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GCE AS / A LEVEL – TWO-SOURCE INTERFERENCE & SINGLE-SLIT DIFFRACTION QUESTION PACK

Legacy PH2 · New spec Unit 2 Topic 5a · AS unit, 20% of A-level

REVISE
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PHYSICS – UNIT 2 · TWO-SOURCE INTERFERENCE & SINGLE-SLIT DIFFRACTION

PH2.5 Wave properties – Young’s slits & single-slit diffraction

Coherence and the conditions for two-source interference, applying $\lambda = ay/D$ for Young’s double-slit, and qualitative single-slit diffraction with intensity envelope.

NEW 2015 SPEC · UNIT 2 TOPIC 5A

Estimated time for entire question pack: ~1 h 25 min

Derived from the legacy PH2 paper’s pace of 80 marks in 1¼ hours.

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH2 papers (2008 modular spec) that maps onto new-spec Unit 2 Topic 5a (2.5).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required. The Data Booklet is allowed.

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Q	Source	Max	Mark
1	PH2 Jun 10 Q2	9	
2	PH2 Jan 11 Q2	7	
3	PH2 Jun 12 Q2	6	
Total		61	

Q	Source	Max	Mark
4	PH2 Jun 11 Q5	14	
5	PH2 Jan 14 Q3	12	
6	PH2 Jan 13 Q2	13	
Total		61	

Two-Source Interference & Single-Slit Diffraction – what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 2: Electricity & Light · Topic 2.5.

Coherence & superposition A

- Coherent sources: constant phase relationship, same frequency.
- Principle of superposition for displacement.

Young's slits A

- Apply $\lambda = ay/D$ for fringe spacing.
- Effect of changing a , y , D , or λ on fringe pattern.
- Conditions for constructive ($n\lambda$) and destructive ($(n+\frac{1}{2})\lambda$) interference.

Single-slit diffraction A

- Qualitative pattern: central bright max wider and brighter than secondary.
- First minimum at $\sin\theta = \lambda/b$; effect of slit width.

Path difference A

- Identify path difference for two-source geometry.
- Convert from extra path length to phase difference.

Two-Source Interference & Single-Slit Diffraction in one page

Quick-reference notes – revisit before each section.

Coherence

Same frequency.
Constant phase difference.
Usually requires single source (e.g. laser) or split source.

Young's slits

a = slit spacing; D = slits-to-screen; y = fringe spacing.
Halve a \Rightarrow double y .
Use longer λ \Rightarrow fringes spread.

Path difference

$n\lambda$ \Rightarrow bright (in phase).
 $(n+\frac{1}{2})\lambda$ \Rightarrow dark (antiphase).

Single-slit

Central max is wider and brighter than secondary maxima.
First min at $\sin\theta = \lambda/b$; widen slit \Rightarrow narrower max.

Diffraction grating preview

More slits \Rightarrow sharper, brighter maxima.
Treated rigorously in u2-5b.

Watch out for

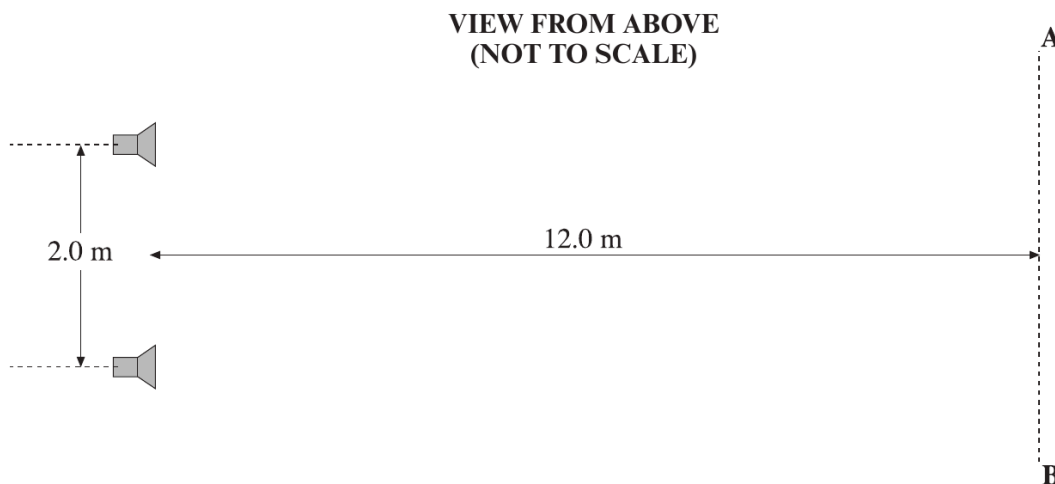
Use consistent units (m throughout).
For Young's slits, formula assumes θ small ($y \ll D$).

