Ethiopian TVET-System

Basic Biomedical Equipment Servicing Level II

Based on May 2011 Occupational Standards

October, 2019

Module Title: INTERPRETING BIOMEDICAL SIGNAL

TTLM Code: EEL BES2 M09 TTLM 1019v1

This module includes the following Learning Guides

LG38: Identify Electronic Communication System in Biomedical Equipment

LG Code: EEL BES2 M11 LO1-LG-38

LG39: Describing Bio Potential Signals

LG Code: EEL BES2 M11 LO2-LG-39

LG40: Identify Signal Conditioning Equipment in the Man-Instrument System

LG Code: EEL BES2 M01 LO3-LG-40

LG41: INTERPRET WORK INSTRUCTIONS

LG Code: EEL BES2 M11 LO4-LG-41

Instruction Sheet	LG38: Identify Electronic Communication System in Biomedical Equipment

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Explaining communication concepts
- Describing modulation and Demodulation
- Explaining principles of super heterodyne receive
- Describing basic Principles of fiber optics

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically,

Upon completion of this Learning Guide, you will be able to:

- Explain communication concepts
- Describe modulation and Demodulation
- Explain principles of super heterodyne receive
- Describe basic Principles of fiber optics

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4".
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3 and Self-check 4" **in page -5, 10, 13 and 17** respectively.

Information Sheet-1	Explaining communication concepts

1. Introduction

Communication systems convey information from one point to another via physical channels that propagate electromagnetic, acoustic, particle density, or other waves. This information is usually manifest as voltages or currents; these may be continuous (often called analog) variables with an infinite number of possible values or discrete (often called digital) variables with a finite set of known possible values. Communications systems linking machines include telemetry systems that convey sensory data one way, networks that convey data two-way among multiple nodes, and memory systems that store and recall information..

1.1 Explain communication concepts

- A communication system conveys information from its source to a destination.

Examples:

- Telephone
- TV
- Radio
- Cell phone
- PDA
- Satellite

- A communication system is composed of the following:

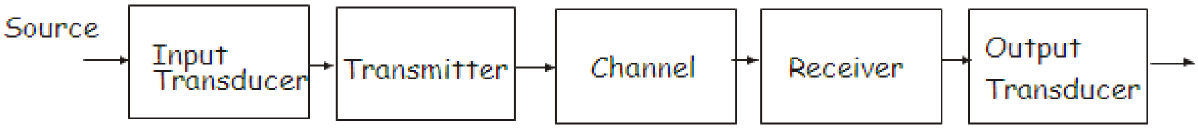


Fig.1 block diagram of communication system

1.1.1 Input Transducer

- Source: Analog or digital
- Example: Speech, music, written text
- Input Transducer: Converts the message produced by a source to a form suitable for the communication system.
- Example:

Speech waves→Microphone→Voltage

1.1.2 Transmitter

- Couple the message to the channel
- Operations: Amplification, Modulation
- Modulation encodes message into amplitude, phase or frequency of carrier signal (AM, PM, FM)
- Advantages:
  - Reduce noise and interference
  - Multiplexing
  - Channel Assignment

Examples: TV station, radio station, web server

1.1.3 Channel

- Physical medium that does the transmission
- Examples: Air, wires, coaxial cable, radio wave, laser beam, fiber optic cable
- Every channel introduces some amount of distortion, noise and interference

1.1.4 Receiver

- Extracts message from the received signal
- Operations: Amplification, Demodulation, Filtering
- Goal: The receiver output is a scaled, possibly delayed version of the message signal (ideal transmission)
- Examples: TV set, radio, web client

1.1.5 Output Transducer

- Converts electrical signal into the form desired by the system

- Examples: Loudspeakers, PC

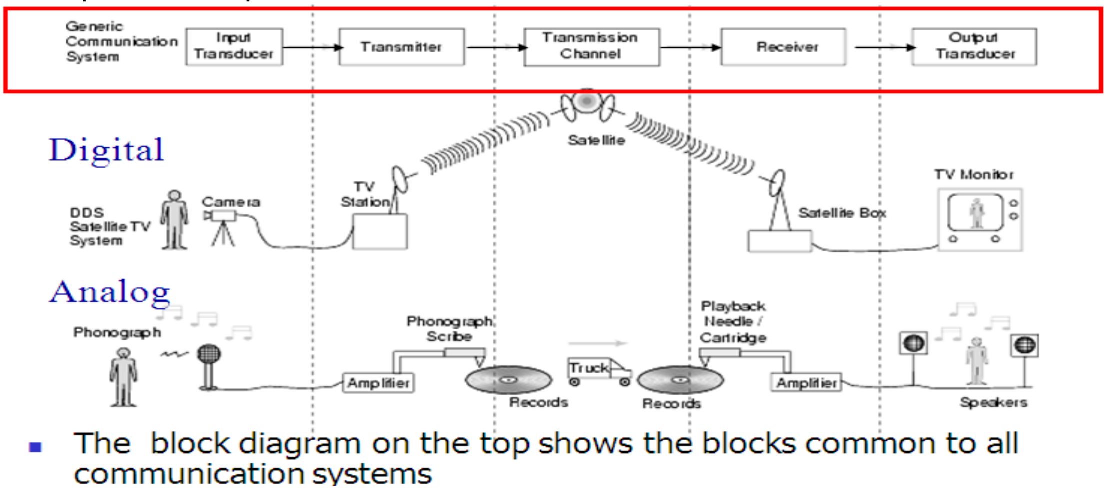


Fig.2 Electronic Communication system

Self-Check -1	Multiple choice

1__________is the transfer of information from one place to another.

A. communication B. information C. Data D. none

2. Physical medium that does the transmission

A. RF amplifier B. Mixer C. IF amplifier D. channel

3.___________converts the message produced by a source to a form suitable for the communication system.

A. actuator B. input transducer C. output transducer D. none

4. Which one is not under the operation of transmitter?

A. amplification B. modulation C. Demodulation D. none

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	**Describing modulation and Demodulation.**

2.1 What is Modulation?

The process of changing some characteristic (e.g. amplitude, frequency or phase) of a carrier
Wave in accordance with the intensity of the signal is known as modulation.

Modulation means to "change". In modulation, some characteristic of carrier wave is changed in accordance with the intensity (i.e. amplitude) of the signal. The resultant wave is called modulated wave or radio wave and contains the audio signal. Therefore, modulation permits the transmission to occur at high frequency while it simultaneously allows the carrying of the audio signal.

Need for modulation. Modulation is extremely necessary in communication system due to the Following reasons:

(i) **Practical antenna length**. Theory shows that in order to transmit a wave effectively, the Length of the transmitting antenna should be approximately equal to the wavelength of the wave.Now,

$$\text{wavelength} = \frac{\text{velocity}}{\text{frequency}} = \frac{3 \times 10^8}{\text{frequency (Hz)}} \text{ metres}$$

As the audio frequencies range from 20 Hz to 20 kHz, therefore, if they are transmitted directly
into space, the length of the transmitting antenna required would be extremely large. For instance, to radiate a frequency of 20 kHz directly into space, we would need an antenna length of 3 ×108/20 × 103= 15,000 metres. This is too long antenna to be constructed practically. For this reason, it is impracticable to radiate audio signal directly into space. On the other hand, if a carrier wave say of 1000kHz is used to carry the signal, we need an antenna length of 300 metres only and this size can be easily constructed.

(ii) **Operating range**. The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater the energy possessed by it. As the audio signal frequencies are small, therefore, these cannot be transmitted over large distances if radiated directly into space. The only practical solution is to modulate a high frequency carrier wave with audio signal and permit the transmission to occur at this high frequency (i.e. carrier frequency).

(iii) **Wireless communication**. One desirable feature of radio transmission is that it should be carried without wires i.e. radiated into space. At audio frequencies, radiation is not practicable
Because the efficiency of radiation is poor. However, efficient radiation of electrical energy is possible at high frequencies (> 20 kHz). For this reason, modulation is always done in communication systems.

In modulation, a message signal, which contains the information is used to control the parameters of a carrier signal, so as to impress the information onto the carrier.

2 .2 the Messages

The message or modulating signal may be either:

- Analogue
- Digital

Types of Modulation

As you will recall, modulation is the process of changing amplitude or frequency or phase of a carrier wave in accordance with the intensity of the signal. Accordingly, there are three basic types of modulation, namely ;

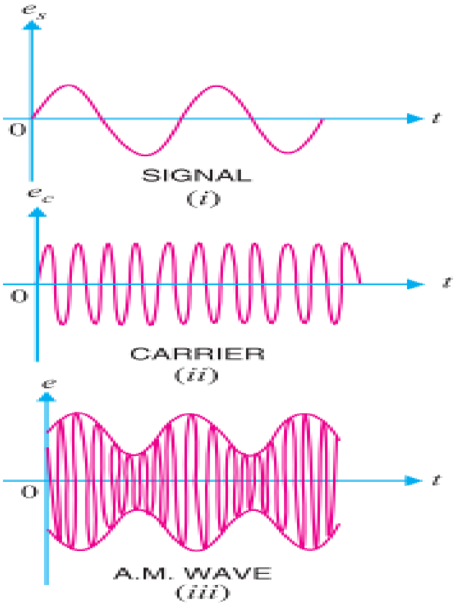
(i) amplitude modulation (ii) frequency modulation (iii) phase modulation

In India, amplitude modulation is used in radio broadcasting. However, in television transmission, frequency modulation is used for sound signal and amplitude modulation for picture signal.

Amplitude Modulation

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, it is called amplitude modulation. In amplitude modulation, only the amplitude of the carrier wave is changed in accordance with the intensity of the signal. However,the frequency of the modulated wave remains the same i.e. carrier frequency. Fig. 16.2 shows the principle of amplitude modulation. Fig. 16.2 (i) shows the audio electrical signal whereas Fig. 16.2 (ii) shows a carrier wave of constant amplitude. Fig. 16.2 (iii) shows the amplitude modulated (AM) wave. Note that the amplitudes of both positive and negative half-cycles of carrier wave are changed in accordance with the signal. For instance, when the signal is increasing in the positive sense, the amplitude of carrier wave also increases.

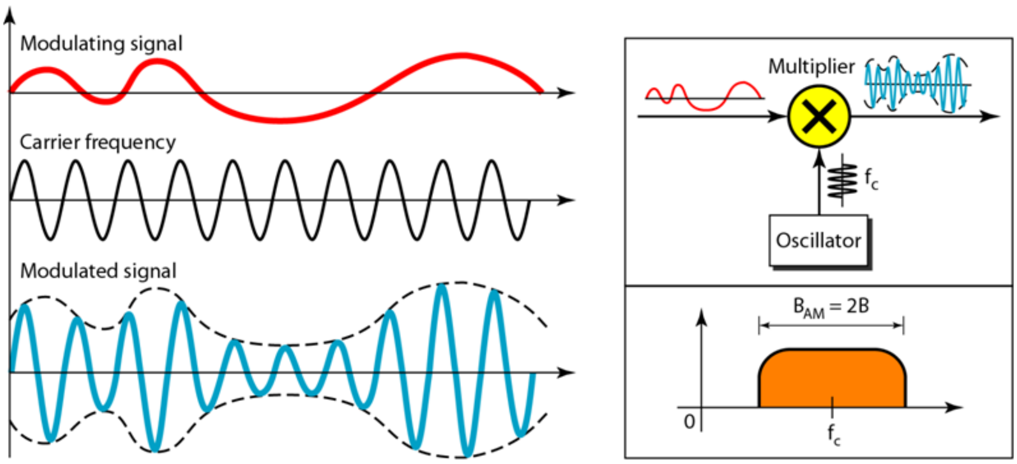
On the other hand, during negative half-cycle of the signal, the amplitude of carrier wave decreases. Amplitude modulation is done by an electronic circuit called modulator.
The following points are worth noting in amplitude modulation:
(i) The amplitude of the carrier wave changes according to the intensity of the signal.
(ii) The amplitude variations of the carrier wave is at the signal frequency fs.
(iii) The frequency of the amplitude modulated wave remains the same i.e. carrier frequency fc



Therefore, our attention in this chapter shall be confined to the first two most important types of.

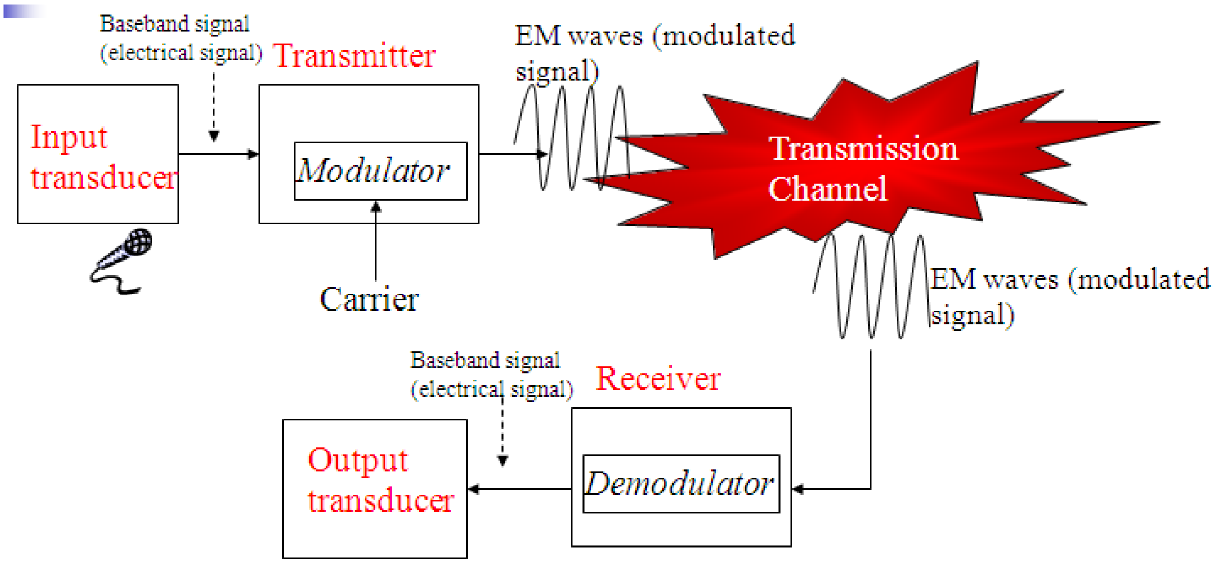
- If the message signal controls amplitude – AMPLITUDE MODULATION (AM)
- If the message signal controls frequency – FREQUENCY MODULATION (FM)
- If the message signal controls phase – PHASE MODULATION (PM)

Example ***Amplitude modulation***



2.3 What is Demodulation?

Demodulation is the process of extracting original signal from a radio wave
Or it is the reverse process (to modulation) to recover the message signal at the receiver.



(http://web.mit.edu/6.02/www/s2012/handouts/14.pdf)

Fig. 3 demodulation

2.4 Antenna principle

ANTENNA

An antenna (or aerial) is a transducer that transmits or receives electromagnetic waves. In other words, antennas convert electromagnetic radiation into electrical current, or vice versa Antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space. Antennas demonstrate a property known as *reciprocity*, which means that an antenna will maintain the same characteristics regardless if it is transmitting or receiving. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned to the same frequency band of the radio system to which it is connected, otherwise the reception and the transmission will be impaired. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain wayantennas used for HF are different from the ones used for VHF, which in turn are different from antennas for microwave. The wavelength is different at different frequencies, so the antennas must be different in size to radiate signals at the correct wavelength. We are particularly interested in antennas working in the microwave range, especially in the 2.4 GHz and 5 GHz frequencies. At 2.4 GHz the wavelength is 12.5 cm, while at 5 Ghz it is 6 cm.

-Directivity

antennas can be omnidirectional, sectorial or directive. Omnidirectional antennas radiate the same pattern all around the antenna in a complete 360 degrees pattern. The most popular types of omnidirectional antennas are the Dipole-Type and the Ground Plane. Sectorial antennas radiate

Primarily in a specific area. The beam can be as wide as 180 degrees, or as narrow as 60 degrees. Directive antennas are antennas in which the beam width is much narrower than in sectorial antennas. They have the highest gain and are therefore used for long distance links. Types of directive antennas are the Yagi, the biquad, the horn, the helicoidal, the patch antenna, the Parabolic Dish and many others.

- Physical construction

antennas can be constructed in many different ways, ranging from simple wires to parabolic dishes, up to coffee cans. When considering antennas suitable for 2.4 GHz WLAN use, another classification can be used:

- Application

we identify two application categories which are Base Station and Point-to Point. Each of these suggests different types of antennas for their purpose. Base Stations are used for multipoint access. Two choices are Omni antennas which radiate equally in all directions, or Sectorial antennas, which focus into a small area. In the Point-to-Point case, antennas are used to connect two single locations together. Directive antennas are the primary choice for this application (http://wireless.ictp.it/handbook/C4.pdf)

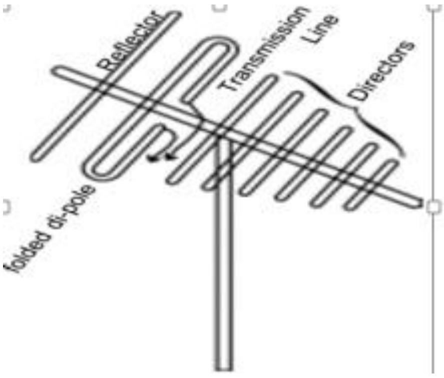


Fig.4 antenna

Self-Check -2	Multiple choice

1__________ is the process of extracting original signal from a radio wave

A. communication **B.** information **C.** Data **D.** Demodulation

2. The process of superimposing (mixing) signal on carrier wave is called ________

A. **RF** amplifier B. Mixer C. **IF** amplifier D. superheterodyne

3.___________ is a transducer that transmits or receives electromagnetic waves.

