Superposition – 2021 AS

1. Nov/2021/Paper_22/No.5

A tube is initially fully submerged in water. The axis of the tube is kept vertical as the tube is slowly raised out of the water, as shown in Fig. 5.1.

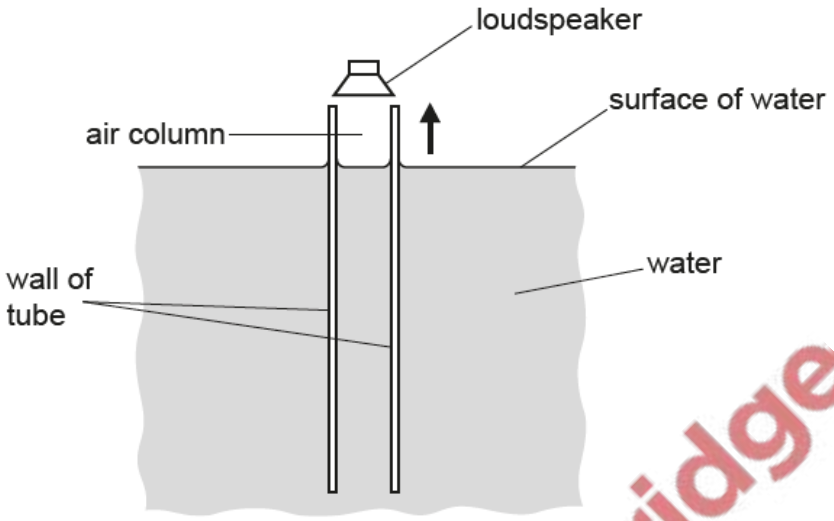

Fig. 5.1

A loudspeaker producing sound of frequency 530 Hz is positioned at the open top end of the tube as it is raised. The water surface inside the tube is always level with the water surface outside the tube. The speed of the sound in the air column in the tube is 340 m s^{-1}.

(a) Describe a simple way that a student, without requiring any additional equipment, can detect when a stationary wave is formed in the air column as the tube is being raised.

.....

..... [1]

(b) Determine the height of the top end of the tube above the surface of the water when a stationary wave is first produced in the tube. Assume that an antinode is formed level with the top of the tube.

height = ... m [3]

(c) Determine the distance moved by the tube between the positions at which the first and second stationary waves are formed.

distance = ... m [1]

[Total: 5]

2. June/2021/Paper_21/No.4

(a) For a progressive wave, state what is meant by *wavelength*.

.....

..... [1]

(b) A light wave from a laser has a wavelength of 460 nm in a vacuum.

Calculate the period of the wave.

period = ... s [3]

(c) The light from the laser is incident normally on a diffraction grating.

Describe the diffraction of the light waves at the grating.

.....

.....

..... [2]

(d) A diffraction grating is used with different wavelengths of visible light. The angle θ of the **fourth**-order maximum from the zero-order (central) maximum is measured for each wavelength. The variation with wavelength λ of $\sin\theta$ is shown in Fig. 4.1.

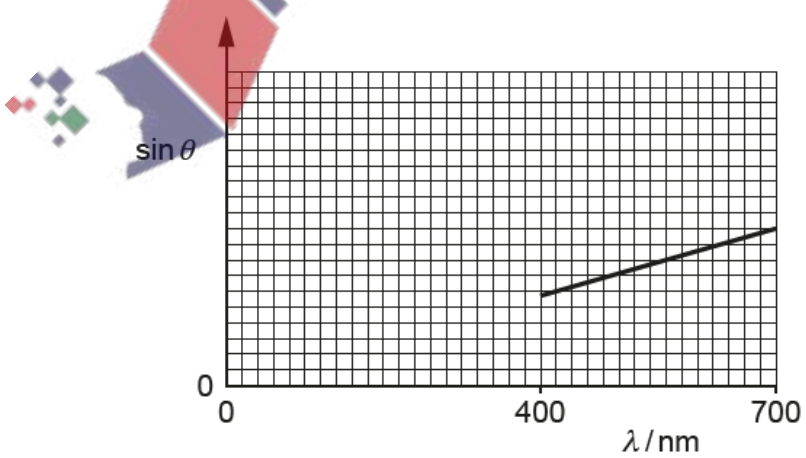

Fig. 4.1

(i) The gradient of the graph is G.

Determine an expression, in terms of G, for the distance d between the centres of two adjacent slits in the diffraction grating.

d = ... [2]

(ii) On Fig. 4.1, sketch a graph to show the results that would be obtained for the **second**-order maxima. [2]

[Total: 10]

3. June/2021/Paper_22/No.4

(a) For a progressive wave, state what is meant by its *period*.

.....

..... [1]

(b) State the principle of superposition.

.....

.....

..... [2]

(c) Electromagnetic waves of wavelength 0.040 m are emitted in phase from two sources X and Y and travel in a vacuum. The arrangement of the sources is shown in Fig. 4.1.

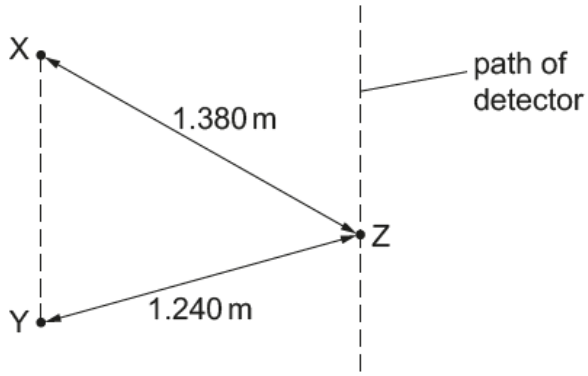

Fig. 4.1 (not to scale)

A detector moves along a path that is parallel to the line XY. A pattern of intensity maxima and minima is detected.

