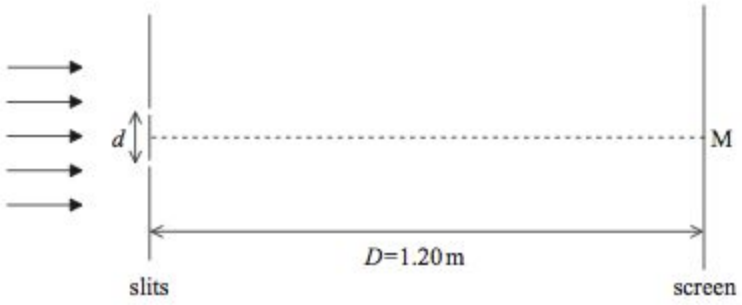
DOUBLE SLIT Problems

1.

G3. This question is about interference.

(a) Coherent monochromatic light is incident normally on two very narrow, parallel slits whose width is small compared to their separation. After the light passes through the slits it is incident on a screen. The mid-point of the screen is at M.



The distance D between the slits and the screen is 1.20 m. The slit separation d is 0.150 mm.

(i) Explain why the intensity of the light at M is a maximum. *[2]*

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(ii) Point P is the closest point to M on the screen where the light intensity is a minimum. The distance MP is 2.62 mm. Calculate the wavelength of light. *[2]*

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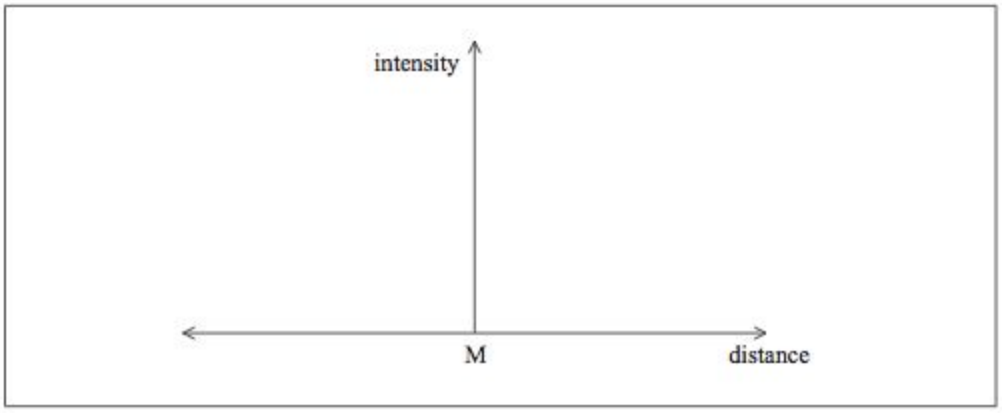
(b) Using the axes below, sketch a graph to show the variation with distance along the screen of the light intensity. *[2]*



(c) The number of slits is greatly increased, each with the same separation as in (a). Describe the differences, if any, in the intensity distribution in (b). *[2]*

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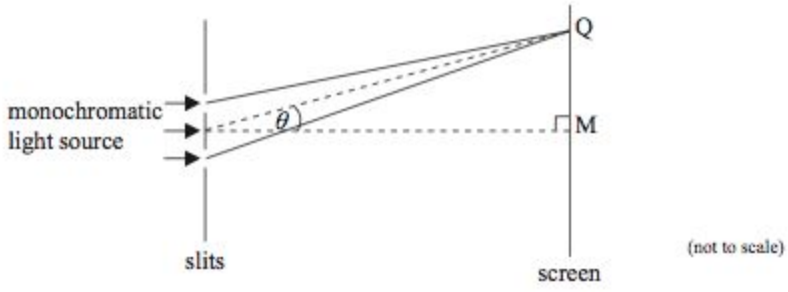
2.

G3. This question is about two-source interference.

(a) Light from a monochromatic source is incident at right angles to two slits. After passing through the slits the light is incident on a distant screen. Point M is the mid-point of the screen.



The separation of the slits is large compared to their width. A pattern of light and dark fringes is observed on the screen.

(i) State the phenomenon that enables light to reach point M on the screen. *[1]*

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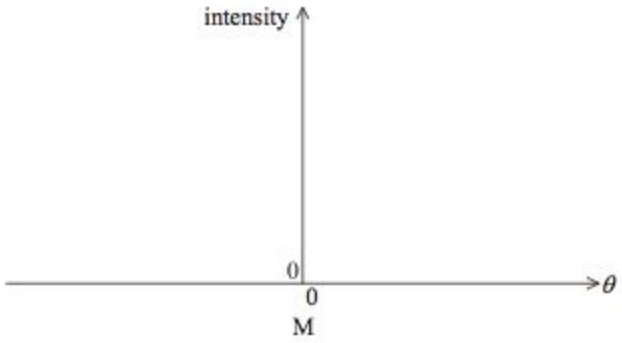
(ii) On the axes below, sketch the intensity of light as observed on the screen as a function of the angle θ. (You do not have to put any numbers on the axes.) *[3]*



(iii) The distance of the screen from the slits is 1.8 m and the slit separation is 0.12 mm. The wavelength of the light is 650 nm. Point Q on the screen shows the position of the first dark fringe.

