Department of Physiology
College of Medicine

Physiology Practical

For

2nd Year Medical Students

(2018-2019)

List of Abbreviations

APB	Abductor pollicis brevis
CMAP	Compound motor action potential
EMG	Electromyography
MNCS	Motor nerve conduction study
MNCV	Motor nerve conduction velocity
ms	Millisecond
MUP	Motor unit potential
mV	millivolt
NCS	Nerve conduction study

Introduction

Welcome to your second year in medical school. This manual has been prepared as a reference to help medical students navigate their way through 2nd year physiology practical sessions. The physiology practical sessions are part of the physiology curriculum that is ingrained in the block system of the first two years of medical school. Its aim is to provide a practical aspect to some of the physiological concepts learned during mainstream lectures allowing students to have hands on experience that will strengthen their understanding of the physiological concepts. Practical sessions will also help them apply the knowledge learned in the classroom in a safe environment.

This manual is meant to be a guide for students providing the structure and topics covered in physiology practical sessions. However, students are encouraged to look for information and broaden their knowledge using other resources.

To make the best of the practical sessions, students are advised to attend the sessions on time and prepare by reading related lecture material prior to the practical sessions. During the sessions, students are encouraged to engage actively and take the opportunity to get hands on experience whenever it is feasible.

Wish you all the best!

Physiology Practical Team

Overview of 2nd Year Medical Student Physiology Practical Sessions

Physiology practical sessions during the second year of medical school are confined to the Neuropsychiatry block and will include the sessions shown in the table below.

Block name	Block duration	Number of sessions	Session title
Neuropsychiatry block	≈ 8 weeks	3 (2-hour-sessions)	EMG and nerve conduction
			Audiometry
			Color vision, light and accommodation reflex

Faculty and Staff Members Involved in Physiology Practical Teaching

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Advice for Students

- Show up to physiology practical sessions on time.
- Read related lecture material prior to the laboratory session.
- Each laboratory session starts with a pre-lab lecture that serves to explain the objectives and procedure to be done in the lab. Listen attentively to these lectures.
- Engage actively in the laboratory activity and take every opportunity to get hands on experience whenever possible.
- Answer the practice questions provided at the end of each lesson.
- Do not depend solely of this guide for information.

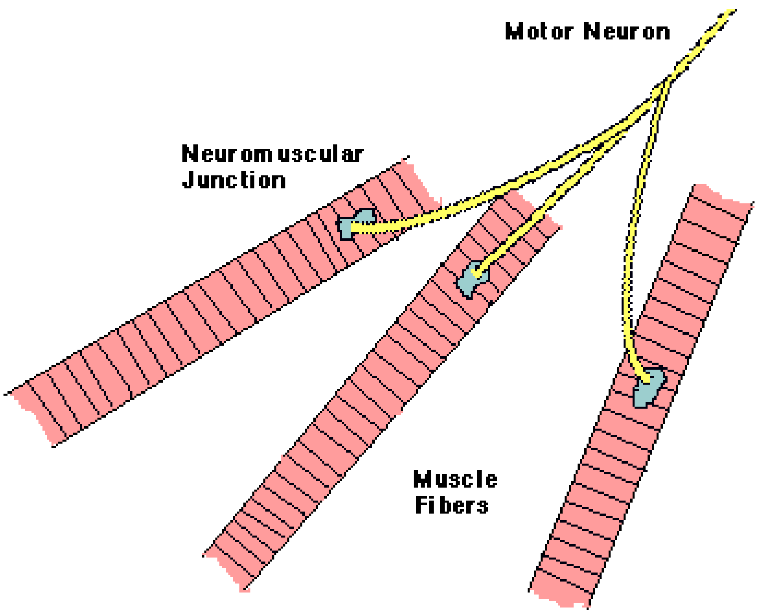
Chapter 1: Neuropsychiatry Block Physiology Practical

There are 3 practical physiology sessions during the neuropsychiatry block which are as follows;

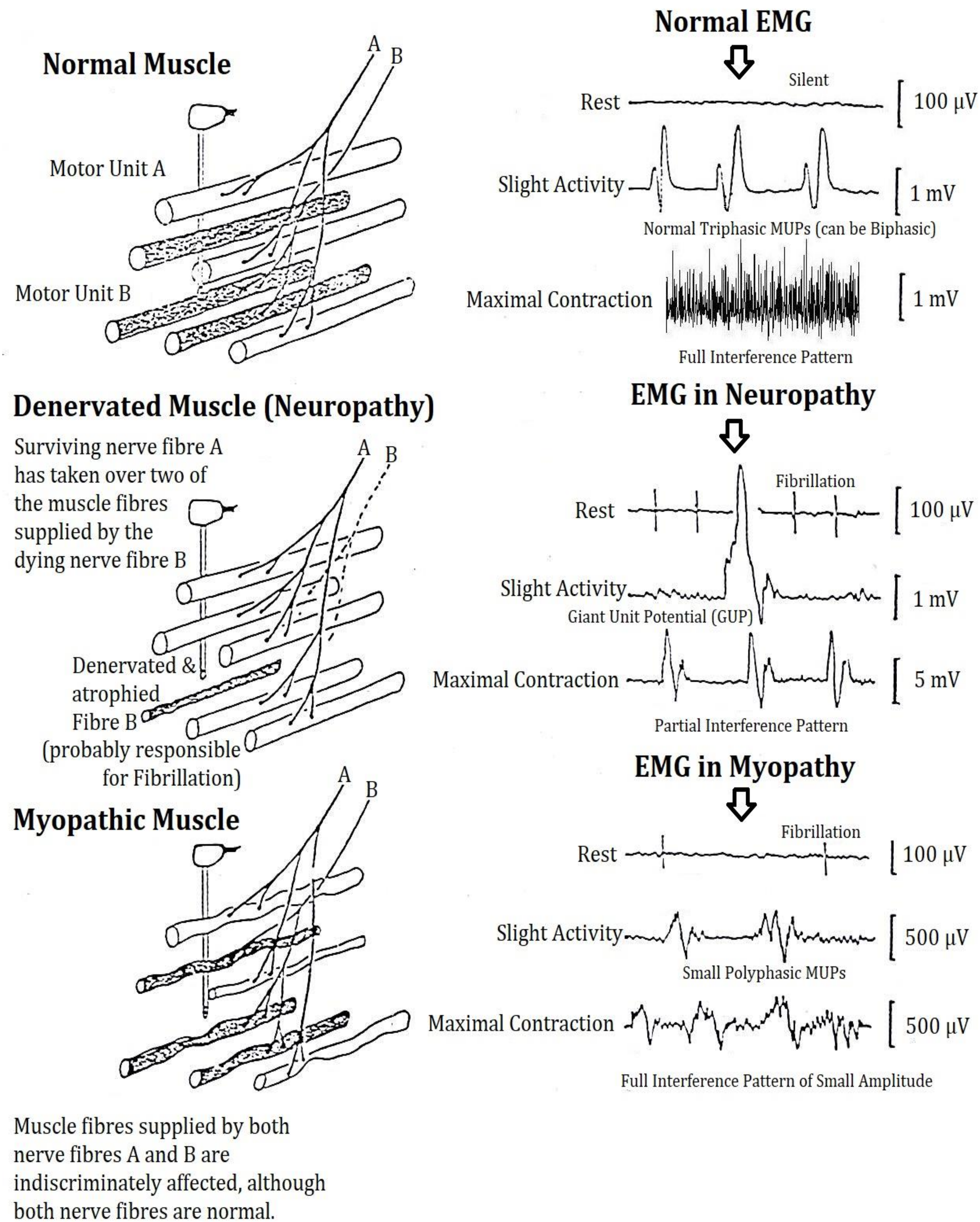
1. EMG and nerve conduction.
2. Audiometry.
3. Color vision, light and accommodation reflex.

