17BEBME603 DIAGNOSTIC AND THERAPEUTIC EQUIPMENT – I 3003 100

OBJECTIVES

The student should be made to:

- Understand the medical devices applied in measurement of parameters related to cardiology, neurology and the methods of continuous monitoring and transmitting them
- Learn some of the cardiac assist devices
- Learn to measure the signals generated by muscles
- Understand the need and use of some of the extracorporeal devices.

OUTCOMES

At the end of the course, the student should be able to:

- Use different medical devices applied in measurement of parameters related to cardiology, neurology
- Explain about cardiac assist devices, its continuous monitoring and transmission
- Measure signals generated by muscles

UNIT I CARDIAC EQUIPMENT 9

Electrocardiograph, Normal and Abnormal Waves, Heart rate monitor, Holter Monitor, Phonocardiography, Plethysmography. Cardiac Pacemaker- Internal and External Pacemaker–Batteries, AC and DC Defibrillator- Internal and External

UNIT II NEUROLOGICAL EQUIPMENT 9

Clinical significance of EEG, Multi channel EEG recording system, Epilepsy, Evoked Potential–Visual, Auditory and Somatosensory, MEG (Magneto Encephalo Graph). EEG Bio Feedback Instrumentation.

UNIT III SKELETAL MUSCULAR EQUIPMENT 9

Generation of EMG, recording and analysis of EMG waveforms, fatigue characteristics, Muscle stimulators, nerve stimulators, Nerve conduction velocity measurement, EMG Bio Feedback Instrumentation.

UNIT IV PATIENT MONITORING AND BIOTELEMETRY 9

Patient monitoring systems, ICU/CCU Equipments, Infusion pumps, bed side monitors, Central consoling controls. Radio Telemetry (single, multi), Portable and Landline Telemetry unit, Applications in ECG and EEG Transmission.

UNIT V SPECIAL DIAGNOSTIC TECHNIQUES 9

Lithotripsy, Principles of Cryogenic technique and application, Endoscopy, Laproscopy.Thermography – Recording and clinical application, ophthalmic instruments.

Total : 45

TEXT BOOK:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Khandpur R.S	Handbook of Biomedical Instrumentation	Tata McGraw Hill	2003

REFERENCES:

S.NO.	Author(s) Name	Title of the book	Publisher	Year of publication
1	Myer Kutz	Standard Handbook of Biomedical Engineering & Design	Mc Graw Hill	2003
2	L.A Geddes and L.E.Baker	Principles of Applied Biomedical Instrumentation	Mc Graw Hill	2008
3	Leslie Cromwell	Biomedical Instrumentation and Measurement	Pearson Education, New	2007
4	Antony Y.K.Chan	Biomedical Device Technology, Principles and design	Charles ThomasPublisher Ltd	2008
5	Joseph J. Carr and John M. Brown	Introduction to Biomedical Equipment Technology	Pearson education	2004
6	John G.Webster	Medical Instrumentation Application and Design	John Wileyand Sons	2006

KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act 1956)
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FACULTY OF ENGINEERING
DEPARTMENT OF BIOMEDICAL ENGINEERING

LECTURE PLAN

NAME OF THE STAFF : Mr.T.S.BELLIRAJ

DESIGNATION : ASSISTANT PROFESSOR

CLASS : B.E-III YEAR BME

SUBJECT : Diagnostic and Therapeutic Equipment – I

SUBJECT CODE : 17BEBME603

S.No	TOPICS TO BE COVERED	TIME DURATION	SUPPORTING MATERIALS	TEACHING AIDS
UNIT-I CARDIAC EQUIPMENT				
1.	Introduction	01	T1 - 1-3	PPT
2.	Electrocardiograph, Normal and Abnormal Waves	01	T1 - 7-24	PPT
3.	Heart rate monitor, Holter Monitor,	01	T1 - 25-30	PPT
4.	Phonocardiography, Plethysmography	01	T1 - 36-38	PPT
5.	Pacemaker- Internal and External Pacemaker–Batteries	01	T1 - 68	PPT
6.	AC Defibrillator	01	T1 - 69	PPT
7.	DC Defibrillator	01	T1 - 70	PPT
8.	Internal	01	T1 - 568	PPT
9.	External	01	T1 - 569 - 570	PPT
Introduction		**01**		
Total Lecture Hours		**08**		
Total Hours		**09**		