A. actuator **B.** input transducer **C.** output transducer **D.** antenna

4. ------------Convert electromagnetic radiation into electrical current, or vice versa

A. actuator B. input transducer C. output transducer D. antenna

***Note:* Satisfactory rating – 8points Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: _____________

Name: ___________________________ Date: _______________

Information Sheet-3	Principles of Superheterodyne

3.1 Principles of Superheterodyne

The process of beating (mixing) two different signals to produce new signal is called as Heterodyning.

i.e mixing of radio wave with an oscillator to produce a new signal ,called intermediate frequency, is called super heterodyne

The superheat radio or to give it its full name the super heterodyne receiver is one of the most popular forms of receiver in use today. Virtually all broadcast radios, televisions and many more types of receiver use the superheat or super heterodyne principle. First developed at the end of the First World War, with its invention credited to the American Edwin Armstrong, the use of the superheat has grown ever since the concept was first discover.

Mixing

The idea of the superheat revolves around the process of mixing. Here RF mixers are used to multiply two signals together. (This is not the same as mixers used in audio desks where the signals are added together). When two signals are multiplied together the output is the product of the instantaneous level of the signal at one input and the instantaneous level of the signal at the other input. It is found that the output contains signals at frequencies other than the two input frequencies. New signals are seen at frequencies that are the sum and difference of the two input signals, i.e. if the two input frequencies are f1 and f2, then new signals are seen at frequencies of (f1+f2) and (f1-f2). To take an example, if two signals, one at a frequency of 5 MHz and another at a frequency of 6 MHz are mixed together then new signals at frequencies of 11 MHz and 1 MHz are generated.

SUPERHETRODYNE

In the superhet or superheterodyne radio, the received signal enters one input of the mixed. A locally generated signal (local oscillator signal) is fed into the other. The result is that new signals are generated. These are applied to a fixed frequency intermediate frequency (IF) amplifier and filter. Any signals that are converted down and then fall within the passband of the IF amplifier will be amplified and passed on to the next stages. Those that fall outside the passband of the IF are rejected. Tuning is accomplished very simply by varying the frequency of the local oscillator. The advantage of this process is that very selective fixed frequency filters can be used and these far out perform any variable frequency ones. They are also normally at a lower frequency than the incoming signal and again this enables their performance to be better and less costly. To see how this operates in reality take the example of two signals, one at 6 MHz and another at 6.1 MHz. Also take the example of an IF situated at 1 MHz. If the local oscillator is set to 5 MHz, then the two signals generated by the mixer as a result of the 6 MHz signal fall at 1 MHz and 11 MHz. Naturally the 11 MHz signal is rejected, but the one at 1 MHz passes through the IF stages. The signal at 6.1 MHz produces a signal at 1.1 MHz (and 11.1 MHz) and this falls outside bandwidth of the IF so the only signal to pass through the IF is that from the signal on 6 MHz.

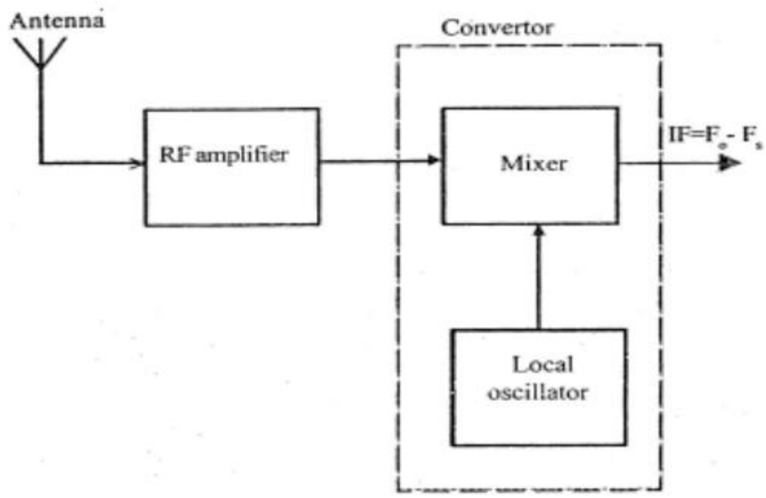


Fig.5 MIXER

3.2 AM RADIO RECEIVER

A receiver which receiver’s amplitude modulated radio signals is called amplitude modulated (AM) radio receiver.

3.2 .1 RF AMPLIFIER: It amplifies the RF signals obtained from the aerial (antenna).

3.2 .2 MIXER: The mixer stage mixes the oscillator signal and RF signal

3.2 .3 IF AMPLIFIER: amplifies the strength of intermediate frequency (IF) signals to improve the sensitivity.

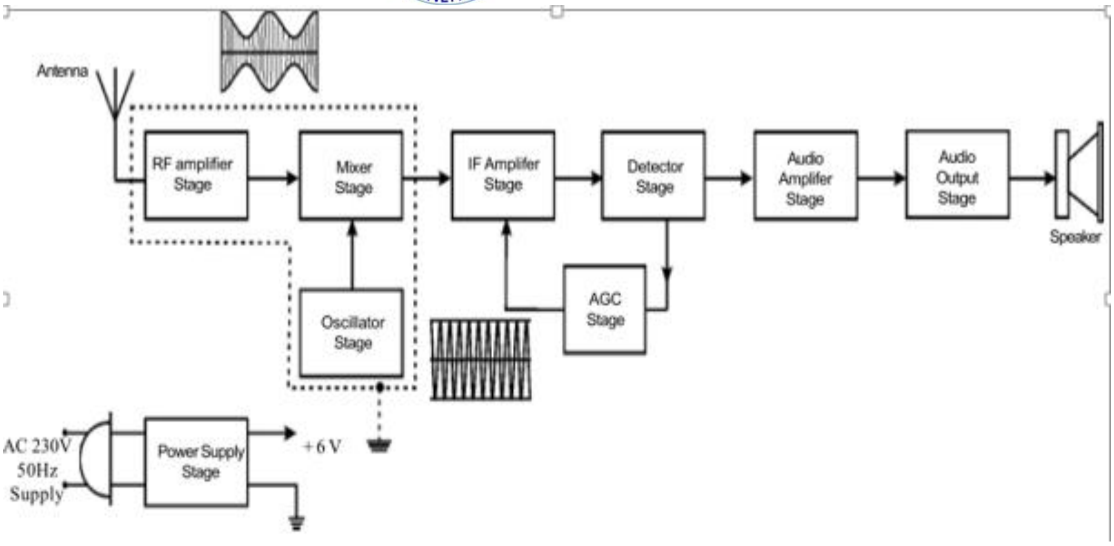


Fig.6 block diagram of am radio receiver

It contains the following stages.1. RF Amplifier 2. Converter 3. IF amplifier4. Detector, AVC 5. Audio Amplifier 6. Power Supp

Self-Check -3	Multiple choice

1__________ It amplifies the RF signals obtained from the aerial (antenna).

. A. communication B. information C. Data D **.**RF amplifier

2. The process of superimposing (mixing) signal on carrier wave is called ________

A. **RF** amplifier B. Mixer C. **IF** amplifier D. superheterodyne

3. The process of beating (mixing) two different signals to produce new signal is called_________

A. Frequency B. Phase C. width D. superheterodyne

3. The process of beating (mixing) two different signals to produce new signal

4.___________ amplifies the strength of intermediate frequency(IF) signals to improve the sensitivity.

A. actuator B. input transducer C. output transducer D. IF AMPLIFIER

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: _____________

Information Sheet-4	Basic Principles of fiber optics

4.1 Basic Principles of fiber optics

Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications. However, infrastructure development within cities was relatively difficult and time-consuming, and fiber-optic systems were complex and expensive to install and operate. Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost. Since 2000, the prices for fiber-optic communications have dropped considerably. The price for rolling out fiber to the home has currently become more cost-effective than that of rolling out a copper based network. Prices have dropped to $850 per subscriberin the US and lower in countries like The Netherlands, where digging costs are low and housing density is high.

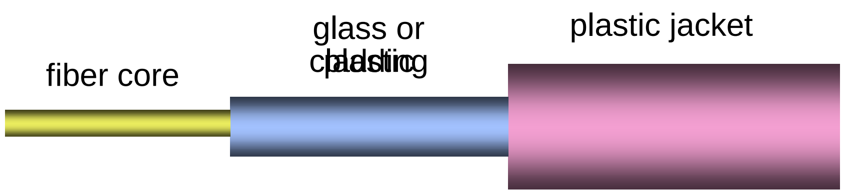
Since 1990, when optical-amplification systems became commercially available, the telecommunications industry has laid a vast network of intercity and transoceanic fiber communication lines. By 2002, an intercontinental network of 250,000 km of submarine communications cable with a capacity of 2.56 Tb/s was completed, and although specific network capacities are privileged information, telecommunications investment reports indicate that network capacity has increased dramatically since 2004.

4.2 What are Fiber Optics?

- **Fiber optics** (optical fibers) are long, thin strands of very pure glass about the diameter of a human hair.

They are arranged in bundles called **optical cables** and used to transmit light signals over long distances.

- a single optical fiber has the following parts:
- **Core -** Thin glass center of the fiber where the light travels
- **Cladding -** Outer optical material surrounding the core that reflects the light back into the core.
- **Buffer coating -** Plastic coating that protects the fiber from damage and moistur



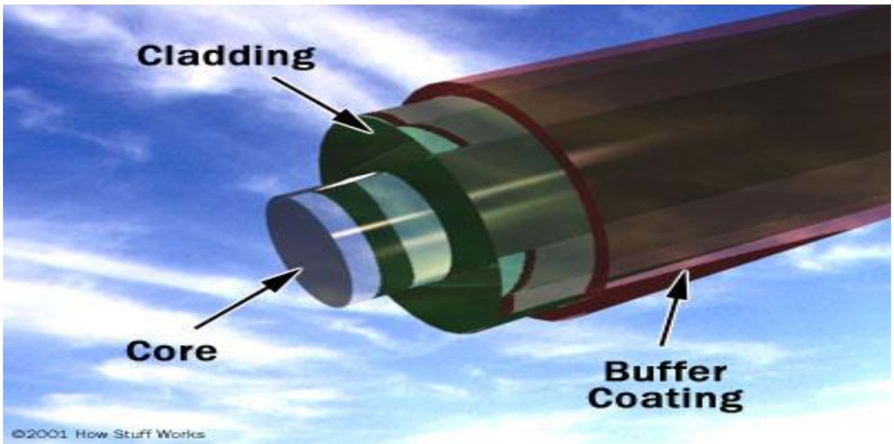


Fig.8 fiber optics parts

Fiber cable types

Fig.9 A cable reel trailer with conduit that can carry optical fiber

Fig.10 Single-mode optical fiber in an underground service pit

Main articles: Optical fiber and Optical fiber cable

An optical fiber consists of a core, cladding, and a buffer (a protective outer coating), in which the cladding guides the light along the core by using the method of total internal reflection. The core and the cladding (which has a lower-refractive-index) are usually made of high-quality silica glass, although they can both be made of plastic as well. Connecting two optical fibers is done by fusion splicing or mechanical splicing and requires special skills and interconnection technology due to the microscopic precision required to align the fiber core

Two main types of optical fiber used in optic communications include multi-mode optical fibers and single-mode optical fibers. A multi-mode optical fiber has a larger core (≥ 50 micrometers), allowing less precise, cheaper transmitters and receivers to connect to it as well as cheaper connectors. However, a multi-mode fiber introduces multimode distortion, which often limits the bandwidth and length of the link. Furthermore, because of its higher dopant content, multi-mode fibers are usually expensive and exhibit higher attenuation. The core of a single-mode fiber is smaller (<10 micrometers) and requires more expensive components and interconnection methods, but allows much longer, higher-performance links.

In order to package fiber into a commercially viable product, it typically is protectively coated by using ultraviolet (UV), light-cured acrylate polymers, then terminated with optical fiber connectors, and finally assembled into a cable. After that, it can be laid in the ground and then run through the walls of a building and deployed aerially in a manner similar to copper cables. These fibers require less maintenance than common twisted pair wires, once they are deployed.

Specialized cables are used for long distance subsea data transmission, e.g. transatlantic communications cable. New (2011–2013) cables operated by commercial enterprises (Emerald Atlantis, Hibernia Atlantic) typically have four strands of fiber and cross the Atlantic (NYC-London) in 60-70ms. Cost of each such cable was about $300M in 2011. *source: The Chronicle Herald.*

Another common practice is to bundle many fiber optic strands within long-distance power transmission cable. This exploits power transmission rights of way effectively, ensures a power company can own and control the fiber required to monitor its own devices and lines, is effectively immune to tampering, and simplifies the deployment of smart grid technology.

How Does an Optical Fiber Transmit Light?

- Suppose you want to shine a flashlight beam down a long, straight hallway.
- Just point the beam straight down the hallway -- light travels in straight lines, so it is no problem. What if the hallway has a bend in it?
- You could place a mirror at the bend to reflect the light beam around the corner.
- What if the hallway is very winding with multiple bends?

Self-Check -4	MATCH

A		B
1	Buffer coating	A. Thin glass center of the fiber where the light travels
2	Cladding	B .Thin glass center of the fiber where the light travels
3	Core	C. Plastic coating that protects the fiber from damage and moisture

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Instruction Sheet	LG39: DESCRIBING BIO POTENTIAL SIGNALS

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Describing basic bioelectric signals

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Describe basic bioelectric signals

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 5.
3. Read the information written in the information "Sheet 1 Sheet 2, Sheet 3"
4. " Accomplish the "Self-check 1, Self-check 2," Self-check 3 **in page -40**,**43** and **45**
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1," **in page -83.**

Information Sheet- 1	Describing bio electric signals

1.1 Bio potential signal

- A signal is a phenomenon that conveys information. Biomedical signals are signals, used in biomedical fields, mainly for extracting information on a biologic system under investigation.
- The complete process of information extraction may be as simple as a physician estimating the patient's mean heart rate by feeling, with the fingertips, the blood pressure pulse or as complex as analyzing the structure of internal soft tissues by means of a complex FMRI machine.

Most often in biomedical applications (as in many other applications), the acquisition of the signal is not sufficient. It is required to process the acquired signal to get the relevant information "buried" in it.

This may be due to the fact that the signal is noisy and thus must be "cleaned" (or in more professional terminology, the signal has to be enhanced) or due to the fact that the relevant information is not "visible" in the signal. In the latter case, we usually apply some transformation to enhance the required information.

The processing of biomedical signals poses some unique problems. The reason for this is mainly the complexity of the underlying system and the need to perform indirect, noninvasive measurements. A large number of processing methods and algorithms is available

1.2 Origin of Biomedical Signals

From the broad definition of the biomedical signal presented in the preceding section, it is clear that biomedical signals differ from other signals only in terms of the application — signals that are used in the biomedical field. As such, biomedical signals originate from a variety of sources.

The following is a brief description of these sources:

1.2 .1. *Bioelectric signals*. The bioelectric signal is unique to biomedical systems. It is generated by nerve cells and muscle cells. Its source is the membrane potential, which under certain conditions may be excited to generate an action potential. In single cell measurements, where specific microelectrodes are used as sensors, the action potential itself is the biomedical signal. In more gross measurements, where, for example, surface electrodes are used as sensors, the electric field generated by the action of many cells, distributed in the electrode's vicinity, constitutes the bioelectric signal. Bioelectric signals are probably

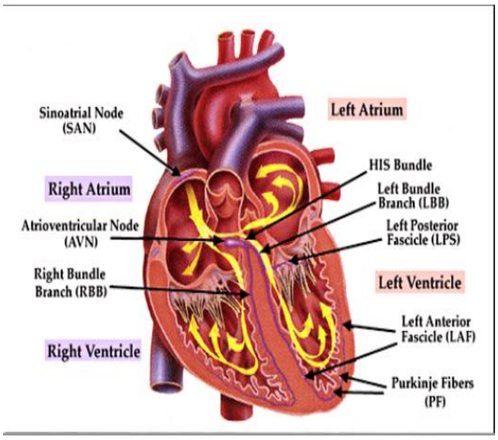
the most important bio signals. The fact that most important bio systems use excitable cells makes it possible to use bio signals to study and monitor the main functions of the systems. The electric field propagates through the biologic medium, and thus the potential may be acquired at relatively convenient locations on the surface, eliminating the need to invade the system. The bioelectric signal requires a relatively simple transducer for its acquisition. A transducer is needed because the electric conduction in the biomedical medium is done by means of ions, while the conduction in the measurement system is by electrons. All these lead to the fact that the bioelectric signal is widely used in most fields of biomedicine.

1.2 .1.1 ECG (electrocardiogram)

- ✓Electro – electric signal
- ✓Cardio – heart
- ✓Gram – recording
- ✓So ECG measures (records) the electric activity of the heart.

  The electrocardiography (ECG) is a diagnostic tool that measures and records the electrical activity of the heart in exquisite detail. Interpretation of these details allows diagnosis of a wide range of heart conditions. These conditions can vary from minor to life threatening.

  An electrocardiogram is a test that measures the electrical activity of the heart. This includes the rate and regularity of beats as well as the size and position of the chambers, any damage to the heart, and effects of drugs or devices to regulate the heart.



Electrocardiography (**ECG)** is a transthoracic interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. The etymology of the word is derived from the Greek *electro*, because it is related to electrical activity, *cardio*, and *graph*, a Greek root meaning "to write". In English speaking countries, medical professionals often write EKG (the abbreviation for the German word elektrokardiogramm) in order to avoid confusion with EEG.

The ECG works mostly by detecting and amplifying the tiny electrical changes on the skin that are caused when the heart muscle "depolarizes" during each heartbeat. At rest, each heart muscle cell has a charge across its outer wall, or cell membrane. Reducing this charge towards zero is called de-polarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through "intrinsic conduction pathways" and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle.

