4.4 Wave Behaviour

Question Paper

Course	DP IB Physics
Section	4. Waves
Topic	4.4 Wave Behaviour
Difficulty	Hard

Time allowed: 20

Score: /10

Percentage: /100

Question 1

In a Young's double-slit experiment, the spacing of the double slits is d and the distance between the slits and the screen on which fringes are formed is D. When monochromatic light of wavelength λ is incident on the slits the distance between adjacent fringes on the screen is s.

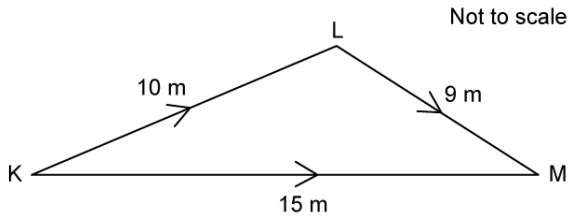
Which row shows another arrangement that produces a fringe spacing of s?

	Wavelength of the light	Distance between the slits and the screen	Spacing of double Slits
A.	4λ	$2D$	$4d$
B.	2λ	$2D$	$2d$
C.	4λ	$2D$	$2d$
D.	4λ	$2D$	$8d$

[1 mark]

Question 2

K is the source of a wave of frequency 25 Hz.



The wave travels to point M by two routes, K → L → M and K → M. The speed of the wave is 15 m s^{-1}.

What is the path difference between the two waves at M in terms of the wavelength λ of the waves?

A. 4λ

B. 6.6λ

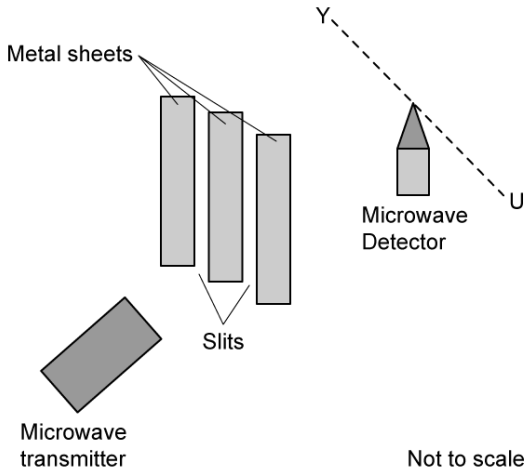
C. 31.6λ

D. 2.4λ

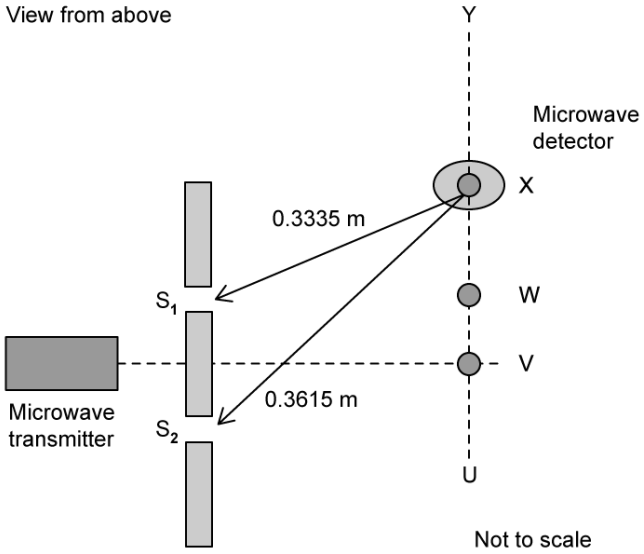
[1 mark]

Question 3

The diagram below shows an arrangement used to investigate double slit interference using microwaves.



The diagram below shows the view from above:



The microwaves from the transmitter are polarised. These waves are detected by the aerial in the microwave detector (probe). The aerial is a vertical metal rod.

The detector is moved along the dotted line UY. As it is moved, maximum and minimum signals are detected. Maximum signals are first detected at points V and W. The next maximum signal is detected at the position X.

The distances between each of the two slits, S_1 and S_2 and the microwave receiver when the aerial is in position X are S_1X = 0.3335 m and S_2X = 0.3615 m

Select the three correct reasons that explain why the signal strength falls to a minimum between U and V, and between V and W.