ELECTROMYOGRAPHY (EMG)

- It is a recording of electrical activity of the muscle by inserting needle electrode in the belly of the muscles or by applying the surface electrodes.
- The potentials recorded on volitional effort are derived from motor units of the muscle, hence known as motor unit potentials (MUPs).
- A motor unit is defined as one motor neuron and all of the muscle fibers it innervates.



- In the patients of muscular weakness, muscle atrophy, traumatic or metabolic neuropathy, EMG along with motor nerve conduction velocity study is considered as an extension of the physical examination rather than a simple laboratory procedure.


Normal Muscle
A
B
Motor Unit A
Motor Unit B
Normal EMG
Rest
Silent
100 μV
Slight Activity
1 mV
Normal Triphasic MUPs (can be Biphasic)
Maximal Contraction
1 mV
Full Interference Pattern
Denervated Muscle (Neuropathy)
Surviving nerve fibre A has taken over two of the muscle fibres supplied by the dying nerve fibre B
A
B
Denervated & atrophied Fibre B (probably responsible for Fibrillation)
EMG in Neuropathy
Rest
Fibrillation
100 μV
Slight Activity
1 mV
Giant Unit Potential (GUP)
Maximal Contraction
5 mV
Partial Interference Pattern
Myopathic Muscle
A
B
EMG in Myopathy
Rest
Fibrillation
100 μV
Slight Activity
500 μV
Small Polyphasic MUPs
Maximal Contraction
500 μV
Full Interference Pattern of Small Amplitude
Muscle fibres supplied by both nerve fibres A and B are indiscriminately affected, although both nerve fibres are normal.

ANALYSIS OF A MOTOR UNIT POTENTIAL (MUP)

MUP	NORMAL	NEUROPATHIC	MYOPATHIC
Duration (milliseconds)	3 – 15 milliseconds	Longer	Shorter
Amplitude	300 – 5000 µV	Larger	Smaller
Phases	Biphasic / triphasic	Polyphasic	May be polyphasic
Resting Activity	Absent	Present	Present
Interference pattern	Full	Partial	Full with small amplitude MUPs

SPONTANEOUS ACTIVITY AT REST

The skeletal muscle is silent at rest in normal people, hence spontaneous activity is absent, when we are not using a muscle and that muscle is at rest.

FIBRILLATION POTENTIALS

These occur at rest when the patient is not contracting his testing muscles.

These are randomly occurring small amplitude potentials.

These are seen in cases of neuropathy or myopathy.

In neuropathy, these potentials are generated from the single muscle fiber of a denervated muscle, possibly due to denervation hypersensitivity to acetylcholine.

Chapter 2: NERVE CONDUCTION STUDIES

- A nerve conduction study (NCS) is a test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor or sensory nerves of the human body.
- Motor Nerve conduction velocity (MNCV) is a common measurement made during this test.
- Based on the nature of conduction abnormalities two principal types of peripheral nerve lesions can be identified:

1) Axonal degeneration
2) Segmental demyelination.

CALCULATION OF MNCV

It can also be calculated by formula:

$$MNCV = \frac{Distance}{L1 - L2}$$

L_1 = latency at elbow.

L_2 = latency at wrist

It should be calculated in m/sec.

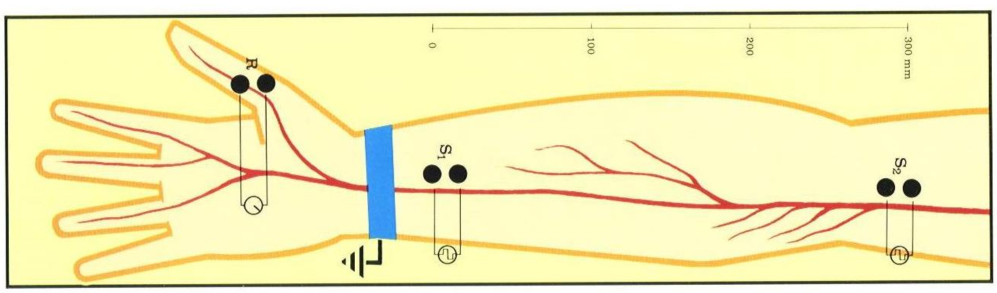
NORMAL VALUES FOR CONDUCTION VELOCITY

- ✓ **In arm**

50 – 70 m / sec.

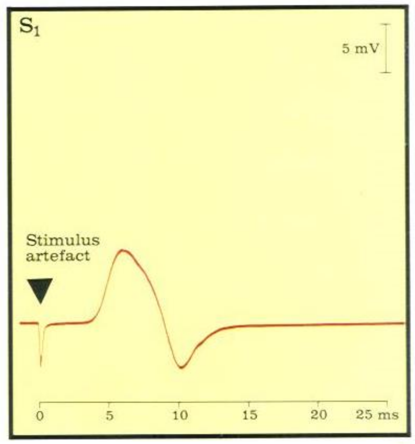
- ✓ **In leg**

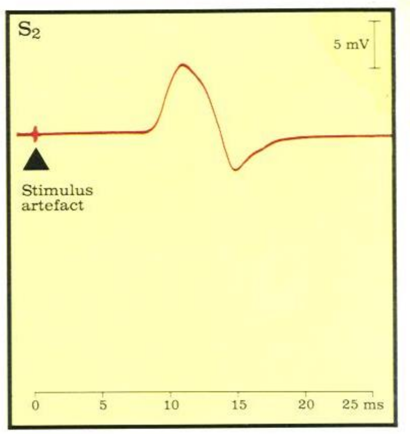
40 – 60 m / sec.



Distance

d = 285 mm





Latency At wrist

L2 = 3.5 ms

Latency At elbow

L1 = 8.5 ms

Hence, MNCV = 285 / 8.5 – 3.5 = 57 m/sec.

Hearing Tests and Pure Tone Audiometry

1.1. Objectives:

At the end of the session, students should be able to:

- Determine the type, degree, and configuration of hearing loss.
- Describe the techniques of Tuning fork tests.
- Plot the frequency-intensity recording and construct the audiograms.
- Interpret the audiograms.

1.2. Important terminology related to this practical

1.2.1. Air conduction

This test assesses the transmission of sound waves through air to the auditory cortex via auditory nerve involving outer, middle and inner ears. The sound is amplified 22 times when it is transmitted through air conduction by the tympanic membrane (17 times) and the ossicles (1.3 times). That is why, air conduction is always better than bone conduction in a normal person.

1.2.2. Bone conduction

This test assesses the transmission of sound waves through the bones of the skull to the cochlea and then through the auditory pathways to the auditory cortex, bypassing the outer and middle ears.

1.2.3. Masking sound

Masking sound is the sound present in the background that interferes with the sound that we want to listen. It is provided constantly to the right ear during the whole audiometry procedure if the left ear is tested so that whatever pure tone is given to the left ear is heard only by the left ear, because the right ear will be busy listening to the masking sound. In the same way, the masking sound will be provided to the left ear, if the right ear is tested.

1.2.4. Pure tone

A pure tone is a single frequency tone with no harmonic content (no overtones). This corresponds to a sine wave.

1.2.5. Audiogram

An audiogram is a chart of hearing sensitivity with the frequency of sound plotted on the X- axis and the intensity of sound on the Y-axis. Intensity (loudness) is the level of sound power measured in decibels and frequency (pitch) is the number of sound waves per second measured in Hertz, Fig-11.

