

# THE PHYSIOLOGY OF HEARING



M. DIN

# PHYSIOLOGY OF HEARING

## SOUND PROPERTIES

LONGITUDINAL WAVES

FREQUENCY → PITCH/TONE

- HERTZ
- 20-20,000 Hz RANGE

PRESSURE → LOUDNESS

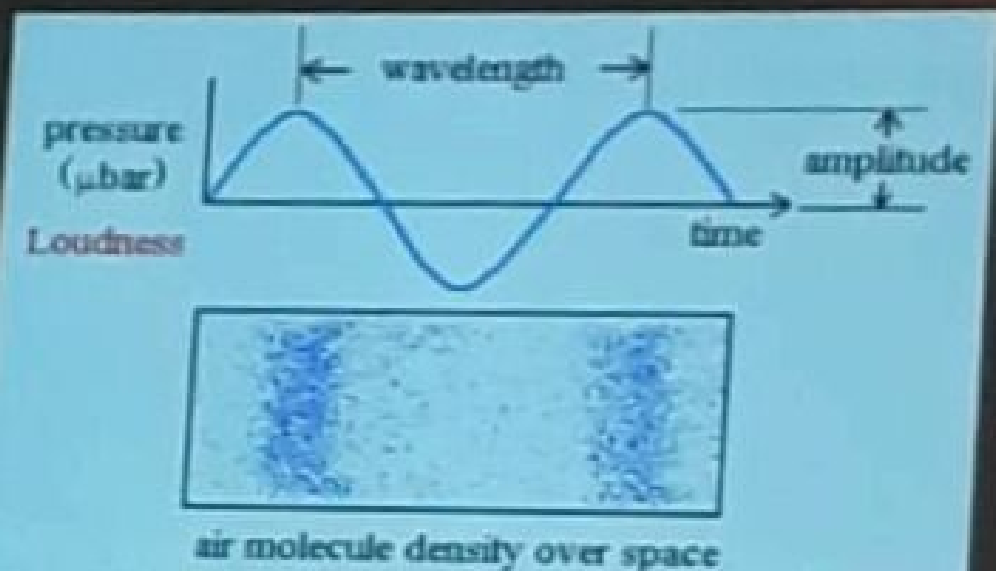
- DECIBELS

VELOCITY

MEDIA INTER-PHASE IMPEDENCE

# Sound

Sound: sensed variations in air pressure



Frequency

Pitch

## *DECIBEL SCALE*

**ZERO dB NOT ZERO SOUND!**

**0dB- THRESHOLD OF HEARING**

**20dB- WHISPER**

**30-40dB- SOFT CONVERSATION**

**50-60 dB- SHOUTING**


**100 dB- DISCOTHEQUE**

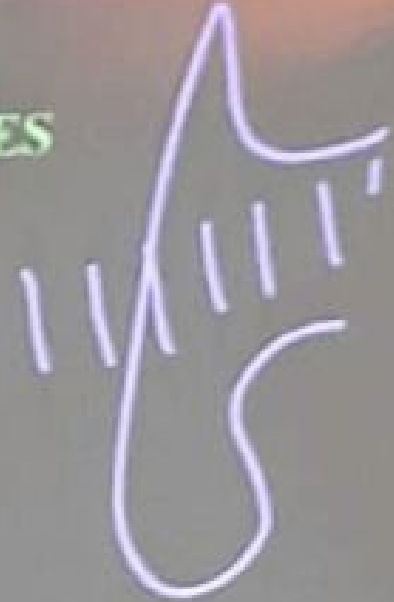
**140 dB- AIR-LINER**

## *SENSITIVITY*

- Range of Hearing: 20 - 20,000 Hz
- Highest Sensitivity: 1,000 - 3,000 Hz
- Lowest Detectable Intensity: 0 dB