Calculate the distance MQ. *[2]*

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(b) Suggest why, even though there are dark fringes in the pattern, no energy is lost. *[2]*

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3.

16. This question is about waves.

(a) State the principle of superposition. *[2]*

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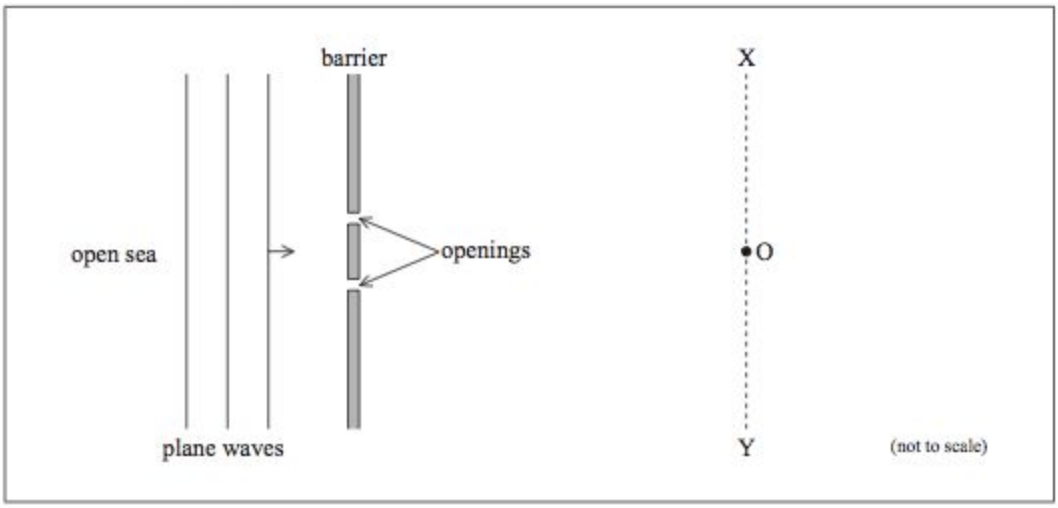
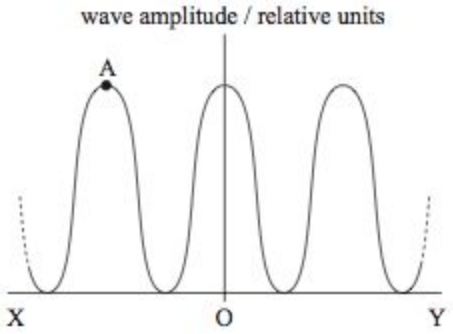
(b) The diagram shows a plan view of a harbour with a floating barrier that has two openings of equal width.



Plane water waves from the open sea are incident on the barrier and the openings act as point sources of waves. The distance from the openings to XOY is much greater than the wavelength of the wave. O is equidistant from the openings.

The graph shows the variation of the magnitude of the wave amplitude that is observed along the line XOY.



(i) State why the two sets of waves emerging from the openings are coherent. *[1]*

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(ii) Explain how the disturbance at point A arises. You may draw on the diagram **of the harbour** to illustrate your answer. *[3]*

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(iii) The wavelength of the waves is doubled. State and explain the effect that this change will have on the graph. *[3]*

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(c) The harbour in (b) is modified to have many narrower openings. The total width of the openings remains the same. Outline **two** ways in which the variation of wave amplitude along XY changes from that shown on the graph in (b). *[2]*

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4.

G1. This question is about interference of light at two parallel slits.

(a) State the condition necessary to observe interference between two light sources. *[1]*

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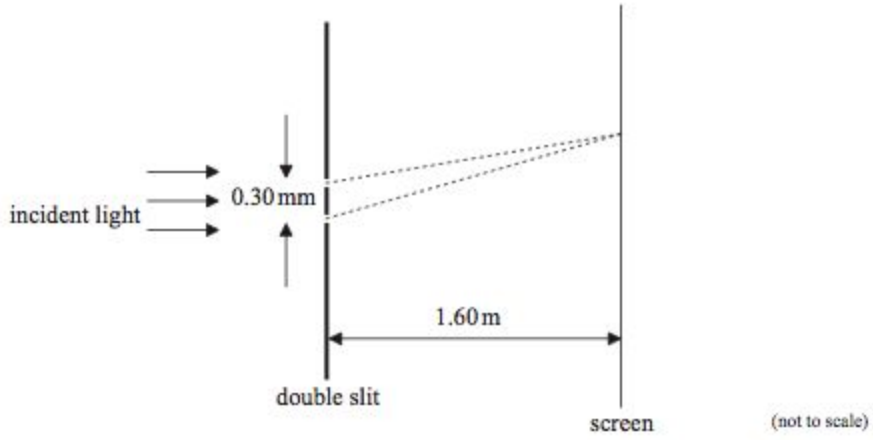
(b) The diagram below shows an arrangement for observing a double slit interference pattern. A parallel beam of coherent light of wavelength 410 nm is incident on two parallel narrow slits separated by 0.30 mm. A screen is placed 1.60 m beyond the slits.