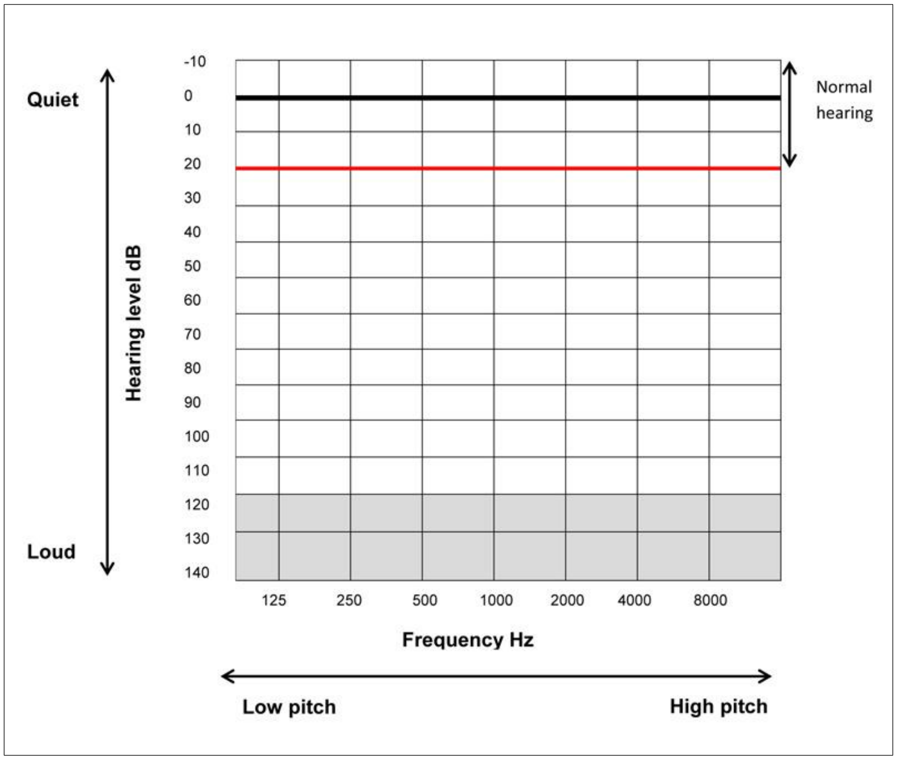


Figure 1. An example of an audiogram chart.

1.3. Tuning fork tests

1.3.1. Rinne's Test:

This test compares air conduction with bone conduction, Fig-12A.

1.3.1.1. Procedure

1. Strike a 512 Hz tuning fork softly on the palm to produce vibration.
2. Place the vibrating tuning fork on the base of the mastoid bone.
3. Ask the subject to tell you when the sound is no longer heard.
4. Immediately bring the tuning fork just in front of the ear.
5. Ask the subject to tell you whether he still hears it or not.

1.3.1.2. Interpretation

Normal subjects will hear sound through air conduction twice as long as bone conduction. They will still hear it in front of the ear when they can't hear anymore from the base of the mastoid bone.

With conductive deafness, bone conduction will be better than air conduction. In this case, when the subject stops hearing sound from the mastoid bone and brings the tuning fork in front of the ear, he will not hear any sound there too.

With sensorineural deafness, the sound through air conduction is heard longer than bone conduction in affected ear, but less than twice longer as is the case in normal subjects.

1.3.2. Weber's Test:

This test distinguishes between conductive and sensorineural deafness, Fig-12B.

1.3.2.1. Procedure

1. Strike a 512 Hz tuning fork softly on the palm to produce vibration.
2. Place the vibrating tuning fork on the vertex of the subject.
3. Ask the subject if the sound is heard better in one ear or the same in both ears.

1.3.2.2. Interpretation

If hearing is normal, the sound will be heard equally in both ears.

The sound is heard better in the affected or diseased ear in a subject with conductive deafness because of the loss of masking effect of the environment and all the receptors for hearing in the affected ear are free to hear the sound.

The sound is obviously heard better in the normal ear than the affected ear in a subject with sensorineural deafness because the cochlea and the neural pathway is intact on the normal side.

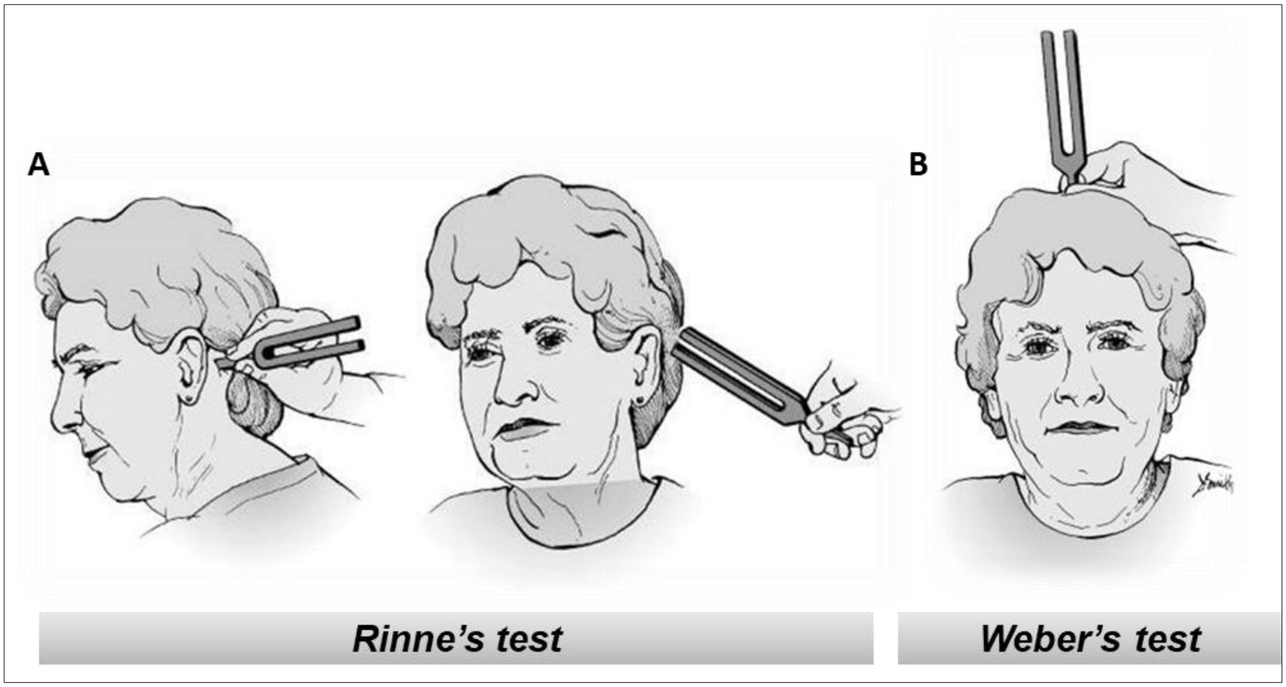


Figure 2. Tuning fork hearing tests. (A) Rinne's test, (B) Weber's test.

1.4. Pure tone Audiometry

Audiometry is the measurement of hearing using an audiometer. An audiometer is an electronic device that produces acoustic stimuli of known frequency and intensity for the measurement of hearing. Simply, it is an earphone connected to an electronic oscillator capable of emitting pure tones ranging from low to high frequencies. In addition to the earphone, an audiometer is equipped with an electronic (bone) vibrator. The earphone is to test air conduction while the electronic vibrator is for testing bone conduction from the mastoid process into the cochlea.