Usually more than 2 electrodes are used and they can be combined into a number of pairs. (For example: Left arm (LA), right arm (RA) and left leg (LL) electrodes form the pairs: LA+RA, LA+LL, RA+LL) The output from each pair is known as a **lead**. Each lead is said to look at the heart from a different angle. Different types of ECGs can be referred to by the number of leads that are recorded, for example 3-lead, 5-lead or 12-lead ECGs (sometimes simply "a 12-lead"). A 12-lead ECG is one in which 12 different electrical signals are recorded at approximately the same time and will often be used as a one-off recording of an ECG, typically printed out as a paper copy. 3- and 5-lead ECGs tend to be monitored continuously and viewed only on the screen of an appropriate monitoring device, for example during an operation or whilst being transported in an ambulance. There may, or may not be any permanent record of a 3- or 5-lead ECG depending on the equipment used.

It is the best way to measure and diagnose abnormal rhythms of the heart,[2] particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances.[3] In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered.[4] The ECG cannot reliably measure the pumping ability of the heart, for

Function of the heart

☞ **Four major functions**

◦ collecting deoxygenated blood from the veins
◦ pumping deoxygenated blood through the lungs
◦ collecting oxygenated blood from the lungs
◦ pumping oxygenated blood to the body

 P Wave – atrial depolarization

 QRS complex –ventricular depolarization

 T Wave – ventricular repolarization

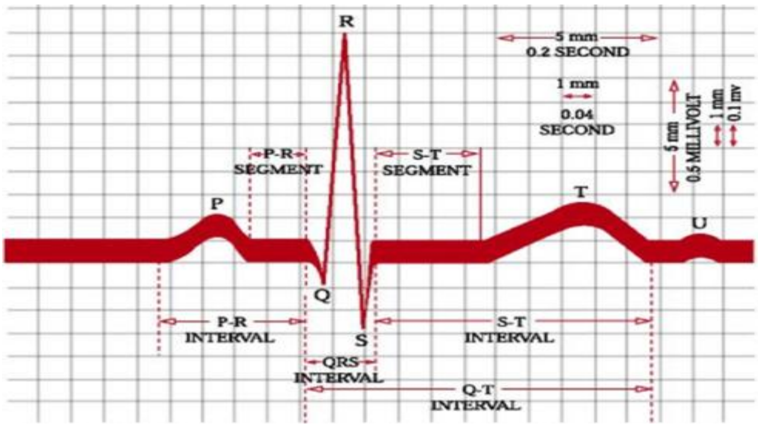


Fig.11 ECG wave form

2.1.1 Leads Configurations

Standard leads

The leads attaching the electrodes, usually, two of electrodes are standard in a "12-Lead"ECG. Each lead will have a specific name. For example: "Lead I" is of the **right arm** electrode and the **left arm electrode**, whereas "Lead II" is of the **right arm** and the **left leg** electrode. "Lead III" is of the **left leg** electrode and the **left arm** electrode. These three leads are standard.

Augmented limb leads: There are three augmented leads AVR, AVL, AVF. In unipolar/augmented leads two of the limb leads are tied together and recorded with respect to the third limb.

Precordial(chest) leads: The second type of unipolar lead.These are V1, V2, V3, V4, V5 and V6.

Electrodes of which are placed directly on the chest.

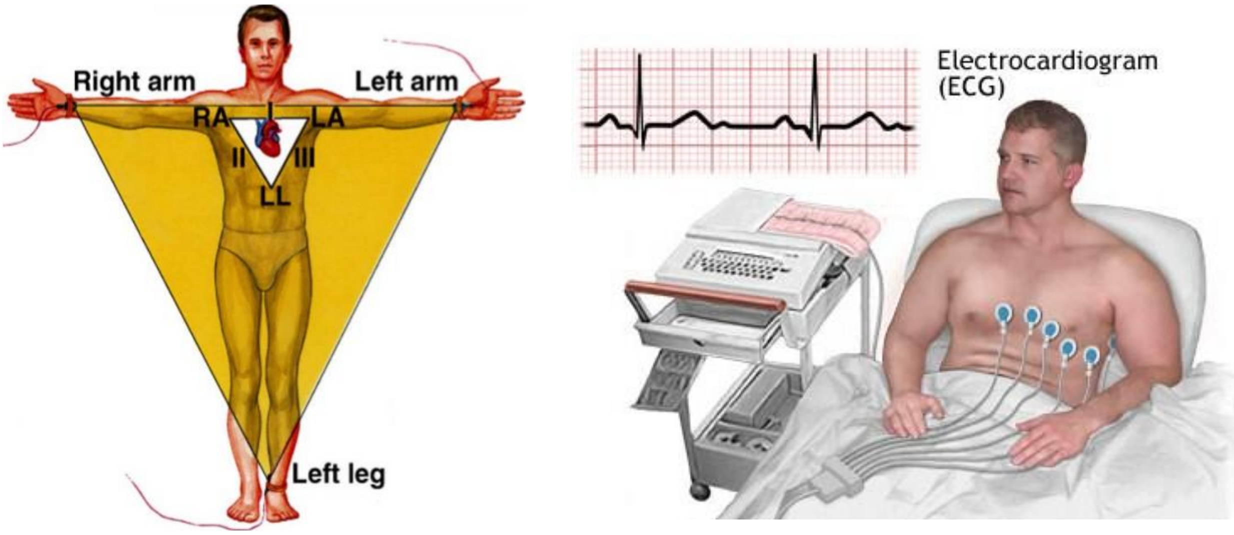
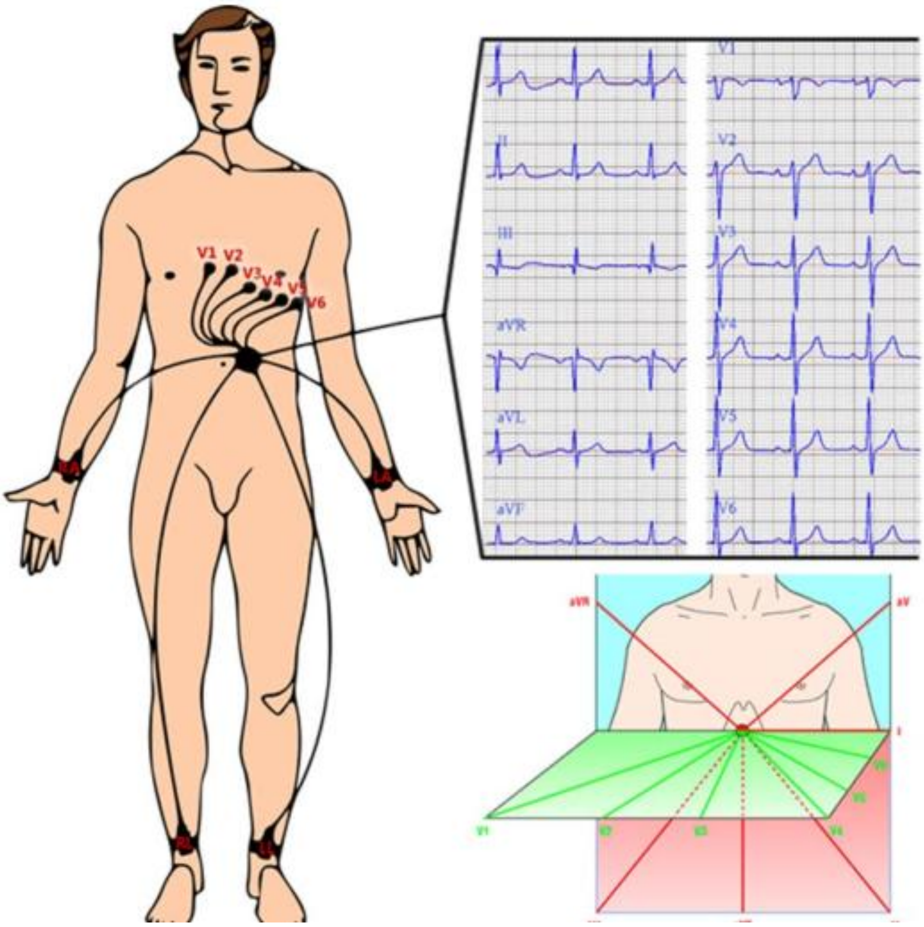


fig.12 ECG electrode placement (*limb electrode*)



V1 - 4th intercostal space R sternal border

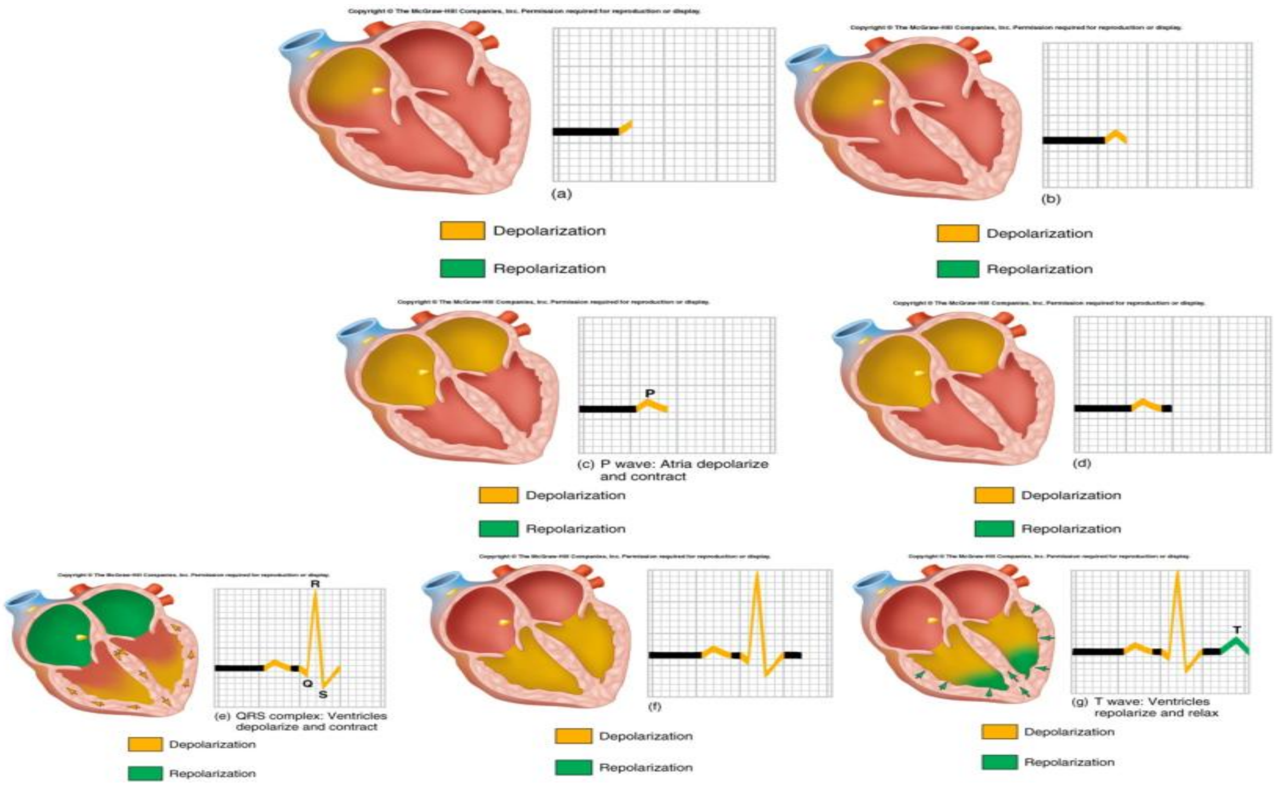
V2 - 4th intercostal space L sternal border

V3 - Between leads V2 and V4.

V4 - 5th L intercostal space in midclavicular line

V5 - Horizontally even with V4, but in the anterior axillary line.

V6 - Horizontally even with V4 and V5 in the midaxillary line. (The midaxillary line is the imaginary line that extends down from the middle of the patient's armpit.)

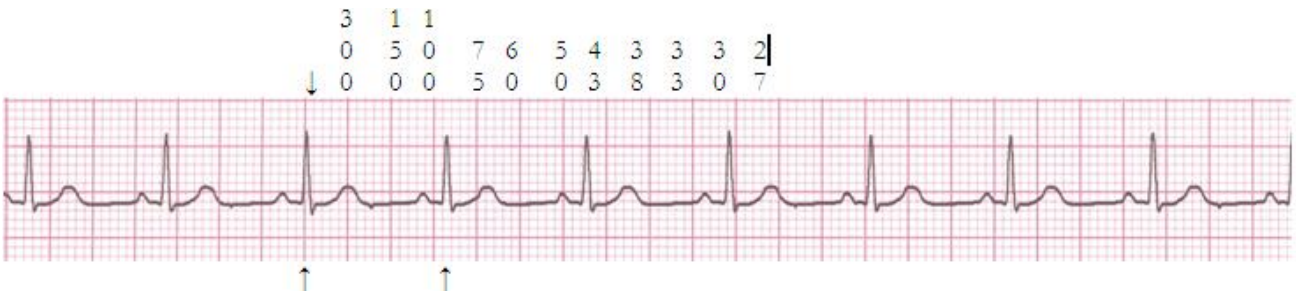


Calculating Heart Rate

Six Second Count, multiplying the number of QRS complexes found over six seconds by a factor of 10 to get the QRS complexes found in a minute.

9x10=90

Triplicate the fastest method to figure a regular heart rate. Memorize the following numbers 300, 150, 100, 75, 60, 50



Find an R wave that land on a bold line.
Count the # of large boxes to the next R wave. If the second R wave is 1 large box away the rate is 300, 2 boxes - 150, 3 boxes - 100, 4 boxes - 75, etc. *Approx. 1 box less than 100 = 95 bpm*

2.2 ENG(Electroneurogram)

ENG:measures the electrical activity of nerves

Neurons and muscle tissue consist of excitable cells

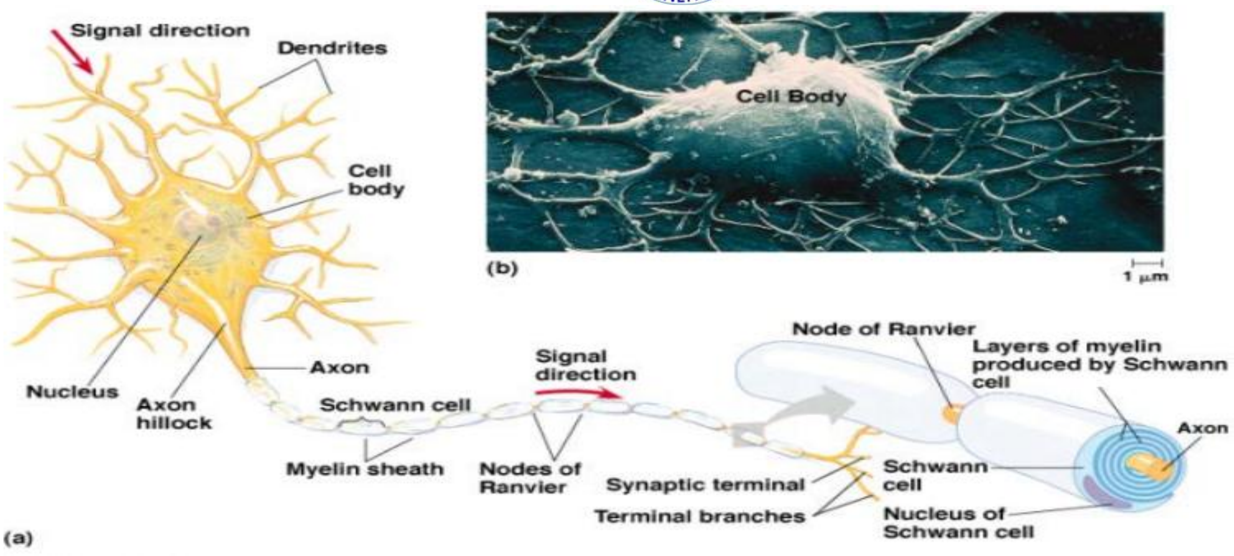


Fig.12 cell bodies

1.2 .1.1 **EMG (electromyogram)**

Electromyography (EMG) is the study of muscle function through analysis of the electrical signals during muscular contractions.