Section index

Use this index to jump straight to the section you need.

Section	Questions	Marks
A Interference & single-slit diffraction	Qs 1-6	61 marks

2. Two loudspeakers are placed 2.0 m apart, and facing the same way, in the middle of a playing field, on a calm day. They are connected to the same signal generator, and therefore produce sound of the same frequency.



- (a) A student walks slowly along the line **AB**, and hears the sound varying regularly in loudness as he walks. The positions where the sound is loudest are 1.8 m apart.

- (i) Use the *Young's fringes* formula to calculate the wavelength of the sound. [2]

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- (ii) Suggest why the results would be less reliable if the experiment were performed in a hall, that is surrounded by walls. [1]

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- (b) The student now stops at a point where the sound is quietest. The teacher then disconnects **one** of the loudspeakers. The student now hears a louder sound. Explain why the sound is louder. Your answer should mention *phase*. [3]

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(c) The disconnected loudspeaker is reconnected, but with the wires to its terminals swapped over, so that the loudspeakers are now sound sources in *antiphase* (exactly out of phase). What difference will be observed by the student if he repeats the walk of part (a)? [1]

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(d) State, giving your reasoning, how the separation between points of quietest sound along AB would change if

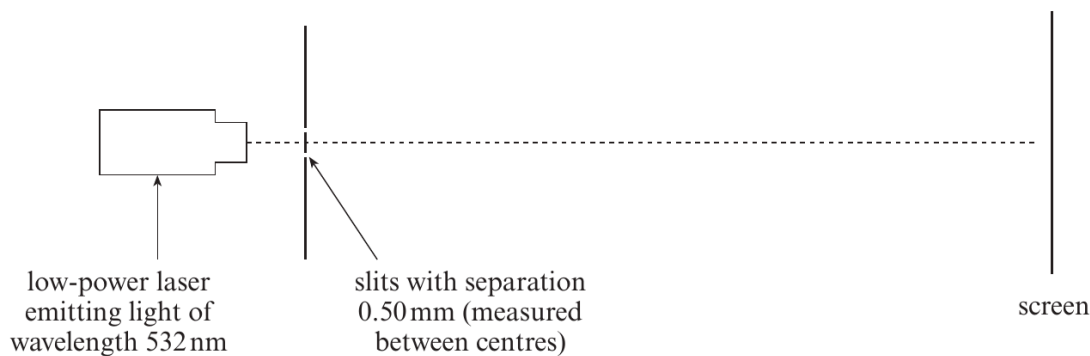
(i) the separation of the loudspeakers were doubled (to 4.0 m), [2]

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(ii) the signal generator were adjusted so that the *frequency* of sound emitted by the loudspeakers were doubled. [The loudspeaker separation is restored to 2.0 m] [2]

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2. A student sets up the apparatus shown, in order to demonstrate two-source interference (Young's fringes).



(a) State what is meant by the following statements.

(i) Light *diffracts* at each slit. [1]

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(ii) The slits act as *coherent* sources. [1]

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(b) The separation of the centres of neighbouring bright fringes on the screen is 2.0 mm. Calculate the distance between the slits and the screen. [3]

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(c) If one of the slits is covered, the dark fringes become brighter. Explain this observation. [2]

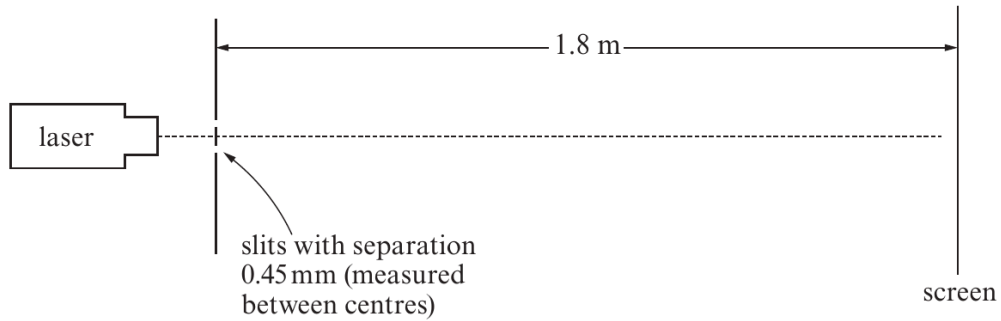
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2. The apparatus shown is set up to produce a clear display on the screen of Young's fringes.