# EXTERNAL EAR

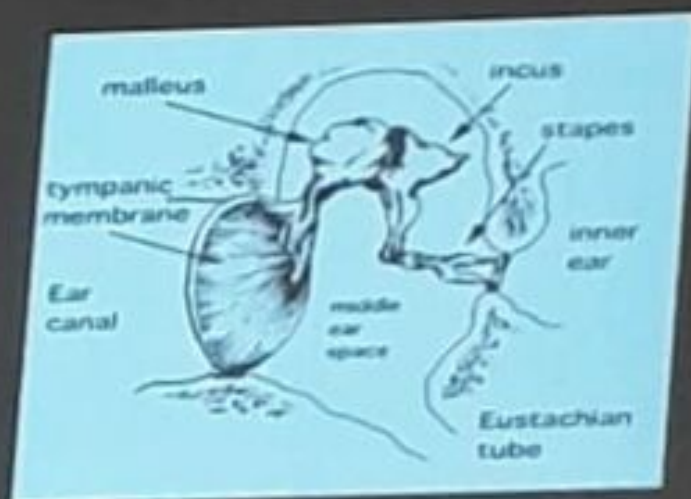
- **Conduction**
- **CONCENTRATION OF SOUND WAVES**  
THE 'EAR TRUMPET' EFFECT
- **RESONANCE**  
AT 2-7 kHz   
10-12 dB gain
- **SOUND DIRECTIONALISATION**  
MONAURAL/BINAURAL
- **Protection of the middle ear/TM**



# The Ossicular Chain

- A: Malleus
- B: Incus
- C: Stapes

Ossicles are smallest bones in the body  
Act as a lever system  
Footplate of stapes enters oval window of the cochlea



