

## Exercise 14 – Refraction of Light

### Past Paper Homework Questions

1. A ray of light passes from air into a substance that has a refractive index of 2.0. In air, the light has a wavelength  $\lambda$  and frequency  $f$ .

Which row in the following table gives the wavelength and frequency of the light in the substance?

	Wavelength	Frequency
A	$\lambda$	$f$
B	$\lambda/2$	$f/2$
C	$\lambda/2$	$f$
D	$2\lambda$	$2f$
E	$2\lambda$	$f$

2. The spectrum of white light from a filament lamp may be viewed using a prism or a grating.

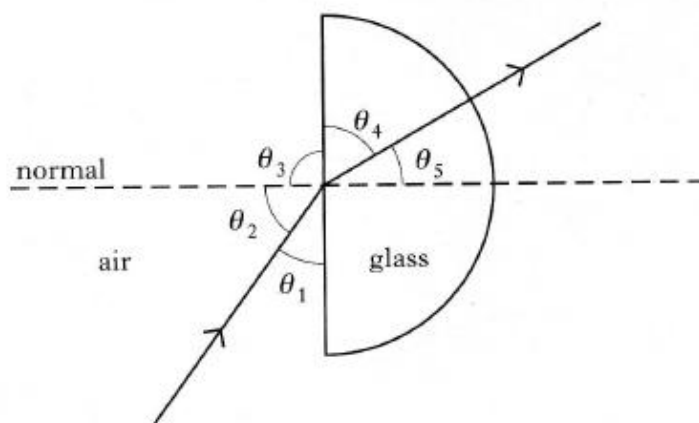
A student, asked to compare the spectra formed by the two methods, made the following statements.

- I The prism produces a spectrum by refraction. The grating produces a spectrum by interference.
- II The spectrum formed by the prism shows all the wavelengths present in the white light. The spectrum formed by the grating shows only a few specific wavelengths.
- III The prism produces a single spectrum. The grating produces more than one spectrum.

Which of the above statements is/are true?

- A I only  
 B II only  
 C I and II only  
 D I and III only  
 E I, II and III

3. The diagram below shows a ray of red light passing through a semicircular block of glass.

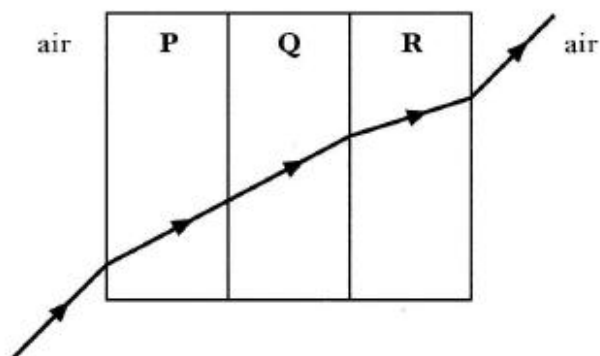


The refractive index of the glass for this light can be calculated from

- A  $\frac{\sin \theta_3}{\sin \theta_4}$   
 B  $\frac{\sin \theta_1}{\sin \theta_4}$   
 C  $\frac{\sin \theta_2}{\sin \theta_5}$   
 D  $\frac{\sin \theta_2}{\sin \theta_4}$   
 E  $\frac{\sin \theta_1}{\sin \theta_5}$

4. An engineer creates an experimental window using sheets of transparent plastics **P**, **Q** and **R**.

A ray of light directed at the window follows the path shown.



Which row in the table gives possible values for the refractive indices of the three plastics?

	<i>P</i>	<i>Q</i>	<i>R</i>
A	1.5	1.9	2.3
B	1.5	1.5	2.3
C	2.3	2.3	1.5
D	2.3	1.9	1.5
E	1.5	1.5	1.2

6. A liquid and a solid have the same refractive index.

What happens to the speed and the wavelength of light passing from the liquid into the solid?

	<i>Speed</i>	<i>Wavelength</i>
A	stays the same	stays the same
B	decreases	decreases
C	decreases	increases
D	increases	increases
E	increases	decreases

5. Microwaves of frequency  $2.0 \times 10^{10}$  Hz travel through air with a speed of  $3.0 \times 10^8$  ms<sup>-1</sup>. On entering a bath of oil, the speed reduces to  $1.5 \times 10^8$  ms<sup>-1</sup>.

