

MUS HW 3 Compact Discs

42 min
42 marks

1. State **two** conditions necessary for total internal reflection to occur at an interface between air and water.

Condition 1

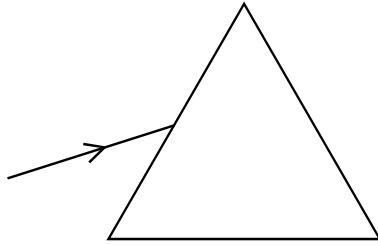
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Condition 2

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(Total 2 marks)

2. A ray of light travelling in air, strikes the middle of one face of an equilateral glass prism as shown.



State what happens to the following properties as the light goes from the air into the glass.

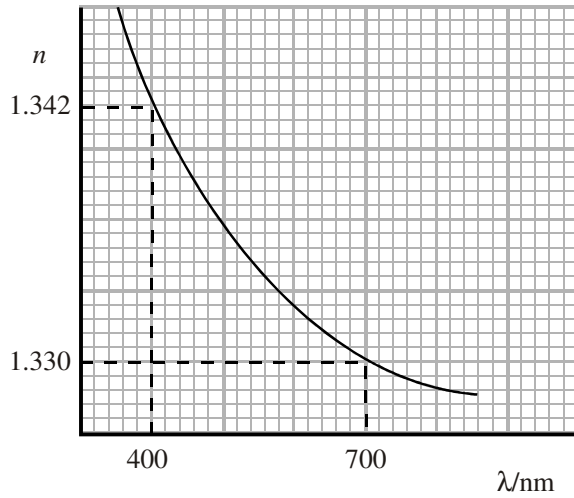
Frequency

Wavelength

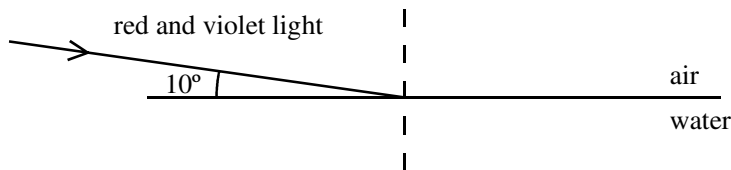
Speed

(Total 3 marks)

3. The graph shows how the refractive index of water, n varies with wavelength λ of the light in a vacuum. The values for red and violet light are indicated.



The diagram shows a mixture of red and violet light incident on an air/water interface.



Calculate the angle of refraction for the red light.

Angle of refraction =

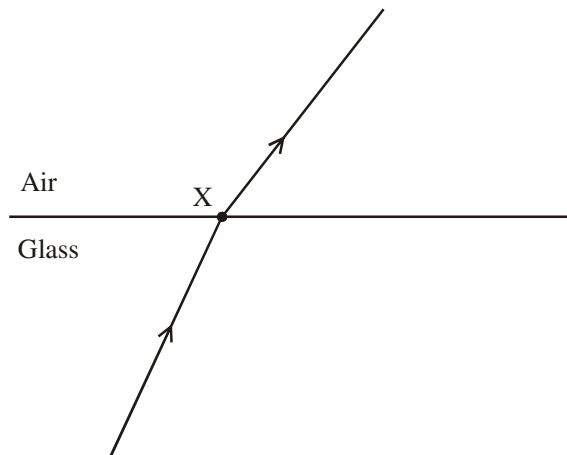
(3)

On the diagram draw the approximate paths of the refracted rays.

(2)

(Total 5 marks)

4. A student carries out an experiment to investigate the refraction of light as it passes from glass into air. He shines a ray of light through a glass block and into the air as shown.



- (a) (i) Add to the diagram to show i the angle of incidence and r the angle of refraction. Measure these two angles.

$i =$

$r =$

(3)

(ii) Hence, calculate the refractive index from air to glass ${}_a\mu_g$.

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${}_a\mu_g = \dots\dots\dots$

(2)

(b) At X, some of the light takes a path different from that shown on the diagram. Add another ray to the diagram showing the path of this light.

(1)

(c) The student increases the angle of incidence and notices that, above a certain angle, the light no longer passes into the air. Explain this observation.

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(2)

(d) Determine the largest angle of incidence which allows the light to pass into the air from this block.

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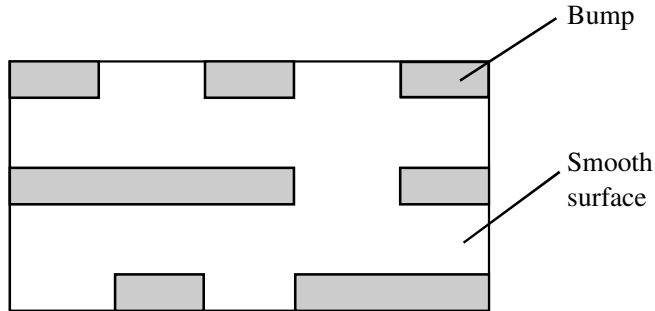
Angle =

(2)

(Total 10 marks)

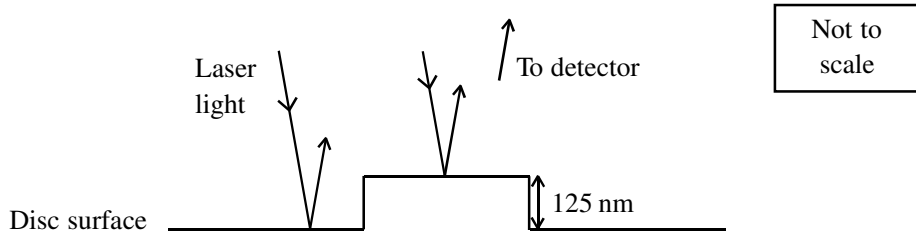
5. Figure 1 shows an enlargement of a small rectangular area of the surface of a compact disc (CD). It shows a series of small bumps on an otherwise smooth surface.

