

Superposition

Question Paper

| | |
|------------|--------------------------------------|
| Level | Pre U |
| Subject | Physics |
| Exam Board | Cambridge International Examinations |
| Topic | Superposition |
| Booklet | Question Paper |

Time Allowed: 30 minutes

Score: /25

Percentage: /100

Grade Boundaries:

- 1 A strip of wet cardboard is fixed on the bottom of a microwave oven. The microwave oven is turned on for a short time. When the card is removed a pattern of dry spots is observed on the cardboard. This is because a standing wave is set up inside the oven.

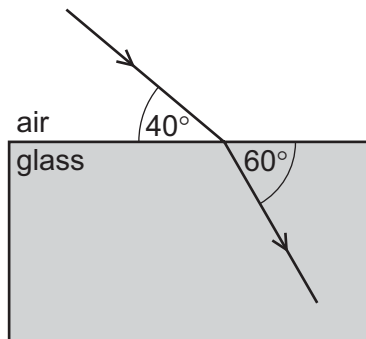
The dry spots are measured and found to occur at 14 mm, 84 mm, 152 mm, 221 mm and 292 mm from the end of the strip.

From this information, what is the frequency of the microwaves?

- A 2.2 GHz B 2.6 GHz C 4.3 GHz D 5.1 GHz

Space for working

- 2 The diagram shows a ray of light passing from air into a glass block.



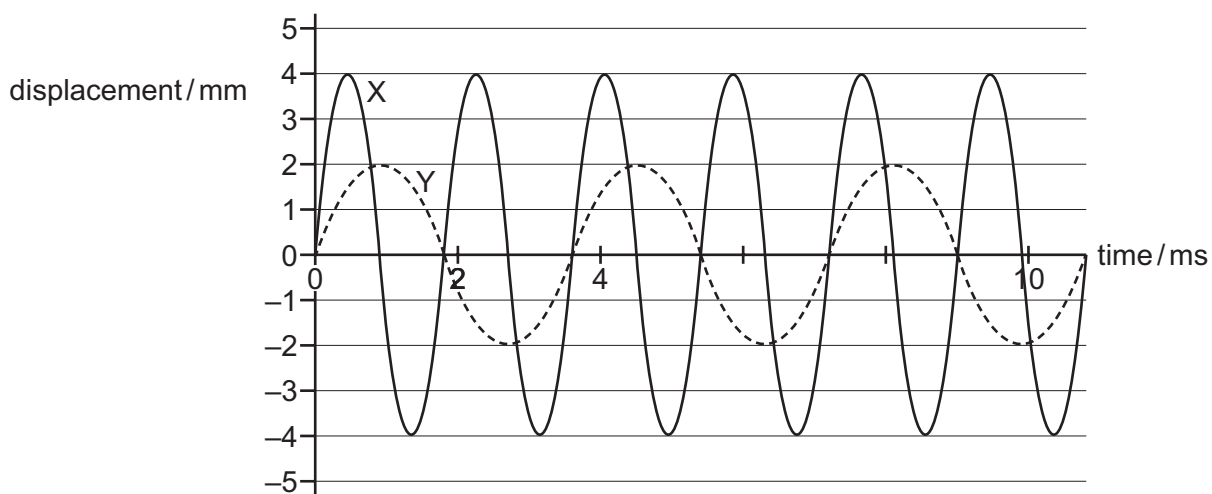
The angle between the ray and the edge of the glass block is 40° in the air and 60° in the glass.

What is the speed of light in the glass block?