1.4.1. Procedure

1. The subject is seated comfortably in a sound proof room, Fig-13.
2. Color-coded earphones are applied (Red for right ear, Blue for left ear).
3. Each ear is tested at a time.
4. Masking sound is delivered to the non-test ear.
5. The ear being tested will be presented with pure tones of varying frequencies. Eight to10 frequencies covering the auditory spectrum are usually tested and the hearing loss is determined for each of these frequencies.
6. The examiner starts testing with a tone of 0 dB at 125 Hz. Then gradually increasing the frequency to 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz, however keeping the tone at 0 dB. If any of the frequencies was not heard we move to a louder tone and repeat the process again.
7. The responses are plotted on the audiogram.
8. This tests air conduction of the subject and the plotted marks are joined to produce the curve for air conduction.
9. The same steps are then repeated with the electronic (bone) vibrator on the mastoid process to test for bone conduction.
10. The responses are plotted on the audiogram as well using a different symbol.
11. The audiogram then will give a measure of the hearing threshold of the subject showing the presence of any hearing loss. It will also show the frequencies affected. Comparing air conduction with bone conduction, gives important clues as to the cause of hearing loss.
12. Normally air conduction is better than bone conduction.

1.5. Degrees of hearing loss

Hearing loss is variable and ranges in severity from mild to profound hearing loss. Figure-14 shows the ranges of hearing thresholds for a given frequency of sound that determine the severity of hearing loss in a subject tested by audiometry.

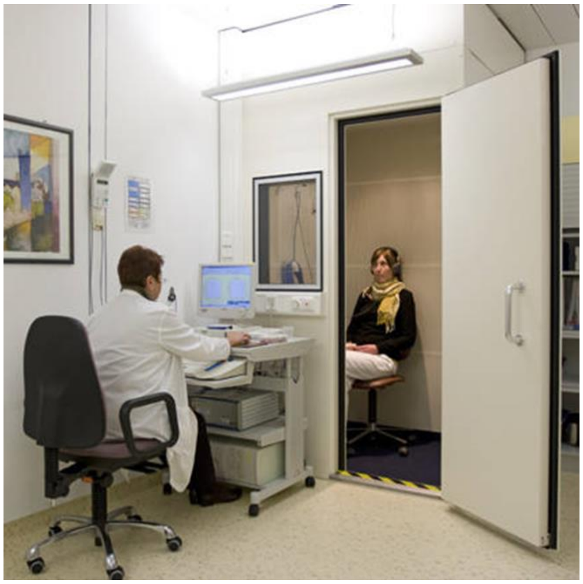


Figure 3. Hearing assessment using and audiometer with the study subject sitting in a sound proof room.

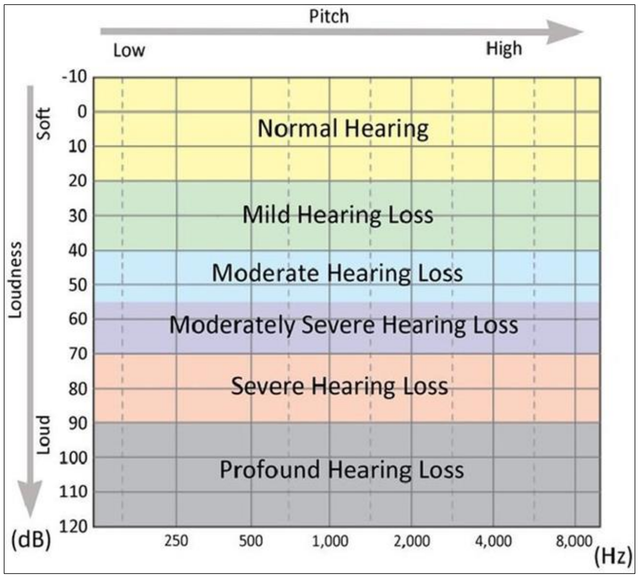


Figure 4. Shows the degree of hearing loss and its corresponding hearing threshold range for each given frequency.

1.6. Types of hearing loss (types of deafness)

Hearing loss can be divided into;

- Conductive hearing loss
- Sensorineural hearing loss
- Mixed hearing loss

1.6.1. Conductive hearing loss (deafness)

Conductive deafness reduces the effective transmission of sound through air conduction, but it does not affect bone conduction. Conductive deafness is due to impaired sound transmission in the external or middle ear. Patients with conductive deafness show better bone conduction compared to air conduction due to loss of sound amplification, Fig-15A.

Causes of conductive deafness include wax in the ear canal, ruptured tympanic membrane, fluid in the middle ear system (otitis media), and fixation of the footplate of stapes to the oval window (Otosclerosis), Fig-16.

1.6.2. Sensorineural Hearing loss (deafness)

Sensorineural hearing loss occurs when there is damage to the inner ear (cochlea), or to the nerve pathways from the inner ear to the brain. Sensorineural hearing loss reduces the ability to hear faint sounds. Even if speech is loud enough to hear, it may sound unclear or muffled to a person with sensorineural hearing loss. The audiogram of a person with sensorineural neural hearing loss will show a decrease or a total loss of hearing for both air and bone conduction. This decreased or lost hearing may affect all frequencies or may be confined to certain frequencies, e.g. only with high frequencies or only with low frequencies, Fig-15B.

Causes of sensorineural hearing loss may be congenital or acquired. Acquired causes for sensorineural hearing loss my include, degenerative diseases such as presbycusis, trauma such as noise and head injury, idiopathic e.g. Meniere's disease, ototoxicity secondary to drugs like aminoglycosides and salicylates and tumors such as acoustic neuroma.

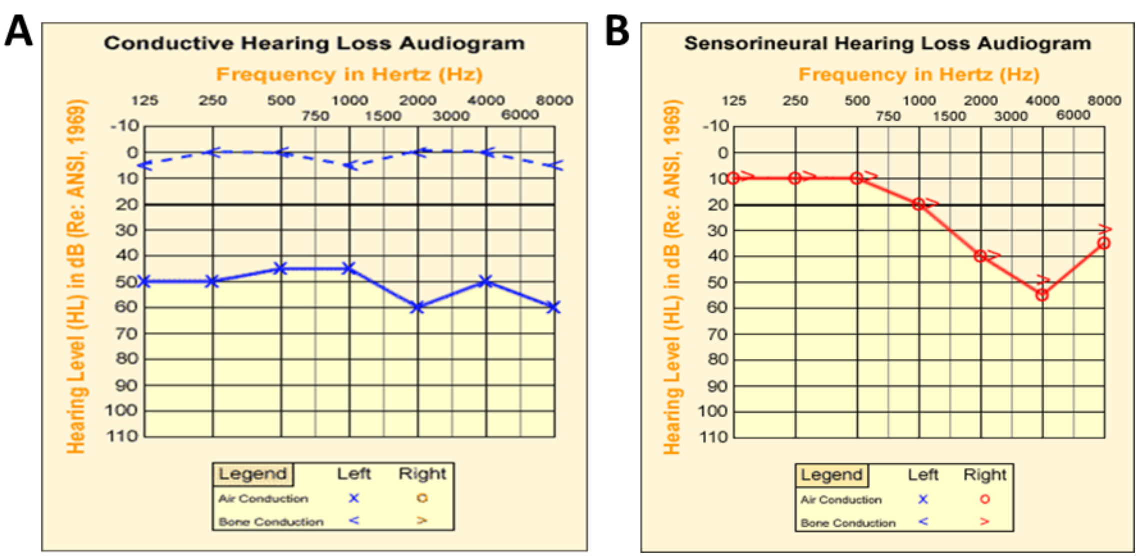


Figure 5. Representative audiograms showing an example of conductive hearing loss in (A) and sensorineural hearing loss in (B).