## MIDDLE EAR



- CONDUCTION

- AMPLIFICATION

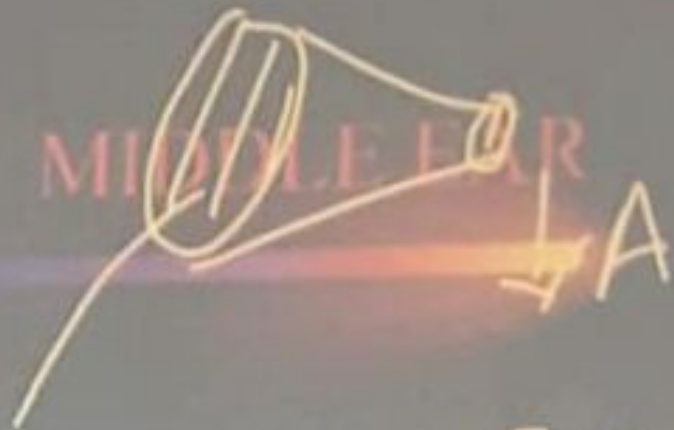
  - SURFACE AREA RATIO OF TM/ Stapes FP

  - OSSICULAR LEVERAGE

  - TM BUCKLING EFFECT

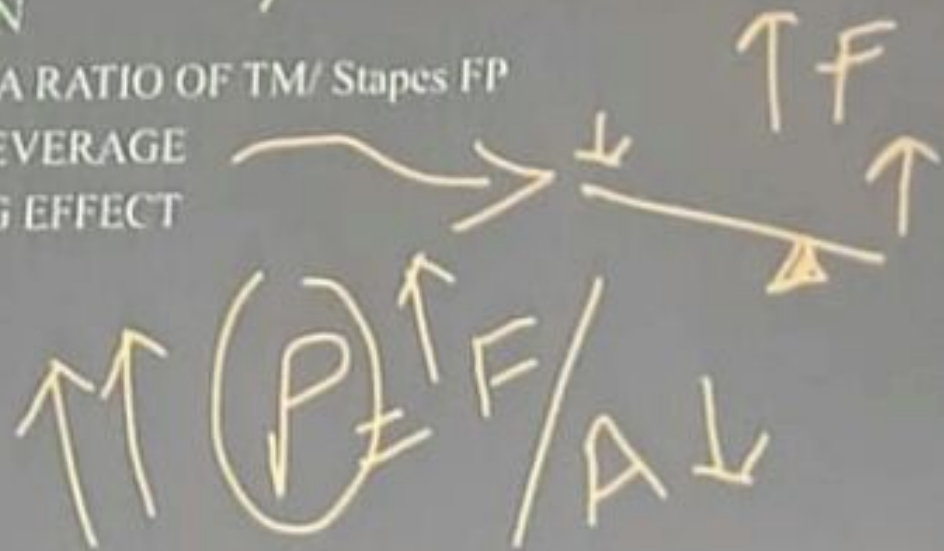


MIDDLE EAR

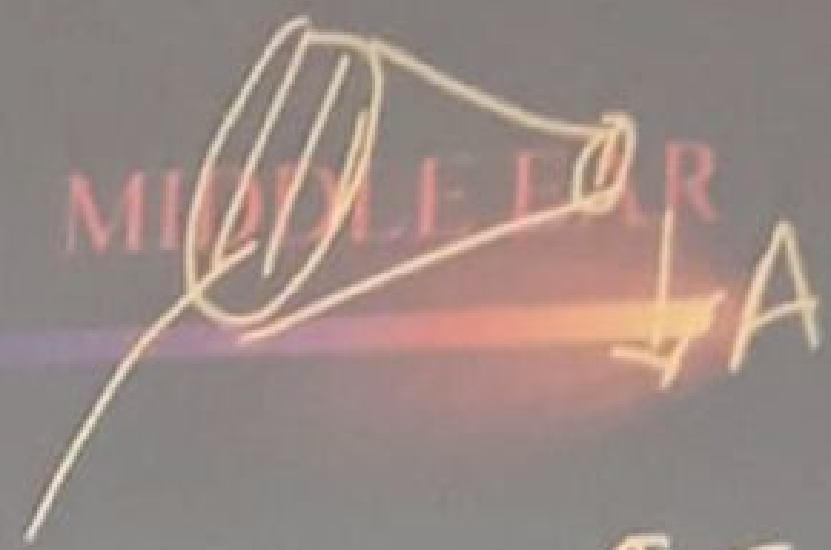


- CONDUCTION
- AMPLIFICATION

SURFACE AREA RATIO OF TM/ Stapes FP  
OSSICULAR LEVERAGE  
TM BUCKLING EFFECT



MIDDLE EAR



• CONDUCTION

• AMPLIFICATION

|| SURFACE AREA RATIO OF TM/ Stapes FP