- A $1.80 \times 10^8 \text{ m s}^{-1}$
B $1.89 \times 10^8 \text{ m s}^{-1}$
C $1.96 \times 10^8 \text{ m s}^{-1}$
D $2.16 \times 10^8 \text{ m s}^{-1}$

Space for working

3 The graph represents two sound waves, X and Y.



Which row shows the intensity and frequency ratios for X and Y?

| | $\frac{\text{intensity of X}}{\text{intensity of Y}}$ | $\frac{\text{frequency of X}}{\text{frequency of Y}}$ |
|----------|---|---|
| A | 2 | $\frac{1}{2}$ |
| B | 2 | 2 |
| C | 4 | $\frac{1}{2}$ |
| D | 4 | 2 |

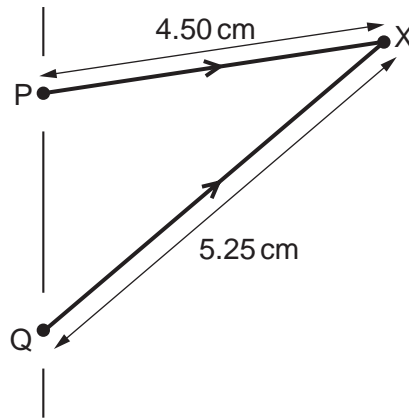
Space for working

4 A laser used as a screen pointer emits light of wavelength λ . It emits n photons per second.

What is the power of the laser?

- A $\frac{n\lambda}{hc}$
- B $\frac{hc}{n\lambda}$
- C $\frac{\lambda}{nhc}$
- D $\frac{nhc}{\lambda}$

5 Two coherent microwaves of wavelength 1.5 cm are in phase at points P and Q in the diagram. They interfere with each other at point X.



What is the phase difference, in radians, of the waves at point X?

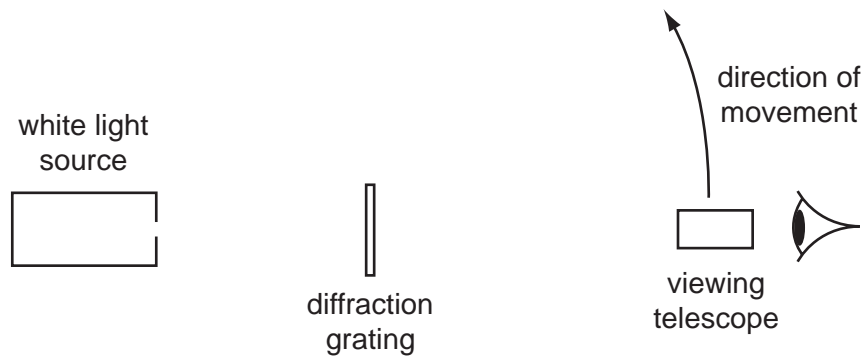
- A 0.75π
- B π
- C 1.5π
- D 2π

Space for working

6 Which statement about standing waves is correct?

- A A standing wave can be produced on a string fixed at two end points, when plucked at the middle.
- B In a standing wave, nodes are separated by one wavelength.
- C In a standing wave, points of zero amplitude are called antinodes.
- D Standing waves can only be produced by the superposition of two transverse waves travelling in opposite directions.

7 The diagram shows a source of white light. The light is incident on a diffraction grating.



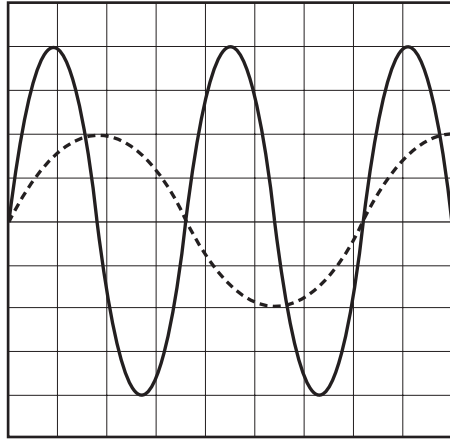
Which diagram represents the spectrum observed when the viewing telescope is moved from the position shown and in the direction shown on the diagram?

