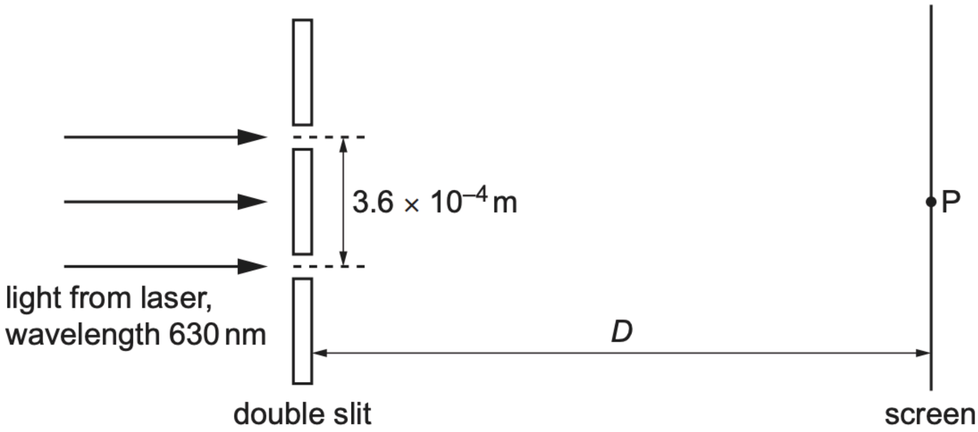
1.

An arrangement for demonstrating interference using light is shown in Fig. 5.2.



Explain why a bright fringe is produced by the waves meeting at point P.

- Phase difference between the waves at P is 0, thus constructive interference.

2.

(b) An arrangement that uses a double slit to demonstrate the interference of light from a laser is shown in Fig. 5.1.

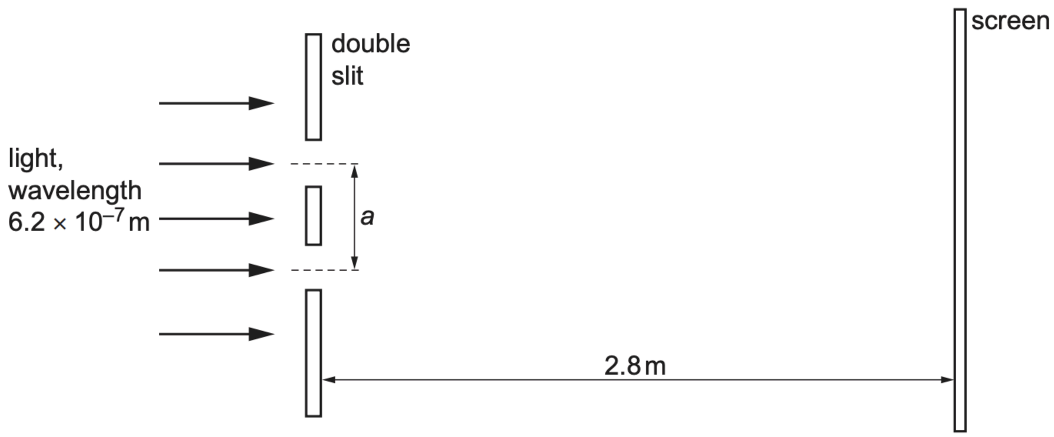
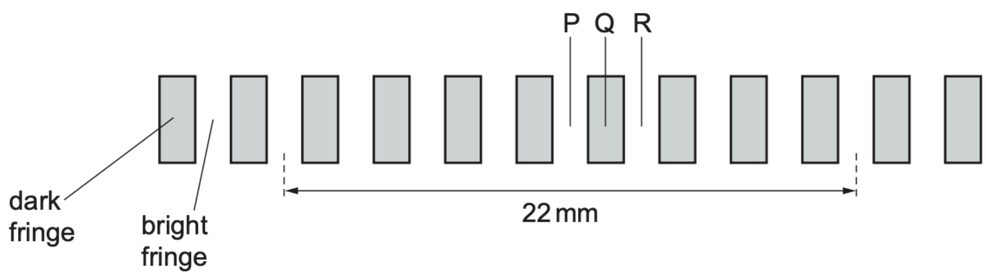


Fig. 5.1 (not to scale)

The light from the laser has a wavelength of 6.2×10^{-7} m and is incident normally on the slits. The separation of the two slits is *a*. The slits and screen are parallel and separated by a distance of 2.8 m.