EMG: Measures the electric activity of active muscle fibers

Electromyography is measuring the electrical signal associated with the activation of the muscle. This may be voluntary or involuntary muscle contraction. The EMG activity of voluntary muscle contractions is related to tension. The functional unit of the muscle contraction is a motor unit, which is comprised of a single alpha motor neuron and all the fibers it enervates. This muscle fiber contracts when the action potentials (impulse) of the motor nerve which supplies it reaches a depolarization threshold. The depolarization generates an electromagnetic field and the potential is measured as a voltage. The depolarization, which spreads along the membrane of the muscle, is a muscle action potential. The motor unit action potential is the and temporal summation of the individual muscle action potentials for all the fibers of a single motor unit. Therefore, the EMG signal is the algebraic summation of the motor unit action potentials within the pick-up area of the electrode being used. The pick-up area of an electrode will almost always include more than one motor unit because muscle fibers of different motor units are intermingled throughout the entire muscle. Any portion of the muscle may contain fibers belonging to as many as 20-50 motor units. Electrodes are always connected very close to the muscle group being measured Rectified and integrated EMG signal gives rough indication of the muscle activity Needle electrodes can be used to measure individual muscle fibers Amplitude: 1-10 mV Bandwidth: 20-2000 Hz Main sources of errors are 50/60 Hz and RF interference

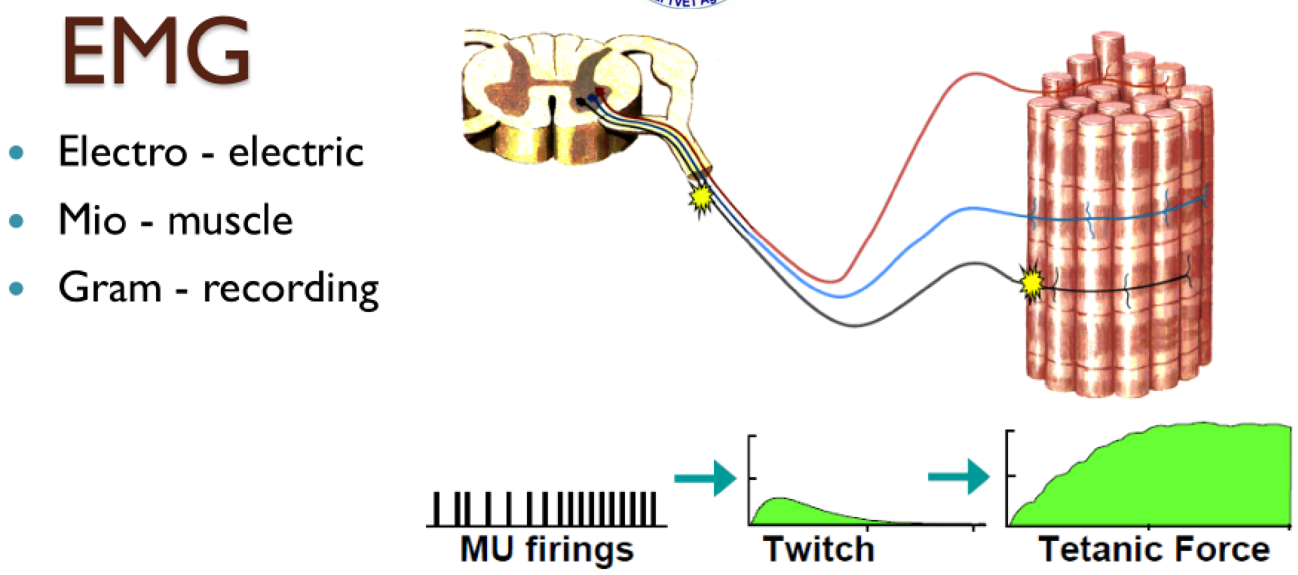


Fig .13 EMG measurement

Electromyography (EMG) is the study of muscle function through analysis of the electrical signals emanated during muscular contractions. Electromyography is often abused and misused by many clinicians and researchers. Many times even experienced electromyographers fail to provide enough information and detail on the protocols, recording equipment and procedures used to allow other researchers to consistently replicate their studies. Hopefully, this chapter will clarify some of these problems and give the reader a basis for being able to conduct electromyography studies as part of their on-going research.

Electromyography is measuring the electrical signal associated with the activation of the muscle. This may be voluntary or involuntary muscle contraction. The EMG activity of voluntary muscle contractions is related to tension. The functional unit of the muscle contraction is a motor unit, which is comprised of a single alpha motor neuron and all the fibers it enervates. This muscle fiber contracts when the action potentials (impulse) of the motor nerve which supplies it reaches a depolarization threshold. The depolarization generates an electromagnetic field and the potential is measured as a voltage. The depolarization, which spreads along the membrane of the muscle, is a muscle action potential. The motor unit action potential is the spatio and temporal summation of the individual muscle action potentials for all the fibers of a single motor unit. Therefore, the EMG signal is the algebraic summation of the motor unit action potentials within the pick-up area of the electrode being used. The pick-up area of an electrode will almost always include more than one motor unit because muscle fibers of different motor units are intermingled throughout the entire muscle. Any portion of the muscle may contain fibers belonging to as many as 20-50 motor units. A single motor unit can have 3-2,000 muscle fibers. Muscles controlling fine movements have smaller numbers of muscle fibers per motor units (usually less than 10 fibers per motor unit) than muscles controlling large gross movements (100-1,000 fibers per motor unit). There is a hierarchy arrangement during a muscle contraction as motor units with fewer muscle fibers are typically recruited first, followed by the motor units with larger muscle

fibers. The number of motor units per muscle is variable throughout the body.
For the purpose of this chapter there are two main types of electromyography: clinical (sometimes called diagnostic EMG) and kinesiological. Diagnostic EMG, typically done by physiatrists and neurologists, are studies of the characteristics of the motor unit action potential for duration and amplitude. These are typically done to help diagnostic neuromuscular pathology. They also evaluate the spontaneous discharges of relaxed muscles and are able to isolate single motor unit activity. Kinesiological EMG is the type most found in the literature regarding movement analysis. This type of EMG studies the relationship of muscular function to movement of the body segments and evaluates timing of muscle activity with regard to the movements. Additionally, many studies attempt to examine the strength and force production of the muscles themselves.
There is a relationship of EMG to many biomechanical variables. With respect to isometric contractions, there is a positive relationship in the increase of tension within the muscle with regards to the amplitude of the EMG signal recorded.
There is a lag time, however, as the EMG amplitude does not directly match the build-up of isometric tension. One must be careful when trying to estimate force production from the EMG signal, as there is questionable validity of the relationship of force to amplitude when many muscles are crossing the same joint, or when muscles cross multiple joints. When looking at muscle activity, with regards to concentric and eccentric contractions, one finds that eccentric contractions produce less muscle activity than concentric contraction when working against equal force. As the muscle fatigues, one sees a decreased tension despite constant or even larger amplitude of the muscle activity. There is a loss of the high-frequency component of the signal as one fatigues, which can be seen by a decrease in the median frequency of the muscle signal. During movement, there tends to be a relationship with EMG and velocity of the movement. There is an inverse relationship of strength production with concentric contractions and the speed of movement, while there is a positive relationship of strength production with eccentric contractions and the speed of movement. One can handle more of a load with eccentric contractions at higher speed. For example: If a weight was very large and you lowered it to the ground in a fast, but controlled manner, you handled a large weight at a high speed via eccentric contractions. You would not be able to raise the weight (concentric contraction) at the speed you were able to lower it. The forced production by the fibers are not necessarily any greater, but you were able to handle a larger amount of weight and the EMG activity of the muscles handling that weight would be smaller. Thus, we have an inverse relationship for concentric contractions and positive relationship for eccentric contractions with respect to speed of movement. With regards to recording the EMG signal, the amplitude of the motor unit action potential depends on many factors which include: diameter of the muscle fiber, distance between active muscle fiber and the detection site (adipose tissue thickness), and filtering properties of the electrodes themselves. The objective is to obtain a signal free of noise (i.e., movement artifact, 60 Hz artifact, etc.). Therefore, the electrode type and amplifier

characteristics play a crucial role in obtaining a noise-free signal.

For kinesiological EMG there are two main types of electrodes: surface and fine wire. The surface electrodes are also divided into two groups. The first is active electrodes, which have built-in amplifiers at the electrode site to improve the impedance (no gel is required for these and they decrease movement artifacts and increase the signal to noise ratio).

The other is a passive electrode, which detect the EMG signal without a built-in amplifier, making it important to reduce all possible skin resistance as much as possible (requires conducting gels and extensive skin preparation). With passive electrodes, signal to noise ratio decreases and many movement artifacts are amplified along with the actual signal once amplification occurs. The advantages of surface electrodes are that there is minimal pain with application, they are more reproducible, they are easy to apply, and they are very good for movement applications. The disadvantages of surface electrodes are that they have a large pick-up area and therefore, have more potential for cross talk from adjacent muscles.

Additionally, these electrodes can only be used for surface muscles. Fine wire electrodes require a needle for insertion into the belly of the muscle. The advantages of fine wire electrodes are an increased band width, a more specific pick-up area, ability to test deep muscles, isolation of specific muscle parts of large muscles, and ability to test small muscles which would be impossible to detect with a surface electrode due to cross-talk. The disadvantages are that the needle insertion causes discomfort, the uncomfortableness can increase the tightness or spasticity in the muscles, cramping sometimes occurs, the electrodes are less repeatable as it is very difficult to place the needle/fine wires in the same area of the muscle each time. Additionally, one should stimulate the fine wires to be able to determine their location, which increased the uncomfortableness of using this type of electrode. However, for certain muscles, fine wires are the only possibility for obtaining their information.

Differences between the recording of surface and fine wire electrodes, in part, are related to the differences in the bandwidths. Fine wire electrodes have a higher frequency and can pick-up single motor unit activity as the fine wire electrode band width ranges from 2-1,000 Hz, whereas surface electrode band width ranges from 10-600 Hz. Whether using surface or fine wire electrodes, there are some electrode configurations that can also aide in decreasing unwanted noise. A monopolar arrangement is the easiest as it is a single electrode and a ground. However, this arrangement picks up more unwanted signals than any of the other potential configurations. Bipolar arrangements are widely used in movement analysis. In this arrangement, there are two active electrodes and a ground. The process is to look at what is common with the two active electrodes and determine that this is noise and throw it away, keeping what is different in the two electrodes as the signal of interest. This is termed a differentially amplified system and is less prone to interference from adjacent and deeper muscles. A third arrangement is that of a double differentiated system. This is a system that has three active electrodes and one ground, therefore, possessing the ability to have two pairs of bipolar signals which are then again differentially amplified. This gives a smaller pick-up area, therefore, even less noise than the bipolar electrode by itself.

These electrode arrangements are unique to the amplified system purchased and much thought should be given when purchasing a system so that at minimum a bipolar system is acquired.
There are many other amplifier characteristics which should be noted. The first of which is the signal to noise ratio.

This is the ratio of the wanted signal to the unwanted signal and is a measure of the quality of the amplified signal.
The higher the ratio, the greater the noise reduction. Electrodes with on-site pre-amps (miniaturized and at the site of the electrode) are some of the best at providing a very large signal to noise ratio.
The gain of the amplifier is also important.
This is the amount of amplification applied to the signal and it should be sufficient enough to have output amplitude at 1.0 volt. Another important characteristic of the amplifier is the bandwidth.
This is simply the range of the collectable frequencies of the amplifier, and one wants this high enough to reject the low frequency movement artifacts and low enough to attenuate the signal as little as feasible. This means in general, one should be collecting in a range from 0 Hz to 600 Hz for surface electrodes and 0 Hz to 1,000 Hz for fine wire electrodes. Using the Nyquest Theorem, this means that one must sample at a minimum of 1,200 Hz for surface electrodes and 2,000 Hz for fine wire electrodes in order to assure capturing the entire signal. Once the signals have been recorded, then one could use a 10-15 Hz high pass filter to eliminate the movement artifacts (some prefer to use an analog filter on the front end, but I prefer to filter movement artifacts after collection). One must make sure all applied filters have zero phase shifts. The measure of the ability of the differential amplifier to eliminate the common mode signal is termed the common mode rejection ratio. The higher the common mode rejection ratio, the better the cancellation of common signals (noise). A value of 10,000 (80dB) is desirable.
The input and impedance of the system should be greater than 1012 ohms and have a low input bias current of the order of 50 pica-amps or less. A high input impedance allows for as much of the signal available for amplification to be amplified. Any signal input below the input bias current is not amplified. With these characteristics in mind, one should be able to purchase an amplifier that is sufficient for collecting electromyography signals. There is also the potential for error introduced by the analog to digital board chosen. Most boards are only 10-12 bit boards and if the system does not allow full use of the collected range, one introduces error. This means if your collection is set-up for +/- 10 volts and you are collecting EMG, which is in the +/- 1 volt range after amplification, you are not optimizing your system and you will have quantization and sampling error. Therefore, one must be sure that the software and hardware arrangement purchased allows for optimization of the collected voltage range within the A-D range.

The electromyographer must have a very good understanding of the anatomy of the human body as electrode location and placement is very important. First of all, one must be sure to clean the skin in order to reduce any skin resistance. This simple task can reduce the resistance of the skin by 200%. For many clinical applications of EMG, the belly of the muscle is used as a site for placing the electrodes. However, to assure repeatability of finding the specific site the electrode was placed, the use of bony landmarks as a reference is a must. There are numerous books and publications describing the exact locations of placement of the electrodes for this purpose. Another widely accepted method of placing the electrodes or surface electrodes is to use the motor point. As with placing the electrodes over the belly of the muscle, there are numerous publications that give the general motor point locations as a starting location, then you can find the exact position by using the motor point finder. Another specific issue that must be addressed is the inter-electrode distance. As many electrodes have a constant inter-electrode distance, several have a variable inter-electrode distance and one must be sure that this distance is kept constant throughout all subjects and trials to assure that the electrodes are over the same muscle fibers.

There are many sources of noise (any unwanted signal collected along side the wanted signal) and some of these sources are: electrostatic field (skin), electromagnetic fields (power lines), motion artifact due to loose electrodes at the skin interface or loose leads on the wires, involuntary reflex activity (clonus), and any other electrical devise that might be in the room when the studies are occurring. The majority of these artifacts can be removed from the system by a few simple means. Proper cleaning of the skin is one such measure. If site pre-amplified electrodes are not used, this becomes a more crucial task. Using bipolar differentially amplified or double differentially amplified systems also help dramatically in the removal of artifacts from the system. Attaching all loose electrode leads and making sure that there is some slack in these leads is important as well. If your system has the possibility to use the battery supply as opposed to line feed for the power source, this is a great advantage and should be utilized. Prior to beginning the collection of data, one should check that the electrodes is making proper contact and that there is no tension on the wires and that all of the wires are plugged into all connectors sufficiently. Once the electrodes are in position the subject should have manual muscle tests applied for this specific muscles being tested to make sure that the electrodes are picking up muscle activity appropriately. If certain electrodes seem to be working inappropriately, one can try switching the leads if possible with their system, or just switching electrode channels to see if this particular electrode works in another channel. If the signal is still bad after switching channels, one can switch electrodes to see if the electrode itself is malfunctioning. One must remember that there is a degradation of the signal as the amount of adipose tissue over the muscle being examined increases. Therefore, it may be difficult to pick-up any usable signal when dealing with obese individuals when using surface electrodes. One disadvantage of using the newer computerized collection systems is that many do not afford one the ability to see a raw EMG signal in real time (like an oscilloscope). It is imperative that one somehow view the raw signal prior to any processing (except an analog anti-aliasing filter) as it is often difficult to differentiate between signal and noise in a raw EMG signal and usually impossible to differentiate if any processing has been done to the EMG signal. Once the investigator looks at the raw signal, they need to determine if there is any filtering which needs to be done. The novice electromyographer may have trouble determining problems in the raw EMG signal. However, there are several items that can be looked at to help in this determination. Wavering base line is seen many times with low frequency movement artifacts.

Additionally, large spikes can be indicative of abrupt movements of the electrode as well. Other things to look for are common signals across all channels and an underlying 60 Hz signal superimposed on the signal. If the signal does not look clean, the investigator may want to filter the data (some investigators say to always filter the data). There are three main types of filters applied to EMG data: high-pass, low-pass, and notch filters. There are many types of filters that can be applied such as: Butterworth, Chebyshev, etc. In this investigator's lab, it is routine practice for us to use a fourth-order Butterworth high-pass digital filter with a 10-15 Hz cut-off, depending on the activity being analyzed (10 Hz for walking and 15 Hz for rapid movements) to remove movement artifacts. On the other end of the spectrum, we use an analog lowpass filter with a cut-off of 600 Hz for surface EMG and 1,000 Hz for fine wire EMG as an anti-aliasing filter. If it was determined that 60 Hz signals were superimpose within the signals, we would use a notch filter which would remove all signals within a 55-65 Hz range.

Now that we have a clean EMG signal, we can begin to look at the signal to gain information about the muscles.

The primary information to be gained is on and off information. In most movement analysis situations, only the raw EMG is used. No processing other than that which is used for cleaning up the raw signal (high and low-pass filters) is used.

However, there are many common forms of processing that are done with EMG signals. The most common are: half-wave rectification (deletion of all negative aspects of the signal), full-wave rectification (absolute value of the entire signal), linear envelope (low-pass filtering of the full-wave rectified signal), root mean square (basically square the signal, take the mean of a timed determinant window about 100-200 ms, then take the square root), integrated EMG (area under the rectified curve can be determined for the entire activity or for pre-set time or amplitude values), and frequency analysis (typically determined via fast Fourier analysis and looking at the power density spectrum). Depending on your application, each of these processing techniques may have merit but each have disadvantages as well, since with any processing done to the data, information is lost.

For comparisons of EMG data from task to task or person to person, data needs to be presented in a common format. Thus, several means of normalization of the signal have been developed for both the time and amplitude domains.

Probably the two most widely used time-base normalization techniques are to either normalize to a task/cycle or to phases within the task/cycle. As an example lets assume we want to look at the EMG of the back muscles with an individual who continually lifts items from the floor and places it in a bin. We can define a cycle as being from the initial movement of the object off the floor until the initial movement of the object off the floor for the successive lift. One would then just simply divide the time-base by the total amount of time it took to perform the task and then all movements would be with respect to the percent of the cycle. This works well for many cyclic tasks, but has disadvantages if the task contains more than one phase. Dividing up the time-base to the percent of a phase works well for task with multiple phases. Using the same lifting task, lets now define the lifting phase as being from the point that the object begins to move from the floor until the subject obtains a fully erect standing position. The second phase would then be from the point at which the subject reached the standing position until the item is placed in the bin and a third phase would begin at the point when the object was placed in the bin until the subject is back in position to lift another object. Each one of these phases is handled as a separate event.

Thus, the time it took to lift from the floor to the standing position would be used as the divisor to make a percent phase for the lifting phase, the time it took from the point when the body reached an erect standing position until the item was in the bin would be used as the divisor for the second phase, and so on for the third phase. This type of time-based standardization is very useful when the task has clear phases that can be determined. For the sake of this example, lets say that the maximum EMG activity occurred just prior to setting the item down in the bin. It is much more meaningful to be able to say that the maximum amount of the EMG was found at 95% of the second phase than to say the maximum EMG was found at 55% of the task. From this point you would have to go back and figure out what movement was going on at 55% of the task. Additionally, the intra and inter subject variability of setting the object in the bin at the same point in a multiphase cycle is typically large. For this reason, our lab prefers to use percents of phases when possible. Many times the amplitude of the signal is normalized as well. Probably the most widely used is to standardize to the maximum voluntary isometric contraction (MVIC) for the specific muscle being used. Based upon published references for manual muscle testing, the examiner then applies a force to the body part in sufficient magnitude that the subject is unable to maintain a static position while exerting against the examiner with a maximum muscle contraction. It is debatable if one can really ever obtain a true MVIC. Therefore, several other techniques have been devised. One of those is to use the maximum level of the signal across the entire task. In the lifting task previously described this would mean to take the maximum EMG level from each specific muscle during the entire task then normalize to this value. Many people prefer to use several peaks (4-5) and average these as the maximum so as to avoid the potential of using an erroneous high-spike as the maximum value. Another means of normalization is to use the mean level of the signal across the entire task.

