InkPhysics

ANSWER BOOK

Diffraction and the single slit

Waves · Year 12

AQA 3.3.2.2 · CIE 8.2.1, 8.2.2 · OCR A 4.4.1(f)(i)

16 questions · 45 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Diffraction is the spreading of a wave as it passes through a gap or around an obstacle (1). The spreading is greatest when the gap width is about the same size as the wavelength (1). [2]

A2 A bright central maximum with much dimmer maxima either side (1). The central fringe is twice as wide as the others and far brighter; the outer fringes decrease in brightness with distance from the centre (1). [2]

A3 The fringes spread out (1): the central maximum (and all the fringes) become wider (1). [2]

A4 The entrance is about the same size as the wavelength (1), so the waves diffract strongly, spreading into the harbour as near-circular wavefronts (1). [2]

A5 In the single-slit pattern the central maximum is twice the width of the other maxima, whereas double-slit fringes are all the same width and evenly spaced (1). In the single-slit pattern the side maxima are much dimmer than the centre, whereas double-slit fringes are (nearly) equally bright (1). [2]

SECTION B · Standard

B1 Diffraction is significant when the gap is comparable to the wavelength (1). Sound wavelengths are of the order of the door width (about a metre), so sound diffracts strongly (1); the wavelength of light is around 10^{-7} m, far smaller than the doorway, so its diffraction is negligible (1). [3]

B2 Red light has a longer wavelength than blue (1), so it diffracts more (1). The fringes, including the central maximum, become wider and more spread out for red than for blue (1). [3]

B3 The central maximum is white (all wavelengths overlap there) (1). The side maxima are spread into colours, with blue/violet closest to the centre and red furthest out, because longer wavelengths diffract more (1); the fringes overlap and become less distinct further out (1). [3]

B4 Most of the light energy passes near the straight-through direction, giving the central fringe its high intensity (1). It spans the region between the first minima on either side (1), which is twice the spacing of the outer fringes, so it is also twice as wide (1). [3]

B5 At first the slit is far wider than the wavelength, so the screen shows a narrow strip of light with very little spreading (1). As the slit narrows the light spreads out more and a diffraction pattern appears: the central maximum and the side fringes become wider (1). The pattern also becomes dimmer, because a narrower slit lets less light through (1). [3]

B6 Greatest spreading when the gap is about 3 cm, comparable to the wavelength (1). A 50 cm gap is many times the wavelength, so there is little diffraction (1); the detector records a strong signal only in the straight-through region directly beyond the gap, falling off sharply at its edges (1). [3]

B7 The amount of spreading depends on how the wavelength compares with the gap width, the ratio of wavelength to slit width (1). Doubling both leaves that comparison unchanged (1), so the width of the central maximum is (almost) unchanged (1). [3]

SECTION C · Stretch

C1 The narrower slit produces the wider central maximum (1), because narrower gaps diffract more (1). However, a narrower slit lets less light through (1), so although its pattern is more spread out, the overall pattern is dimmer than that from the wider slit (1). [4]

C2 Laser light is monochromatic (single wavelength) and coherent (1), so the diffracted waves keep a constant phase relationship and the same fringe positions (1). This gives a sharp, well-defined pattern of a single colour rather than a blurred, overlapping one (1). [3]

C3 Spreading is greater when the wavelength is a larger fraction of the slit width (1). W beats X because, for the same slit, the longer wavelength diffracts more; W beats Y because, for the same wavelength, the narrower slit diffracts more (1). So arrangement W gives the widest central maximum and should be chosen (1). [3]

C4 The filter transmits only the long-wavelength red light, so the whole pattern, including the central maximum, becomes red and dimmer (1). Each side maximum becomes a single red fringe instead of a spectrum (1), centred where the red (outer) edge of the coloured fringe was, because red diffracts most (1). Only one wavelength now forms the pattern, so the minima are properly dark and the fringes stay distinct further from the centre (1). [4]