An interference pattern of bright fringes and dark fringes is formed on the screen. The distance on the screen across 8 bright fringes is 22 mm, as illustrated in Fig. 5.2.



Separation a of the slits = 6.3×10^{-4}m

(c) Fringe P is the central bright fringe of the interference pattern in **(b)**. Fringe Q and fringe R are the nearest dark fringe and the nearest bright fringe respectively to the right of fringe P, as shown in Fig. 5.2.

(i) Calculate the difference in the distances (the path difference) from each slit to the centre of fringe Q.

difference in the distances = ... m [1]

(ii) State the phase difference between the light waves meeting at the centre of fringe R.

phase difference = ...° [1]

- Path difference = $n\lambda = \frac{1}{2} \times \lambda = \frac{1}{2}(6.2 \times 10^{-7}) = 3.1 \times 10^{-7}$m
- Phase difference between waves meeting at R = 360 (because constructive interference)

3.

A stretched string PQ has length 1.2 m. One end of the string is attached to a vibration generator and the other end is attached to a wall, as shown in Fig. 5.1.

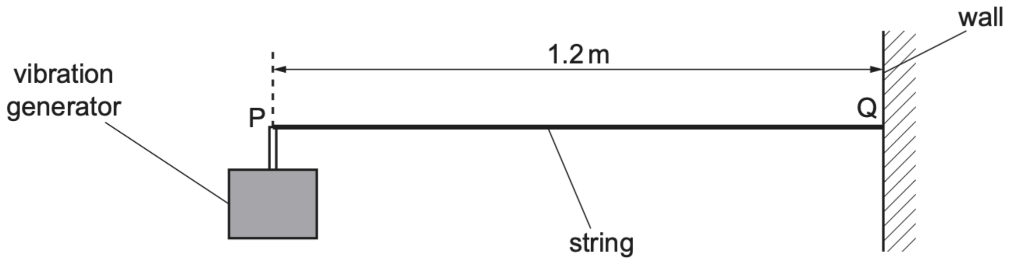
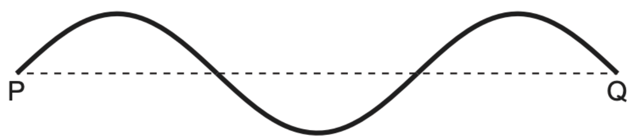


Fig. 5.1

The vibration generator is switched on and a stationary wave is formed on the string. The string is shown at one instant of time in Fig. 5.2.

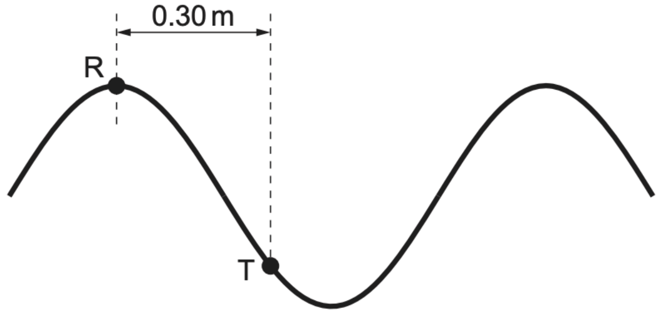


Explain how a stationary wave is formed between the vibration generator and the wall.

- wave travels along string and reflects at fixed point / wall
- incident and reflected waves superpose

4.

Points R and T on the string are a horizontal distance of 0.30 m apart and in the positions shown in Fig. 5.4.