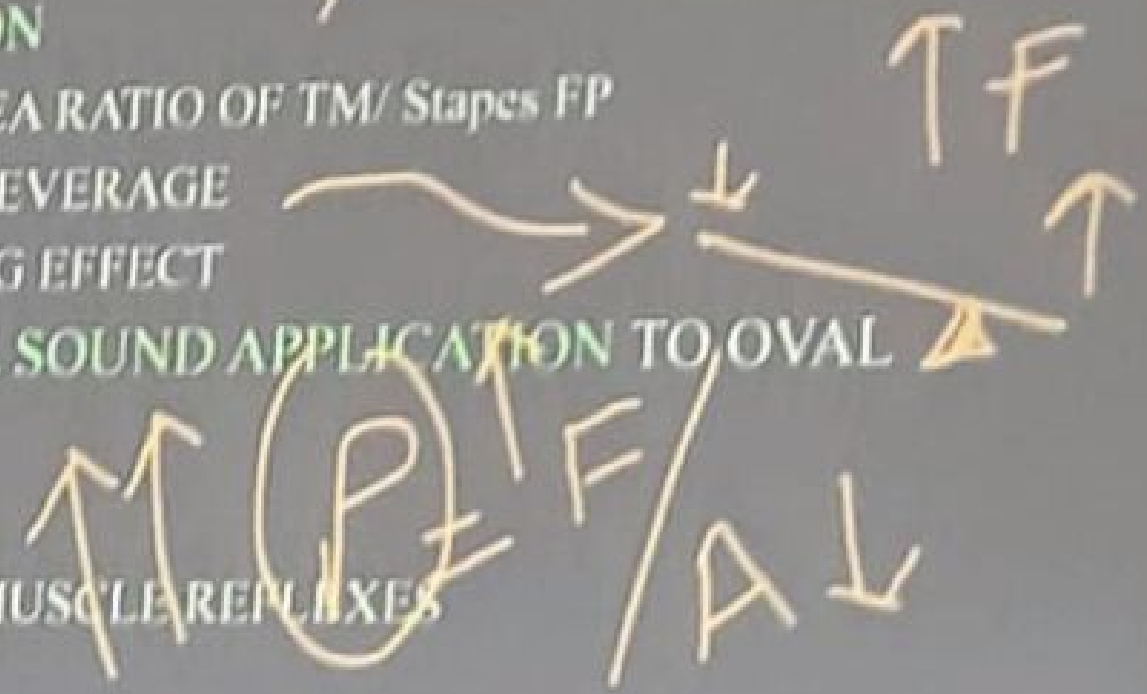
|| OSSICULAR LEVERAGE

TM BUCKLING EFFECT

• PREFERENTIAL SOUND APPLICATION TO OVAL WINDOW

• PROTECTION

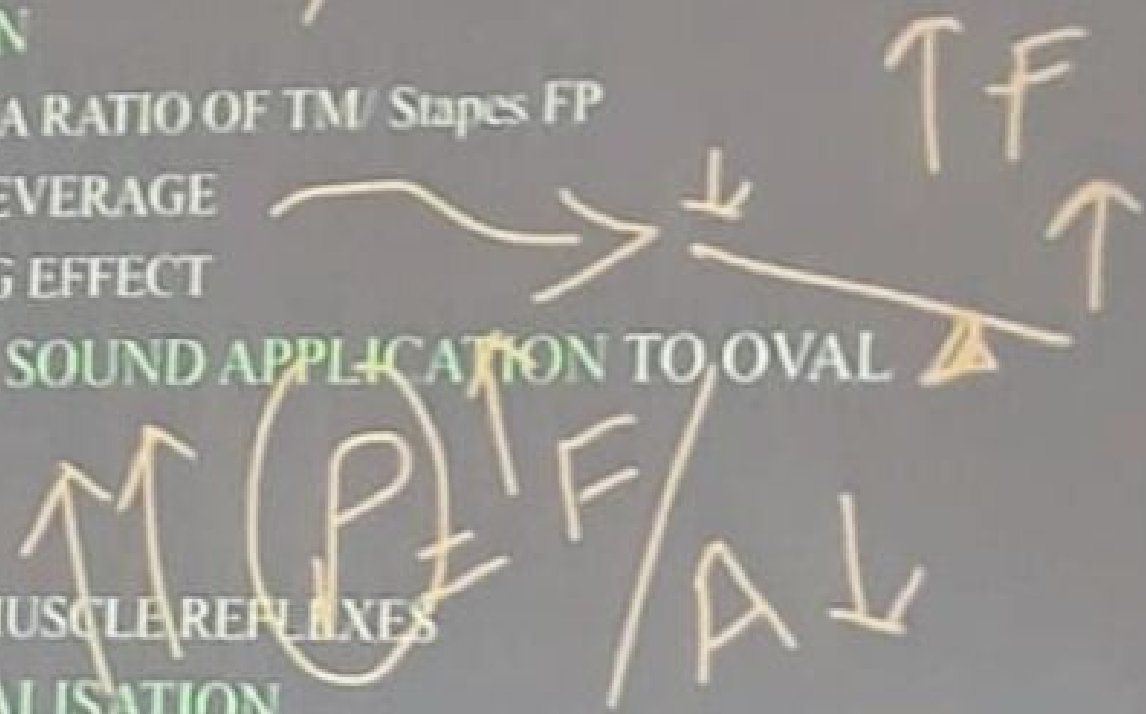
MIDDLE EAR MUSCLE REFLEXES



MIDDLE EAR



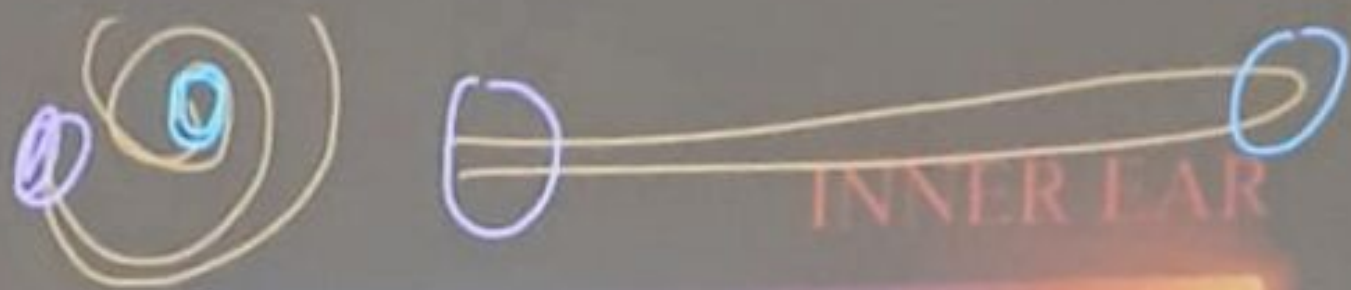
- CONDUCTION
- AMPLIFICATION
  - SURFACE AREA RATIO OF TM/ Stapes FP
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  - TM BUCKLING EFFECT
- PREFERENTIAL SOUND APPLICATION TO OVAL WINDOW
- PROTECTION
  - MIDDLE EAR MUSCLE REFLEXES
- PRESSURE EQUALISATION



# Eustachian Tube



- Lined with mucous membrane; connects middle ear to back of the throat (nasopharynx)
- Equalizes air pressure
- Normally closed except during yawning or swallowing
- Not a part of the hearing process



- **TRANSDUCTION**  
HAIR CELL DEPOLARISATION
- **FREQUENCY LOCALISATION**  
PLACE CODING PRINCIPLE
- **LOUDNESS EFFECTS**  
FREQUENCY OF DISCHARGE  
'FRINGE CELL' STIMULATION

# HEARING PATHWAY

AIR CONDUCTION (WHOLE PATH)