However, this is much less sensitive to any rapid peaks that were obtained during the task and would heavily skew the data if the majority of the signal contained times when the muscle was not active. A problem that exists when using the maximum or mean level across the entire task is that the EMG signal will vary based upon the velocity of the joints during the contractions. Therefore, unless one standardizes the velocity of the task, this method may not allow for comparisons across tasks. Another technique very similar to the MVIC is to use a known level of force (e.g., Divide by the amplitude of the EMG when lifting 20 lbs. at the specific velocity that the task will be performed). Another variation of this is to use the amplitude of the EMG signal when exerting a known force against an immovable object, therefore, eliminating velocity from the equation. All of these

methods have positive and negative attributes and they are means of trying to compare amplitudes between muscles and individuals. Additionally, if the subjects being examined have any pathological conditions that involve the muscles you are testing it will be virtually impossible to get a true MVIC and questionable whether the other normalization techniques are of any value as well. Regardless of the normalization technique used, whether it is time-based and/or amplitude based, one must remember that absolute information will be lost. Now that we have cleaned up the data and completed any normalization that we may want to do, it is time to look at the signal and try to interpret its meaning. First of all, one must understand that there is a large variability of the EMG signal itself. Whether this is task-to-task variability within the same person or person-to-person variability within the same task, many combinations of muscle activity can produce the same movements because of the redundancy present in the neuromuscular system. EMG can be variable from task to task because of this normal redundancy, velocity or cadence changes, or slightly different movement patterns even though under observation they look the same. A normal range of EMG phasing will exist for a task but one must be very cautious of trying to define discreet points in the tasks where these patterns begin and end. This must be kept in mind when interpreting the EMG signals. Other factors enter into the equation with interpreting the EMG of individuals with pathological conditions that influence the task-to-task variability.
The changes in velocity or cadence, the onset of fatigue, and the presence of pain can all effect the EMG patterns. Another factor, which makes interpretation of the signal difficult, is cross talk. Cross talk is interference of the EMG signals from adjacent muscles or deeper muscles that are within the pick-up area of the electrode. There are no fixed solutions available at this point and the size of the patient and size of the electrode lead does play a major role in the ability to decrease or increase cross talk. For example, if your system has electrodes with fixed active electrode distances which are large and you are working with a pediatric population you can be assured that your data will have large amounts of muscle information from adjacent and underlying muscles that is not wanted with your data. Many examiners utilize fine wire electrodes in order to try to remedy this problem.
Now that we spent much time filtering and normalizing our data, it is time to discuss what the EMG signal can actually tell us. The muscle on and off timing patterns and relative increases and decreases in muscle activity are the two main parameters gained from the electromyography data. EMG data cannot tell us how strong the muscle is, if one muscle is stronger than another muscle, if the contraction is a concentric or eccentric contraction, or if the activity is under voluntary control by the individual. The strength of the muscle or determining one muscle to be stronger than another is one of the main areas that researchers want to use EMG data for. The normalizing to the MVIC, the average, or max during the cycle are all attempts to allow us to be able to compare from muscle to muscle within the same person and from muscle to muscle between individuals. This is routinely done but one must be cautious of the results due to the problems inherent with the collection techniques and variability among muscles, individuals, and tasks. Besides using EMG for determining the EMG patterns (times of activation and times of rest) many researchers use electromyography for evaluating the

changes in the signals as the muscles fatigue. All of these are valuable uses of electromyography in occupational biomechanics.

EMG capture

Differential amplifier

- Input from two different points of the muscle
- Close (usually 1-2cm)
- Electrodes aligned with the direction of muscle fibers
- Surface EMG
- Subcutaneous EMG

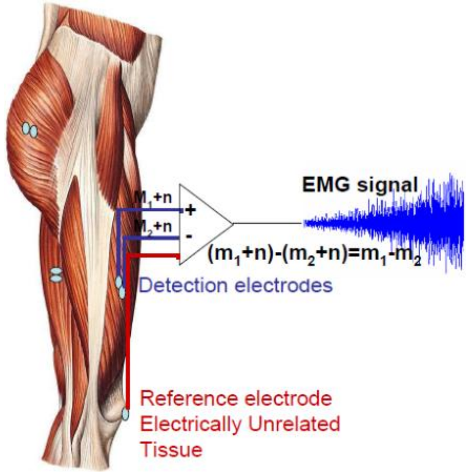


Fig .14 EMG capture

1.2 .1.2 Electroencephalography (EEG):

- ✓ EEG: Measures the brain's electric activity from the scalp
- ✓ Measured signal results from the activity of billions of neurons
- ✓ (EEG) measures the activity of large numbers (populations) of neurons.

Cerebrum

(Frontal,Parietal,Temporal and Occipital lobes)

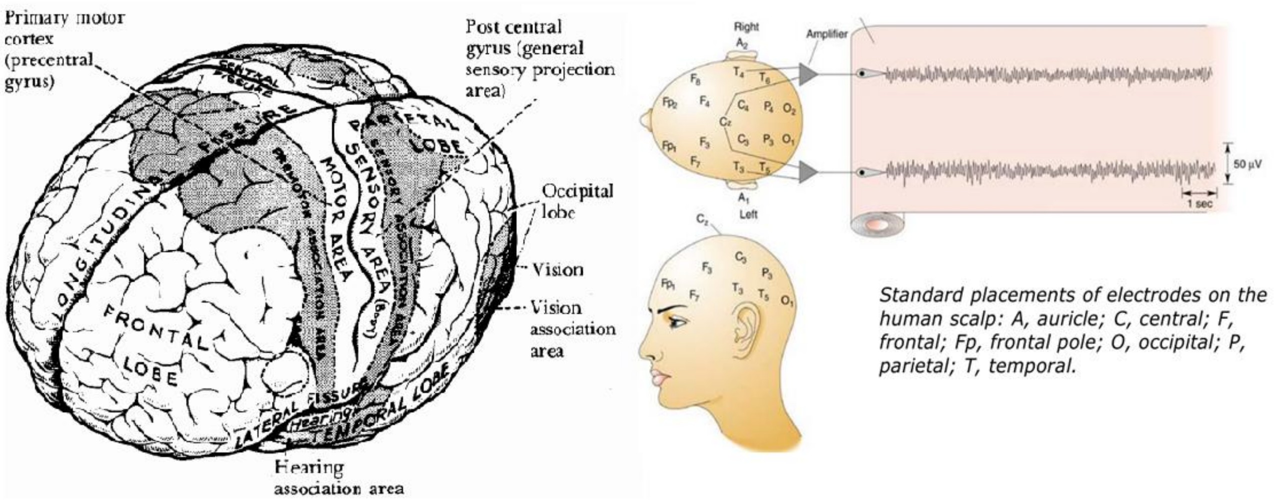


Fig .15 EEG electrode placement

Characteristics of EEG signal

- ✓ EEG rhythms correlate with patterns of behavior (level of attentiveness, sleeping, waking, seizures, coma).
- ✓ Rhythms occur in distinct frequency ranges:

◦ Gamma: 20-60 Hz ("cognitive" frequency band) -

◦ Beta: 14-20 Hz (activated cortex) – 2-20uV

◦ Alpha: 8-13 Hz (quiet waking) – 5-100uV
◦ Theta: 4-7 Hz (sleep stages) – 5-100uV

- ◦ Delta: less than 4 Hz ("deep sleep") – 20-200Uv
- Higher frequencies: active processing, relatively de-synchronized activity
- (Alert wakefulness, dream sleep).
- Lower frequencies: strongly synchronized activity (no dreaming sleep, coma).
- cognitrn.psych.indiana.edu/bu
- EEG measurement setup:
- EEG measurement setup 10-20 Lead system is most widely clinically accepted

1.2 .1.3 Electrooculography (EOG):

- EOG: Electric potentials are created as a result of the movement of the eyeballs
- Potential varies in proportion to the amplitude of the movement
- In many ways a challenging measurement with some clinical value Amplitude: 0.01-0.1 mV Bandwidth: DC-10 Hz
- Primary sources of error include skin potential and motion Applications: eye position, sleep state

1.2 .1.4 ENG (electroneogram)

The ENG is an electrical signal observed as a stimulus and the associated nerve action potential propagate over the length of a nerve. It may be used to measure the velocity of propagation (or conduction velocity) of a stimulus or action potential in a nerve [10]. ENGs may be recorded using concentric needle electrodes or silver - silver-chloride electrodes (Ag - AgCl) at the surface of the body. Conduction velocity in a peripheral nerve may be measured by stimulating a motor nerve and measuring the related activity at two points that are a known distance apart along its course. In order to minimize muscle contraction and other undesired effects, the limb is held in a relaxed posture and a strong but short stimulus is applied in the form of a pulse of about 100 V amplitude and 100 - 300 fis duration [10]. The difference in the latencies of the ENGs recorded over the associated muscle gives the conduction time. Knowing the separation distance between the stimulus sites, it is possible to determine the conduction velocity in the nerve [10]. ENGs have amplitudes of the order of 10 ^V and are susceptible to power-line interference and instrumentation noise.

2. **Bio impedance signals**. The impedance of the tissue contains important information concerning its composition, blood volume, blood distribution, endocrine activity, automatic nervous system activity, and more. The bio impedance signal is usually generated by injecting into the tissue under test sinusoidal currents (frequency range of 50 kHz–1 MHz, with low current densities of the order of 20–20 mA). The frequency range is chosen to minimize electrode polarization problems, and the low current densities are chosen to avoid tissue damage mainly due to heating effects. Bio impedance measurements are usually performed with four electrodes. Two source electrodes are connected to a current source and are used to inject the current into the tissue. The

two measurement electrodes are placed on the tissue under investigation and are used to measure the voltage drop generated by the current and the tissue impedance.
3. *Bioacoustics signals*. Many biomedical phenomena create acoustic noise. The measurement of this acoustic noise provides information about the underlying phenomenon. The flow of blood in the heart, through the heart's valves, or through blood vessels generates typical acoustic noise. The flow of air through the upper and lower airways and in the lungs creates acoustic sounds. These sounds, known as coughs, snores, and chest and lung sounds, are used extensively in medicine. Sounds are also generated in the digestive tract and in the joints Since the acoustic energy propagates through the biologic medium, the bioacoustics signal may be conveniently acquired on the surface, using acoustic transducers (microphones or accelerometers).
4. **Bio magnetic signals.** Various organs, such as the brain, heart, and lungs, produce extremely weak magnetic fields. The measurements of these fields provides information not included in other bio signals (such as bioelectric signals).
Due to the low level of the magnetic fields to be measured, bio magnetic signals are usually of very low signal-to-noise ratio.
5. *Biomechanical signals*. The term biomechanical signals includes all signals used in the biomedicine fields that originate from some mechanical function of the biologic system. These signals include motion and displacement signals, pressure and tension and flow signals, and others. The measurement of biomechanical signals requires a variety of transducers, not always simple and inexpensive. The mechanical phenomenon does not propagate, as do the electric, magnetic, and acoustic fields. The measurement therefore usually has to be performed at the exact site. This very often complicates the measurement and forces it to be an invasive one.
6. *Biochemical signals*. Biochemical signals are the result of chemical measurements from the living tissue or from samples analyzed in the clinical laboratory signal. Partial pressures of oxygen (pO2) and carbon dioxide (pCO2) in the blood or respiratory system are other examples. Biochemical signals are most often very low frequency signals. Most biochemical signals are actually dc signals.
7. **Bio optical signals.** Bio optical signals are the result of optical functions of the biologic system, occurring naturally or induced by the measurement. Blood oxygenation may be estimated by measuring the transmitted and backscattered light from a tissue (*in vivo* and *in vitro*) in several wavelengths. Important information about fetus may be acquired by measuring fluorescence characteristics of the amniotic fluid. Estimation of the heart output may be performed by the dye dilution method, which requires the monitoring of the appearance of recirculated dye in the bloodstream.

Classification of Bio signals

.

1. Classification according to source. Bio signals may be classified according to their source or physical nature. This classification was described in the preceding section. This classification may be used when the basic physical characteristics of the underlying process is of interest, for example, when a model for the signal is desired.
2. Classification according to biomedical application. The biomedical signal is acquired and processed with some diagnostic, monitoring, or other goal in mind. Classification may be constructed according to the field of application,.
3. Classification according to signal characteristics. From point of view of signal

analysis, this is the most relevant classification method. When the main goal is processing, it is not relevant what the source of the signal is or to which biomedical system it belongs; what matters are the signal characteristics.

Self-Check -1	Multiple choice

1__________ is used measure electrical activity of heart

. A. ECG B.EMG C. ENG D EEG

2. Measures the brain's electric activity from the scalp

A. ECG B.EMG C. ENG D EEG

3.___________ originate from some mechanical function of the biological system.

A. Biomechanical Signals **B.** Biochemical Signals **C.** Bioelectric Signals **D**. IF AMPLIFIER

4. in ECG wave "**P** "Represents

A. atrial repolarization B. Atrial depolarization

C. ventricular depolarization D. ventricular repolarization

5. in ECG wave "**T** "Represents

A. atrial repolarization B. Atrial depolarization

C. ventricular depolarization D. ventricular repolarization

Information Sheet- 2	Origin of Bioelectric Signals

The source of bioelectric signals is the activity of single *excitable* neural or muscular cell. Indeed, the collective electrical activity of a large group of active cells in vicinity changes the properties of the electric field which propagates in the volume conductor consisting of the various tissues of the body. The changes in this electrical field is then indirectly monitored and measured by electrodes placed on the skin. In clinical practice, two electrode and multiple electrode recording configurations are commonly used. Multiple electrode configuration provides a spatial description of bioelectric phenomena whereas the two electrode setup is useful to study the time course of the electrical source. However, in both measurement configurations, the activity of neural or muscular cell (in unknown locations) transmitted through an inhomogeneous medium is monitored from a distance. Therefore, it is difficult to analyze the noninvasively collected information and to characterize the electrical source. In spite of these difficulties, analyzing the electric signals, recorded on the skin surface, plays a crucial role in clinical decision- making.

Biomedical signals are used primarily for extracting information on biological system under investigation

The sources of signals may originate in physiology, activities associated with living organ

Bioelectric Signals:-are generated by ***nerve cells*** and ***muscle cells***.
Their basic source is the **cell membrane potential** which under certain conditions may be excited to generate an action potential.
The electric field generated by the action of many cell constitutes the bio-electric signal.
Example

- ECG &EEG signals.

Bioacoustics Signals: The measurement of acoustic signals created by many biomedical Phenomena provides information about the underlying phenomena.
Examples of such signals are;

- The flow of blood in the heart, through the heart's valves
- The flow of air through the upper and lower airways and in the lungs

Biomechanical Signals: These signals originate from some mechanical function of the biological system.
They include all types of motion and displacement signals, pressure and flow signals
Example: The movement of the chest wall in accordance with the respiratory activity
Biochemical Signals: The signals which are obtained as a result of chemical measurements From the living tissues or from samples analyzed in the laboratory.

The examples are

- measurement of partial pressure of carbon dioxide (pCO2), partial pressure

Of oxygen (pO2) and concentration of various ions in the blood.

Bio-optical Signals: These signals are generated as result of optical functions of the Biological systems, occurring either naturally or induced by Measurement process.

For example, blood oxygenation may be estimated by measuring the transmitted/back scattered light from a tissue at different wavelengths.

Bio-impedance Signals : The impedance of the tissue is a source of important information Concerning its composition, blood distribution and volume.

The bio-impedance signal is also obtained by injecting sinusoidal current in the tissue and measuring the voltage drop generated by the tissue impedance.