- A
- B
- C
- D

key
w = white
r = red
v = violet

Space for working

- 8 A microphone is connected to an oscilloscope and picks up sound waves X and Y. The diagram shows the displays on the oscilloscope screen. The same oscilloscope settings are used for both sound waves.



key
 — signal X
 - - - - signal Y

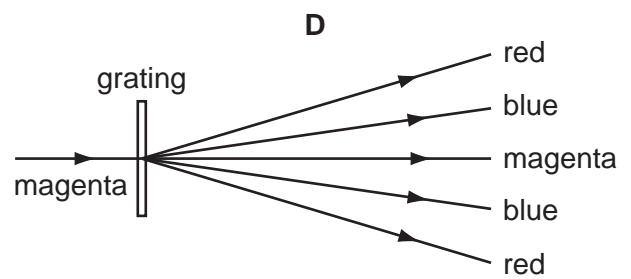
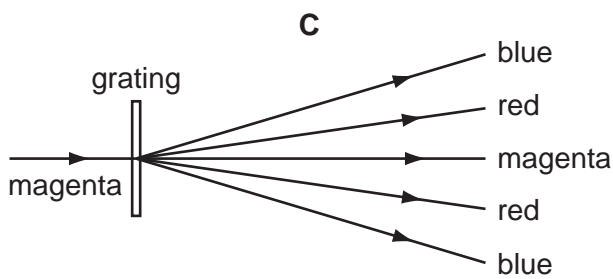
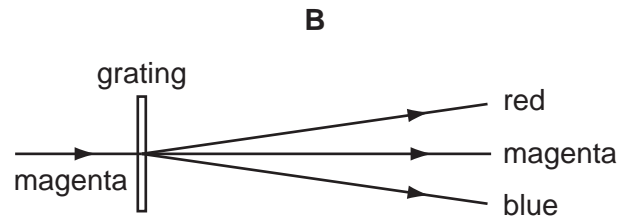
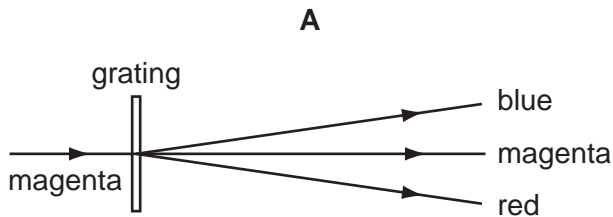
The frequency and intensity of signal X are f_x and I_x .
 The frequency and intensity of signal Y are f_y and I_y .

What are the frequency and intensity ratios?

| | $\frac{f_y}{f_x}$ | $\frac{I_y}{I_x}$ |
|----------|-------------------|-------------------|
| A | 0.5 | 0.25 |
| B | 0.5 | 0.5 |
| C | 2 | 0.25 |
| D | 2 | 0.5 |

Space for working

- 9 Magenta light consisting of a mixture of blue and red light is incident on a diffraction grating.
What is the expected arrangement of first orders about the central zero order?



- 10 Light produced by a calcium discharge lamp strikes a diffraction grating, with 800 slits per mm, at right angles to the surface.

The second order spectrum includes a line at an angle of 41.0° to the normal.

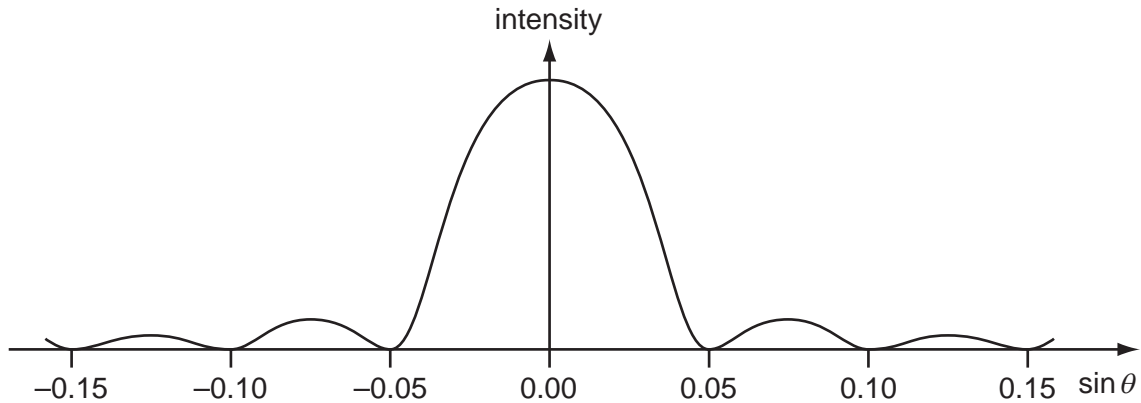
What is the wavelength of the light producing this line?