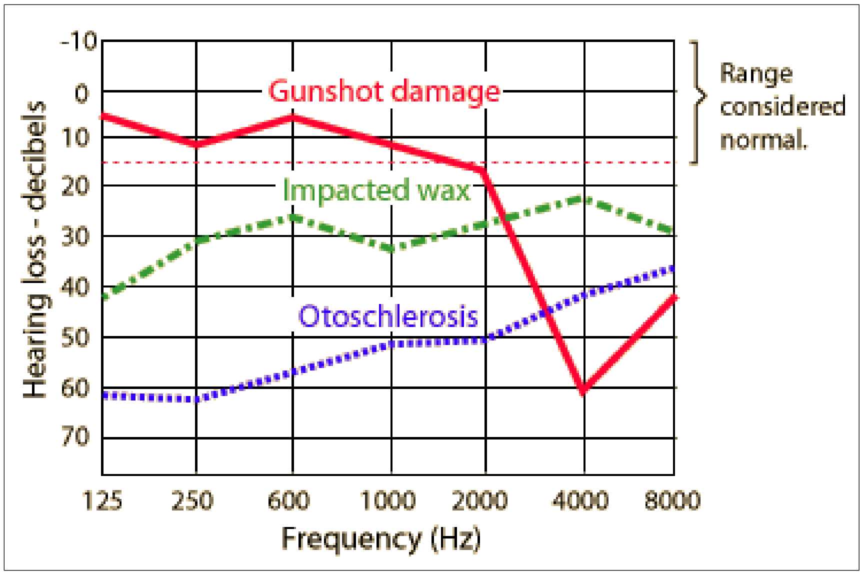


Figure 6. Audiogram recordings showing various patterns of deafness

1.6.3. Mixed Hearing loss

Sometimes a conductive hearing loss occurs in combination with a sensorineural hearing loss . In other words, there may be damage in the outer or middle ear and in the inner ear (cochlea) or auditory nerve. When this occurs, the hearing loss is referred to as a mixed hearing loss. The audiogram shows a mixed picture of both patterns, Fig-13.

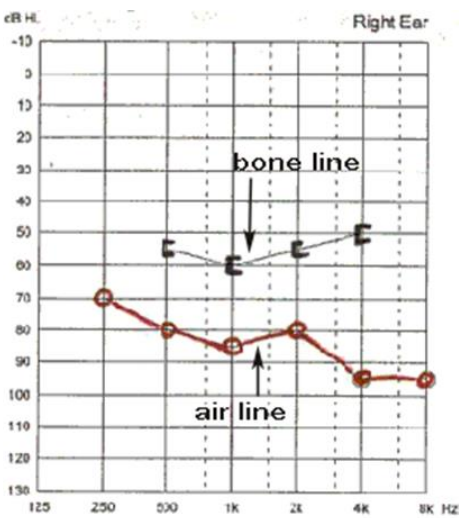
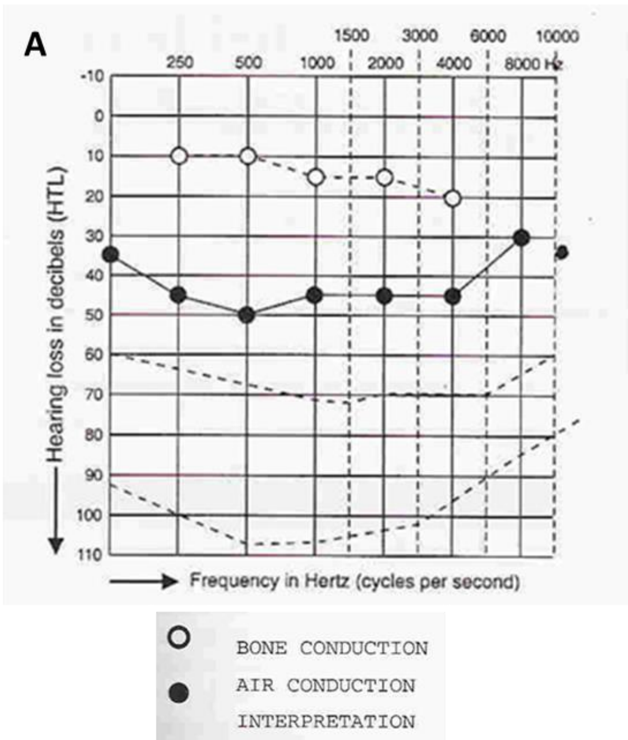
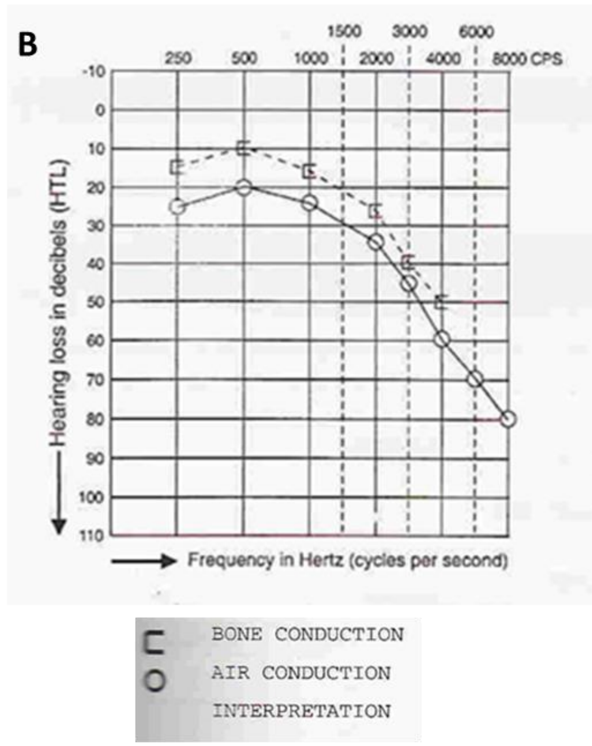


Figure 7. Audiogram showing mixed sensoineural hearing loss.

1.7. Practice questions

1. **The audiograms shown below were recorded from right ear of two different subjects, subject (A) and (B). Describe the findings observed for each graph and identify the most likely type of hearing loss that each represents**





	Subject A	Subject B
Findings		
Interpretation		
Possible causes		

Vision (Visual Acuity, Color Vision, Light and Accommodation Reflex)

Visual Acuity is defined as the shortest distance by which two lines can be separated and still perceived as two lines.

It depends on the refractive ability of the refractive media (cornea and lens) of the eye and the density of the photoreceptors. Refractive ability refers to the ability of the eyes to bend parallel rays of light coming from infinity to focus on the retina.

The fovea centralis is the place of greatest visual acuity during the daylight and the mid-peripheral portion of the retina is the place of greatest visual acuity in the dim light.

1.8. Testing far vision

1.8.1. Equipment

- Snellen's chart, Fig-18.

1.8.2. Procedure

- Ask the subject to stand about 6-meter (20-feet) away from the Snellen's chart. This distance is referred to as "d".
- Keep wearing eye glasses if they are for distant vision.
- Cover one of his eyes with an eye patch.
- Ask him to read the chart from the other eye and find out the smallest letters he could read.
- Note the distance written below the last line he is able to read fully. This distance is referred to as "D".
- Repeat the same procedure for the other eye.