State the phase difference between the oscillations of points R and T

- 180˚

NOTE:

For standing wave, within same loop = 0˚ phase difference

If the points are separated by a node / 1 loop and next loop = 180˚ phase difference

5.

A horizontal string is stretched between two fixed points A and B. A vibrator is used to oscillate the string and produce an observable stationary wave.

At one instant, the moving string is straight, as shown in Fig. 5.1.

a. On Fig. 5.1, sketch a line to show a possible position of the string a quarter of a cycle later than the position shown in the diagram. The dots in the diagram represent the positions of the nodes on the string. Point P on the string is moving downwards.

- line has an approximate sinusoidal shape with maximum downward displacement at P and zero displacement at each node

b. A particle on the string has zero displacement at time t = 0. From time t = 0 to time t = 0.060s, the particle moves through a total distance of 72mm. Calculate the amplitude of oscillation of the particle.

(number of periods / cycles) (= t / T) = 0.060 / 0.040

(= 1.5)

---

amplitude = 72 / 6

= 12 mm

6.

Two coherent sources X and Y of microwaves of frequency 2.5×10^{10} Hz are a distance of 0.18 m apart in a vacuum, as shown in Fig. 6.1.

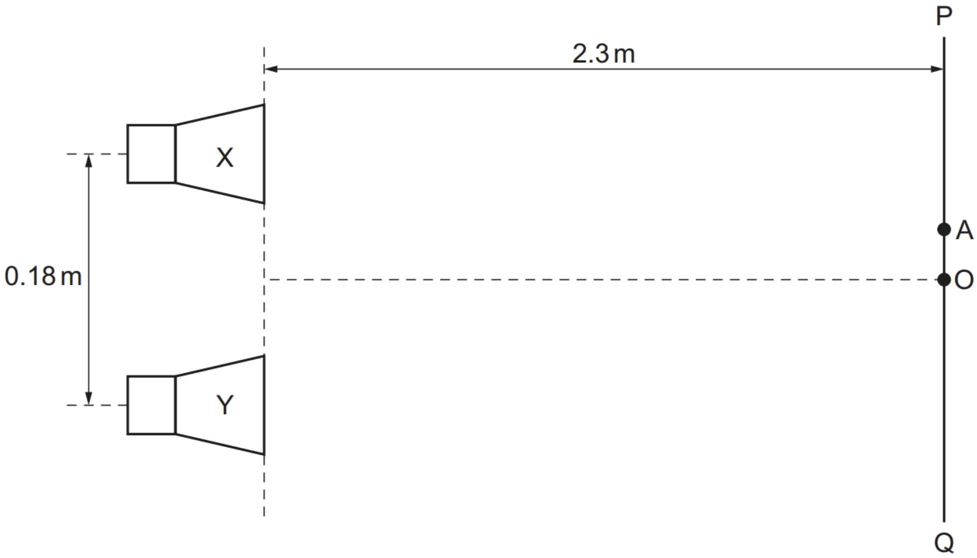


Fig. 6.1 (not to scale)

There is a phase difference of 90° between the waves emitted at the two sources.

A microwave detector moves along the line PQ, which is parallel to the line joining the two sources and 2.3 m away from it.

Point O is on the line PQ at a position that is equidistant from the two sources.
Point A is the position on line PQ where the intensity of the microwaves is the greatest.

7. Explain why the position of greatest intensity is not at point O.
   - for maximum intensity waves must be in phase at detection
   - phase difference at source means waves are not in phase / have a 90° phase difference at O

8. On Fig. 6.1, draw a cross (×) to show the position of the point on line PQ where the intensity minimum that is the closest to point O occurs. Label this point B.
   - point B labelled on the line PQ below O
   - distance OB = distance OA

9. For point A on line PQ, determine the difference in the distances Δx travelled by the microwaves from X and the microwaves from Y.

$$\Delta x = 0.012 / 4$$

$$= 0.0030 \text{ m}$$

- At point O, there is no path difference
- Phase difference between point A and O = 90˚. 90˚ = ¼ x 360
- so path difference = 0.012/4 = 0.003

NOTE: When waves have a 90˚ phase difference at source, at a point O which is equidistant from both sources, there will be a phase difference also equal to 90˚. In the above question, point A is where there is 0˚ phase difference. Point O has 90˚. For minimum intensity, 180˚ phase difference is required. Thus OA = OB.