Example

- The measurement of galvanic skin resistance (GSR)
- The measurement of respiration rate based on bio-impedance

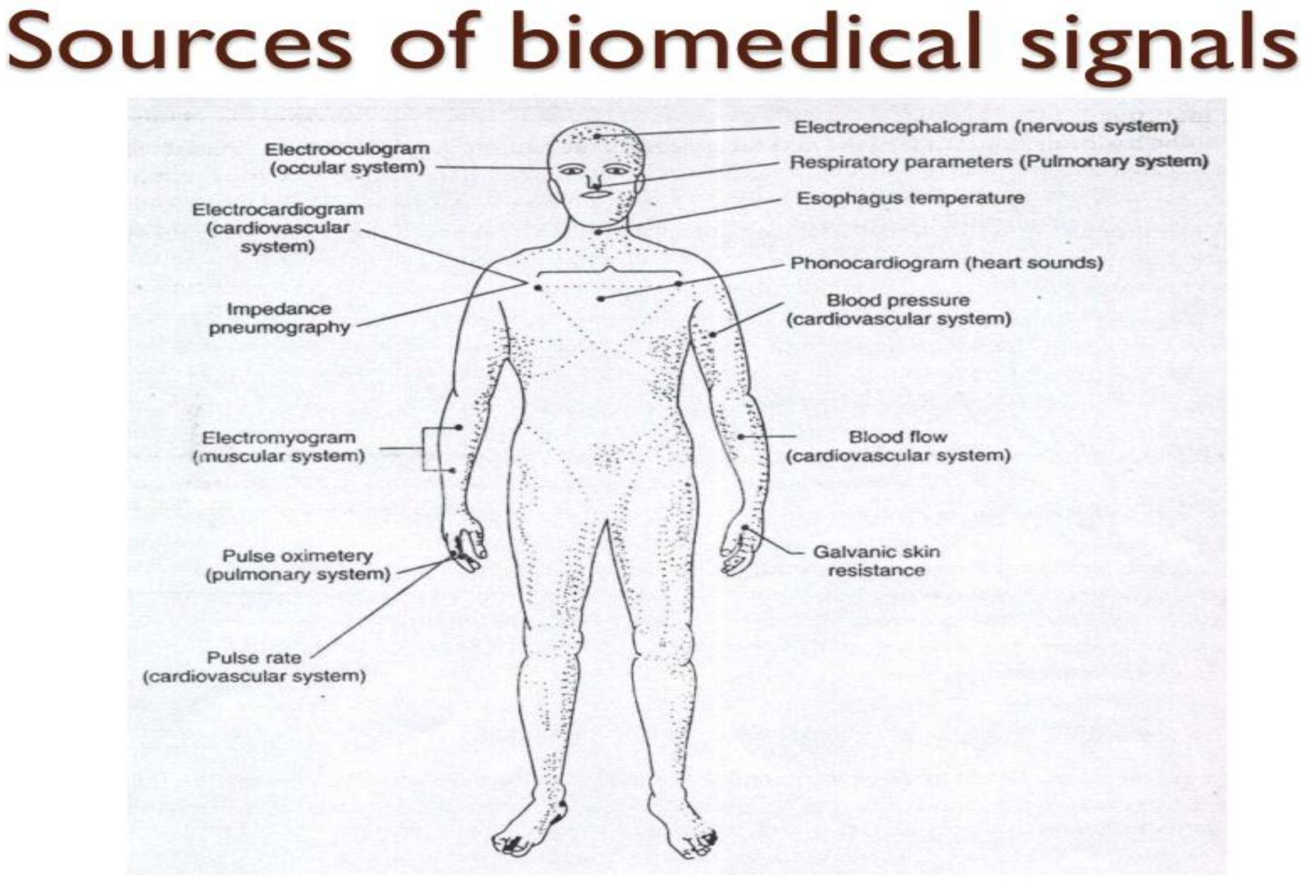


Fig.16 source of biomedical signal

Self-Check -2	Multiple choice

1. Source of Bioelectric potential is ____________ in nature.
   A) Electronic B) Electric **C)** Ionic D) mechanical
2. The principal ion that is not involved with the phenomena of producing cell potentials is
   A) Sodium B) potassium C) chlorine **D)** hydrogen
3. The variation of the electrical potential associated with the passage of a pulse along the membrane of a muscle cell or a nerve cell is called __________
   A) Muscle potential **B)** Action potential
   C) Resting potential D) half-cell potential

Information Sheet- 3	Explain propagation of action potentials

What are bio potentials?

Bio potential:

- An electric potential that is measured between points in living cells, tissues, and organisms, and which accompanies all biochemical processes.
- Also describes the transfer of information between and within cells strictly on the measurement of potentials

Mechanism behind biopotentials1

- Concentration of potassium (K +) ions is 30-50 times higher inside as compared to outside
- Sodium ion (Na +) concentration is 10 times higher outside the membrane than inside
- In resting state the member is permeable only for potassium ions
- Potassium flows outwards leaving an equal number of negative ions inside
- Electrostatic attraction pulls potassium and chloride ions close to the membrane
- Electric field directed inward forms

sodium-potacium pump

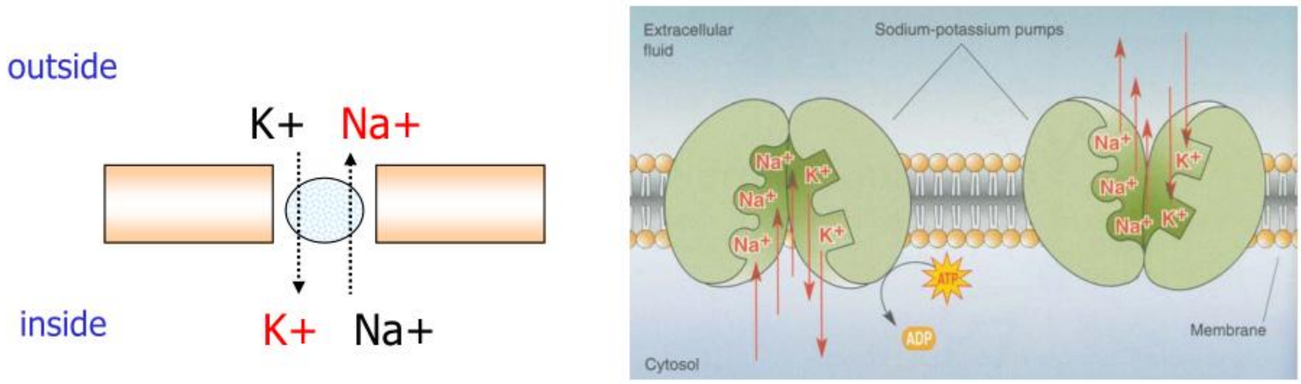


Fig.16 propagation of action potentials

Mechanism behind bio potentials 2:

- When membrane stimulation exceeds a threshold level of about 20 mV, so called action potential occurs: Sodium and potassium ionic permeability's of the membrane change
- Sodium ion permeability increases very rapidly at first, allowing sodium ions to flow from outside to inside, making the **inside more positive** The more slowly increasing

potassium ion permeability allows potassium ions to flow from inside to outside, thus returning membrane potential to its resting value

- While at rest, the Na-K pump restores the ion concentrations to their original values the number of ions flowing through an open channel >10. 6 /sec

Self-Check -3	Multiple choice

1. Which of the following statements is true about transmembrane electrical potential?

A) The chemical gradient drives Cl– and K+ inwards

B) The electrical gradient drives Na+ and Ca+2 inwards

C) The chemical gradient drives Na+ and Ca+2 inwards and K+ outward

D) The chemical gradient drives Cl– and K+ outwards

2. Diffusion of K+ out of the cell makes the inside of it less positive, or more negative and acts to restore the original resting membrane potential. This process is called

A) Repolarization B) Depolarization

C) Hyperpolarization D) Overshoot

3. Which of the following statements about action potential is false?

A) Na+/K+ pumps are directly involved in creating the action potential

B) Na+ and K+ concentrations are not significantly changed during an action potential

C) This includes both positive and negative feedback loops

D) Only a relatively small number of Na+ and K+ actually diffuse across the membrane

Note: **Satisfactory rating – 6points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: ___________________________ Date: ________________

Instruction Sheet	LG40: Identify Signal Conditioning Equipment in the Man-Instrument System

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Displaying equipment.
- Recording , data processing and transmission equipment
- Identify control devices using sample medical equipment.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Display equipment.
- Record , data processes and transmission equipment
- Identify control devices using sample medical equipment.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2, and Sheet 3".
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3" **in page 55, 57, and 60** respectively.

1.1 Displaying equipment

The electrical output of the signal – processing unit (SPU) must be converted into a form that can be perceived by one of the human beings senses and that can convey the information obtained by the measurement in a meaningful way.

The data presentation element is the final element in the measurement system, its function being to communicate the measured value of the variable to a human observer. It is important that the measured value is presented as clearly and easily as possible, otherwise the value registered by the observer may be different

The input to the display machine is the modified electric signal from the SPU. Its output is some form of visual, audible, or sometime tactile information.

In Man – Machine system the display machine may include a graphic pen recorder which produces & permanent record of data.

Choice of data presentation elements

If no permanent record of measured variables is required, then displays can be used. A choice must first be made between analogue pointer–scale indicators and digital displays

Here are four types of digital display technology in wide current use: light emitting diodes (LED), cathode ray tubes (CRT), liquid crystal displays (LCD) and electroluminescent displays (EL). LEDs have high power consumption, which makes them only suitable for small-scale character displays; they are not used in graphic displays. CRTs are used for character and graphics displays, monochrome and color, but have the disadvantage of high operating voltages and are high-volume bulky devices. LCDs are used for both character and graphics displays. LCD character displays, usually monochrome, have much lower power consumption than equivalent LED displays. LCD graphics displays, monochrome and color, are flat screen panels and have lower operating voltages and power consumption than equivalent CRT devices. Electroluminescent displays are also flat screen and are used for both character and graphics monochrome displays. They have higher operating voltages and power consumption than equivalent LCD devices but greater contrast ratio and viewing angle. A record of the time variation of the measured variables would be essential, for example, in the following situations:

(a) **High-speed events**, e.g. a human heartbeat, which are too fast to be followed by a human observer. Changes in the recorded blood pressure waveform will then show clearly any irregular or abnormal behavior.

(b**) The monitoring of a complex process such as a gas compressor which has a number of associated measured variables**. If the compressor breaks down, then the exact sequence of events drop in lubricating oil pressure – rise in bearing temperature – drop in delivery pressure can be found and the cause of failure established.

(c) **Large amounts of data which are to be used in numerical calculations**. Examples are the calculations of the yield and efficiency of a chemical reactor from composition, temperature, pressure and flow-rate data, and the value of gas transferred from supplier to customer in a given month.

Chart recorders give a record, on paper, of the time variation of a measured variable; these can be analogue or digital and the record can be either a continuous line or a series of dots. They can record up to six variables

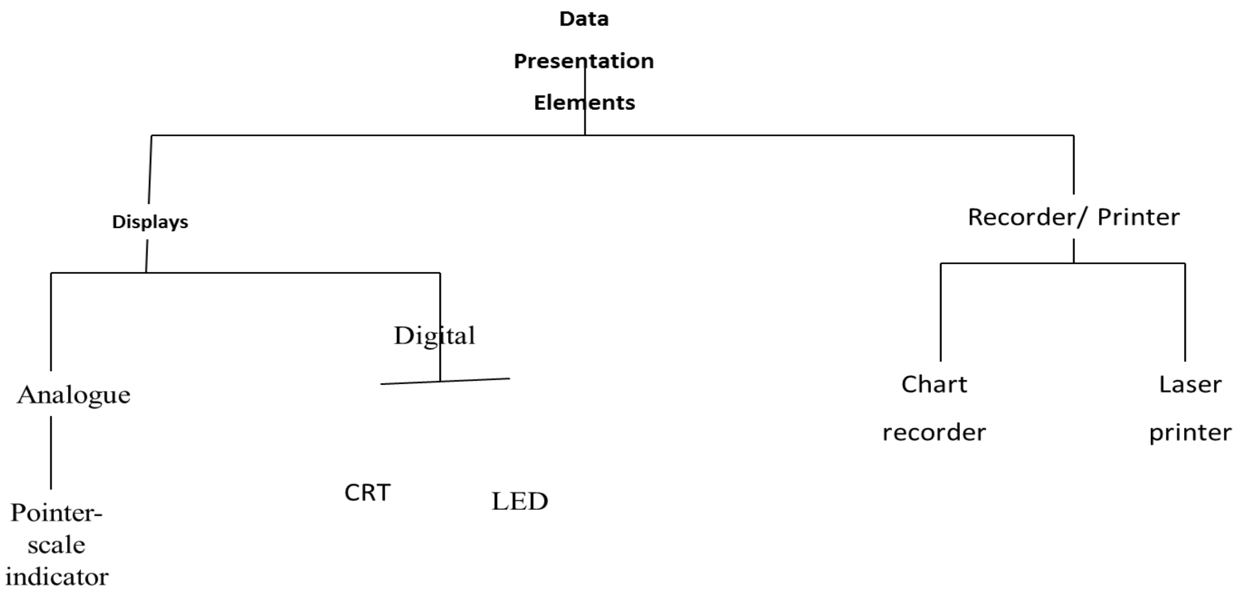


Fig.17 displaying equipment

Digital display principles

Character displays

These are used to display the numerals 0 to 9, the letters of the alphabet A to Z in either upper or lower case format, and a few other symbols such as punctuation marks. Displays showing alphabetical and numerical information are often referred to as alphanumeric

Each character format is an array of segments or dots; these elements are referred to as pixels. To display a character each pixel must be separately switched ‘on’ and ‘off’ independently of the other pixels

Graphic displays

Graphic displays are used to show line diagrams, graphs, waveforms, bar charts, etc., and consist of a large number of pixels arranged in rows (along the y-axis) and columns (along the x-axis). A typical graphic display consists of 320 × 240, i.e. 76 800, pixels each of area 0.33 mm × 0.33 mm, giving a total viewing area of 120 mm × 92 mm. To make electrical contact with each individual pixel would require 76 800 electrical connections occupying an area of a few square metres! Since this is clearly impossible, some method of multiplexing must be found. The principle of pixel matrix multiplexing is based on time division multiplexing, where one pair of conductors can serve many pixels by suitable timing of the voltage across the conductors. The pixels are arranged in a matrix of columns (x) and rows (y). Each column (x) and each row (y) has an electrical conductor giving a corresponding matrix of conductors. Each pixel, with position coordinates (x, y), is connected across the corresponding x and y conductors at their point of intersection (Figure 11.5(a)). The voltage applied to a column conductor will be present at all of the pixels in that column; the voltage applied to a row conductor will be present at all of the pixels in that row. The minimum voltage to turn a pixel 'on', i.e. to emit or modulate light, is VS . The column voltages Vx switch between 0 and +VS/2; there will be m transitions during each repetition period T, where m is the number of pixels in each column. The row voltages Vy switch between 0 and −VS/2; there will be n transitions during each repetition period T, where n is the number of pixels in each row. A pixel at position (x,y) is switched on during a time interval when the column voltage Vx is +VS /2 and the row voltage Vy is −VS/2. Figure 11.5(a) shows a 3 × 3 matrix of pixels and Figure 11.5(b) the corresponding column voltage waveforms Vx and row voltage waveforms Vy. The pixel (2, 1) is switched on during time interval 0 to T/3. The pixels (1, 1), (2, 1), (1, 3) and (2, 3) are switched on during the time interval T/3 to 2T/3. Pixel (3, 2) is switched on during time interval 2T/3 to T. In this example there are six electrical conductors for nine pixels so that the saving in external connections is small. However, in the above example of a 320 × 240 matrix, 320 + 240 = 560 external connections are required to address 76 800 pixels. All waveforms are repeated every repetition period T; this is to refresh the display. Provided T is sufficiently short, the brightness of the screen remains reasonably constant without flicker.

Cathode ray tube

Cathode Ray Tube (CRT)

Definition: The CRT is a display screen which produces images in the form of the video signal. It is a type of vacuum tube which displays images when the electron beam through electron guns are strikes on the phosphorescent surface. In other Words, the CRT generates the beams, accelerates it at high velocity and deflect it for creating the images on the phosphorous screen so that the beam becomes visible.

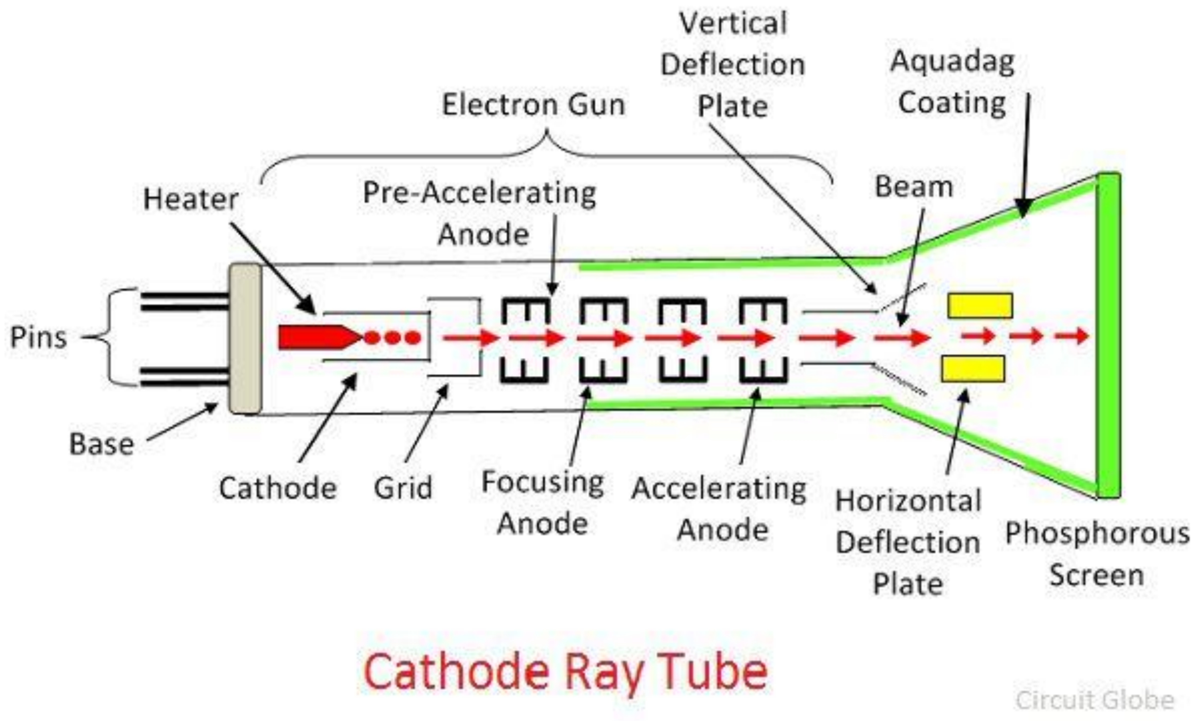


Fig.18 CRT

Working principle of CRT

The working of CRT depends on the movement of electrons beams. The electron guns generate sharply focused electrons which are accelerated at high voltage. This high-velocity electron beam when strikes on the fluorescent screen creates luminous spot

Cathode-ray-tube

After exiting from the electron gun, the beam passes through the pairs of electrostatic deflection plate. These plates deflected the beams when the voltage applied across it. The one pair of plate moves the beam upward and the second pair of plate moves the beam from one side to another. The horizontal and vertical movement of the electron are independent of each other, and hence the electron beam positioned anywhere on the screen.