1.8.3. Interpretation

$$\text{Visual Acuity (VA)} = \frac{\text{d}}{\text{D}}$$

Where,

d = the distance from where the subject is reading the chart.

D = the distance from which a normal subject can read that line.

Suppose the smallest letter that can be read by the subject is in the line below which the distance is mentioned "9 meter", then the Visual Acuity of that eye is:

$$\text{Visual Acuity (VA)} = \frac{6}{9}$$

It means that the subject is able to read from 6 meters only which a normal person can read from 9 meters, so his visual acuity for the far vision is disturbed. Normal Visual Acuity for far vision is 6/6 (in meters) or 20/20 (in feet).

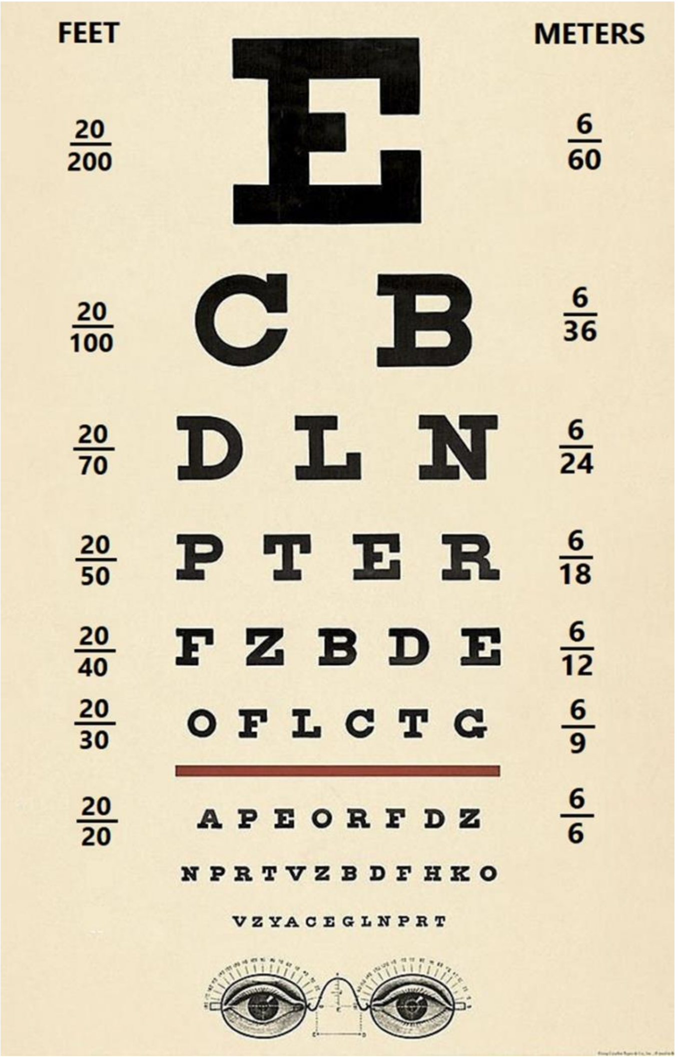


Figure 8. Snellen's chart.

1.8.4. Refractive Errors

1.8.4.1. Myopia

Myopia is a refractive error in which close objects are seen clearly, but the far objects appear blurred, that is why this condition is also called ***nearsightedness***. It occurs if the eyeball is too long or the lens has too much curvature. As a result, the light entering the eye from a distant object isn't focused exactly on the retina but focuses in front of it, so that distant object looks blurred, Fig-19A. This refractive error can be corrected by applying ***concave (minus) lenses*** in front of the eyes or performing surgery to flatten cornea that will decrease the refractive ability of the cornea and the light rays from a far object will focus on the retina.

1.8.4.2. Hyperopia

If the eyeball is smaller or the lens is weak, the image from a near object is focused behind the retina, making the object look blurred, Fig-19B. In these cases near vision is affected and the far vision remains intact, so this refractive error is known as ***farsightedness*** or in medical terms, hypermetropia. These patients need ***convex (plus) lenses*** in front of eye so that the light rays entering the eyes from any near object will focus exactly on the retina and the near objects can be seen clearly then.

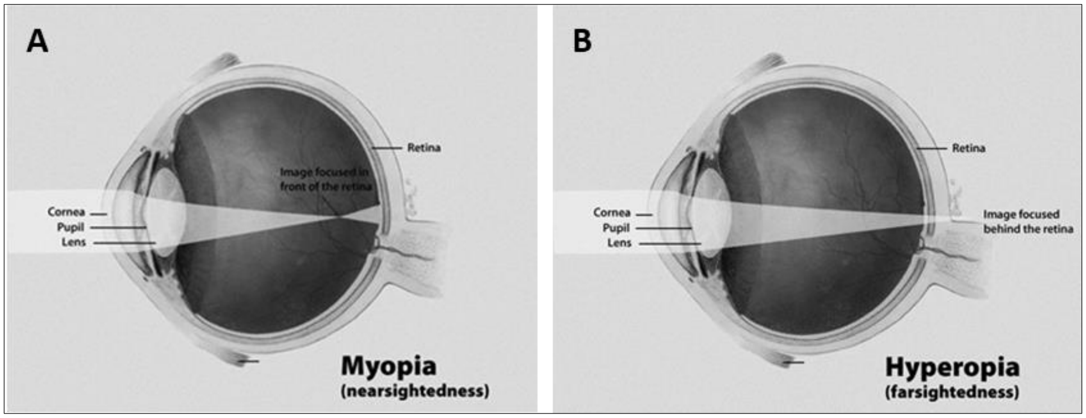


Figure 9. Errors of refraction. (A) A myopic eye with the image focusing in front of the retina. (B) A hyperopic eye with the image focusing behind the retina.

1.9. Testing near vision

The near vision test is measuring your ability to read and see objects within an arm's distance from the body. This test is important if you have hypermetropia or presbyopia.

Most clinics record the near vision as a Snellen fraction (distance equivalent) or as a Jaeger notation such as J1, found on the side of reading cards adjacent to the line of print. In performing the near visual acuity assessment it is of great importance to note at what distance the chart is to be held from the patient. Some charts are calibrated for 12, 14, or 16 inch testing distances. Patients should be wearing their corrective lenses even if they are for distance viewing. If the patient wears specific reading glasses, they should be worn rather than the distance glasses.

1.9.1. Equipment

- Jaeger's chart.

1.9.2. Procedure

- Ask the subject to hold the Jaeger's chart at a distance of 14 inches (36 cm) from his eyes.
- Keep wearing eye glasses if any.
- Cover one of his eyes with an eye patch.
- Ask him to read from the largest line to the smallest line that he can read easily or ask him to recognize the smallest size of the picture drawn in the chart and take note.
- Repeat the same procedure for the other eye.

1.9.3. Interpretation

The Jaeger type scale ranges from J1+ to J16 with J1+ being the smallest type. J1+ is considered the equivalent of 20/20 distance visual acuity at the reading distance indicated on the card (14 inches from your eyes), so a person with normal near vision should be able to read up to this line.

Suppose that the subject can read or recognize the picture up to the line marked J3, it means that he can read or recognize at 36 cm distance from his eye which can be read or recognized by a normal subject at 72 cm.