(a) The bright fringes result from constructive interference. Explain, in terms of *phase* and *path difference*, why there are bright fringes. You may add to the diagram above, or draw your own diagram(s) to assist your explanation. [2]

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Examiner
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- (b) (i) The centres of the bright fringes are measured to be 2.4mm apart. Calculate the wavelength of the light from the laser. [2]

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- (ii) To obtain an accurate value of wavelength, it is better to use a diffraction grating than a double slit. Give **two** reasons for this. [2]

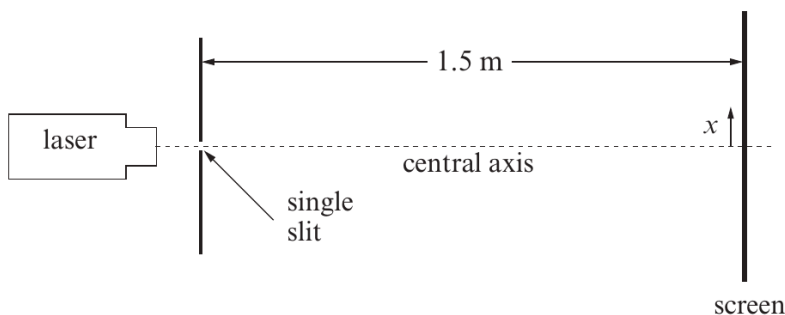
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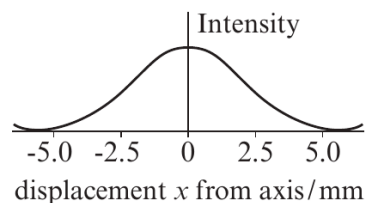
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5. (a) Apparatus is set up as shown.



The graph shows how the intensity of light on the screen varies with displacement x from the central axis.

[Note the expanded displacement scale.]



(i) Name the wave property being demonstrated. [1]

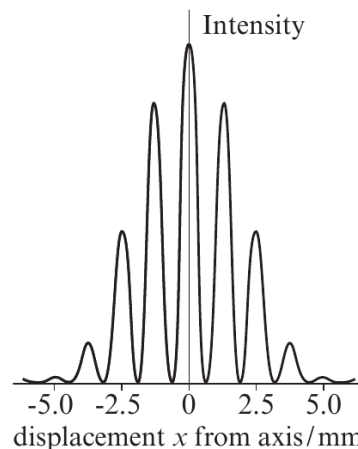
(ii) What can be deduced about the width of the slit compared with the wavelength of the light from the laser? Give your reasoning. Calculations are not needed. [2]

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(iii) What would happen to the graph if the width of the slit were to be increased? [2]

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(b) The single slit is now replaced by two parallel slits, each of the same width as the single slit in (a). The centres of the slits are 0.75 mm apart. The intensity of light on the screen near the central axis now varies as shown.



(i) Determine from the graph the separation of the bright interference fringes. [1]

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(ii) Hence find the wavelength of the light. [2]

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(iii) Explain in terms of *interference*, *phase*, and *path difference* how the **bright** fringes arise. Assume that the slits act as in-phase sources. [3]

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(iv) Suggest why the brightness of the bright fringes decreases with displacement x from the central axis, in the region shown on the graph. [1]

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(c) It is easier to obtain clear fringes in the experiment of part (b) using a laser rather than an ordinary light source. Give two reasons for this. [2]

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Examiner
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3. (a) S_1 and S_2 are two wave sources, oscillating in phase.

(i) State what is meant by 'oscillating in phase'.

[1]

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(ii) For constructive interference at some point, P , of the waves from S_1 and S_2 the *path difference* = 0 or λ or 2λ or 3λ

+ P

S_1 ●

S_2 ●

State clearly what is meant by *path difference*, adding to the diagram if it will help your explanation.

[1]

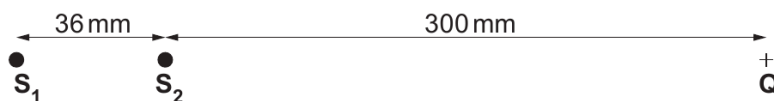
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- (iii) In the set-up shown below, the in-phase sources, S_1 and S_2 , are emitting, in all directions, microwaves of wavelength 12 mm.