Distance XZ is 1.380 m and distance YZ is 1.240 m.

(i) State the name of the region of the electromagnetic spectrum that contains the waves from X and Y.

..... [1]

(ii) Calculate the period, in ps, of the waves.

period = ... ps [3]

(iii) Show that the path difference at point Z between the waves from X and Y is 3.5λ, where λ is the wavelength of the waves.

[1]

(iv) Calculate the phase difference between the waves at point Z.

phase difference = ...° [1]

(v) The waves from X alone have the same amplitude at point Z as the waves from Y alone.

State the intensity of the waves at point Z.

..... [1]

(vi) The frequencies of the waves from X and Y are both decreased to the same lower value. The waves stay within the same region of the electromagnetic spectrum.

Describe the effect of this change on the pattern of intensity maxima and minima along the path of the detector.

.....

..... [1]

[Total: 11]

4. June/2021/Paper_23/No.4

(a) State the principle of superposition.

.....

.....

..... [2]

(b) Two waves, with intensities I and $4I$, superpose. The waves have the same frequency.

Determine, in terms of I, the maximum possible intensity of the resulting wave.

maximum intensity = ... I [2]

(c) Coherent light of wavelength 550 nm is incident normally on a double slit of slit separation 0.35 mm. A series of bright and dark fringes forms on a screen placed a distance of 1.2 m from the double slit, as shown in Fig. 4.1. The screen is parallel to the double slit.

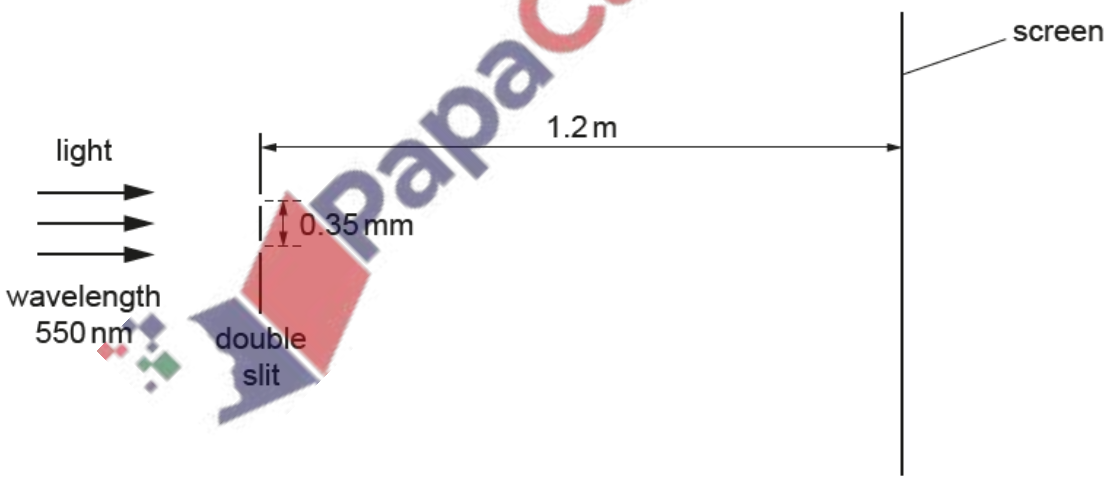

Fig. 4.1 (not to scale)

(i) Determine the distance between the centres of adjacent bright fringes on the screen.

distance = ... m [3]

(ii) The light of wavelength 550 nm is replaced with red light of a single frequency.

State and explain the change, if any, in the distance between the centres of adjacent bright fringes.

.....

.....

..... [1]

[Total: 8]

5. March/2021/Paper_22/No.4

(a) State the principle of superposition.

.....

.....

..... [2]

(b) A transmitter produces microwaves that travel in air towards a metal plate, as shown in Fig. 4.1.

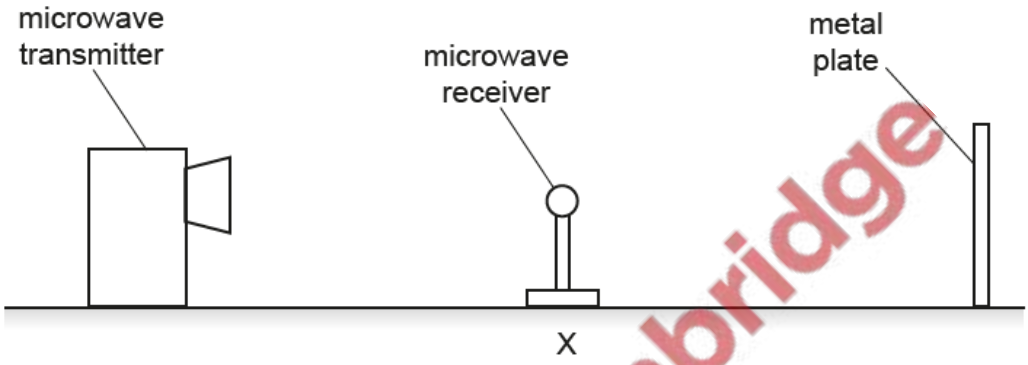

Fig. 4.1

The microwaves have a wavelength of 0.040 m. A stationary wave is formed between the transmitter and the plate.

(i) Explain the function of the metal plate.

.....

..... [1]

(ii) Calculate the frequency, in GHz, of the microwaves.

frequency = ... GHz [3]

(iii) A microwave receiver is initially placed at position X where it detects an intensity minimum. The receiver is then slowly moved away from X directly towards the plate.

1. Determine the shortest distance from X of the receiver when it detects another intensity minimum.

distance = ... m

2. Determine the number of intensity maxima that are detected by the receiver as it moves from X to a position that is 9.1 cm away from X.

number = ...
[2]

[Total: 8]