EAC [?] TM [?] ME [?] COCH [?] CN [?] [?] Br

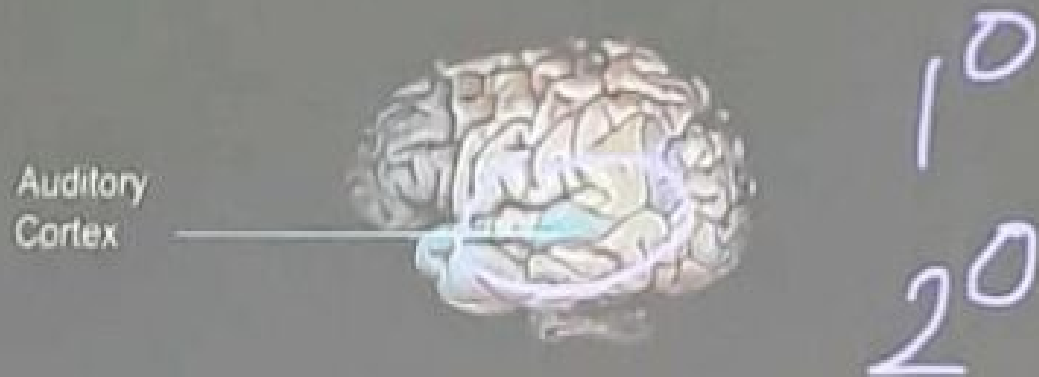
SKULL BONES

BONE CONDUCTION

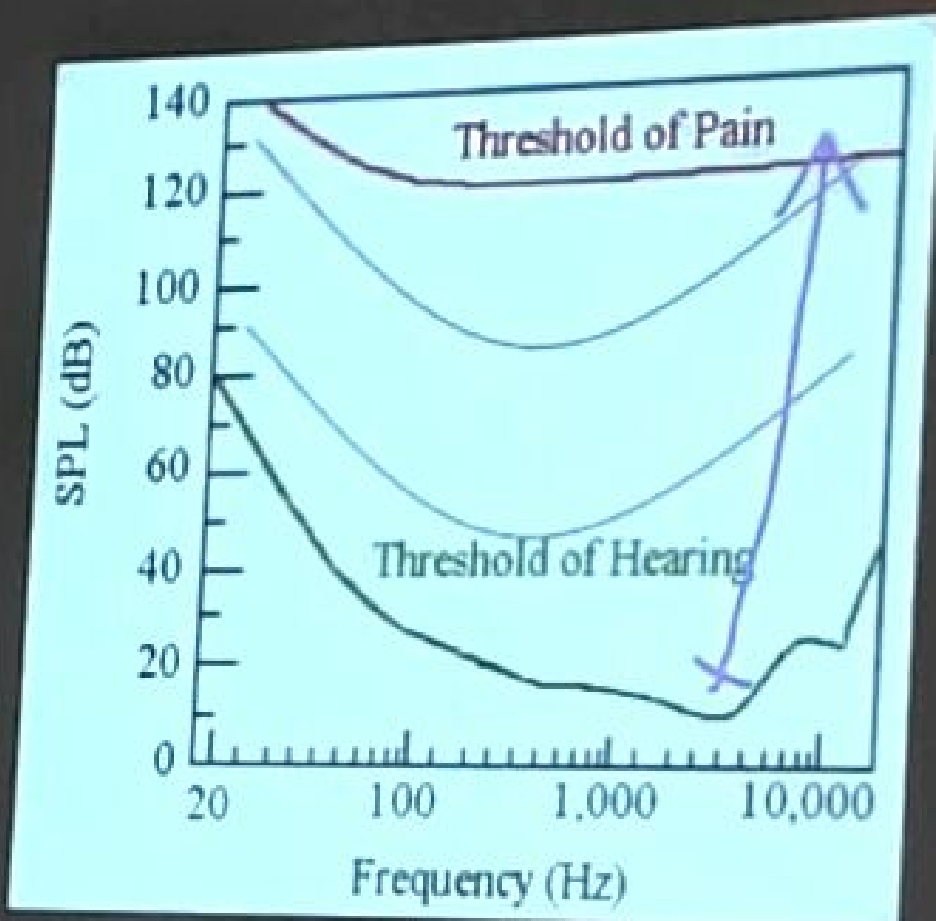
NB AC > BC

## *AI Cortical Receptive Fields*

- Receptive Fields: Set of stimuli which activate a sensory neuron



# DYNAMIC RANGE





## *Sound directionalisation*

### *Binaural*

- *Time of arrival difference*
- *Loudness difference*

### *Monaural*

- *Maximum alignment*
- *Resonance patterns*

### *Other cues*

- *Head & neck searching movements*
- *'Sound source' identification*
  - *Lip reading*



# HEARING LOSS

- ORGANIC
  - CONDUCTIVE
  - SENSORI-NEURAL
  - MIXED

- NON-ORGANIC
  - FEIGNED
  - PSYCHO-SOMATIC

## *Hearing assessment*



- **Presence of hearing loss**
- **Type of hearing loss**
- **Amount of hearing loss**
- **Cause of hearing loss**

*Basic clinical tests:  
Finger friction/watch ticking test*

- Measure distance at which a normal person hears watch ticking or finger friction
- This distance can be compared with the distance which a patient hears the same sound
- Compare right and left ears

## *SCHWABACH'S TEST*

- COMPARE BONE CONDUCTION OF SUBJECT WITH EXAMINER

NORMAL- SAME

CHL- SUBJECT PROLONGED

SNHL- SUBJECT SHORTENED

## RINNE'S TEST

- NORMAL- AC > BC: RINNE'S POSITIVE
- CONDUCTIVE HEARING LOSS (>25 dB)  
BC > AC: RINNE'S NEGATIVE
- SENSORI-NEURAL HEARING LOSS  
AC > BC: RINNE'S POSITIVE
- !!! RINNE'S FALSE NEGATIVE  
IN UNILATERAL SNHL  
Subject answers from the non- tested ear





