Scholarship Physics Waves Interference (Vsound ~ 340 ms-1)

1. You are listening to music in the garden. Your neighbour is on the other side of a picket fence. The vertical air gaps are 16 cm apart. What frequencies will they hear loudest?

Your radio

Your neighbour

300

1. Explain how the interference pattern produced by four slits, (separation d) is different to the pattern produced by two slits, (separation d)
2. Explain why it is difficult to see an interference pattern with X rays.
3. A beam of X rays is fired at a crystal as shown. Part of the beam reflects from the first crystal plane and some from the second crystal plane. Write an equation in terms of wavelength (λ) and θ for the **shortest distance** between the crystal planes that will cause the two reflected beams to interfere **destructively** at the detector.

θ

detector

1. Explain why there is a limit to the smallest size object you can see with an optical microscope. Explain what the solution is.
2. Explain how an array of radio transmitters could be used to guide planes onto a runway. Discuss how you could avoid a plane landing on the wrong antinode.
3. i) Explain **how** a piano tuner can use a tuning fork and beats to tune a piano.

ii) **Can** a piano tuner use a tuning fork and beats to tune a piano **exactly**?

1. (this is an old Scholarship question…)

transmitter

receiver

a

b

c

wall

A transmitter emits microwaves. As the receiver moves up, the intensity varies.

1. Explain why.
2. What is the relationship between a,b,c and λ if the receiver is at a maximum. (state any assumptions)
3. Using , the wavelength of the 1st loud will be 0.08m, giving a frequency of 4250 Hz

The next will be for n=2, 8500Hz, then 12 750Hz and 17 000Hz.

1

2

1

2

3

4

With two slits, if the path difference is λ/4, the waves will be out of phase by 90o, so will only partially cancel. With four slits, at the same angle, 1 and 3 have a pd of λ/2 and are out of phase by 180o so they cancel, as do 2 and 4. So at the same angle, a node is produced.

 For one slit there is one node between the antinodes.

 For each extra slit there is an extra node.

This makes the area between the antinodes much darker.

This will make the pattern more defined.

1. Interference can only be seen when the slits (sources) are close together in comparison with the wavelength. X rays are very short wavelength so the slits must be very close together. X ray interference can be seen with crystals. The separation of the ions in the lattice is comparable with the X ray wavelength.
2. The path difference must be λ/2 so by geometry,

T (thickness)

T= λ/4 cos θ

λ/4

θ

1. Light waves diffract around an obstacle. If it is small in comparison with the wavelength, the light diffracts so much that the light continues almost unaffected.

The solution is to use a shorter wavelength. This is the principle behind electron microscopes. Electrons have extremely short wavelength.

1. A line of equally spaced transmitters perpendicular to the runway will produce an interference patern. A radio on the plane can be tuned to the transmitted frequency and land on the central antinode. To avoid landing on another antinode, the transmitters could produce two frequencies. The plane could have two radios. They would only pick up a signal on both radios on the central antinode. (as long as the frequencies are chosen so they are not whole number multiples of each other.)
2. i) Explain how a piano tuner can use a tuning fork and beats to tune a piano.

They play “A” on the tuning fork and listen for beats. When they hear them, they know the piano is too high or too low. They change the tension until the beat period gets longer and longer

ii) No. as they get closer to being the same, the beat period gets longer until it tends to infinity. A difference of say 0.001 Hz would cause a fluctuation in loudness (loud quiet loud) over 1000s. This would be hard to detect.

1. Waves arrive from the transmitter and also reflected off the wall. Depending on the path difference, these two waves can arrive in phase or out of phase, causing interference.

a

transmitter

receiver

a

b

c

The signal coming from the wall acts as if it has come from a second point distance “a” behind the wall.



this assumes that “a” is small compared with “b” ie θ <10O