	Reason 1	Reason 2	Reason 3

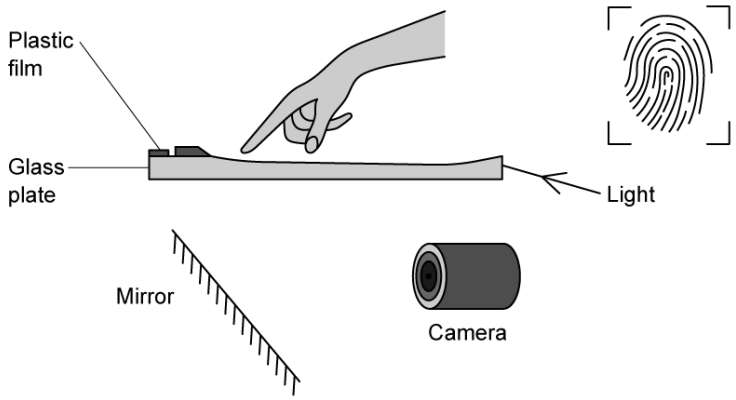
A	Waves are out of phase	Gives rise to a path difference	Constructive interference occurs
B	Waves are out of phase	Gives rise to a path difference	Destructive interference occurs
C	Path difference for the two waves	Gives rise to a phase difference	Destructive interference occurs
D	Path difference for the two waves	Gives rise to a phase difference	Constructive interference occurs

[1 mark]

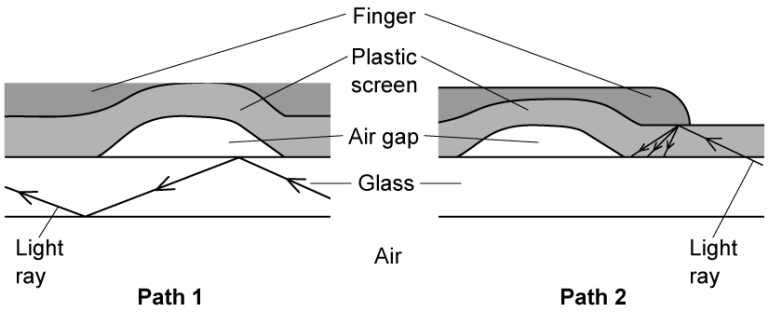
Question 4

Our fingerprints are made up of a series of ridges on the end of the finger. These ridges can be 'read' by electronic devices.

The diagram below shows a certain type of fingerprint detector below, which works by scattering light when pressure is applied to a plastic screen. The ridges of the fingerprint press the plastic film against the glass when the finger is pressed to the screen.



When not in use, the plastic screen and the glass have a small air space between them. The diagram below shows the two possible paths for the light when the finger is pressed down.



Which row in the table correctly describes the properties of the fingerprint detector that cause the bright and dark patches on the image produced by the camera?

	Bright	Dark
A.	glass and plastic have identical optical densities	glass and air have different optical densities
B.	glass and plastic have different optical densities	glass and air have different optical densities
C.	the plastic screen has a lower optical density than soft tissue in the finger	total internal reflection within the glass sends light rays to the camera
D.	the plastic screen and soft tissue in the finger have identical optical densities	identical optical densities between the glass and plastic prevent light from reaching the camera

[1 mark]

Question 5

A sound source X_1 is positioned *w* cm to the left of sound source X_2. Both sound sources are *y* m below the detection line AB. AB runs parallel to X_1X_2 . When a sound detector is slowly moved along the line AB, a maxima is first detected at P, followed by a minima at Q, with another maxima at R and a minima at S. PQRS are all equidistant apart with $X_1S = X_2S$.

Which one of the following is a correct expression for the wavelength of the sound?

A. $X_1Q - X_1P$

B. $X_1R - X_1Q$

C. $X_1Q - X_2Q$

D. $X_1R - X_2R$

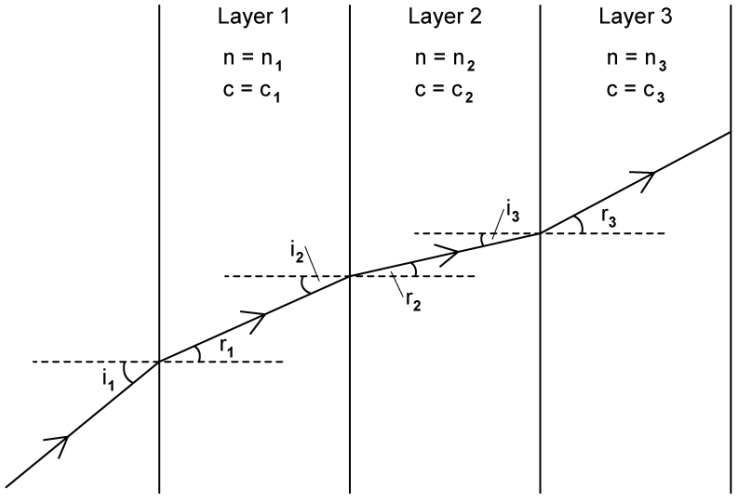
[1 mark]

Question 6

A ray of light is incident on a material made from three layers, each having a different optical density, so that in each layer the light travels at a different speed.