# *SOUND LEVEL MEASUREMENT*

## *DECIBEL SCALE*

*SOUND PRESSURE IN dB*

$$= 20 \times \text{Log}_{10} \text{ measured SP / reference SP}$$

*Reference SP is the least amount of sound that  
can be heard by a normal hearing person at a  
specific frequency*

$$= 20\text{mPa } (20 \times 10^{-6} \text{ N/m}^2)$$

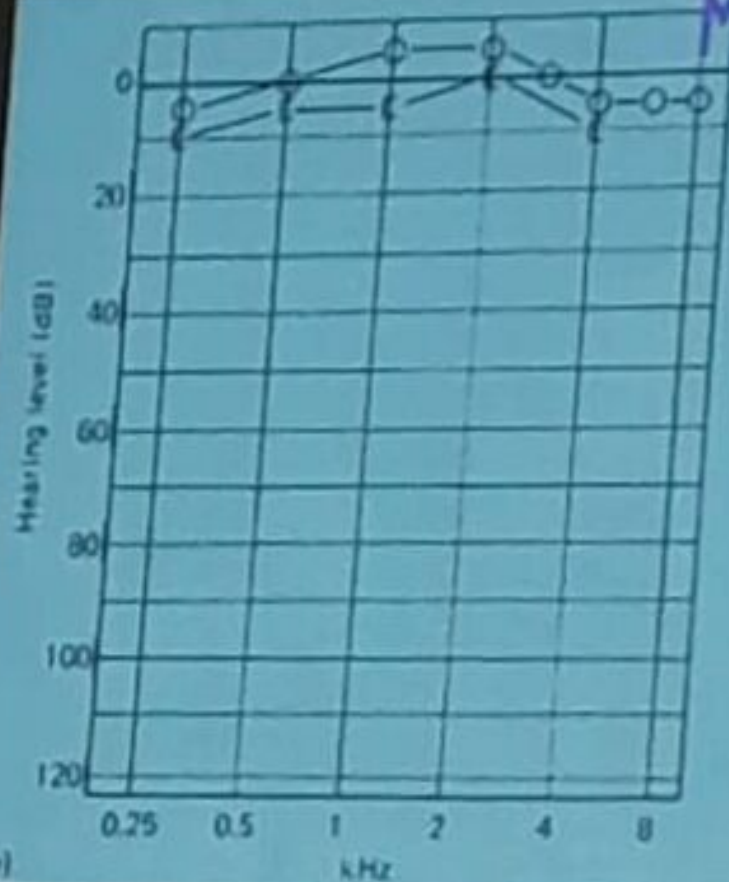
## *PTA- nomenclature*

- O Right ear AC
- X Left ear AC
- | Right ear BC with masking
- | left ear BC with masking
- If no masking BC-  $\Delta$
- Air conduction readings linked, BC left unattached

