A-Level Physics

Physics of the Ear

Question Paper

Time available: 70 minutes
Marks available: 37 marks

1. (a) A point source of sound has a power of 17 W.

Calculate, in dB, the intensity level at a distance of 12 m from the source.

intensity level = _____ dB

(3)

(b) The frequency of a sound is increased from 3.0 kHz to 8.0 kHz with no change in intensity.

One change in the sound perceived by a person with normal hearing is an increase in pitch.

Explain **one** other change to the sound perceived by the person as the frequency is increased from 3.0 kHz.

_____

_____

_____

_____

_____

_____

(2)

(Total 5 marks)

2. Three customers, **P**, **Q** and **R**, are sitting in a café listening to music from a loudspeaker. Customer **P** is 11 m from the loudspeaker. At the position of customer **P**, the sound intensity is 3.4×10^{-8} W m^{-2}.

(a) Customer **P** moves to a distance of 7.0 m from the loudspeaker.

Calculate the sound intensity at the new position of customer **P**.
Assume that the loudspeaker is a point source.

sound intensity = _____ W m^{-2}

(2)

(b) The sound intensity level is 65 dB at the position of customer **Q** and 42 dB at the position of customer **R**.

Calculate the ratio $\frac{\text{sound intensity at the position of } \mathbf{Q}}{\text{sound intensity at the position of } \mathbf{R}}$

ratio = _____

(2)

(c) Customer **Q** perceives the loudness of the sound differently to customer **R**.

Discuss whether the use of intensity level or intensity is more appropriate to compare the perceived loudness.

_____

_____

_____

_____

(2)

(d) Customers **P**, **Q** and **R** move to the same distance from the loudspeaker.

Customer **P** is 80 years old and has hearing loss due to her age.

Customer **Q** is 35 years old and has hearing loss due to working in an extremely noisy environment.

Customer **R** is 35 years old and has no hearing loss.

The hearing defects of **P** and **Q** affect their perception of the music being played.

Describe how their perceptions are different from that of **R**.

(3)

(Total 9 marks)

3. (a) Sound waves are incident on a human ear.

Describe how the frequency and amplitude of the vibrations change as the wave is transmitted through the ear to the fluid in the inner ear.

(2)

(b) Explain how the components of the ear act to amplify the pressure changes due to the sound wave.

_____

_____

_____

_____

_____

_____

(3)

(c) A sound intensity meter, set to the dB scale, is placed near to a source of sound. The intensity level reading on the sound meter is 82 dB.

Calculate in, W m^{-2}, the intensity of the sound at the meter.

intensity = _____ W m^{-2}

(3)

(d) The sound intensity meter is 2.0 m from the source which is emitting sound equally in all directions.

Calculate the power emitted by the source.

power = _____ W

(2)

(Total 10 marks)

4. (a) Define the threshold of hearing, I_o.

_____

_____

_____

_____

(2)

(b) Sound intensity levels are usually measured in decibels which is based on a logarithmic scale. State **two** reasons why this logarithmic scale is used.

reason 1 _____

_____

reason 2 _____

_____

(2)

(c) Hearing loss might be due to ageing or exposure to excessive noise. For each cause, state how the hearing loss varies with frequency over the audible range.

(i) Loss due to ageing.

_____

_____

(1)

(ii) Loss due to excessive noise.

_____

_____

(2)

(Total 7 marks)

5. (a) A sound source of constant output power is used to generate a sound which is measured using a sound meter. When set to the dB scale, the sound meter displayed 60 dB as the reading when the frequency of the sound was 1 kHz.

(i) State and explain what the reading would be for a sound of frequency 1 kHz if the meter was changed to the dBA scale.

_____

_____

_____

(1)

(ii) State and explain what would happen to the reading on **each** scale if the frequency of the sound was changed to 500 Hz.

_____

_____

_____

_____

_____

_____

(2)

(b) A drill is operated in an otherwise silent room. The drill produces sound of power 2.0 W which is given out equally in all directions. A sound meter is placed 5.0 m from the drill and is set to the dB scale.
Calculate the reading on the sound meter.

$I_0 = 1.0 \times 10^{-12}\ \text{Wm}^{-2}$

answer = _____ dB

(3)

(Total 6 marks)