- (I) Determine whether there is constructive or destructive interference at Q , giving your reasoning. [2]

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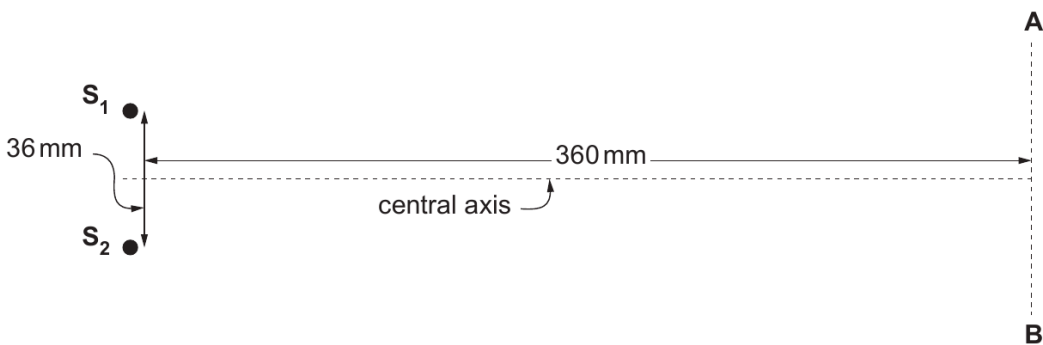
- (II) Discuss whether or not the observed signal strength would vary if a microwave detector were moved to the right, from point Q . [2]

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- (iv) The same microwaves sources are now arranged as shown, and the detector is moved along the line AB .



- Use the equation for double slit interference to determine the approximate spacing between points of maximum microwave intensity. [2]

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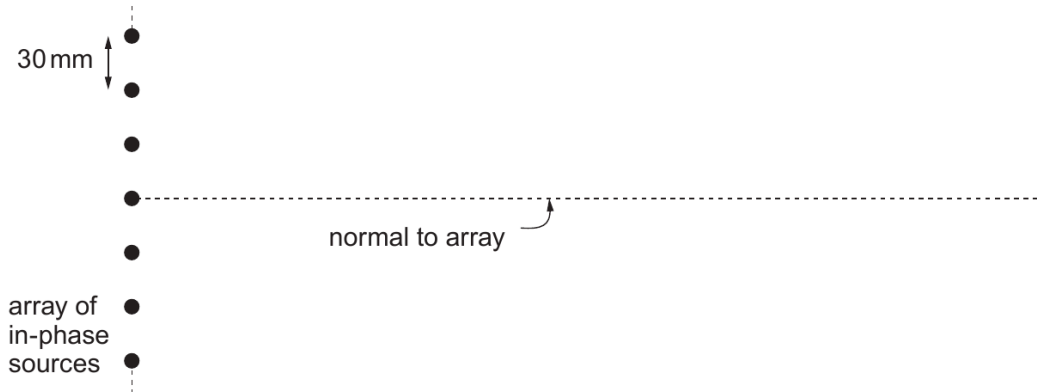
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(b) An 'array' of regularly-spaced, in-phase wave sources produces an interference pattern similar to that of a diffraction grating, that is sharply-defined beams (maxima) of waves at specific angles to the normal.

In the array shown the sources emit waves of wavelength 12 mm.



Find all the angles to the normal at which beams (maxima) occur.

[4]