10. State the conditions required for the formation of stationary waves
    - Two waves travelling at same speed in opposite directions overlap
    - Waves are same type and have same frequency/wavelength

11. The intensity of light incident on a double slit is increased without changing the frequency. Describe how the appearance of the fringes after this change is different from, and similar to, their appearance before this change.
    - Bright fringes are brighter
    - No change to dark fringes
    - No change to fringe separation / fringe spacing

12. A motorcycle rider passes a stationary pedestrian and moves directly away from her. As the rider moves away, he operates a horn. The pedestrian hears sound that is increasing in frequency. State the variation, if any, in the speed of the motorcycle when the rider operates the horn.
    - Speed is decreasing

13.

A beam of vertically polarised monochromatic light is incident normally on a polarising filter, as shown in Fig. 5.1.

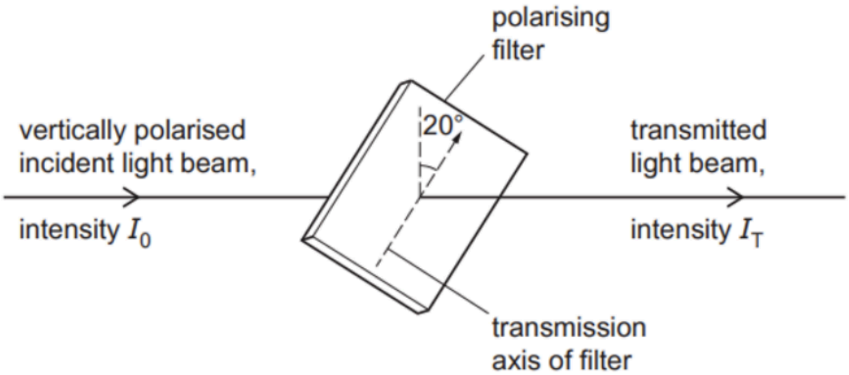


Fig. 5.1

The filter is positioned with its transmission axis at an angle of 20° to the vertical.
The incident light has intensity I_0 and the transmitted light has intensity I_T.

The filter is now rotated, about the direction of the light beam, from its starting position shown in Fig. 5.1. The direction of rotation is such that the angle of the transmission axis to the vertical initially increases.

Calculate the minimum angle through which the filter must be rotated so that the intensity of the transmitted light returns to the value that it had when the filter was at its starting position.

- 140˚

14.

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.

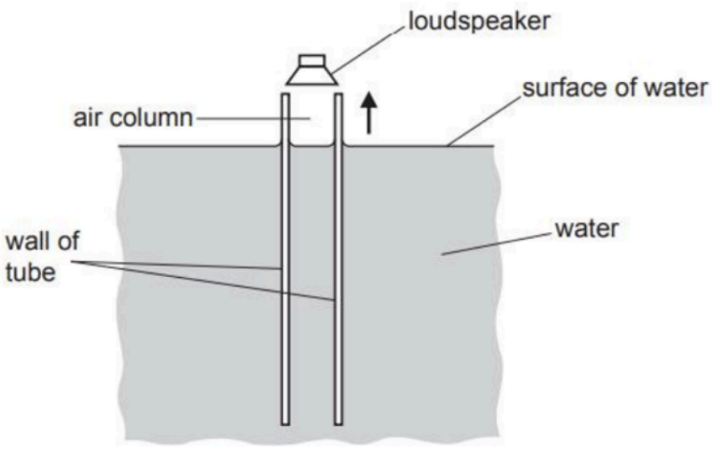


Fig. 5.1

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 $340\,m\,s^{-1}$.