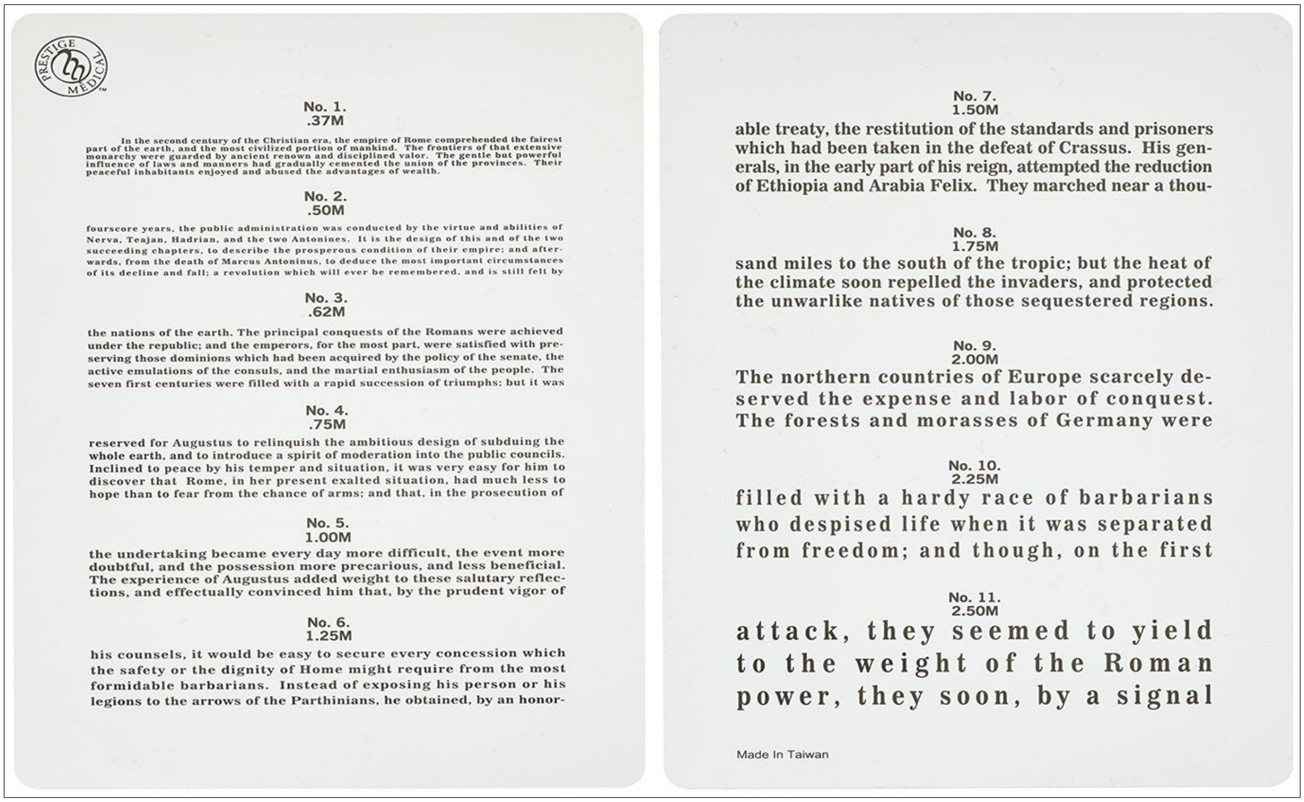


Figure 10. Jaeger's chart.

1.10. Testing for Astigmatism

Astigmatism is a type of refractive error that causes blurred vision mainly due to the irregular shape of the cornea and sometimes uneven curvature of the lens inside the eye can also cause astigmatism. An irregular shaped cornea or lens prevents light from focusing properly on the retina. Astigmatism frequently occurs with other vision conditions like myopia and hypermetropia. Slight amounts of astigmatism usually don't affect vision and don't require treatment. However, larger amounts of astigmatism cause distorted or blurred vision, eye discomfort and headaches and need to be treated by adding ***cylindrical lenses*** in eyeglasses that will correct the astigmatism by altering the way light enters your eyes.

1.10.1. Equipment

- Astigmatism chart.

1.10.2. Procedure

- Ask the subject to stand at a 6-meter (20-feet) distance from an Astigmatism chart.
- Remove eye glasses if any.
- Cover one of his eyes with an eye patch.
- Ask him to see the chart from the other eye. This chart consists of a number of dark lines radiating from a central point, like spokes of a bicycle wheel. If astigmatism is present, some of the spokes will appear sharp and dark, whereas the others will appear blurred and lighter because they come to focus either in front of or behind the retina when they pass through uneven curvature of the cornea.
- Repeat the same procedure for the other eye.

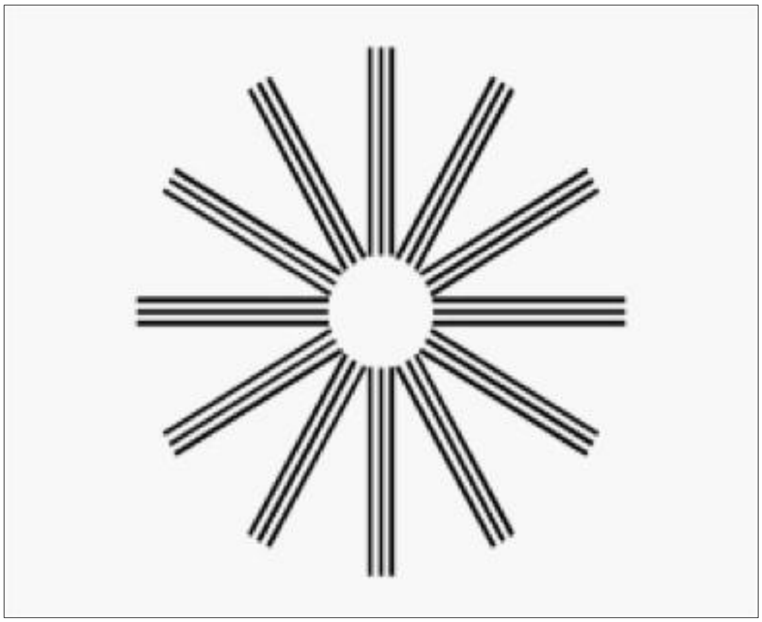


Figure 11. Astigmatism chart.

1.11.Demonstration of the blind spot

The blind spot is the area in the visual field where an object cannot be seen keeping one eye closed. It is due to the fact that light rays from that area of the visual field focus on the optic disc of the retina which lacks photoreceptors.

1.11.1. Equipment

- Blind spot card, Fig-22.

1.11.2. Procedure

- Hold the blind spot card in your right hand and bring it in front of your face about 20 inches away from your right eye.
- Close your left eye.
- Focus on the “plus” sign which can be easily done if the “plus” sign is positioned in line with your right eye.
- Keeping your right eye focused on the “plus” sign, gradually bring the blind spot card closer to your face until the “circle” drawn on the blind spot card disappears. This is the blind spot of your right eye. If you move the blind spot card further close to your right eye, the circle will reappear.
- Repeat the same procedure for the left eye, but this time you will focus on the circle and the plus sign will disappear.

Figure 12. Blind spot card.

1.12. Determination of near point

Near point is the nearest possible distance at which the near object can be clearly seen. The near point of vision changes dramatically with age, averaging about 8cm at the age of 10 and about 100 cm at the age of 70, table-2.

Table 1. Changes in near point with age.

Age	Near point
10 years	8 cm
20 years	10 cm
30 years	12.5 cm
40 years	18 cm
50 years	40 cm
60 years	83 cm
70 years	100 cm

1.12.1. Equipment

- Common pin.

