AQA Physics A Level

10.2 Physics of the Ear

Flashcards

What is the definition of sound intensity and what equation links intensity, power and area through which sound waves pass?

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The amount of sound energy that passes per second per unit area. It's proportional to amplitude^2

$$I = P / A$$

I = intensity in W/m^2 or decibels, P = power in W, A = area through which sound waves pass, m^2

An alarm sounds with power 6.2W, calculate the intensity of the sound 4m away assuming sound waves spread equally in all directions.

An alarm sounds with power 6.2W, calculate the intensity of the sound 4.0m away assuming sound waves spread equally in all directions.

SA sphere = $4\pi r^2$ $A = 4\pi \times 4 \times 4 = 64\pi$

Intensity = $6.2 / 64\pi = 0.031$ W/m^2 (2sf)

What are the 3 main sections of the ear?

What are the 3 main sections of the ear?

- outer ear (auditory canal and pinna).
- middle ear (eustachian tube and ossicles).
- inner ear (semicircular canals, cochlea and auditory nerve).

What membrane separates the outer and middle ear and what separates the middle and inner ear?

What is the name of the membrane which separates the outer and middle ear and what separates the middle and inner ear?

Tympanic membrane (eardrum) separates outer and middle, the round and oval window separate middle and inner.

Name the fluid that fills the inner ear and state its purpose.

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Perilymph (in the cochlear duct it is endolymph) it allows vibrations to pass to the basilar membrane in the cochlea.

Name a part of the ear involved in maintaining balance.

Name a part of the ear involved in maintaining balance

Semicircular canals.

How are the longitudinal sound waves channeled into the auditory canal and why do they make the tympanic membrane vibrate?

How are the longitudinal sound waves channeled into the auditory canal and why do they make the tympanic membrane vibrate?

The external ear (pinna) funnels sound in, concentrating the energy onto a smaller area which increases its intensity. Sound waves cause vibration as they consist of variations in air pressure-the tympanic membrane is attached to the malleus ossicle in the middle ear which passes on the vibration.

What is the function of the ossicles?

What is the function of the ossicles?

1. To pass the vibrations of the eardrum from malleus to incus to stapes (which is connected to the oval window that transmits them to the perilymph where pressure waves make the basilar membrane vibrate).
2. To amplify the force of the vibrations by about 50%.
3. To reduce the amount of energy reflected back from the inner ear.

How is the basilar membrane affected by different frequencies of sound?

How is the basilar membrane affected by different frequencies of sound?

Different regions of the basilar membrane have different natural frequencies so when a sound of particular frequency enters the ear one part resonates (vibrates with large amplitude).

Why are nerve impulses triggered where the basilar membrane resonates?

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Hair cells attached to the membrane trigger nerve impulses along the auditory nerve at the point of resonance.

Which features of sound do frequency and intensity affect respectively?

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Frequency affects pitch.

Intensity affects loudness.

The weakest intensity heard depends on the frequency, 3000 Hz is the frequency the ear is most sensitive to.

What is the level over which sounds can be felt known as?

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Threshold of feeling, it is equal to about 1Wm^-2.

What is the relationship between perceived loudness and intensity?

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$\Delta L \propto \log(\text{new } I / \text{original } I)$

ΔL = increase in decibels, dB

I = intensity

So when the intensity of a sound doubles and doubles again the loudness increases in fixed steps (when frequency is constant).

What is the definition of: ‘threshold of hearing’?

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The minimum intensity of sound of frequency 1000Hz that can be heard by a normal ear.

How is the intensity level of a sound of intensity I defined?

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Intensity level = $10\log(I/I_0)$

Intensity level units = decibels,dB

I_0 = threshold of hearing, 1x10^-12 Wm^-2

A dog 5m away barks with intensity 0.56Wm^-2, calculate the intensity level at this distance in dB.

A dog 5.0m away barks with intensity 0.56Wm^-2, calculate the intensity level at this distance in dB.

Intensity level = 10log(0.56/1x10^-12)

=117.482…

= 120 dB (2sf)

What is the dBA scale?

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An adjusted decibel scale that accounts for how the ear responds differently to different frequencies, sounds of the same intensity level have the same loudness on the dBA scale.

How do you generate an equal loudness curve?

How do you generate an equal loudness curve?

1. Generate a control frequency of 1000Hz at a fixed intensity level.
2. With a second signal generator set a different frequency.
3. Alter the intensity level of the 2nd signal generator until the sounds seem to be equally loud, note this intensity level.
4. Repeat for different frequencies and plot the curve on a graph of intensity level against frequency.
5. At 1000Hz the intensity level (dB) will equal the loudness in phons.

What is the general shape of an equal loudness curve for a normal ear?

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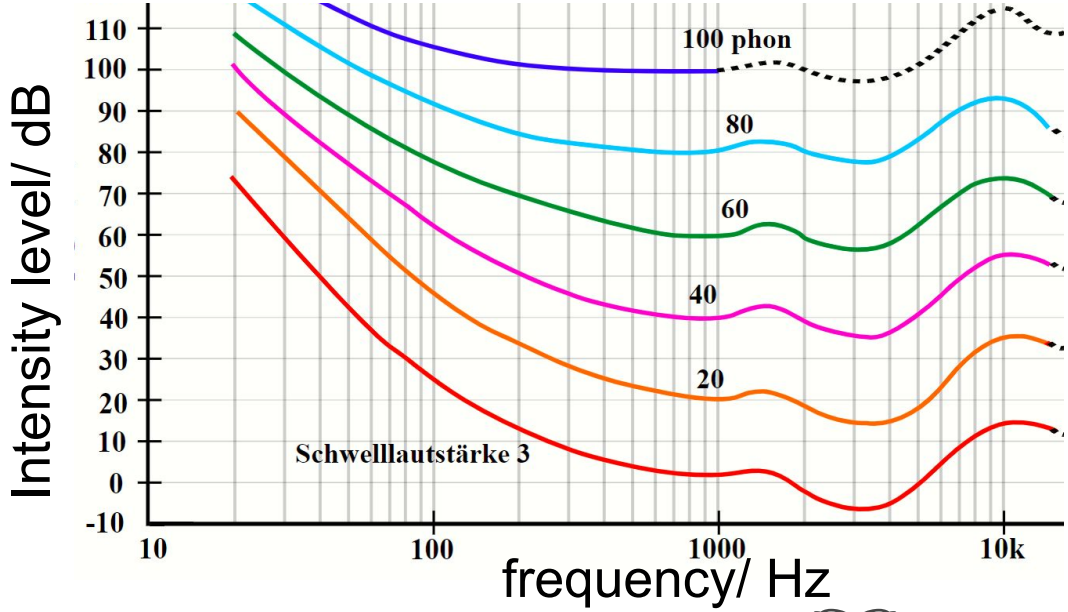

https://upload.wikimedia.org/wikipedia/commons/c/c8/Kurve_gleicher_lautst%C3%A4rke.svg

How can an equal loudness curve be used to show age related and noise related hearing loss?

How can an equal loudness curve be used to show age related and noise related hearing loss?

For hearing loss, higher intensity levels are needed for the same loudness compared to a normal ear, a peak in the curve shows damage at specific frequencies.