UNIT-II NEUROLOGICAL EQUIPMENT				
10	Clinical significance of EEG	01	T1 – 148 - 149	PPT
11	Multi channel EEG recording system	01	T2 – 150 – 151	PPT
12	Epilepsy, Evoked Potential	01	T1 – 152 - 154	PPT

13	Visual,	01	T2 – 175 - 203	PPT
14	Auditory and Somatosensory	01	T1 – 156 - 157	PPT
15	MEG (Magneto Encephalo Graph)	01	T1 – 568 - 569	PPT
16	EEG	01	T2 - 161	PPT
17	Bio Feedback Instrumentation	01	T3 – 34 - 92	PPT
18	Bio Feedback Instrumentation	01	T2 – 137 - 165	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-III SKELETAL MUSCULAR EQUIPMENT				
19	Generation of EMG,	01	T1 – 120 – 127	PPT
20	recording and analysis of EMG waveforms	01	T1 – 128 – 139	PPT
21	fatigue characteristics	01	T1 – 106 - 107	PPT
22	Muscle stimulators	01	T1 - 157	PPT
23	nerve stimulators	01	T1 - 152 - 157	PPT
24	Nerve conduction velocity measurement	01	T1 - 332 - 336	PPT
25	EMG.	01	T1 - 289 - 290	PPT
26	Bio Feedback Instrumentation	01	T1 – 390 - 410	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-IV PATIENT MONITORING AND BIOTELEMETRY				
27	Patient monitoring systems	01	https://prezi.com/l-e4nfgnkb9j/a-model-of-the-image-degradation-restoration-process/	PPT
28	ICU/CCU Equipments	01	T1 – 290 - 297	PPT
29	Infusion pumps,	01	T1 – 351 - 352	PPT
30	bed side monitors	01	T1 – 887	PPT
31	Central consoling controls	01	T1 – 362 - 381	PPT
32	Radio Telemetry (single, multi),	01	T1 - 368 - 373	PPT
33	Portable and Landline Telemetry unit	01	T1 - 446 - 451	PPT
34	Applications in ECG	01	https://en.wikipedia.org/wiki/Tomography	PPT

35	EEG Transmission	01	T2 - 542	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

UNIT-V SPECIAL DIAGNOSTIC TECHNIQUES				
36	Lithotripsy	01	T1 – 553	PPT
37	Principles of Cryogenic technique and application	01	T1 - 542	PPT
38	Endoscopy	01	T1 - 548	PPT
39	Laproscopy	01	T1 - 479	PPT
40	Thermography	01	T2 - 477 - 504	PPT
41	Recording	01	T1 – 507 - 603	PPT
42	clinical application	01	T1 – 577 - 603	PPT
43	ophthalmic	01	https://www.ndt.net/article/aero2012/papers/we2a1.pdf	PPT
44	Ophthalmic instruments	01	https://mayfieldclinic.com/pe-spect.htm	PPT
45	Ophthalmic instruments	01	https://www.healthline.com/health/pet-scan	PPT
Total Lecture Hours		**09**		
Total Hours		**09**		

Total No of Hours for Introduction: 01 Hrs

Total No of Lecture Hours Planned: 44 Hrs

Total No of Hours Planned : 45 Hours

TEXT BOOK:

S.NO.	**Author(s) Name**	**Title of the book**	**Publisher**	**Year of publication**
1	Khandpur R.S	Handbook of Biomedical Instrumentation	Tata McGraw Hill	2003

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UNIT I

CARDIAC EQUIPMENT

HEART RATE MONITOR

- A **heart rate monitor** is a personal monitoring device that allows one to measure one's heart rate in real time or record the heart rate for later study.
- It is largely used by performers of various types of physical exercise.

History

- Early models consisted of a monitoring box with a set of electrode leads which attached to the chest.
- The first wireless EKG heart rate monitor was invented in 1977 by Seppo Säynäjäkangas, founder of Polar Electro, as a training aid for the Finnish National Cross Country Ski team.
- As 'intensity training' became a popular concept in athletic circles in the mid-80s, retail sales of wireless personal heart monitors started from 1983.