1.12.2. Procedure

- Ask the subject to sit comfortably.
- Select the test eye and close the other eye.
- Hold a common pin at an arm’s length (about 10 inches) in front of his eye and ask him to look at the pin-head.
- Keeping the pin-head in focus, gradually bring the pin closer to his eye.
- Ask the subject to indicate when the pin-head first appears to be blurred or cannot be seen.
- Measure the distance with a ruler.
- Repeat the same procedure for the other eye.

1.13.Testing Accommodation

The process of accommodation can be tested by observing Purkinje-Sanson images in a dark room.

1.13.1. Purkinje-Samson images

If a small bright light, usually a candle, is held in front of and a little to one side of the eye in a very dark room, three images are seen:

1. The first image comes from the cornea and it is small, bright and upright.
2. The second image comes from anterior surface of the lens. It is large, upright but less bright.
3. The third or last image comes from posterior surface of the lens and it is small, bright and inverted.

During accommodation, the second image comes closer to the first image and also becomes smaller than when the eye was at rest. And since an image reflected from a convex surface is diminished in proportion to the convexity of that surface, it is obvious that the front of the lens became more convex when the eye adjusted itself for near vision and this is how we can observe the process of accommodation by using these images.

1.13.1.1. Equipment

- A candle and a dark room.

1.13.1.2. Procedure

- Make the subject comfortably seated in a dark room.
- Ask him to look at a distant object.
- Hold a candle light in front of and a little to the side of the subject's any one eye.
- Look into the subject's eye from the side opposite to the candle.
- Observe how many images of the candle light are reflected in the subject's papillary area and take note of the relative size, brightness and position of the images.
- Now ask the subject to look at a nearby object and observe carefully the changes that are produced in the size, brightness and position of the images, Fig-23.

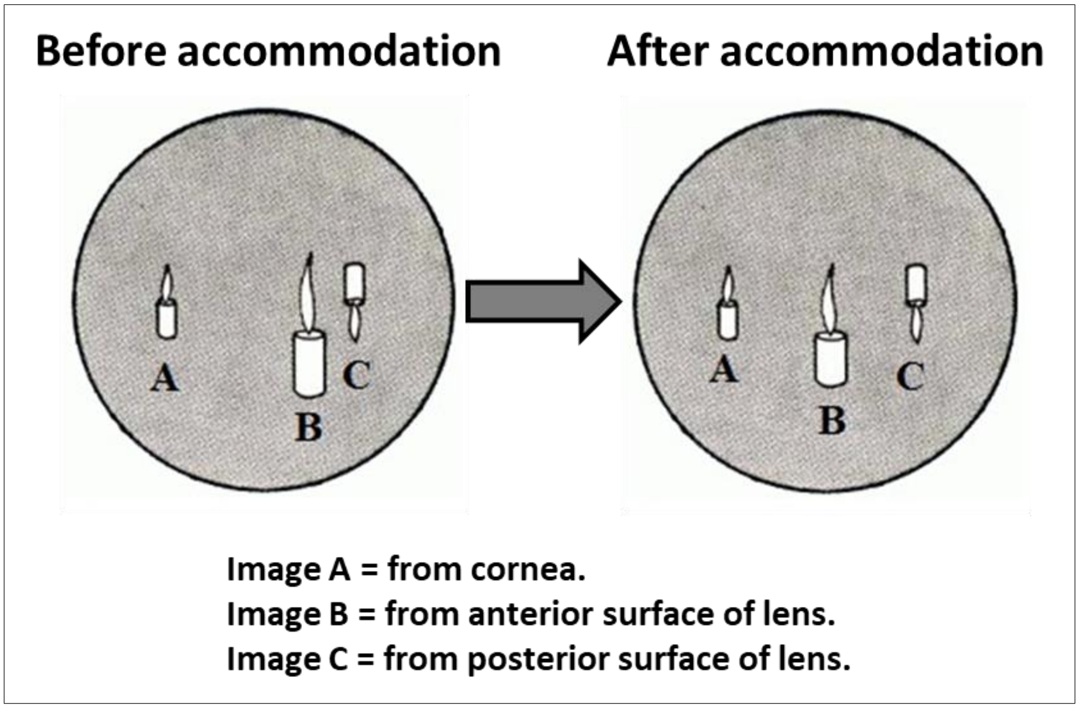


Figure 13. Images reflected on the pupillary area using the candle light experiment in a dark room.

1.14. Test for Color Vision

Color vision is the function of the cones. There are three types of cones in our eyes; red, green and blue. Relative lack or deficiency of one, two or all of them will lead to a defect in color vision.

1.14.1. Equipment

- Ishihara's colored plates, Fig-24.

1.14.2. Procedure

- Select the eye for testing and close or cover the other eye.
- Ask the subject to read the numbers showing in several colored Ishihara's plates or trace the zigzag pathway given in some plates.
- Note if the subject has difficulty or fails to read the number or trace the path correctly in a plate and then refer to the key given for that plate to decide which type of color blindness he is having.
- Repeat the same procedure for the other eye.

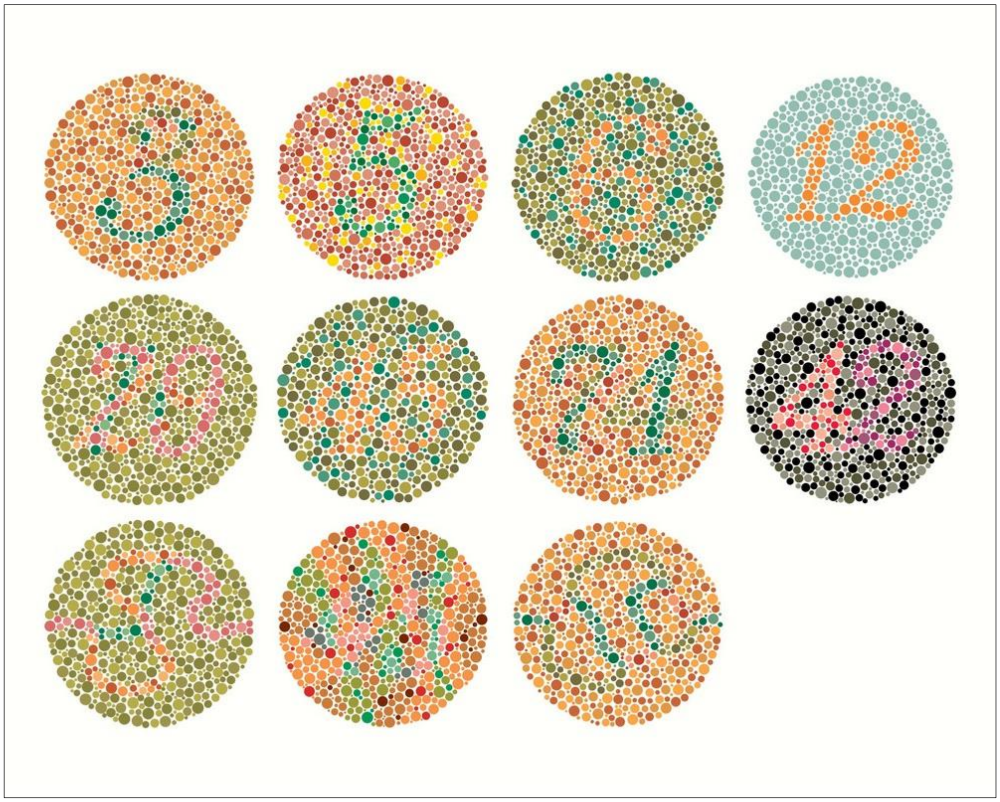


Figure 14. Ishihara's color test plates.

-End of physiology practical guide-