Calculate the fringe spacing on the screen. *[2]*

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(c) The slits in (b) are replaced by a large number of slits of the same width and separation as the double slit. Describe the effects that this change will have on the appearance of the fringes on the screen. *[3]*

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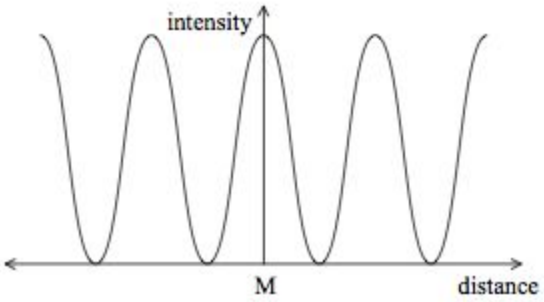
G3. (a) (i) the path difference between the two rays at M is zero;
so constructive interference occurs; ***[2]***

(ii) distance MP is $\frac{\lambda D}{2d}$;

and so $\lambda = \left(\frac{2.62\times10^{-3}\times2\times0.150\times10^{-3}}{1.20} = \right) 6.55\times10^{-7}\ \text{m}$; ***[2]***

*Award **[2]** for a bald correct answer.*

(b)

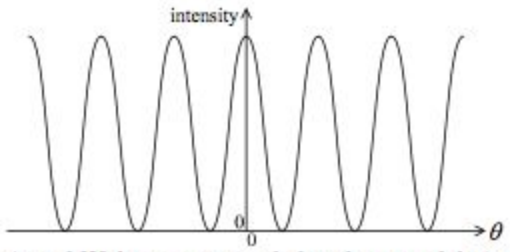


maxima of equal intensity;
equally separated; *(judge by eye)* ***[2]***

(c) position of maxima the same;
maxima narrower/sharper;
maxima brighter;
appearance of secondary maxima; ***[2 max]***

G3. (a) (i) diffraction; *[1]*

(ii) correct general shape $\left(\cos^2\theta\right)$ touching the horizontal axis;
constant amplitude;
equally spaced maxima; *[3]*
Diagram must have at least three fringes.
Award [0] for single slit diffraction pattern.



Award [3] for correct graph that shows modulation by single slit diffraction.

(iii) $\mathrm{MQ} = \frac{1}{2}\frac{\lambda D}{d}$;

$\mathrm{MQ} = \left(\frac{650\times10^{-9}\times1.80}{2\times0.12\times10^{-3}} = \right) 4.9\,\mathrm{mm}$; *[2]*

(b) the energy gets redistributed/the total energy in the pattern is the same as the total emitted energy;
the energy that would have appeared at minima now appears at the maxima; *[2]*

16. (a) net displacement of the medium;
equals the resultant/sum of individual displacements; ***[2]***
*Award **[1 max]** for reference to amplitude rather than displacement.*
*Award **[0]** for reference only to troughs and crests.*

(b) (i) division of wavefront so constant phase; ***[1]***

(ii) interference/superposition occurs at A;
between waves from each opening;
waves arrive in phase / path difference is one wavelength;
producing a (1st order) maximum; ***[3 max]***
*Award **[3 max]** for clear points that appear on diagram.*

(iii) maxima occur when the path difference is an integral number of wavelengths;
because wavelength doubles, larger distances/angles required to achieve same path difference;
successive maxima fringes are twice as far/further apart; ***[3]***

or

quotes double slit/grating formula;
substitute 2λ into equation and states all other terms stay constant;
successive maxima fringes are twice as far/further apart;

(c) *Assuming spacing of openings stays the same.*
same separation of maxima;
maxima increase in amplitude/intensity;
maxima narrower/sharper;
formation of secondary maxima; ***[2 max]***
*Award **[2 max]** for other reasonable responses if the response clearly states an assumption that the openings are closer or further apart than before.*

G1. (a) the light from the sources must be coherent / phase difference must be constant *(allow "in phase")* / the electric fields must have the same polarization; ***[1]***

(b) fringe spacing $= \frac{1.60\,\text{m} \times 410\,\text{nm}}{0.30\ \text{mm}}$;
2.2 mm; ***[2]***
*Award **[2 max]** for a response that makes use of $n\lambda$ in the double slit formula*
*Award ECF **[1 max]** if answer is for a value of n greater than 1.*
*Award **[2]** for a bald correct answer.*

(c) sharper fringes / *OWTTE*;
brighter;
same spacing; ***[3]***