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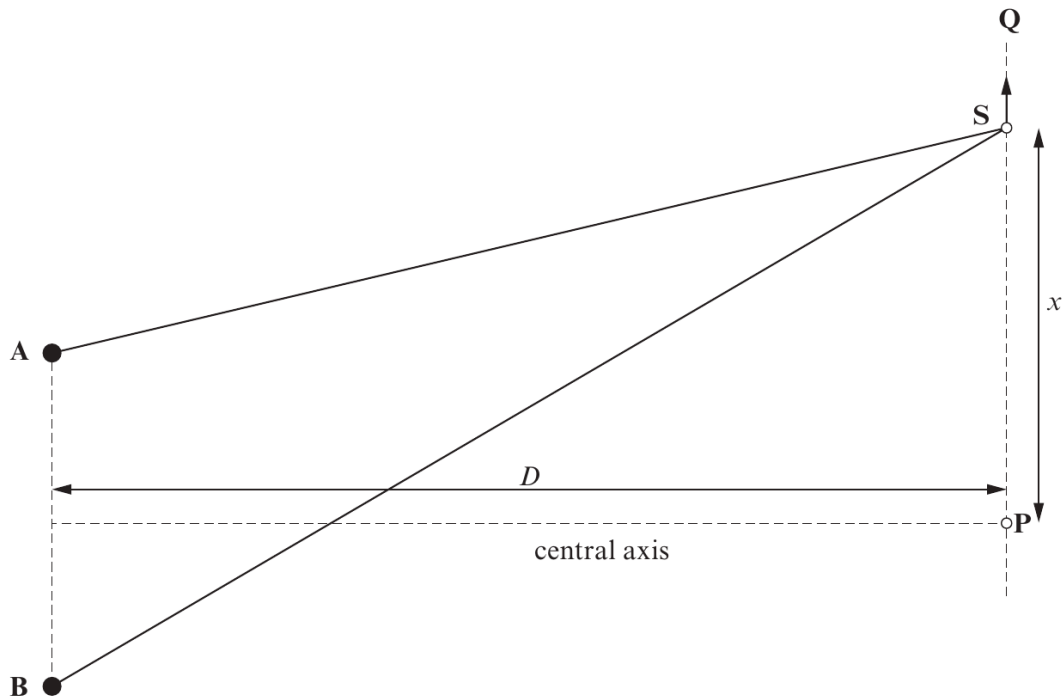
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2. (a) Two in-phase sources, **A** and **B**, emit microwaves.



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As a microwave sensor, **S**, is moved from **P** towards **Q**, the intensity is found to vary, with the first three maxima when $x = 0$, when $x = 10.0$ cm and when $x = 22.0$ cm.

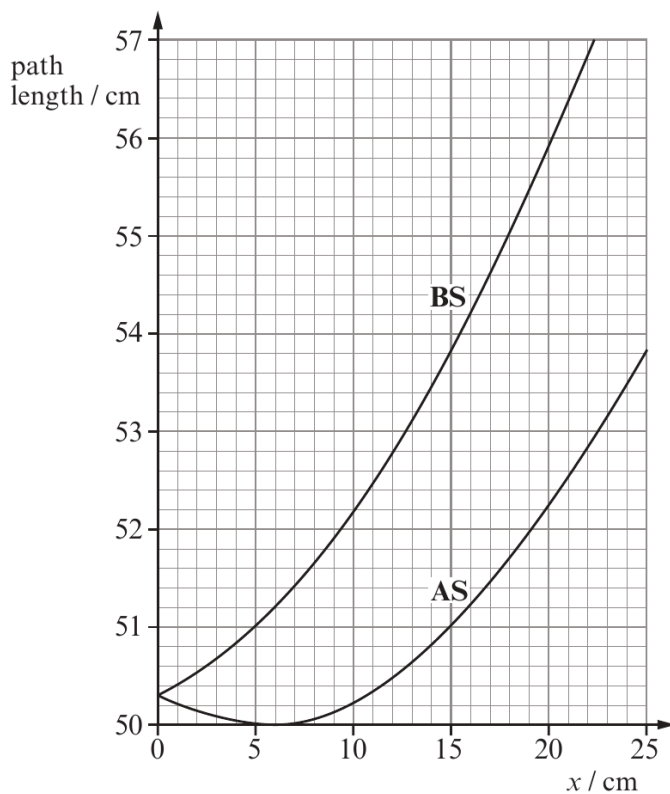
- (i) Explain why there is a maximum at point **P**. [2]

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- (ii) The graphs show how the *path lengths*, **BS** and **AS** depend on the distance x of the sensor from **P**.



Use these graphs to determine the wavelength of the microwaves, showing your working. [2]

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- (iii) (I) The distance marked D on the diagram on the page opposite is 50.0 cm. The distance **AB** between the sources is 10.0 cm. Use the Young's fringes formula to obtain a value for the wavelength. [Make use of the distance from the central maximum at **P** to the next maximum.] [2]

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(II) Give one reason, based on the set-up, or on the positions of the maxima, why it is not strictly appropriate to use the Young's fringes formula here. [1]

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(b) A diffraction grating has 5.0×10^5 slits per metre. When a laser beam is shone normally at the grating, the third order beams emerge at angles of 72.3° to the normal.

(i) Determine the wavelength of the light. [3]

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(ii) Show that 7 (but no more than 7) beams of light emerge from the grating. [3]

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END OF QUESTION PACK

6 questions · 61 marks · ~1 h 25 min

Source: WJEC PH2 (2008 modular spec)

Curated for WJEC Physics 2015 spec AS Unit 2 – Topic 5a (2.5)

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