Composition

- Modern heart rate monitors usually comprise two elements: a chest strap transmitter and a wrist receiver (which usually doubles as a watch) or mobile phone.
- In early plastic straps, water or liquid was required to get good performance. Later units have used conductive smart fabric with built-in microprocessors that analyze the EKG signal to determine heart rate.
- More recent devices utilise optics to measure heart rate using Infrared light.This is achieved by production of infrared light by an internal bulb, as Infrared light is absorbed by the blood, a sensor measures the amount that the infrared light is darkened by.
- If it is significantly darker, due the pulse causing a temporary increase in the amount of blood that is travelling through the measured area, that is counted as a pulse.
- Strapless heart rate monitors (often referred to as "wearables") now allow the user to just touch two sensors on a wristwatch display for a few seconds to view heart rate data.
- These are popular for comfort and ease of use, though they don't give as much detail as monitors that use a chest strap.
- Some models of these variations of heart rate monitors utilise an infrared sensor to measure the heart rate, as opposed to two electrodes.

- More advanced models offer measurements of heart rate variability, activity, and breathing rate to assess parameters relating to a subject's fitness. Sensor fusion algorithms allow these monitors to detect core temperature and dehydration.
- Another style of heart rate monitor replaces the plastic around-the-chest strap with fabric sensors - the most common of these is a sports bra for women that includes sensors in the fabric.

In old versions, when a heart beat is detected a radio signal is transmitted, which the receiver uses to determine the current heart rate.

- This signal can be a simple radio pulse or a unique coded signal from the chest strap (such as Bluetooth, ANT, or other low-power radio link); the latter prevents one user's receiver from using signals from other nearby transmitters (known as cross-talk interference).

Newer versions include a microprocessor, which is continuously monitoring the EKG and calculating the heart rate, and other parameters.

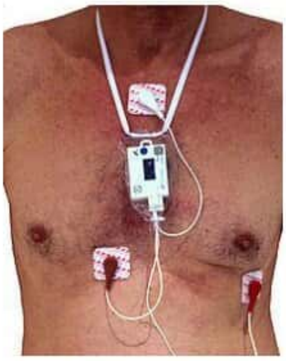
- These may include accelerometers that can detect speed and distance, eliminating the need for foot worn devices.
- There are a wide number of receiver designs, with various features.
- These include average heart rate over exercise period, time in a specific heart rate zone, calories burned, breathing rate, built-in speed and distance, and detailed logging that can be downloaded to a computer.
- The receiver can be built into a smartwatch or smartphone. Wrist bands with integrated sensor work optically, and have poor accuracy.

HOLTER MONITOR

- In medicine, a **Holter monitor** (often simply "Holter" or occasionally **ambulatory electrocardiography device**) is a portable device for continuously monitoring various electrical activity of the cardiovascular system for at least 24 hours (often for two weeks at a time).
- The Holter's most common use is for monitoring heart activity (electrocardiography or ECG). Its extended recording period is sometimes useful for observing occasional cardiac arrhythmias which would be difficult to identify in a shorter period of time.
- For patients having more transient symptoms, a cardiac event monitor which can be worn for a month or more can be used.

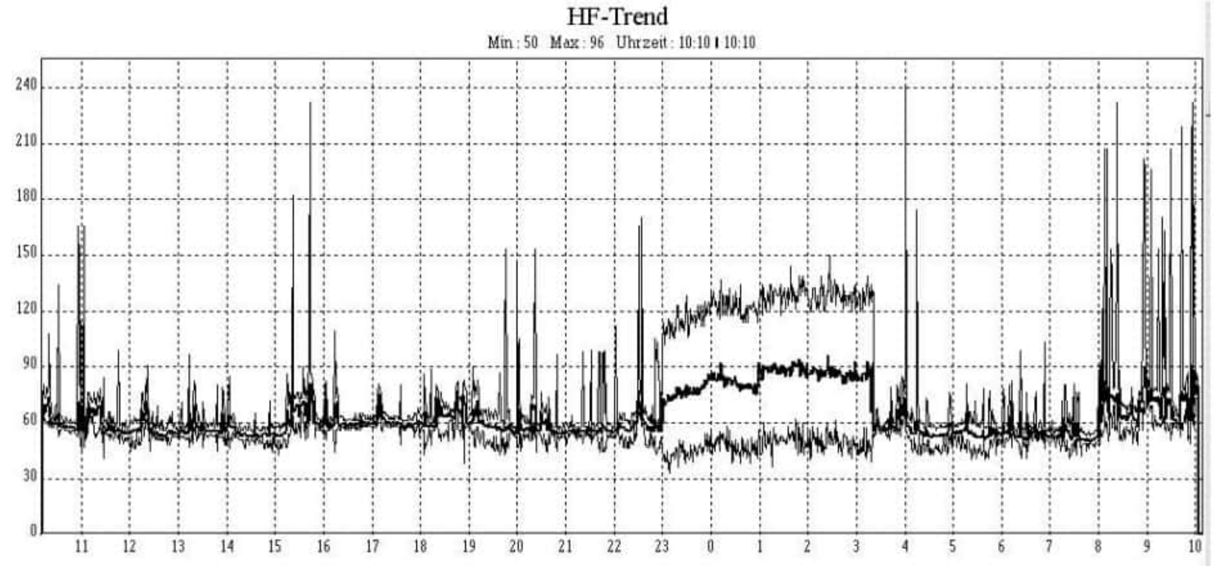
The Holter monitor was developed at the Holter Research Laboratory in Helena Montana by experimental physicists Norman J. Holter and Bill Glasscock, who started work on radio telemetry in 1949.

