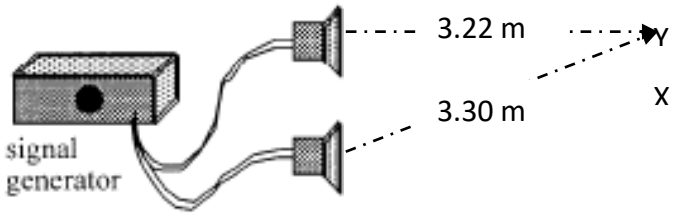
Higher Grade Physics

Unit 2 : PARTICLES & WAVES

Interference & Diffraction

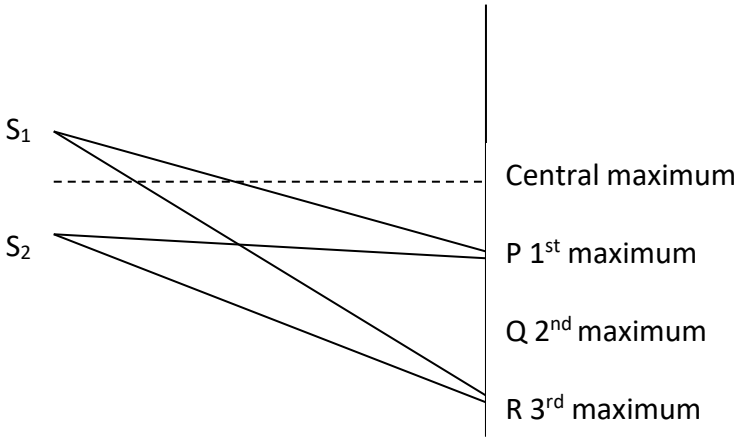
Path Difference

1. Two loudspeakers are connected to the same signal generator as shown below:



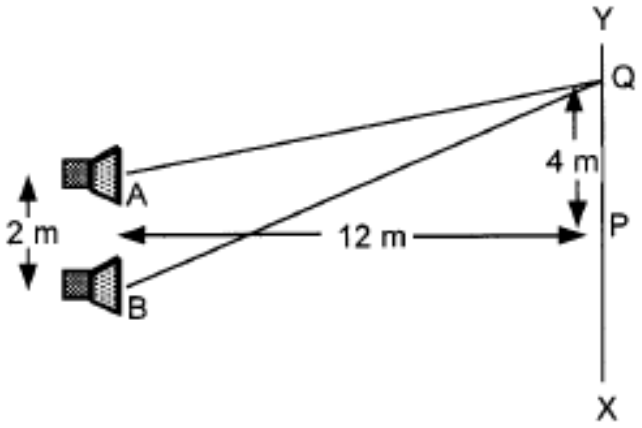
A microphone at X detects maximum intensity. When the microphone is moved slowly upwards, it detects the first minimum at Y. Calculate the wavelength of the sound emitted from the loudspeaker.

2. S_1 and S_2 are two coherent wave sources giving an interference pattern along a line :



The first maximum occurs at P, where $S_1P = 20$ cm and $S_2P = 18$ cm.
What is the path difference ($S_1R - S_2R$) for the third maximum?

3. In an experiment on sound interference, two sources **A** and **B** are placed 2 m apart.
As a girl walks from **X** to **Y** she hears a point of maximum loudness at point **P** and the next at point **Q**. Using information from the diagram :



(a) find the distances AQ and BQ

(b) calculate the wavelength of the sound

(c) calculate the frequency of the sound.

4. In the microwave experiment shown below, **C** is the zero order maximum and **D** is the first order maximum. **AD** = 52 cm and **BD** = 55 cm.

   (a) What is the path difference at point **D**?

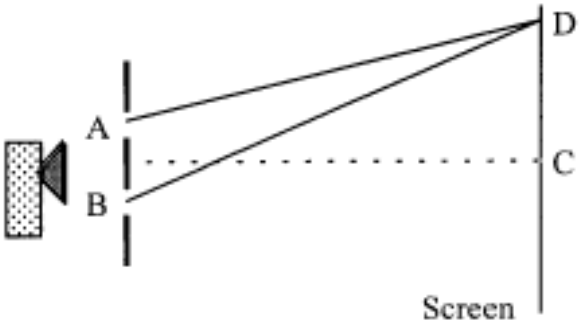
   (b) What is the wavelength of the microwaves?