- A** $1.6 \times 10^{-6} \text{ m}$ **B** $4.1 \times 10^{-7} \text{ m}$ **C** $4.6 \times 10^{-7} \text{ m}$ **D** $8.2 \times 10^{-7} \text{ m}$

Space for working

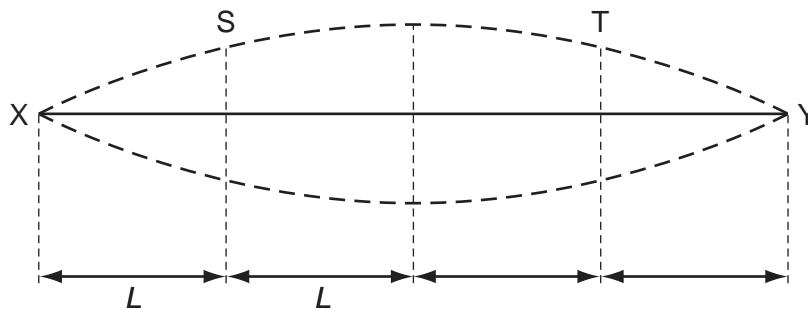
- 11 A parallel, monochromatic beam of electromagnetic radiation is incident at right angles onto a single slit of width 0.010 mm.

The graph shows how the intensity of the radiation varies with the sine of the angle θ through which the light is diffracted.



What is the wavelength of the radiation?

- A** 500 nm **B** 750 nm **C** 500 μm **D** 750 μm
- 12 A uniform wire XY is fixed at its ends and vibrates transversely in its fundamental mode.



What is the phase difference between the displacement of a particle at S and that of a particle at T?

- A** 0° **B** 45° **C** 135° **D** 180°

Space for working

- 13 A standing wave is set up on a rope of length 1.0 m fixed at both ends.

Which statement is correct?

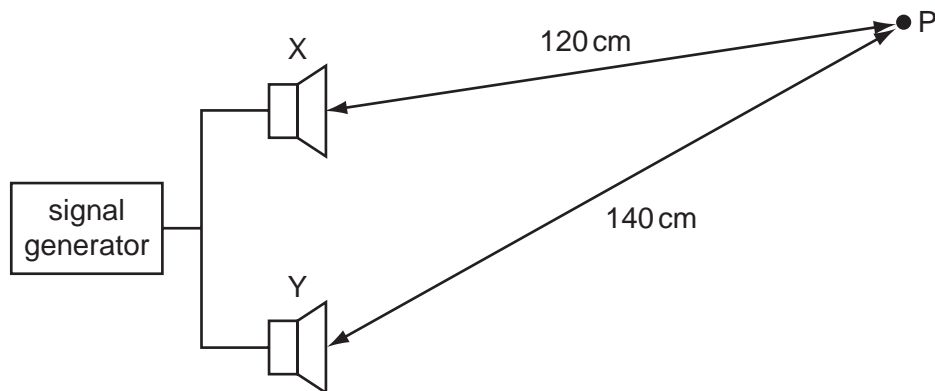
- A A harmonic of wavelength 0.4 m may be set up on the rope.
- B The fundamental mode has a wavelength of 1 m.
- C The midpoint of the rope is always stationary.
- D There are five nodes on the rope for the 5th harmonic.

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- 14 The output from a single signal generator is connected to two speakers, X and Y, so that the sound waves produced by each speaker are in phase.

The wavelength of the sound is 30 cm.

P is a point near the speakers.