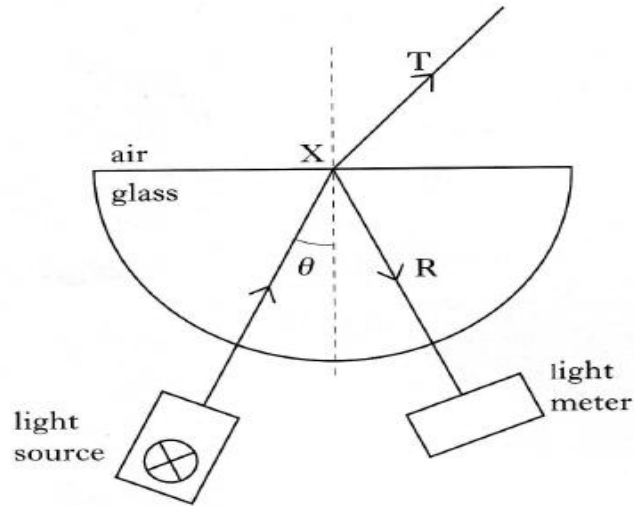
The frequency of the microwaves in the oil is

- A  $1.0 \times 10^{10}$  Hz
- B  $2.0 \times 10^{10}$  Hz
- C  $4.0 \times 10^{10}$  Hz
- D  $3.0 \times 10^{18}$  Hz
- E  $6.0 \times 10^{18}$  Hz.

7. A student is investigating the effect that a semicircular glass block has on a ray of monochromatic light.

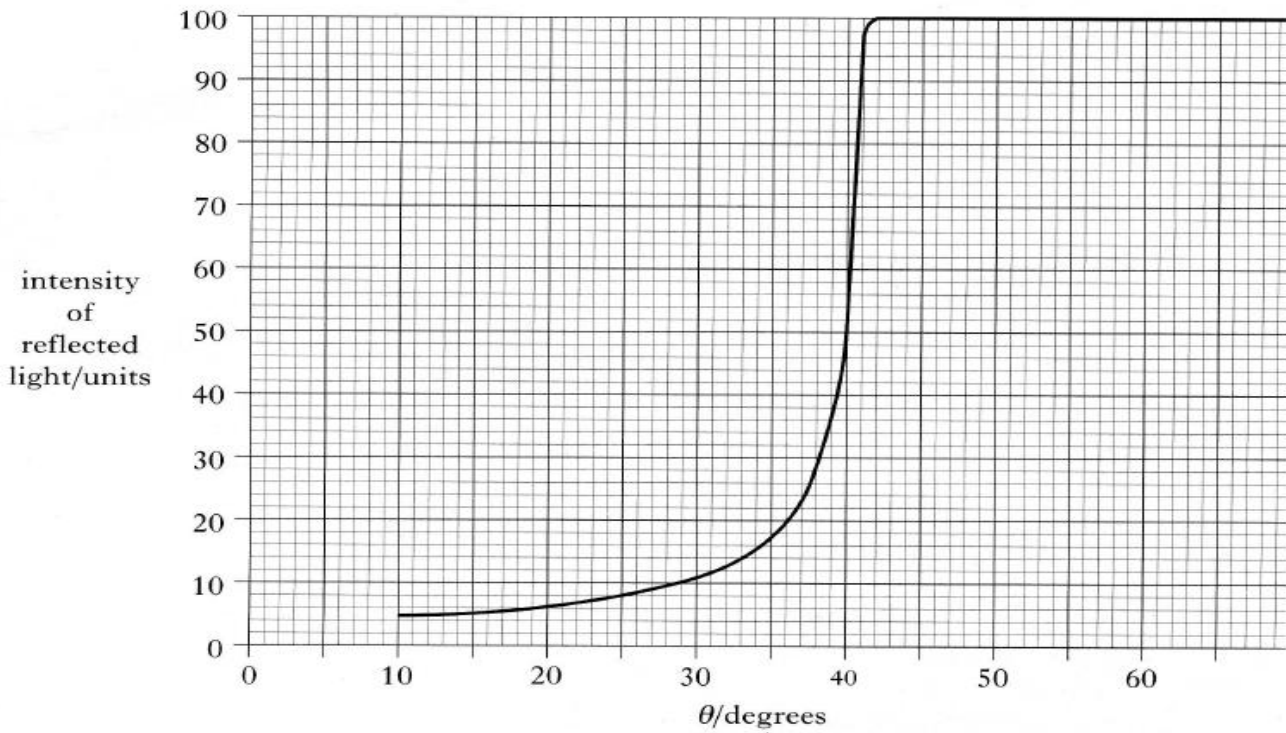
She observes that at point X the incident ray splits into two rays:

- T — a transmitted ray  
R — a reflected ray.



