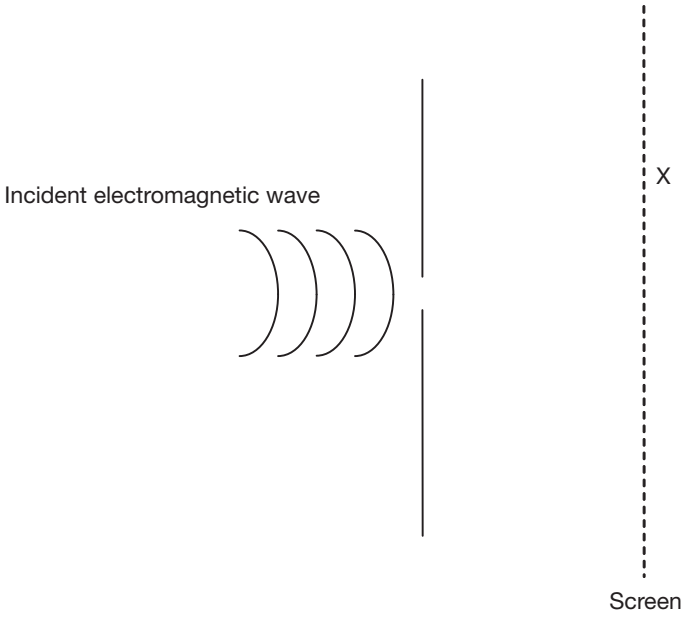
A4 Diffraction. © IBO 2007

Diffraction at a single slit

A.4.1 **Sketch the variation with angle of diffraction of the relative intensity of light diffracted at a single slit.** © IBO 2007

A.4.1.1 An electromagnetic wave is incident on a single slit opening as shown in the figure. The distance between wavefronts is the wavelength. Draw a diagram to illustrate how the intensity of the pattern would change along the screen.



A.4.1.2 Explain why a diffraction pattern is seen with a single slit.

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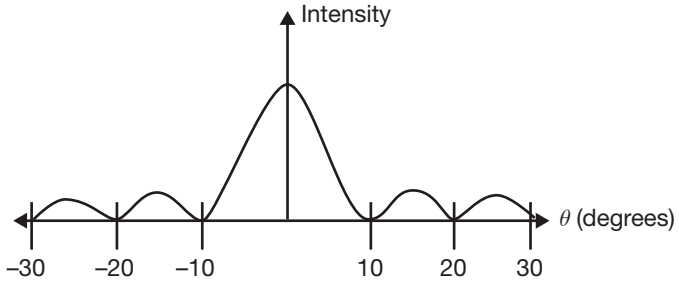
A.4.1.3 The intensity of interference fringe as a function of angle θ is shown in the figure below. The angle θ is the angle between the centre of the slit to the location of the fringe.



(a) Explain why the intensity of the peaks reduces on either side of the central maximum.

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(b) Discuss how the central maximum is different from other fringes.

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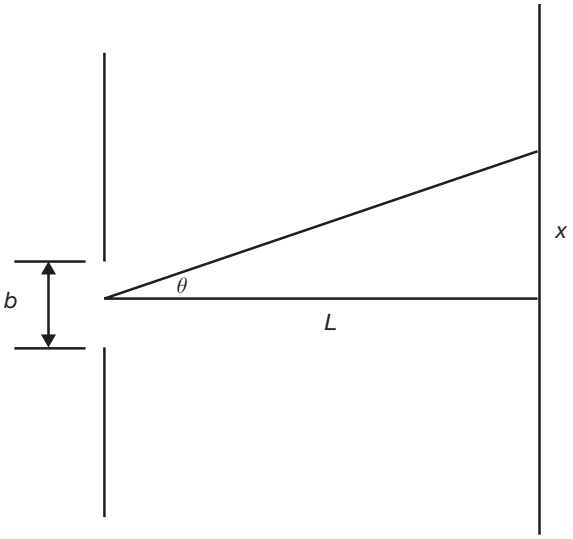
A.4.2 **Derive the formula $\theta = \frac{\lambda}{b}$ for the position of the first minimum of the diffraction pattern produced at a single slit.** © IBO 2007

A.4.3 **Solve problems involving single-slit diffraction.** © IBO 2007

Note that A.4.2 and A.4.3 are combined and questions carry A.4.2 numbers.

A.4.2.1 Consider the figure which shows the location of the 1st order dark fringe (first minimum).



(a) What is the relationship between path difference and wavelength for the first minimum?

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(b) With reference to the figure, derive a relationship between θ, λ and b for the first minimum.

