram. The angle of incidence is 40°.

   The colours in the white light refract by different amounts. If the refractive index of red light is 1.53, and that of violet light is 1.55, calculate the angular separation of the red and violet rays in the spectrum produced by the prism.
7. **For light incident on the surface of e.g. glass or water, the Brewster angle θ_B is the angle of incidence for which the reflected ray is completely plane polarized horizontal to the surface. This occurs when the angle between the refracted ray and the reflected ray is 90°. Can you work out θ_B using Snell's law if you know the refractive indices n_1 and n_2? (*Hint:* Remember that $\sin(90^\circ - \theta^\circ) = \cos\theta^\circ$.)

Lesson Objectives

1. To be able to answer refraction questions.
2. To understand why total internal reflexion occurs.

Textbook pp. 188–192

REMINDER: Office hours are week 2 Tuesdays 3.45–5.0 p.m. in room 19.
Next office hours: Tuesday 23 February 2012

Specification Requirement

Refraction at a plane surface

Refractive index of a substance s, $n = \frac{c}{c_s}$

Candidates are not expected to recall methods for determining refractive indices.

Law of refraction for a boundary between two different substances of refractive indices n_1 *and* n_2 *in the form*

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

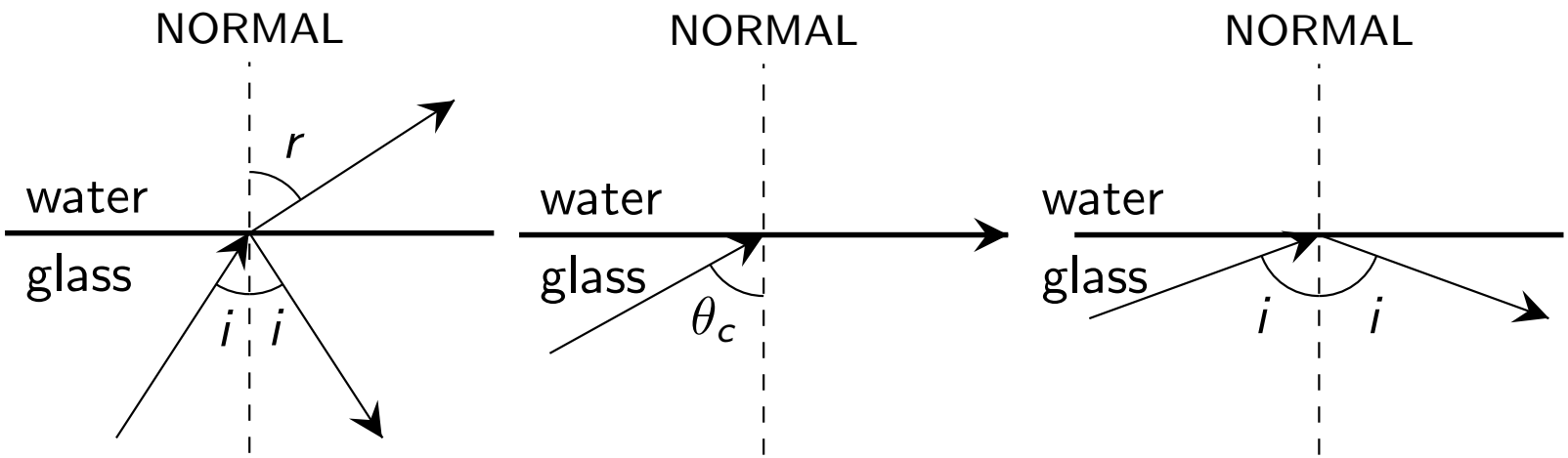
Total internal reflection including calculations of the critical angle at a boundary between a substance of refractive index n_1 *and a substance of lesser refractive index* n_2 *or air;*

$$\sin\theta_c = \frac{n_2}{n_1}$$

Simple treatment of fibre optics including function of the cladding with lower refractive index around central core limited to step index only; application to communications.

[AQA GCE AS and A Level Specification Physics A, 2009/10 onwards]

Total internal reflexion



Calculating critical angle

e.g. For light travelling from glass ($n_1 = 1.52$) into air ($n_2 = 1$), we can find θ_c using Snell's law and the fact that θ_c is the angle of incidence for which the angle of refraction is $90°$:

$$\begin{aligned} n_1 \sin\theta_1 &= n_2 \sin\theta_2 \\ \sin\theta_1 &= \frac{n_2 \sin\theta_2}{n_1} \\ \sin\theta_c &= \frac{1 \times \sin(90°)}{1.52} \\ &= 41.1°. \end{aligned}$$