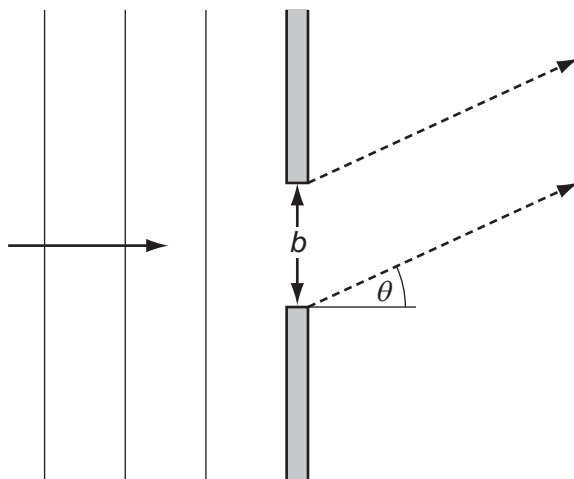


Which of the following is a way of expressing the phase difference between the waves arriving at P from X and Y?

- A 0 radians
- B $\frac{\pi}{3}$ radians
- C $\frac{2\pi}{3}$ radians
- D π radians

Space for working

- 15 Light of wavelength λ , from a distant source to the left of the diagram, falls on a narrow slit of width b .



Light passing through the slit spreads out and is incident on a distant screen.

At which **small** angle θ is it certain that there will be zero intensity?

- A** 0 **B** $\frac{\lambda}{b}$ **C** $\frac{b}{\lambda}$ **D** $\frac{\lambda}{2b}$
- 16 A thin beam of monochromatic light falls on a diffraction grating at normal incidence. The third order diffracted beam occurs at an angle of 50° to the normal.

What is the highest order visible with this grating at this wavelength?

- A** 3 **B** 4 **C** 5 **D** 6

Space for working

- 17 A strip of wet cardboard is fixed on the bottom of a microwave oven. The microwave oven is turned on for a short time. When the card is removed a pattern of dry spots is observed on the cardboard. This is because a standing wave is set up inside the oven.

The dry spots are measured and found to occur at 14 mm, 86 mm, 156 mm, 225 mm and 293 mm from the end of the strip.

From this information, what is the frequency of the microwaves?

- A** 2.2GHz **B** 2.6GHz **C** 4.3GHz **D** 5.1GHz

- 18 Laser light is incident upon a double slit and the resulting interference pattern is viewed on a distant screen. A very thin transparent film is then placed in front of one of the slits, such that the light emerging from this slit is now 180° out of phase with the light emerging from the other slit.

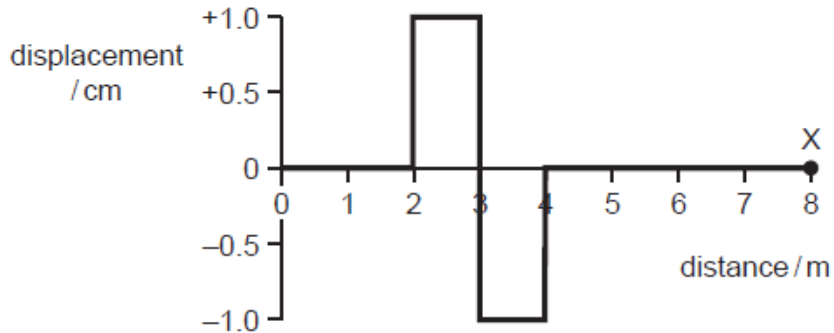
What change, if any, will there be in the interference pattern observed on the screen?

- A** The interference pattern will be much dimmer.
B The interference pattern will shift slightly.
C There will be no change.
D There will be no interference pattern as there is no longer coherence.