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(c) Write the condition for the nth order dark fringe.

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(d) Write the condition for the nth order bright fringe, not including the central maximum.

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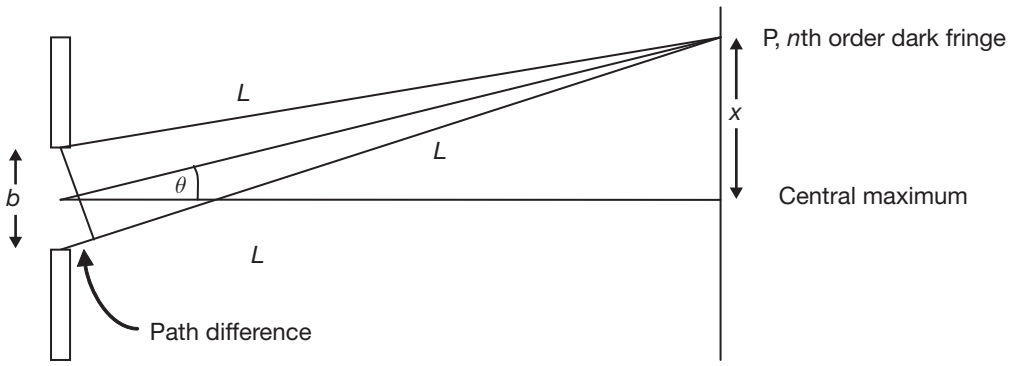
A.4.2.2 Consider a single-slit pattern with a monochromatic light source as shown in the figure.



(a) For L to be much larger than b and θ to be a small angle, show that for the nth order dark fringe $\frac{x}{L} = \frac{n\lambda}{b}$, where b and λ are of comparable magnitude and x is half the width of the central maximum.

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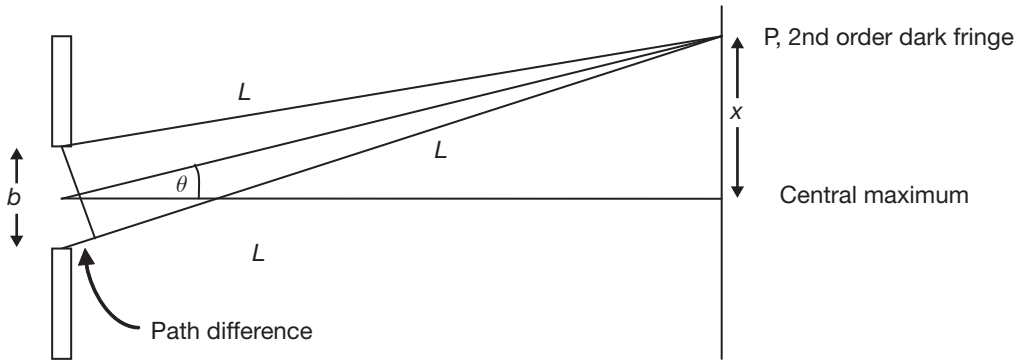
(b) Show that for the *n*th order bright fringe $\frac{x}{L} = \frac{(n+\frac{1}{2})\lambda}{b}$. Note that the relationship is opposite to that for double-slit interference.

(c) A 500 nm light passes through an opening of 1×10^{-5} m. What is the angle θ to the (i) 1st minimum and (ii) 3rd minimum?

A.4.2.3 A monochromatic light of wavelength 500 nm is incident on a gap of width 0.09 mm. A screen is placed 2.5 m from the gap.



(a) Estimate the distance *x* from the centre of the central maximum to the second order bright fringe.

(b) What is the thickness of the central maximum?

(c) What is the angular width of the central maximum?

A.4.2.4 Monochromatic light of wavelength 520 nm is shone through a single slit and a diffraction pattern is obtained on a screen. Calculate the slit width, *b*, when the first minimum band is at $\theta = 10°$.

A.4.2.5 What is the wavelength of the monochromatic light beam which, when shone through a single slit of width 2.0 μm gives the first minimum at an angle $\theta = 15°$?

A.4.2.6 What is the wavelength of the monochromatic light beam which, when shone through a single slit of width 2.0 μm gave the first maximum at an angle $\theta = 18°$?

A.4.2.7 If a single slit is replaced by a circular aperture of diameter *b*, then the first minimum is located at an angle θ, such that $\sin\theta = 1.22\frac{\lambda}{d}$, where θ is the angle from the central axis to the circular pattern of the first minimum.

When a 550 nm monochromatic light beam shines through an aperture of diameter 1.2 μm, what would be the angle θ?