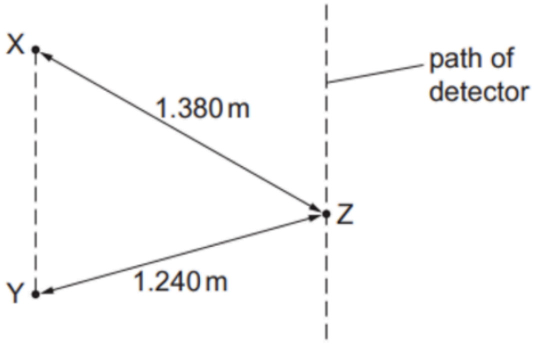
15. Describe a simple way that a student, without requiring any additional equipment, can detect when a stationary wave is formed in the air column as the tube is being raised.
    - A much louder sound can be heard

16. Determine the distance moved by the tube between the positions at which the first and secondary stationary waves are formed
    - wavelength / 2 = 0.64 /2 = 0.32m OR
      2nd harmonic – 1st harmonic = (3 x 0.64)/4 – (1 x 0.64)/4 = 0.32

17. State the principle of superposition
    - When 2 or more waves meet/ overlap at a point
    - Resultant displacement is the sum of the individual displacements

18.

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.



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.

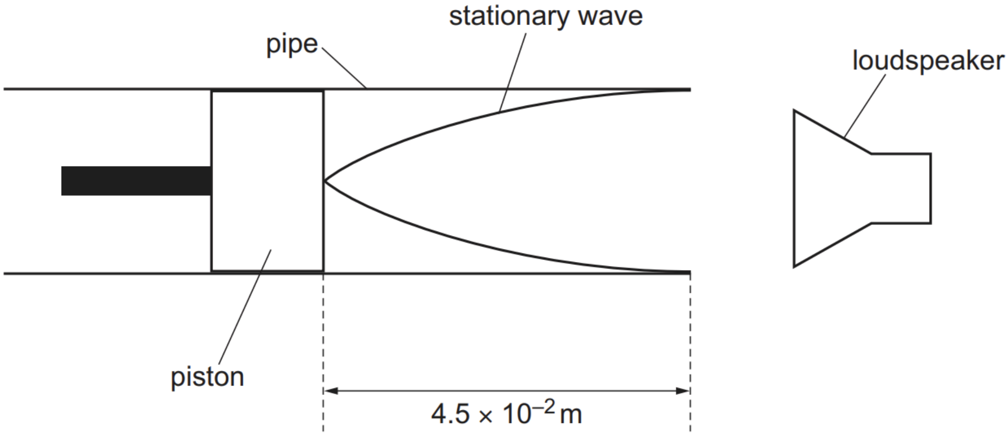
- Increase in distance between adjacent maxima/minima

19. Describe the diffraction of light waves at diffraction grating
    - Waves pass through/ enter the slits
    - Waves spread into geometric shadow

20.

A pipe is open at one end and closed at the other with a piston. The piston can slide freely and is at a distance of 4.5×10^{-2} m from the open end of the pipe.

A loudspeaker is positioned near the open end of the pipe and emits a sound wave of a single constant frequency. A stationary wave is formed in the pipe, as illustrated in Fig. 4.1.



The piston is moved to the left. The frequency of the sound wave emitted by the loudspeaker is then changed so that a stationary wave is formed with same number of antinodes as in Fig. 4.1. State and explain the change that is made to the frequency of the sound wave.

- the node–antinode distance is longer OR the wavelength (of the wave) is longer
- the speed of sound is constant so the frequency of the wave is lower

21. A microwave of intensity I_0 and amplitude A_0 meets another microwave of the same frequency and of intensity ¼ I_0 travelling in the opposite direction. Both microwaves are vertically plane polarised and superpose where they meet. Explain, without calculation, why these two waves cannot form a stationary wave with zero amplitude at its nodes.
    - the waves have different amplitudes
    - cannot have resultant displacement that is always zero OR cannot have complete destructive interference at nodes OR at nodes resultant amplitude is the difference of the amplitudes