The student uses a light meter to measure the intensity of ray R as angle  $\theta$  is changed.

- (c) The graph below is obtained from the student's results.



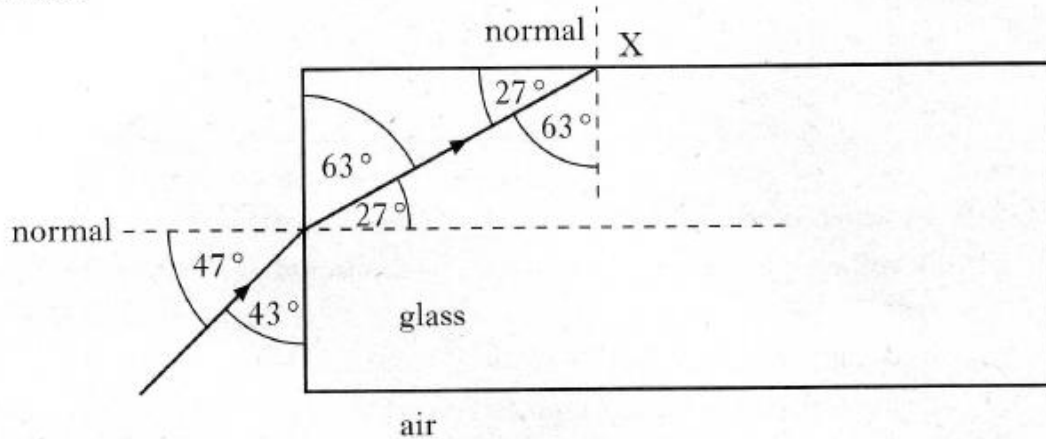
- What is the value of the critical angle in the glass for this light?
- Calculate the refractive index of the glass for this light.
- As the angle  $\theta$  is increased, what happens to the intensity of ray T?

8. (a) Light of wavelength  $486 \times 10^{-9} \text{ m}$  is viewed using a grating with a slit spacing of  $2.16 \times 10^{-6} \text{ m}$ .

Calculate the angle between the central maximum and the second order maximum.

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- (b) A ray of monochromatic light passes from air into a block of glass as shown.

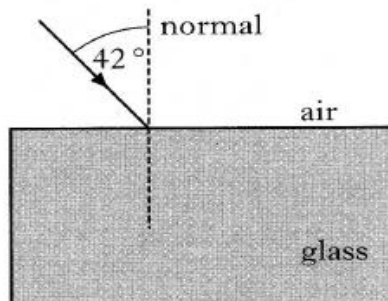


- (i) Using information from the diagram, show that the refractive index of the glass for this light is 1.61.  
 (ii) Show by calculation whether the ray is totally internally reflected at point X.

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9. A laser produces light of frequency  $4.74 \times 10^{14} \text{ Hz}$  in air.

A ray of light from this laser is directed into a block of glass as shown below.

