Past-paper walk-through

Diffraction ▪ 8.2

eXercise

Questions in this set

- 9702/12 N25 Q28 ▪ 1 mark
- 9702/14 N25 Q26 ▪ 1 mark
- 9702/21 N25 Q4 ▪ 10 marks
- 9702/13 J25 Q30 ▪ 1 mark
- 9702/14 J25 Q26 ▪ 1 mark
- 9702/12 M25 Q28 ▪ 1 mark

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 28

9702/12 N25 ▪ Q28 ▪ 1 mark

A light wave passes through a single slit and a diffraction pattern forms.
What happens to the frequency and the speed of the wave when it is diffracted?

	frequency	speed
A	decreases	increases
B	increases	decreases
C	no change	decreases
D	no change	no change

Question 28

[1]

A decreases / increases

B increases / decreases

C no change / decreases

D no change / no change

Question 28

	frequency	speed
A	decreases	increases
B	increases	decreases
C	no change	decreases
D	no change	no change

Solution 28

A decreases / increases

B increases / decreases

C no change / decreases

D no change / no change ✓

Why

- Diffraction changes the *direction* in which the wave spreads, not the wave itself.
- The frequency is fixed by the source, so it cannot change.
- The medium is unchanged, so the speed – and hence the wavelength – stays the same.

Question 26

9702/14 N25 ▪ Q26 ▪ 1 mark

For a progressive transverse wave, what describes the term diffraction? **[1]**

A the change in observed frequency of a wave due to a movement of the wave source

B the spreading of a wave as it passes through a gap or around an obstacle

C when oscillations of a wave are confined to one plane

D the resultant displacement of two waves is equal to the sum of the displacements of the individual waves when the waves meet

Solution 26

A the change in observed frequency of a wave due to a movement of the wave source

B the spreading of a wave as it passes through a gap or around an obstacle ✓

C when oscillations of a wave are confined to one plane

D the resultant displacement of two waves is equal to the sum of the displacements of the individual waves when the waves meet

Why

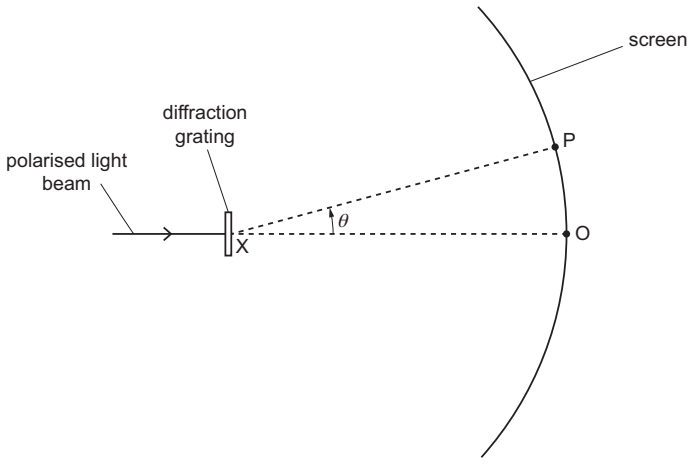
- Diffraction is the spreading of a wave as it passes through a gap or around an obstacle.
- A describes the Doppler effect and C describes polarisation.
- D is the principle of superposition.

Question 4

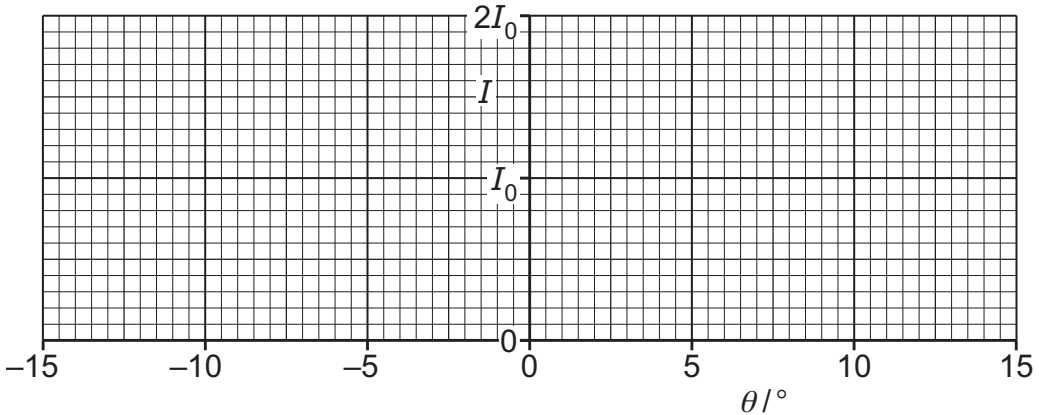
9702/21 N25 ▪ Q4 ▪ 10 marks

(a) State what is meant by diffraction of a wave. **[2]**

Question 4



Question 4



Question 4

9702/21 N25 ▪ Q4 ▪ 10 marks

(b)(i) The diffraction grating has a line spacing of 5.0×10^{-6} m.
The light transmitted by the diffraction grating illuminates a circular screen. The diffraction grating is at the centre X of the circle.
The central bright fringe is formed at point O on the screen and has intensity I_0.
P is a point on the screen where the line XP is at a variable angle θ to the line XO.
The intensity I of light on the screen at P varies with θ.
Show that the angle θ at which the first-order bright fringe is formed is $6.2°$. **[2]**

(b)(ii) Determine the value of θ at which the second-order bright fringe is formed. **[1]**

(b)(iii) On Fig. 4.2, sketch the variation of the intensity I with θ for values of θ from $-15°$ to $+15°$. **[3]**

Question 4

9702/21 N25 ▪ Q4 ▪ 10 marks

(c) A polarising filter is placed in the path of the light beam that is incident on the diffraction grating in Fig. 4.1. The transmission axis of the filter is at 45° to the vertical.