The working parts of a CRT are enclosed in a vacuum glass envelope so that the emitted electron can easily move freely from one end of the tube to the other.

Construction of CRT

The Electrons Gun Assembly, Deflection Plate Assembly, Fluorescent Screen, Glass Envelope, Base are the important parts of the CRT. The electron gun emits the electron beam, and through deflecting plates, it is strikes on the phosphorous screen. The detail explanation of their parts is explained below.

Electrons Gun Assembly

The electron gun is the source of the electron beams. The electron gun has a heater, cathode, grid, pre-accelerating anode, focusing anode and accelerating anode. The electrons are emitted from the highly emitted cathode. The cathode is cylindrical in shape, and at the end of it, the layer of strontium and barium oxide is deposited which emit the high emission of electrons at the end of the tube.

The electron passes through the electron in the small grid. This control grid is made up of nickel material with a centrally located hole which is coaxial with the CRT axis. The electron which is emitted from the electron gun and passes through the control grid have high positive potential which is applied across the pre-accelerating and accelerating anodes.

The beam is focused by focusing anode. The accelerating and focusing electrodes are cylindrical in shape which has a small opening in the center of each electrode. After exiting the focusing anode, the beams passes through the vertical and horizontal deflecting plates.

The pre-accelerating and accelerating anode are connected to the positive high voltage of about 1500V and the focusing anode are connected to the lower voltage of about 500V.There are two methods of focusing the electron beam. They are the Electrostatic Focusing Beam and the Electromagnetic Focusing.

Electrostatic Deflection Plates

The deflection plate produces the uniform electrostatic field only in the one direction. The electron beam entering into the deflection plates will accelerate only in the one direction, and hence electrons will not move in the other directions.

Screen for CRT

The front of the CRT is called the face plate. The face plate of the CRT is made up of entirely fibre optics which has special characteristics. The internal surface of the faceplate is coated with the phosphor. The phosphorous converts the electrical energy into light energy. The energy level of the phosphorous crystal raises when the electron beams strike on it. This phenomenon is called cathodoluminescence.

The light which is emitted through phosphorous excitation is called fluorescence. When the electron beam stop, the phosphorous crystal regain their original position and release a quantum of light energy which is called phosphorescence or persistence

Self-Check -1	Multiple choice

1. Which of the following is digital display?
   A. pointer scale indicator B**.** laser printer C.CRT D**.** all
2. ------------- Is the final element in the measurement system.

A. Data presentation B. signal conditioning C. amplifying D) filtering

3. Which of the following is analog display?

A. pointer scale indicator B. laser printer C.CRT D. all

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________ Date: _______________

Information Sheet-2	Recording, data processing and transmission equipment

1.1 Recording, data processing and transmission equipment

It is often necessary, or at least desirable to record measured information for possible later use or to transmit it from one location to another.

(Local to Local or local to global).

Where automatic storage or processing of data is required or where computer control is employed on online analog or digital computer may be part of instrumentation system.

Recorders are of two types

Graphic pen recorder is a device used to produce a paper record of analog waveforms.
Magnetic tape recorder is a device used for data recording for future playback.

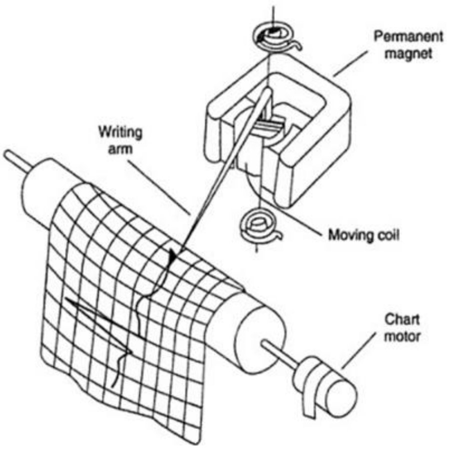


Fig.19 recording element

Data Transmission Element
When the functional elements of the measuring system are spatially separated then it becomes necessary to transmit signals from one element to another. This function is performed by data transmission element. It is an essential functional element where remote control operation is desired.

Self-Check -2	Short an swear

1. --------- is a device used to produce a paper record of analog waveforms.
   A. Graphic pen recorder B. Magnetic tape recorder C.LED D. CRT

2----------- Is a device used for data recording for future playback?

A. Graphic pen recorder B. Magnetic tape recorder C.LED D. CRT

Note: **Satisfactory rating – 6 points   Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: _________________________   Date: _______________

Information Sheet-3	Identify control devices using sample medical equipment

1.1 Identify control devices using sample medical equipment

Where ever it is desirable to have automatic control of the stimulus, transducers or any other part of Man – Machine system, a control system is incorporated.

It usually consists of a feedback loop in which part of the output from the signal processing unit (SPU) or display machine is used to control the operation of the system in some way.

PHYSIOLOGICAL SYSTEMS OF THE BODY

- Within the human body can be found Biological, chemical, electrical, thermal, hydraulically pneumatically, physical, magnetic mechanical & dynamical & many other types of the systems each of them communicates with an external environment & internally with the other systems of the body.
- By the help of a multilevel control system and communication network, these individual systems are organized to perform many complex functions of the body.
- Through the integrated operations of all these systems, & their various subsystems, man is able to sustain life, learn to perform usual tasks, acquire personality and behavioral traits, and even reproduce himself.

Example of bedside patient monitoring system

The patient monitoring system is designed to display an electrocardiogram, heart rate with high and low alarms, pulse rate, dynamic pressure of other waveforms received from external preamplifiers. It also gives immediate historical data on the patient for trend information on heart rate, temperature, and systolic and diastolic blood pressures for periods up to eight hours. The system basically consists of three circuit blocks: **Preamplifier section, Logic boards** and **Display part**.

The preamplifiers incorporate patient isolation circuits based on optical couplers.

Logic boards: Various amplified signals are carried to a multiplexer and then to an analog-to-digital converter, included in the logic board. The central processing unit along with memory gives X and Y output for the CRT display. The character generator output is pined with the Y output for numeric display on the CRT. The alarm setting, selection switches for different parameters and the defibrillator synchronization system communicate with CPU.

Display part: CRT display tube use EHT (extra high tension) supply, blanking and X,Y amplifier for display all the important information.

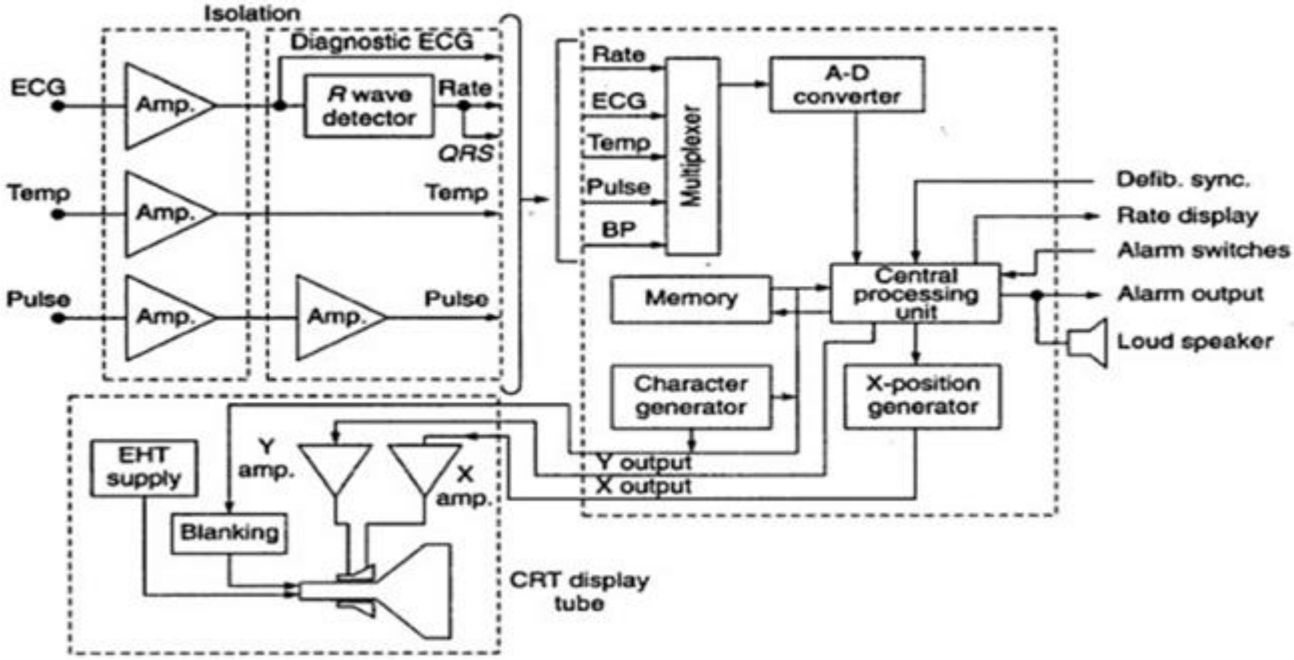


FIG.19 ***The patient monitoring system***

Self-Check -3	Multiple choice

1-------------------------- Designed to display an electrocardiogram, heart rate with high and low alarms, pulse rate, dynamic pressure of other waveforms received from external preamplifiers

A. display unit B. amplifier C. filtering D. patient monitoring system

2. ----------------------------------- incorporate patient isolation circuits based on optical couplers

A. preamplifiers B. amplifier C. filtering D. patient monitoring system

3. ------------------------------------ Various amplified signals are carried to a multiplexer and then to an analog-to-digital converter

A. preamplifiers B. amplifier C. filtering D. Logic boards

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________

Rating: ____________

Name: _________________________ Date: _______________

Instruction Sheet	LG41: INTERPRET WORK INSTRUCTIONS

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Reading and interpreting work instructions
- Determining job requirements.
- Selecting Tools, equipment and testing devices needed to carry out the interpretation work
- Performing the interpretation

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Read and interpret work instructions
- Determine job requirements.
- Select Tools, equipment and testing devices needed to carry out the interpretation work
- perform the interpretation

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information "Sheet 1, Sheet 2,".
4. Accomplish the "Self-check 1, Self-check 2, Self-check 3, and Self-check 4 **in page 66, 68, 77, 79** respectively.

Information Sheet-1	Read and interpret work instructions

Why are effective Work Instructions so important?

Work Instructions are the most basic tool used in every business or organization to help an employee follow a sequence of steps. Inadequate Work Instructions could result in returned product, loss of materials, customer complaints, or liability issues. Work Instructions can have a major impact on a management system effectiveness. If instructions are difficult to follow, employees will make errors in implementing the steps. Optimizing Work Instructions can lead to a more effective management system.

What is a Work Instruction?

- A Work Instruction is a detailed sequence of steps that a technician needs to follow each time he/she performs a task.
- The purpose of a Work Instruction is to organize steps in a logical format so that a technician can easily follow it independently.
- Procedures for a process can be very long with multiple steps.
- Work Instructions enable us to remove some of the detail

We follow "Work Instructions" of some form or another throughout our daily routine. How many times have you arrived in a parking garage and missed the big poster by the elevator door, "Pay for parking before you go up to get your car"? The simplest Work Instructions fail and result in injuries and loss of life daily:

- "Stop"
- "One Way"
- "Wet Floor"

These are simple instructions, yet we fail in implementing them. Writing a complex instruction for an assembly of tens or hundreds of pieces becomes more difficult and presents many more opportunities for failures.

Systematic Approach for Developing an Effective Work Instruction

Organizing your instructions in a systematic format is no different than organizing your inventory. When your inventory is well organized, your employees can find your product quickly and speed up your delivery process. Work Instructions that are following a systematic format will allow your employees to find information quickly and therefore perform the tasks you can see how much more difficult it is to read a sentence WHEN *font changes.* That's why a consistent format for your Work Instructions is so important. Employees can read the information faster and absorb it quicker if it follows the same format. Once you create one, you can use it to create a template. This template can be followed for creating other in

Self-Check -1	Multiple choice

1--------------------- Is a detailed sequence of steps that a technician needs to follow each time he/she performs a task.

A. Work Instruction B. Procedures C. instruction D. all

2. ------------------------ The simplest Work Instructions fail and result in injuries and loss of life daily:

A. Stop **B.** One Way **C.** Wet Floor **D.** All

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________
Rating: _____________

Name: __________________________ Date: _______________

Information Sheet-2	**Determine job requirements.**

2.1 Determine job requirements.

Process Approach for Developing an Effective Work Instruction

Creating an effective Work Instruction is a process, not an activity or a one time project. You will not be able to tell if a Work Instruction is effective until you implement it. Many organizations view their documented process as a static and burocratic system. Major effort is applied to creating the system but very little resource is provided to ensure its effectiveness over time.

Work Instructions are a type of document that will help you organize a single task usually performed by one individual. Creating Work Instructions is necessary when the process is quite involved and involves many tasks. If the process involves few tasks the "Work Instruction" can be included within procedure without distracting from the individuals understanding of the overall process. The document you are creating has a purpose of explaining the process to the reader. The content will depend on the skill level of the reader. Below is a simple formula that will help you determine the content of Work Instructions.

Employee Readiness = Education + Skill Level (Experience) + Training +Procedure & Work Instruction Content + Frequency Task is Performed+ Automation

If your employees are highly educated or skilled they may need very little time to acquire the knowledge to perform tasks or process. On the other hand if your employees do not speak the language and multilingual instructions are out of the question your Work Instructions may be made up of **pictures**.

There is no perfect format for all organizations. The types that will work best for an individual company will be developed over time through trial and error. When first deciding on how to construct the system, evaluate what format the instructions are currently taking. Look for hand written instructions, instructions taped to the wall or to the bulletin board, or written in the manual or catalog.

Individuals process information differently. Some are visual and process pictures faster. Other employees may process written text better. If you are writing procedures for engineers, a flow chart will save you a lot of time. Others may be totally lost trying to process a flow chart. A system needs to accommodate all types of learners.

Self-Check -2	Short answer

1. Employee Readiness include :

A. Education **B**. Skill Level **C.** Training D .all

2. There is perfect format for all organizations

   A. True B .false

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: ______________

Name: ___________________________ Date: ________________

Information Sheet-3	Selecting and testing Tools, equipment

3.1 Tools

Voltage surge

Definition: Voltage surge is defined as the sudden rise in excessive voltage which damages the electrical equipment of an installation. The overvoltage in the lines occurs because of a rise in voltage between both phases and between phase and ground. The voltage surges are mainly classified under two heading; internal and external voltages.

Types of Voltage Surge

The overvoltage in the power station can be caused either by the internal disturbance or by the atmospheric eruption. On the basis of the generation of overvoltages the voltage surge are classified into two categories. These are

1. Internal Overvoltage
2. External Overvoltage

1. Internal Overvoltage

When the voltage in the system raises itself beyond the rated voltage, then such type of voltage is called internal overvoltage. The internal voltage may be transient, dynamic or stationary in nature. If the overvoltage wave is transient in nature, then there frequency is unrelated to the normal frequency, and it will persist few cycles only.

Transient overvoltage can be caused by the operation of circuit breakers when switching inductive or capacitive loads. These voltages can also be generated by interrupting very small current or by the sudden grounding of one phase of a system with an insulated neutral.

Dynamic overvoltage occurs at the normal frequency and persists only for a few seconds. These voltages may be generated by the disconnection of a generator or because of suddenly thrown off a large portion of the load.

Stationary overvoltage occurs at system frequency and remains for sometimes may be for an hour. Such type of voltages is generated when an earth fault on one line is continued for a long time. This voltage can also be caused when the neutral is grounded through an arc suppression coil, thereby leading to the overvoltage on the sound phase.

These voltages exceed three to five times the normal phase to neutral peak voltage of the system and relatively harmless for equipment having proper insulation.

The internal overvoltage mainly causes because of the following reasons;

Switching Operation on Unloaded Line – During the switching operation, the line is connected to a source of voltage and travelling waves are set up which rapidly charge the line. These waves instantly attained the voltage of the magnitude not exceeding twice the supply voltage at the instant of disconnection.

Sudden Opening of Load Line – When the load on the line is suddenly opened a transient voltage of the value of $e = i z0$ is set up, where i is the instantaneous value of the current at the instant of opening of the line and $Z0$ is the natural or the surge impedance of the line. The transient overvoltage of the line does not depend on the line voltage and therefore low voltage transmission system is liable to overvoltage of the same magnitude as compared to high voltage system.

Insulation Failure – The failure of insulation between the line and the earth is very frequent. When the insulation breakdown occurs the potential at fault suddenly falls from maximum to zero and therefore a negative voltage wave of very steep front in the form of surges are generated in both directions.

External Overvoltage's

The overvoltage which is caused by the atmospheric discharge such as static discharge or lightning strokes such type of voltage is called external overvoltage. External overvoltage can cause considerable stress on the insulation. The intensity of the voltages is varied in the case of the lightning.

The intensity of lightning depends on the how directly the line is struck, i.e., directly by the main discharge, directly by a branch or streamer, or by the induction due to a flash passing near to but not touching the line.

The installation in the power station is mainly classified into two types the one which is electrically exposed, resulting in the apparatus being subjected to overvoltage's of the atmospheric origin and another which is electrically non-exposed and therefore not subject to this type of overvoltage.

https://circuitglobe.com/voltage-surge.html

Spectrum analyzer

Spectrum analyzer measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. The primary use is to measure the power of the spectrum of known and unknown signals. The input signal that a spectrum analyzer measures is electrical; however, spectral compositions of other signals, such as acoustic pressure waves and optical light waves, can be considered through the use of an appropriate transducer. Optical spectrum analyzers also exist, which use direct optical techniques such as a monochromatic to make measurements.

spectra of electrical signals,dominant frequency, power, distortion, harmonics, bandwidth, and other spectral components of a signal can be observed that are not easily detectable in time domain waveforms. These parameters are useful in the characterization of electronic devices, such as wireless transmitters.