   (c) What is the path difference to the second order maximum?

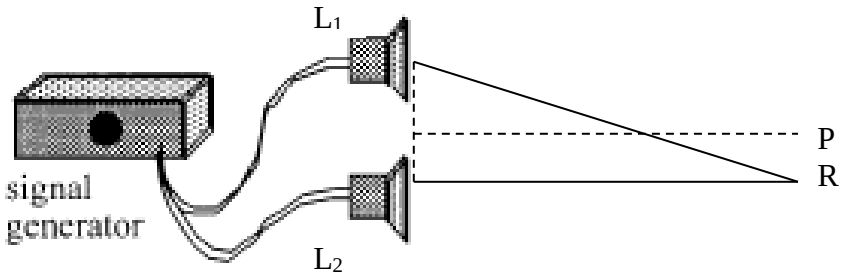
   (d) What is the path difference to the minimum next to C?

   (e) What is the path difference to the second minimum?

   (f) What is the path difference at point **C**?



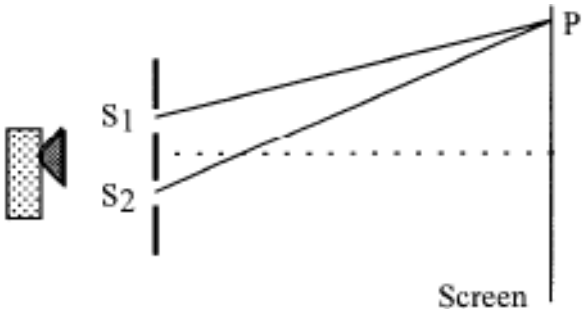
5. L_1 and L_2 are loudspeakers connected to a signal generator. A sound interference pattern is produced :



   At P, equidistant from L_1 and L_2 , a microphone registers a maximum. The next maximum is registered at R, where the distances L_1R = 4·6 m and L_2R = 4·3 m. If the speed of the sound in air is 330 ms^{-1}, what is the frequency of the note emitted by the loudspeakers ?

6. In a microwave interference experiment, P is the first minimum away from the centre. The measured distances are:

   S_1P = 42.1 cm
   S_2P = 46.6 cm



   Calculate the wavelength of the microwaves.

7. The sketch shows the experimental arrangement used to investigate microwaves passing through a double-slit system.

As the probe is moved along the scale meter reading increases and decreases repeatedly.

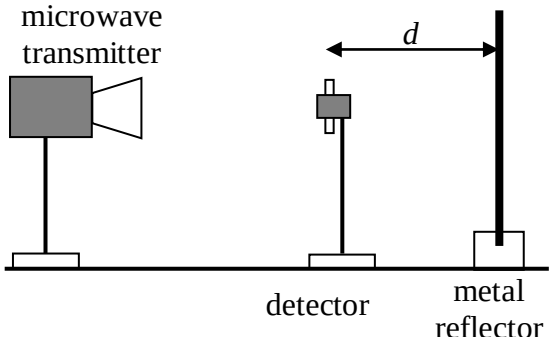
(a) The probe gives one of its maximum readings in the position shown, 32 cm from one slit and 38 cm from the other.
Could the microwaves be:

(i) 3 cm
(ii) 12 cm ?

Give a reason for your answer in each case.

(b) Explain how a minimum reading on the meter occurs.

8. A microwave transmitter emits radiation which has a wavelength of 30 mm. When a metal reflector is placed, as shown below, a maximum signal is detected by the detector.