Suggest how the variation of intensity with θ for the light on the screen compares with the answer in **(b)(iii)**. **[2]**

Solution 4

(a)

Mark scheme

- wave passing through gap / aperture **B1**
- (wave) spreads (out) **B1**

Solution 4

(b)(i) Worked steps

- $n\lambda = d\sin\theta$, with $n = 1$ for the first order.
- $\sin\theta = \dfrac{\lambda}{d} = \dfrac{540 \times 10^{-9}}{5.0 \times 10^{-6}} = 0.108$
- $\theta = \sin^{-1}(0.108) = 6.2°$, as required.

Solution 4

Mark scheme

- $n\lambda = d \sin\theta$ C1
- $\theta = \sin{-1}\ [(540 \times 10{-9}) / (5.0 \times 10{-6})] = 6.2°$ A1

Solution 4

(b)(ii)

Worked steps

- Second order: $\sin\theta = \dfrac{2\lambda}{d} = 0.216$
- $\theta = 12.5^\circ \approx 12^\circ$

Note it is **not** exactly twice 6.2°: the relation is a sine, not the angle itself. At these small angles the two are close, which is why the scheme accepts 12°.

Mark scheme

- $\theta = 12^\circ$ **A1**

Solution 4

(b)(iii)

Worked steps

Three separate marks: where the peaks are, what sits between them, and their heights.

- Draw sharp maxima at $\theta = 0$, $\pm 6^\circ$ and $\pm 12^\circ$ — five peaks in all.
- Between the peaks the intensity falls to **zero**; a grating gives narrow maxima with darkness between, not a wavy line.
- The central peak reaches I_0; the outer peaks are equal to or lower than it.

Mark scheme

- peaks / maxima shown at $\theta = 0$, $\pm 6^\circ$ and $\pm 12^\circ$ **B1**
- peaks / maxima and zero intensity in between **B1**
- central peak / maxima at intensity I0 and the other peaks all equal to or less than I0 **B1**

Solution 4

(c)

Worked steps

A polarising filter halves the intensity of unpolarised light and does nothing else here.

- The peaks stay at exactly the **same angles**: the grating spacing and the wavelength are unchanged, and polarisation does not affect where waves interfere constructively.
- Every peak's intensity is **halved**, including the central one.

Mark scheme

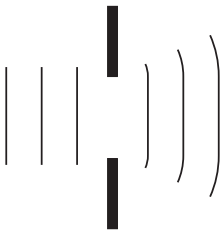
- peaks / maxima all at the same angles (as before) **B1**
- intensity (of all peaks / maxima) halved **B1**

Question 30

9702/13 J25 ▪ Q30 ▪ 1 mark

30 A ripple tank contains water at a constant depth.

A water wave of constant frequency travels towards a gap in a barrier placed in the ripple tank.



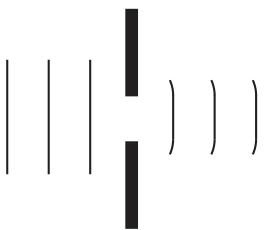
The gap is made smaller.

Question 30

Which diagram represents the wave before and after the barrier?

A

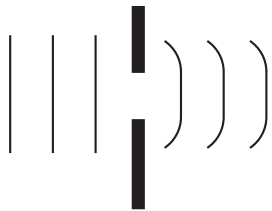
B

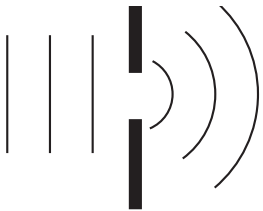


C

D

Question 30





Solution 30

Answer: **D**

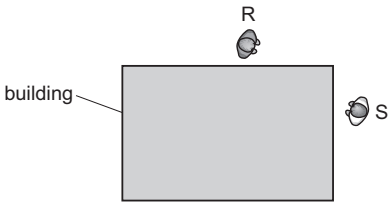
Why

- Making the gap narrower increases the diffraction, so the wave spreads more beyond the barrier.
- The frequency and the water depth are unchanged, so the wavelength is the same on both sides.
- The right diagram therefore keeps the wavefront spacing and curves the fronts more.

Question 26

9702/14 J25 ▪ Q26 ▪ 1 mark

26 A student makes a sound at point R near a building. A second student, standing at point S around the corner of the building, hears the sound. The building is a solid structure and there are no other structures nearby.



Which effect best explains how the student at point S is able to hear the student at point R?

A diffraction

Question 26

B interference

C polarisation

D reflection

Solution 26

Answer: **A**

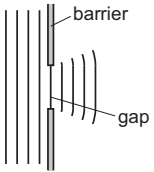
Why

- The sound bends around the edge of the building, which is diffraction.
- Speech has a wavelength comparable to the size of the obstacle, so the spreading is large.
- Interference needs two sources, sound cannot be polarised, and there is nothing here to reflect from.

Question 28

9702/12 M25 ▪ Q28 ▪ 1 mark

28 The diagram shows a water wave in a shallow tank. The wave is diffracted through a gap in a barrier and spreads. The wavelength of the wave is much smaller than the width of the gap.



The wavelength of the wave and the width of the gap are both changed by a small amount.

Which combination of changes **must** increase the amount of spreading due to diffraction?

	wavelength	width of gap

Question 28

A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

Solution 28

Answer: **C**

Why

- Diffraction spreads a wave most when its wavelength is comparable to the width of the gap.
- So the spreading grows if the wavelength increases or the gap narrows.
- Doing both together must increase it; changing them the same way could cancel out.