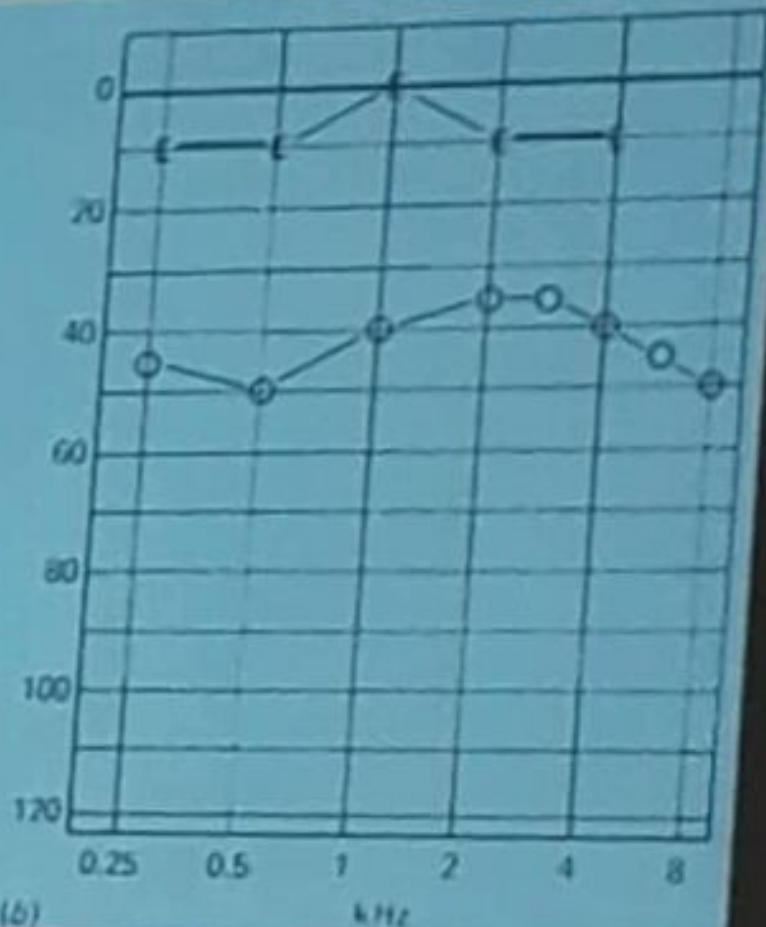


# AUDIOGRAMS

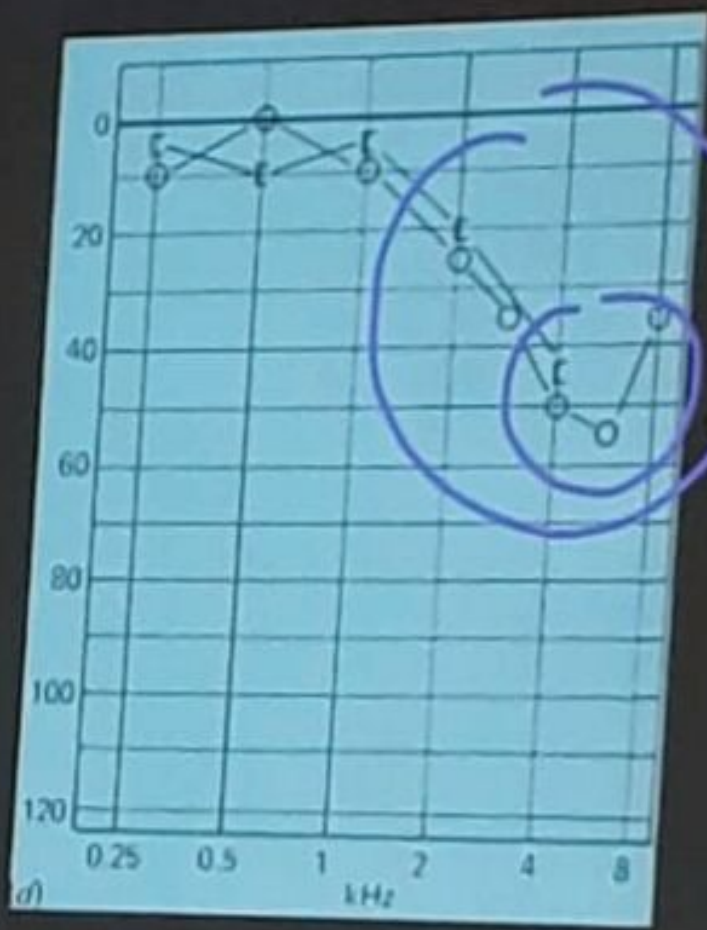
Normal- AC=BC



CHL- AC > BC



# AUDIOGRAM



SMHL- BC&AC affected equally

Mixed hearing Loss-  
both conductive and  
sensorineural  
components