- For layer 1: refractive index = n_1 and the speed of light = c_1
- For layer 2: refractive index = n_2 and the speed of light = c_2
- For layer 3: refractive index = n_3 and the speed of light = c_3
- Angle of incidence = i
- Angle of refraction = r

This is illustrated in the diagram below:



Which is the correct expression for c_3, the speed of light in the third layer?

A. $\frac{c_1 n_1}{n_3}$

B. $\frac{c_2 n_2}{c_3}$

C. $\frac{c_1 n_1}{n_2}$

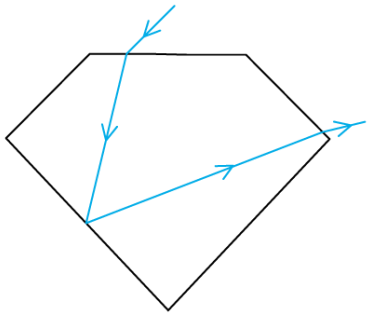
D. $\frac{c_2 n_2}{sin(r_3)}$

[1 mark]

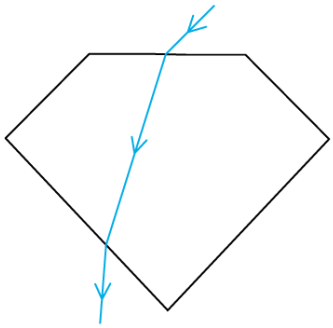
Question 7

Diamonds are highly valued because of their sparkle. This is caused by total internal reflection, which reflects most of the light that falls onto a cut diamond out of the face we see. Fake gems, called 'paste', are often used in jewellery because they are cheaper. However, paste gems sparkle much less than real diamonds.

The diagrams show a possible path of light through a real diamond, and another through a fake.



Path of light in a diamond



Path of light in an identical 'paste' gem

If:

- n = refractive index;
  - n_d is the refractive index of the diamond
  - n_f is the refractive index of the fake
- v = speed of light
  - v_d is the speed of light in the diamond
  - v_f is the speed of light in the fake

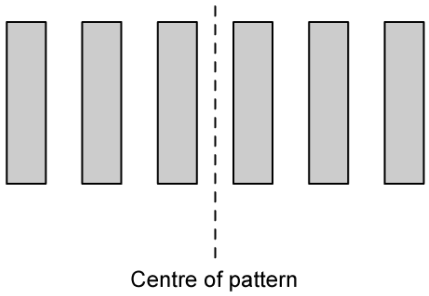
Which row in the table contains only statements which must be true?

	Critical angle of diamond	$\frac{n_d}{n_f}$	v_d
A	Very small	> 1	$< v_f$
B	Very small	< 1	$> v_f$
C	Very large	> 1	$< v_f$
D	Very large	< 1	$> v_f$

[1 mark]

Question 8

A double slit interference experiment is conducted using monochromatic light of wavelength λ. The centre of the observed pattern is a bright fringe.



What is the path difference between two waves which interfere to give the second dark fringe from the centre?

A. λ

B. 1.5λ

C. 2.5λ

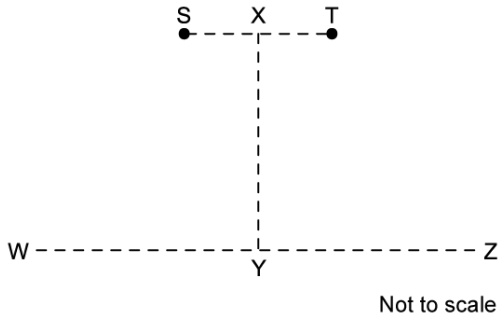
D. 3.5λ

[1 mark]

Question 9

A student is investigating the interference of waves. They set up coherent waves produced at points S and T and travel outwards in all directions.

The line XY is halfway between S and T and perpendicular to the joining line S and T. The distance XY is much greater than the distance ST.



Which line or lines would an interference pattern be seen along?

A. WZ only

B. XY only

C. Both XY and WZ

D. Neither XY or WZ

[1 mark]

Question 10

When moving from material A to material B, the direction of a ray of light moves away from the normal. If n_A and n_B are the refractive indices of materials A and B respectively, then which of the following statements is true in this situation?

A. The ratio of $\frac{n_A}{n_B}$ is larger than one

B. The ratio of $\frac{n_A}{n_B}$ is less than one

C. The ratio of $\frac{n_A}{n_B}$ is exactly than one

D. The ratio of $\frac{n_A}{n_B}$ cannot be known without more information

[1 mark]