

## State Examination Commission – Physics Higher Level, 2011

### Question 8

- a) Destructive interference can occur when waves from coherent sources meet. Explain the underlined term. Give two other conditions necessary for total destructive interference to occur. (14)

The diagram shows a standing wave in a pipe closed at one end. The length of the pipe is 90 cm.

- Name the points on the wave labelled P and Q.
- Calculate the frequency of the standing wave.
- What is the fundamental frequency of the pipe?

The clarinet is a wind instrument based on a pipe closed at one end.

What type of harmonics is produced by a clarinet? (24)

- b) An audio speaker at a concert emits sound uniformly in all directions at a rate of 100 W. Calculate the sound intensity experienced by a listener at a distance of 8 m from the speaker.

The listener moves back from the speaker to protect her hearing. At what distance from the speaker is the sound intensity level reduced by 3 dB. (18)

(speed of sound in air = 340 ms<sup>-1</sup>)

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- a) Destructive interference can occur when waves from coherent sources meet. Explain the underlined term.

Coherent sources are wave sources of the same frequency and between which there is a constant phase difference.

Give two other conditions necessary for total destructive interference to occur. (14)

They must have the same amplitude and be 180° out of phase ( or  $[n+1/2]\lambda$  out of phase) for complete constructive interference to occur.

The diagram shows a standing wave in a pipe closed at one end. The length of the pipe is 90 cm.

- Name the points on the wave labelled P and Q.

P is a node, and Q is an anti-node

- Calculate the frequency of the standing wave.

$$\begin{aligned}5 \lambda/4 &= L \\5 \lambda/4 &= 0.90 \\5c/4f &= 0.90 \\f &= (5 \times 340)/(4 \times 0.90) \\f &= 472.2 \text{ Hz}\end{aligned}$$

- What is the fundamental frequency of the pipe?

$$\begin{aligned}\lambda/4 &= L \\\lambda/4 &= 0.90 \\c/4f &= 0.90 \\f &= (340)/(4 \times 0.90) \\f &= 94.4 \text{ Hz}\end{aligned}$$

The clarinet is a wind instrument based on a pipe closed at one end.

What type of harmonics is produced by a clarinet? (24)

Only odd harmonics  $f_1, f_3, f_5$ , etc

b) An audio speaker at a concert emits sound uniformly in all directions at a rate of 100 W. Calculate the sound intensity experienced by a listener at a distance of 8 m from the speaker.

$$I = P/A = P/4\pi r^2 = 100/4\pi(8)^2 = 0.12 \text{ W m}^{-2}$$

The listener moves back from the speaker to protect her hearing. At what distance from the speaker is the sound intensity level reduced by 3 dB. (18)

If the sound intensity level is halved to a value of  $I = 0.06 \text{ W m}^{-2}$ , the sound intensity level will decrease by 3 dB.

$$I = P/4\pi r^2 = 100/4\pi(x)^2 = 0.06 \text{ W m}^{-2}$$

Solving for x gives,  $x = 11.5 \text{ m}$  from the speaker.