The display of a spectrum analyzer has frequency on the horizontal axis and the amplitude displayed on the vertical axis. To the casual observer, a spectrum analyzer looks like an oscilloscope and, in fact, some lab instruments can function either as an oscilloscope or a spectrum analyzer.

Oscilloscope

An oscilloscope, or scope for short, is an electronic test instrument that is used to observe an electronic signal, typically voltage, as a function of time. In other words it is a voltage versus time plotter. Oscilloscopes come in two basic types, analogue or digital, and support

various features and functions useful for measuring and testing electronic circuits. An oscilloscope is a
key piece of test equipment for any electronics designer

Parts of an Oscilloscope

internally, an oscilloscope is a fairly complex piece of electronic equipment. Fortunately, its operation is simplified through the use of various features and knowing its internal workings is not key to its use.
Despite this, as a good designer, it is important to understand the correct operation of test equipment and any affect it may have on the circuit under test

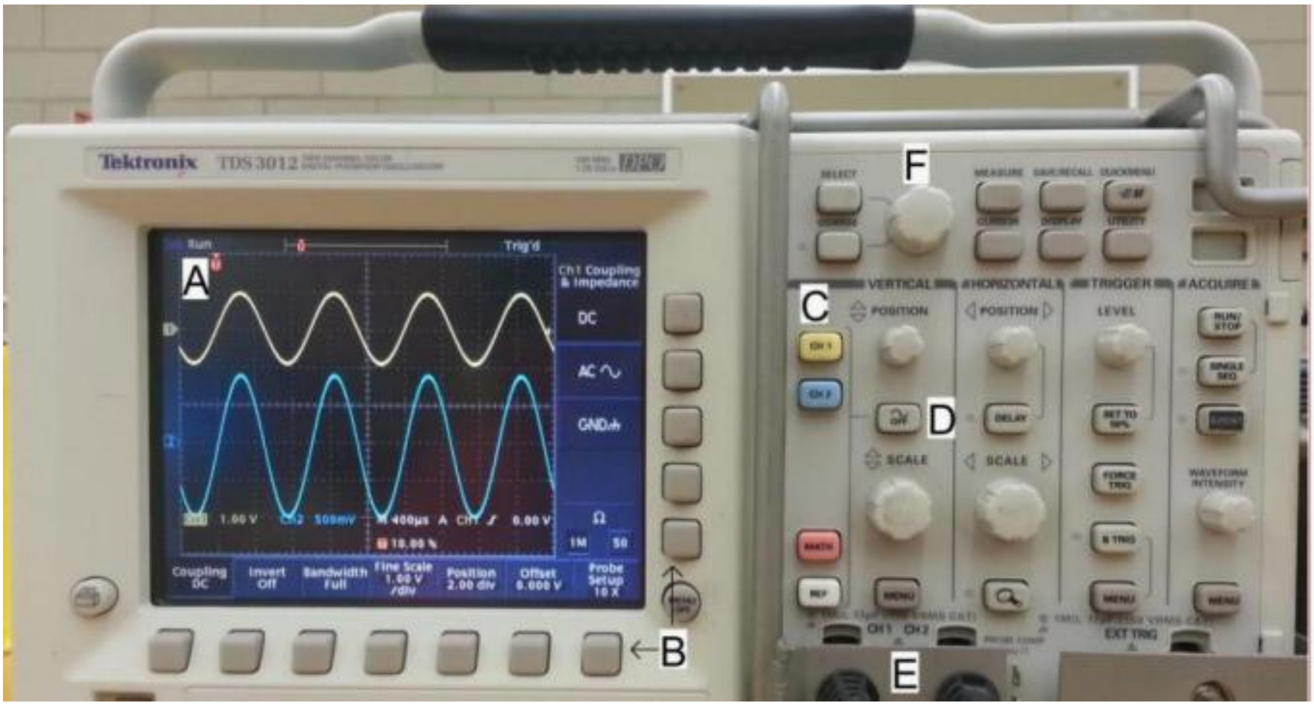


Fig.21 oscilloscope

Display: The main feature of an oscilloscope is its display (Figure 1 A). Analogue versions of oscilloscopes use Cathode Ray Tube (CRT) displays, while digital scopes
b. Probes: The voltage signals that are to be measured must be transferred to the oscilloscope. This is done using oscilloscope probes.

Probes are specially designed to minimize noise and interference, while also creating a known load effect on the circuit
(so it can be accounted for). Some probes also have protective features to prevent any
damage a signal may cause to the oscilloscope (such as overvoltage)

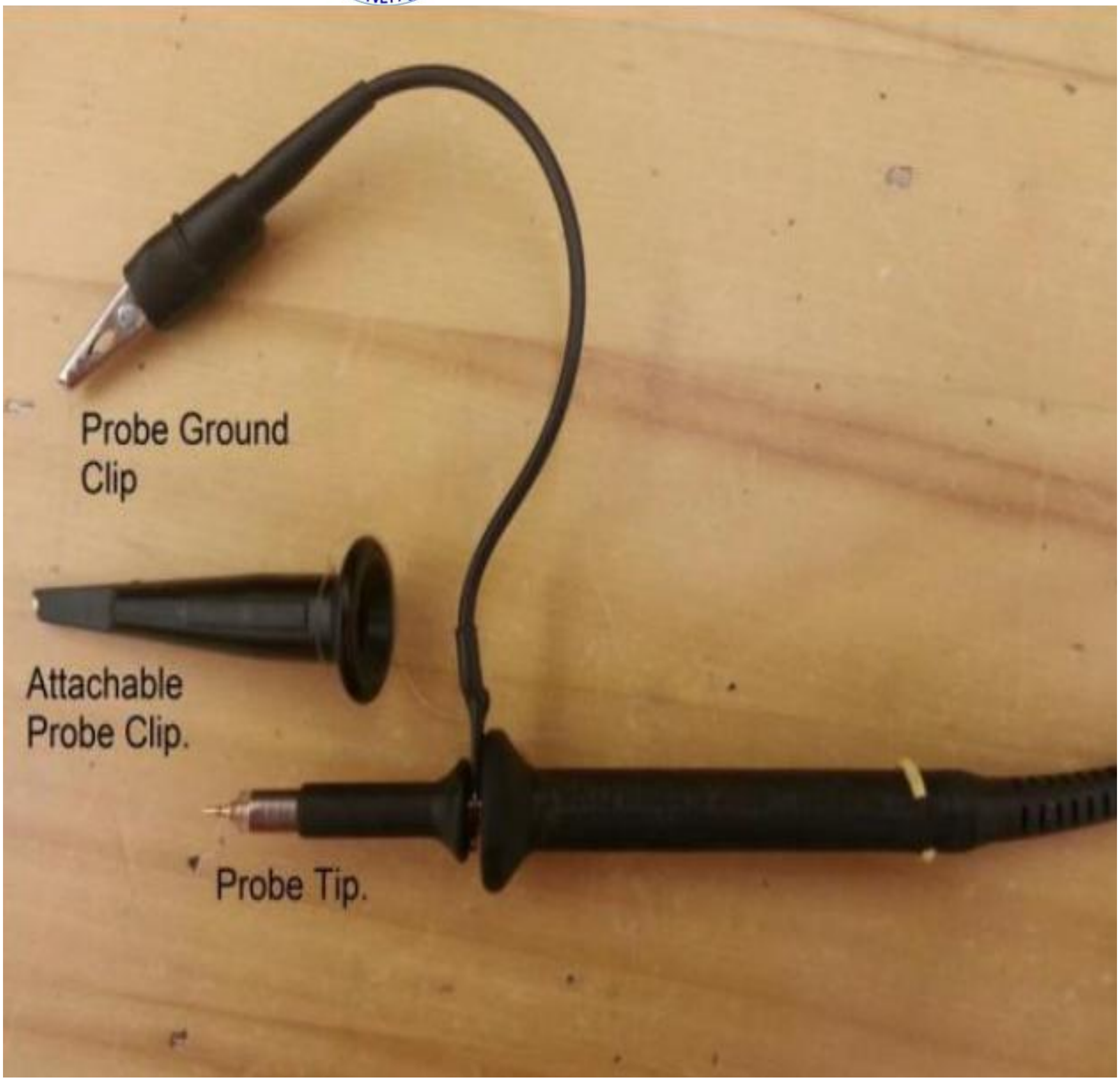


Fig .22 oscilloscope cable

c. Channels; an oscilloscope channel generally refers to the input (Figure 1 E) of signal (kind of like tuning in a TV channel, except that you can see more than one channel at a time on a scope). It can also refer to the path of the signal through the oscilloscope. An oscilloscope can have 1 or more channels, and it is common to have 2or 4. Having multiple channels allows for the simultaneous measurement of multiple signals, making comparisons and other functions easier. Each channel typically has its own set of controls or a common set that is toggled. Channel waveforms can be removed from the display using the off button

D. Controls: The controls of an oscilloscope can be used to adjust almost any aspect of the scope from display parameters to advanced mathematical functions. The controls themselves consist of dials, toggles, buttons, and switches

Multimeter

What is a multimeter?

Multimeter is a devise used to measure voltage, resistance and current in electronics & electrical equipment
It is also used to test continuity between 2 points to verify if there is any breaks in circuit or line
There are two types of multimeter Analog & Digital

- Analog has a needle style gauge
- Digital has a LCD display

Signal Generator

The signal generator is exactly what its name implies: a generator of signals used as a stimulus for electronic measurements. Most circuits require some type of input signal whose amplitude varies over time. The signal may be a true bipolar AC1 signal (with peaks oscillating above and below a ground reference point) or it may vary over a range of DC offset voltages, either positive or negative. It may be a sine wave or other analog function, a digital pulse, a binary pattern or a purely arbitrary wave shape.

The signal generator can provide “ideal” waveforms or it may add known, repeatable amounts and types of distortion (or errors) to the signal it delivers. See Figure 2. This characteristic is one of the signal generator’s greatest virtues, since it is often impossible to create predictable distortion exactly when and where it’s needed using only the circuit itself. The response of the DUT in the presence of these distorted signals reveals its ability to handle stresses that fall outside the normal performance envelope

Waveform Characteristics

Wave forms have many characteristics but their key properties pertain to amplitude, frequency, and phase:

Amplitude: A measure of the voltage “strength” of the waveform. Amplitude is constantly changing in an AC signal. Signal generators allow you to set a voltage range, for example, —3 to +3 volts. This will produce a signal that fluctuates between the two voltage values, with the rate of change dependent upon both the wave shape and the frequency.

Frequency: The rate at which full waveform cycles occur. Frequency is measured in Hertz (Hz), formerly known as cycles per second. Frequency is inversely related to the period (or wavelength) of the waveform, which is a measure of the distance between two similar peaks on adjacent waves. Higher frequencies have shorter periods.

Phase: In theory, the placement of a waveform cycle relative to a 0 degree point. In practice, phase is the time placement of a cycle relative to a reference waveform or point in time

3.2 Equipment/testing devices

3.2.1 Communication device

A communication device is a hardware device capable of transmitting an analog or digital signal over the telephone, other communication wire, or wirelessly.

A classic example of a communication device is a computer modem, which converts a computer's digital information to an analog signal for transmission over a telephone line. Similarly, a modem receives analog signals, and converts them to digital, for processing by the computer. This process is called modulation/demodulation, from which the modem gets its name. Other examples of communication devices include a NIC (network interface card), Wi-Fi devices, and access points.

Communication device examples

Below is a full listing of all the different types of communications devices you may encounter when dealing with a computer

- Bluetooth devices
- Infrared devices
- Modem (over phone line)
- Network card (using Ethernet)
- Smartphone
- Wi-Fi devices (using a Wi-Fi router)

https://www.computerhope.com/jargon/c/communication-devices.htm

3.3 Lifting equipment

Cables are longitudinal steel elements consisting of a number of steel threads twisted in a special way.

Cable Slings are steel cables with loops at their ends, used to hoist loads. They are less flexible than slings.

Crane is a machine designed to lift loads based on the fundamental principle of the leve**r.** It includes a counterweight, a support point, and the load to be hoisted**.**

Critical Lift is a lift requiring more than 80% of the crane's rated capacity and/or a lift carried out under non-routine conditions (lifting over energized power lines or over existing facilities etc.).

Beam Clamp is a manufactured clamp designed to be attached to a beam for lifting, pulling, tie off points, and/or other functions as engineered.

Hoist for Light Equipment is a hydraulic machine designed to lift light equipment for its maintenance.

Hoisting Equipment is equipment used to mechanically move loads between two points.

Man Lift is a machine that has a cage-type platform which is elevated to carry out works at different heights.

Material Hoist is a machine designed to elevate and transport a heavy load over some front

3.4 Fastening equipment

A **fastener** (US English) or **fastening** (UK English is a hardware device that mechanically joins or affixes two or more objects together. In general, fasteners are used to create non-permanent joints; that is, joints that can be removed or dismantled without damaging the joining components. is an example of creating permanent joints. Steel fasteners are usually made of stainless steel, carbon steel, or steel. Other alternative methods of joining materials include: crimping, welding, soldering, brazing, taping, gluing, cement, or the use of other adhesives. Force may also be used, such as with magnets, vacuum (like suction cups), or even friction (like sticky pads). Some types of woodworking joints make use of separate internal reinforcements, such as dowels or biscuits, which in a sense can be considered fasteners within the scope of the joint system, although on their own they are not general purpose fasteners.

Furniture supplied in flat-pack form often uses cam dowels locked by cam locks, also known as conformant fasteners. Fasteners can also be used to close a container such as a bag, a box, or an envelope; or they may involve keeping together the sides of an opening of flexible material, attaching a lid to a container, etc. There are also special-purpose closing devices, e.g. a bread clip.

Items like a rope, string, wire, cable, chain, or plastic wrap may be used to mechanically join objects; but are not generally categorized as fasteners because they have additional common uses. Likewise, hinges and springs may join objects together, but are ordinarily not considered fasteners because their primary purpose is to allow articulation rather than rigid affirming.

3.5 calibrator

- Electrical safety analysers
- Patient monitor testers (simulators)
- Incubator / radiant warmer analysers

- Defibrillator / AED / pacemaker analysers
- Infusion device analysers
- Electrosurgical unit testers
- Ventilator / gas-flow analysers
- Pressure / flow meters

Self-Check -3	Multiple choice

1. Oscilloscope gives __________

a) Actual representation   c) approximate representation

b) Visual representation   d) incorrect representation

2. Oscilloscope is __________

a) A ohmmeter c) a voltmeter

b) An ammeter d) a multimeter

3. Typically oscilloscope represents __________

a) Current and time c) voltage and time

b) Resistance and time d) power and time

4. A typical frequency range of RF signal generator is:

(a) 50 kHz to 110 MHz (c) 50 MHz to 110 kHz

(b) 50 Hz to 110 kHz (d) None of above

5-----------------is Light Equipment is a hydraulic machine designed to lift light equipment for its maintenance

A. Critical Lift C. Crane

B. Hoist D. Beam Clamp

Note: **Satisfactory rating – 10 points Unsatisfactory - below 5 points**

Answer Sheet

You can ask you teacher for the copy of the correct answers.

Score = ___________
Rating: ____________

Name: _________________________ Date: ______________

Information Sheet-3	Perform the interpretation

3.1 Samples of Work Instructions

Every individual on daily basis is faced with some type of Work Instruction. It could be an instruction from the equipment manual, how to operate a mower, car gadgets. Some Work Instructions may be in the format of a form like a bank withdrawal or tax form. Some Work Instructions may be a flow chart in which you follow arrows to the next task. More and more the instructions are created in the computer database style. Here are some samples of Work Instructions:

- Control of Trial Documentation
- process step instruction
- service steps
- software manual
- appliance instruction
- Income Tax Form
- job application
- prescription label
- recipe
- directions
- street signs
- checklists
- payroll tracking
- Control of Document Alert
- assembly instruction
- work standards
- health instruction
- safety instruction
- work checklist
- inspection instruction
- user instruction
- labels
- computer screen instruction
- equipment maintenance
- testing instructions
- product specifications

Samples of Ineffective Work Instructions An ineffective Work Instruction can result in nonconformances, losses of product and lost customers and revenue. An ineffective Work Instruction is confusing. It can have too much or too little information. A Work Instruction that gives an opportunity for many interpretations or multiple meanings will be implemented incorrectly. Remember, once the training is completed, Work Instructions and procedures are what most employees depend on. **ISO Work Instructions** ISO auditors look at instructions everywhere. Instructions **taped to equipment**, **written with a marker on a wall**, **pinned to bulletin board, or written on sticky notes** indicate a lack of standardization. ISO certification requires control over instruction for consistent implementation. Employees will write notes anywhere it is convenient for them to remember the steps. After a while these notes become obsolete and a newer employee may implement them without knowing that they are wrong.

Controlling Work Instructions (all instructions) that are critical to producing consistent product or service can be a difficult taks. All that work is justified to provide employees the right Work Instruction

Self-Check -4	Multiple choice

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. An ineffective Work Instruction can result in--------------------. (3 points)

    A. Nonconformance C. lost customers and revenue.

    B. losses of product D. all

2. ISO auditors look at instructions at

A. taped to equipment C. written on sticky notes

B. Written with a marker on a wall D. all

***Note:* Satisfactory rating – 6 points** **Unsatisfactory - below 3 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ___________
Rating: ____________

Name: ___________________________ Date: ________________

Reference

1. http//howstuffworks.com;
2. https://the9000store.com/iso-9001-2015-requirements/iso-9001-2015-context-of-the-organization/processes-procedures-work-instructions/

Operation Sheet 1	Calculate heart rate using regular ECG waveform rhythm

Step 1: prepare necessary materials and tools

Step 2: prepare regular rhythm ECG waveform print out

Step 3: Count Number of R wave in 6 second

Step 4: Multiply number of R wave by 10

Step 5: Identify range of heart and interpret the signal

Acknowledgement

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