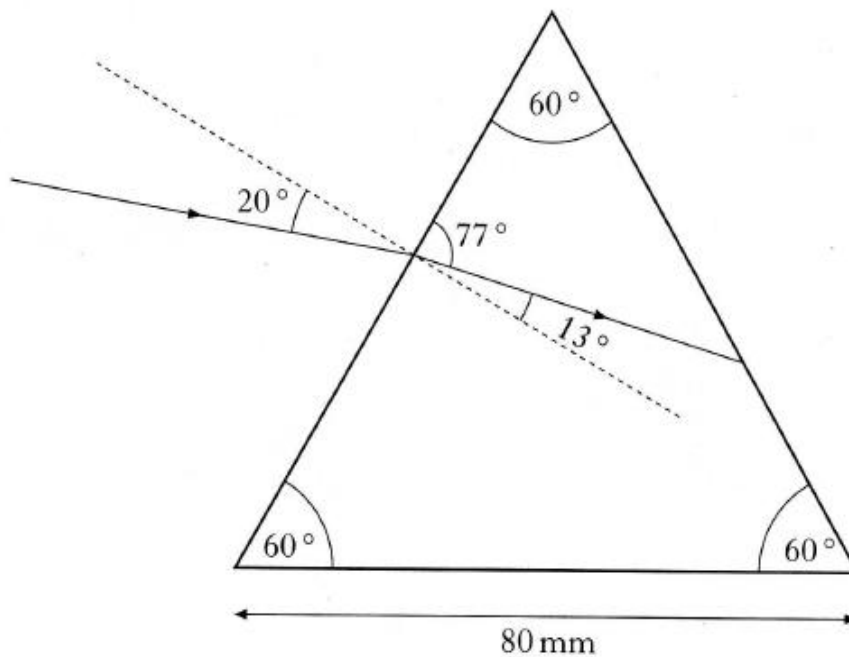


The refractive index of the glass for this light is 1.60.

- (i) What is the value of the frequency of the light in the block of glass?  
 (ii) Calculate the wavelength of the light in the glass.

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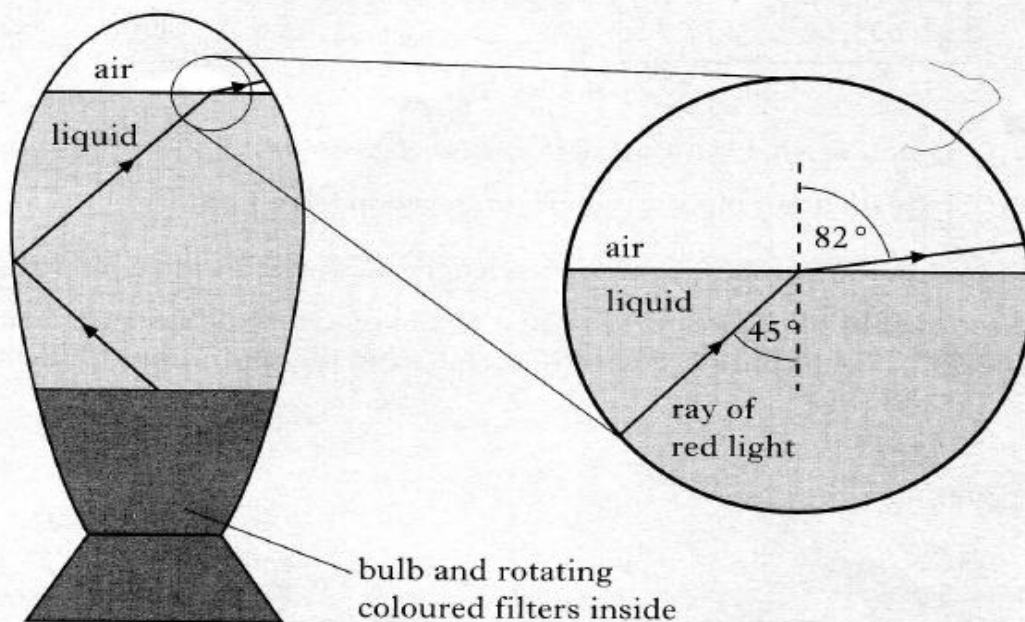
10. A ray of red light is directed at a glass prism of side 80 mm as shown in the diagram below.



- (a) Using information from this diagram, show that the refractive index of the glass for this red light is 1.52. 1
- (b) What is meant by the term *critical angle*? 1
- (c) Calculate the critical angle for the red light in the prism. 2
- (d) Sketch a diagram showing the path of the ray of red light until after it leaves the prism. Mark on your diagram the values of all relevant angles. 3

11. A decorative lamp has a transparent liquid in the space above a bulb. Light from the bulb passes through rotating coloured filters giving red or blue light in the liquid.

(a) A ray of red light is incident on the liquid surface as shown.



- (i) Calculate the refractive index of the liquid for the red light.
- (ii) A ray of blue light is incident on the liquid surface at the same angle as the ray of red light.

The refractive index of the liquid for blue light is greater than that for red light. Is the angle of refraction greater than, equal to or less than  $82^\circ$  for the blue light?

You must explain your answer.