Figure 1



The presence or absence of a bump is detected by shining laser light perpendicularly onto the disc surface. Where there is a bump, some of the light hits the top of the bump, and some hits the disc surface next to the bump.

Figure 2



The height of the bumps on the surface of the disc is 125 nm. The wavelength of the light used to read the disc is 500 nm.

- (a) Explain whether the light received by the detector when a bump is present has a maximum or minimum intensity.

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(3)

- (b) For this detection system to work, the light reflected from the disc must be coherent. Explain the meaning of coherent.

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(1)
(Total 4 marks)

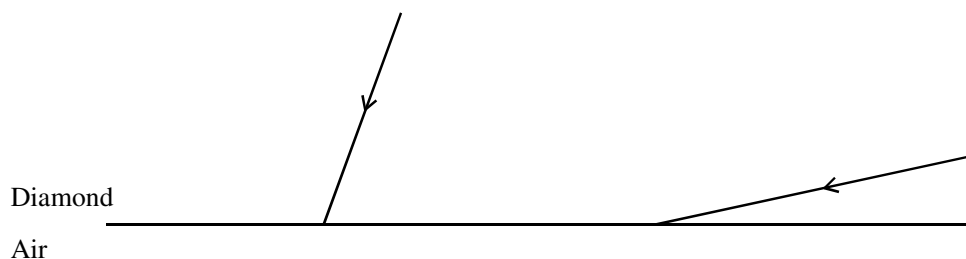
6. Diamonds are one of the most beautiful but expensive jewels available today. Their beauty is due largely to the way in which they sparkle when light falls on them. The way a jewel sparkles is related to how light is reflected inside the jewel which depends upon its refractive index.

- (a) (i) Diamond has a refractive index of 2.42. Show that the critical angle C for light passing from diamond into air is about 24° .

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(2)

- (ii) Add appropriate normals to the following diagram at the diamond-air interface and then sketch the paths that the two light rays would follow. One of them hits the interface at an angle smaller than C , and the other at an angle greater than C .



(2)

(iii) On the above diagram label

1. an incident angle i ,
2. an angle of refraction r .

(2)

(iv) Explain how the amount of light reflected inside the jewel depends on the refractive index, using the terms **critical angle** and **total internal reflection**.

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(3)

(b) There have been many attempts to make imitation diamonds but they have always lacked the sparkle of the real thing. Recently, however, a semiconductor company has manufactured a mineral called moissanite. This has similar properties to diamond, but is much cheaper.

The refractive index of moissanite is about 2.67. Comment on the critical angle and hence the sparkle of this mineral compared with diamond.

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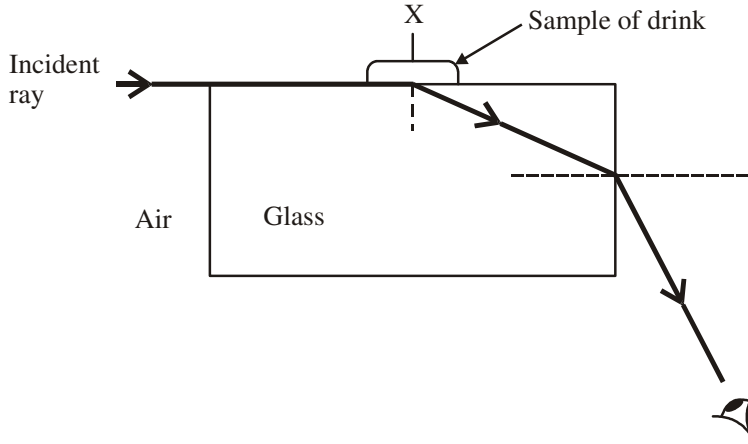
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(1)

(Total 10 marks)

7. A student decided to carry out an investigation using a Pulfrich refractometer. Her uncle was diabetic and she thought he would find it useful to know the sugar concentration of various drinks.

The diagram shows the refractometer she used.



Label the critical angle C on this diagram.

(1)

One of the samples studied was found to have a refractive index of 1.09 between the liquid and the glass. Show that the critical angle for light in the refractometer is about 67° for this sample.

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(2)

A black line is drawn on the glass block at position X. When looking through the glass block from different angles this black mark is not always seen. Explain why this is the case.

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(3)

These are some of the results obtained by the student.

Drink sample tested	Refractive index between liquid and glass
Orange Squash	1.05
Summer Fruits	1.10

Which has a higher concentration of sugar, Orange Squash or Summer Fruits? Explain your answer.

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(2)
(Total 8 marks)