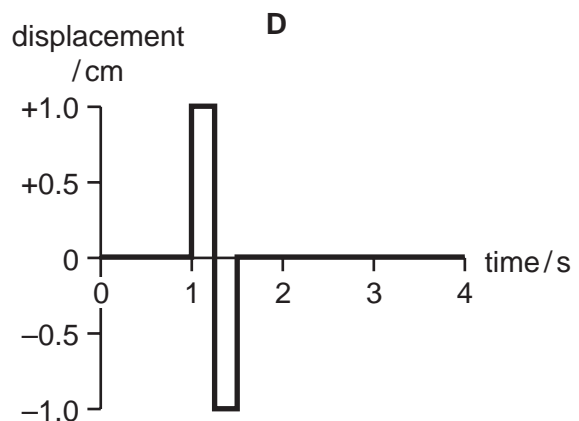
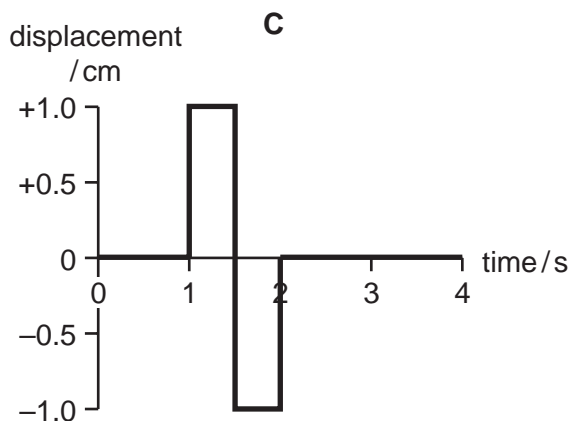
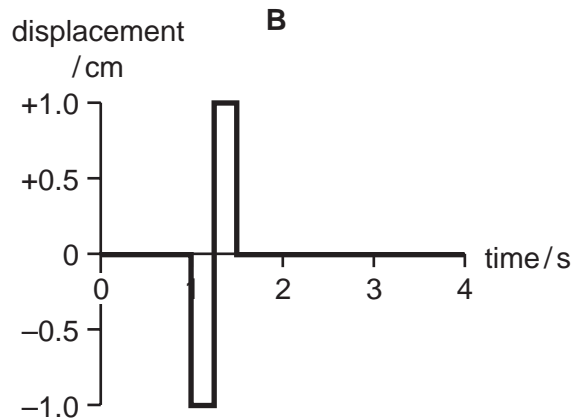
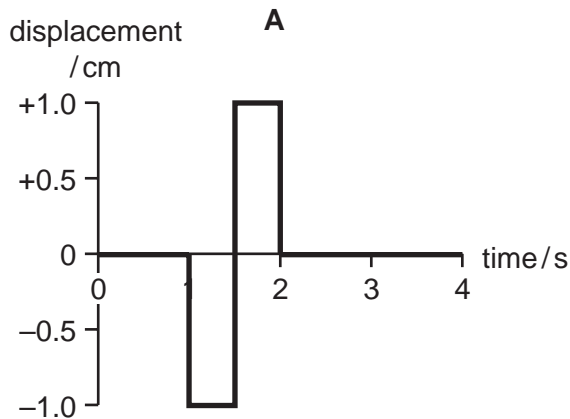
Space for working

19. The diagram shows a square-wave pulse at time $t=0$.

The pulse is travelling to the right at a speed of 4.0 ms^{-1} .