Distance *d* could be

A 10 mm
B 20 mm
C 45 mm

Slit Separation

9. If a grating has 4000 rulings per cm, what is the slit separation ?

10. If a slide has 250 lines per mm, what is the slit separation ?

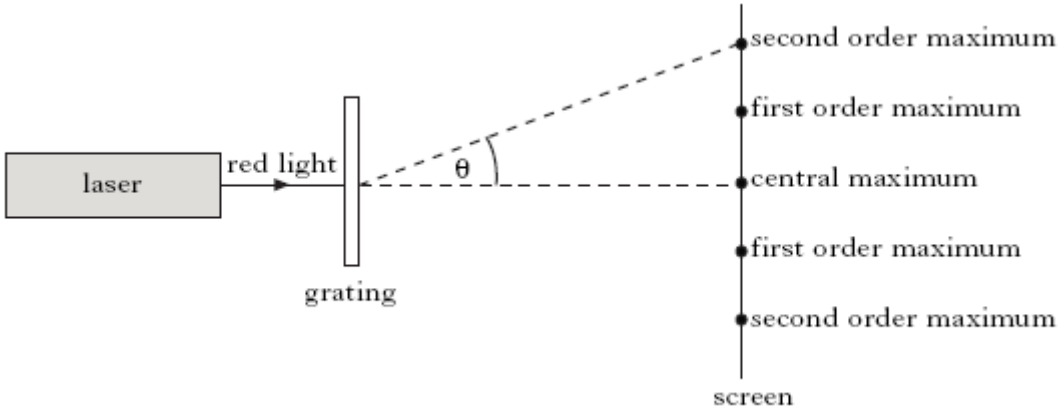
11. Find the slit spacing on a diffraction grating with
    (i) 300 lines per mm
    (ii) 5000 lines per cm
    (iii) 450 lines per mm

Grating Equation

12. If the first order spectrum for light of wavelength 6×10^{-7} m occurs at 14^0, what is the slit separation ?

13. If a grating has 5900 lines per cm and the first order spectrum is at 20^0, what is the wavelength of the light ?

14. If red light, of wavelength 7×10^{-7} m, from a laser passes through a grating of 5000 lines per cm, what will be the angle between the central maximum and second order maximum ?



15. Light of wavelength 650 nm passes through a grating of 4000 lines per cm. Calculate the angle between the central and first order maxima.

16. Light of wavelength 500 nm passes through a grating. The angle between the central and second order fringes is 30^0. Calculate the slit spacing of the grating.

17. Monochromatic light of wavelength 6×10^{-7} m is passed through a diffraction grating. The third order fringe is diffracted through an angle of 31^0. Calculate the distance between the centre of the slits on the diffraction grating.

18. White light is passed through a grating with 5000 lines/cm. Given that the range of wavelengths is 400 to 700 nm. Calculate the angle between the extremes of the first order maxima.

19. Light from a cadmium source is directed through a diffraction grating with 5000 lines per cm. First order fringes are observed at the following angles : $18{\cdot}80^0$, $14{\cdot}70^0$ and $15{\cdot}53^0$. Calculate the wavelength of each line.

20. A continuous spectrum is viewed with a spectrometer using a diffraction grating of 1000 lines/cm. First order blue, green and red fringes are viewed at $2{\cdot}5^0$, $3{\cdot}1^0$ and $4{\cdot}0^0$ respectively. Calculate the wavelengths of red, green and blue light.

21. A diffraction grating with 600 lines per millimetre is used with a monochromatic light source to produce an interference pattern. The first order fringe is obtained at an angle of 20.5^0.

    (a) Calculate the wavelength of the light.

    (b) At what angle would the first order fringe be diffracted through if a grating with 1400 lines per millimetre were used?

22. Using a spectrometer, light of wavelength 5×10^{-7} m is passed through a diffraction grating with 600 lines per millimetre. What is the angle between the first order maximum and the second order maximum?

23. A diffraction grating with a spacing of 3.3×10^{-6} m is set up on a spectrometer. A filter is used to transmit a strong blue line from a cadmium source. The two first order maxima are separated by an angle of 17.2^o.

    (a) Find the wavelength of the blue line in cadmium.

    (b) Determine the angle between the two second order maxima.

24. When a monochromatic light beam is shone through a diffraction grating an interference pattern, a series of dots, is obtained. Describe three changes which could be made to the experimental apparatus to spread the dots (the maxima) out.

25. White light, with a range of wavelengths from 440 nm to 730 nm is passed through a grating with 500 lines/mm.

    (a) Describe what would be seen.

    (b) Explain the pattern produced.

    (c) Calculate the angle between the extremes of the first order maximum, i.e. the angle between violet and red.

26. Spectra can be produced from white light by two methods as shown below.

    (a) Copy and complete the above diagrams to show the spectra produced.

    (b) List the differences between the two spectra produced.