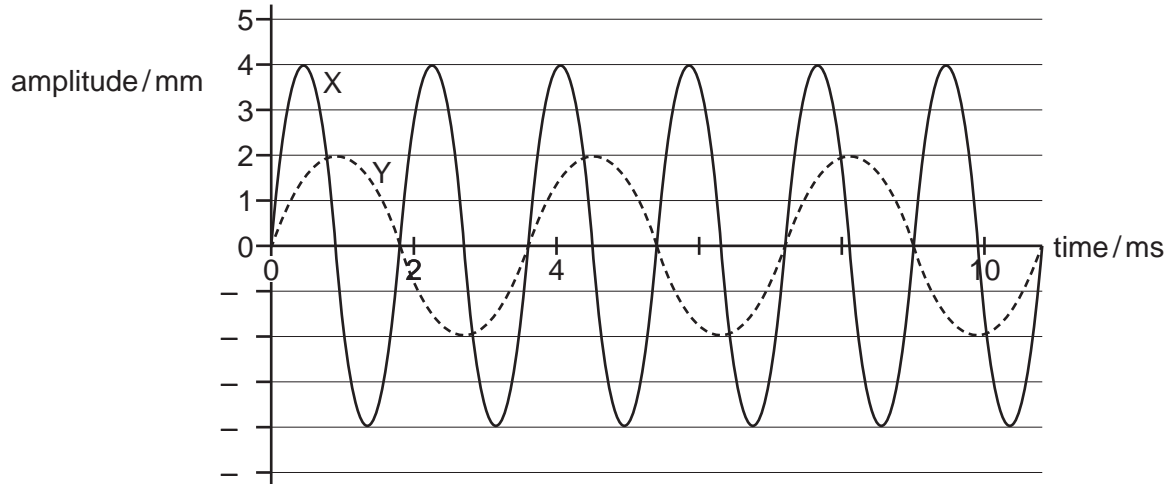


Which graph correctly shows how the displacement of point X will vary over the next 4 seconds?



Space for working

20 The graph shows how the amplitude varies with time for two sound waves, X and Y.



Which row shows the intensity and frequency ratios for X and Y?

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21 Which statement about standing waves is correct?

- A** A standing wave can be produced on a string fixed at two end points, when plucked at the middle.
- B** In a standing wave, nodes are separated by one wavelength.
- C** In a standing wave, points of zero amplitude are called antinodes.
- D** Standing waves can only be produced by the superposition of two sets of progressive transverse waves travelling in opposite directions.

Space for working

- 22 Two waves are defined to be coherent if
- A they are emitted by identical sources close together.
 - B they have a constant phase difference between them.
 - C they have the same amplitude and frequency.
 - D they have the same wavelength and speed.

- 23 What is the relationship between phase difference $\Delta\phi$ in radians, path difference x and wavelength λ ?

A $\Delta\phi = \frac{x}{\lambda}$

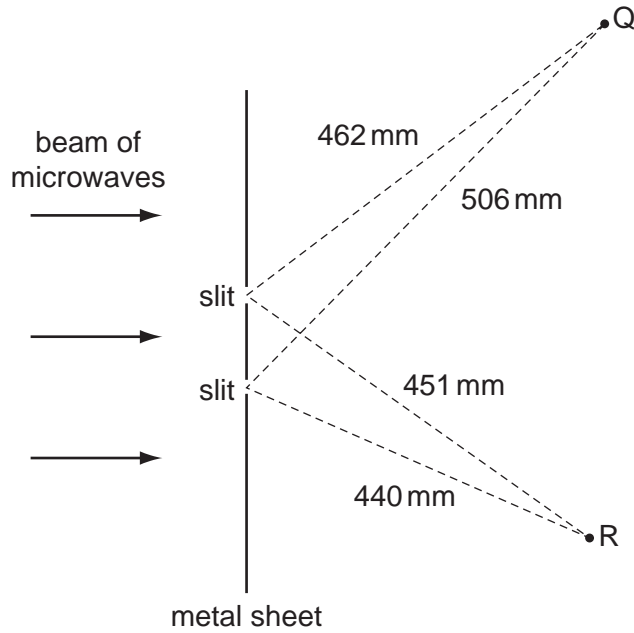
B $\Delta\phi = \frac{\lambda}{x}$

C $\Delta\phi = \frac{2\pi x}{\lambda}$

D $\Delta\phi = \frac{2\pi\lambda}{x}$

Space for working

- 24 A beam of microwaves, with wavelength 22 mm, passes through two slits in a metal sheet. Q and R are microwave detectors.



When Q and R are at the distances shown, what are their readings?

| | Q | R |
|----------|---------|---------|
| A | maximum | maximum |
| B | maximum | zero |
| C | zero | maximum |
| D | zero | zero |

Space for working

- 25 A loudspeaker is placed facing a wall. It emits a continuous note of constant frequency. A standing wave is set up between the loudspeaker and the wall. At the wall, the standing wave has a node of displacement and an antinode of pressure.

The frequency of the note is now doubled and a standing wave is again formed.

What will there now be at the wall?

- A** an antinode of displacement and an antinode of pressure
- B** an antinode of displacement and a node of pressure
- C** a node of displacement and an antinode of pressure
- D** a node of displacement and a node of pressure