- When used to study the heart, much like standard electrocardiography, the Holter monitor records electrical signals from the heart via a series of electrodes attached to the chest. Electrodes are placed over bones to minimize artifacts from muscular activity.
- The number and position of electrodes varies by model, but most Holter monitors employ between three and eight.
- These electrodes are connected to a small piece of equipment that is attached to the patient's belt or hung around the neck, keeping a log of the heart's electrical activity throughout the recording period.



Inventor	Norman Holter and Bill Glasscock at Holter Research Laboratory

Atrial fibrillation recorded by a Holter monitor



Data storage

- Older devices used reel to reel tapes or a standard C90 or C120 audio cassette and ran at a 1.7 mm/s or 2 mm/s speed to record the data.
- Once a recording was made, it could be played back and analyzed at 60x speed so 24 hours of recording could be analyzed in 24 minutes.
- More modern units record an EDF-file onto digital flash memory devices. The data is uploaded into a computer which then automatically analyzes the input, counting ECG complexes,
- calculating summary statistics such as average heart rate, minimum and maximum heart rate, and finding candidate areas in the recording worthy of further study by the technician.

Components

- Each Holter system consists of two basic parts – the hardware (called monitor or recorder) for recording the signal, and software for review and analysis of the record.
- Advanced Holter recorders are able to display the signal, which is very useful for checking the signal quality.
- Very often there is also a "patient button" located on the front site allowing the patient to press it in specific cases such as sickness, going to bed, taking pills…. A special mark will be then placed into the record so that the doctors or technicians can quickly pinpoint these areas when analyzing the signal.

Recorder

- The size of the recorder differs depending on the manufacturer of the device. The average dimensions of today's Holter monitors are about 110x70x30 mm but some are only 61x46x20 mm and weigh 99 g.
- Most of the devices operate with two AA batteries. In case the batteries are depleted, some Holters allow their replacement even during monitoring.
- Most of the Holters monitor the ECG just in two or three channels. Depending on the model (manufacturer), different counts of leads and lead systems are used.
- Today's trend is to minimize the number of leads to ensure the patient's comfort during recording. Although 2/3 channel recording has been used for a long time in the Holter monitoring history, recently 12 channel Holters have appeared.
- These systems use the classic Mason-Likar lead system, thus producing the signal in the same representation as during the common rest ECG and/or stress test measurement.
- These Holters then allow to substitute stress test examination in cases the stress test is not possible for the current patient.
- They are also suitable when analyzing patients after myocardial infarction. Recordings from these 12-lead monitors are of a significantly lower resolution than those from a standard 12-lead ECG and in some cases have been shown to provide misleading ST segment representation, even though some devices allow setting the sampling frequency up to 1000 Hz for special-purpose exams like the late potential.
- Another interesting innovation is the presence of a triaxial movement sensor, which records the patient physical activity, and later shows in the software three different statuses: sleeping, standing up, or walking.
- This helps the cardiologist to better analyze the recorded events belonging to the patient activity and diary. Holter monitoring is a very useful part of an ECG.
- Some modern devices also have the ability to record a vocal patient diary entry that can be later listened to by the doctor.

Analyzing software

- When the recording of ECG signal is finished (usually after 24 or 48 hours), it is up to the physician to perform the signal analysis.
- Since it would be extremely time demanding to browse through such a long signal, there is an integrated automatic analysis process in the software of each Holter device which automatically determines different sorts of heart beats, rhythms, etc.
- However the success of the automatic analysis is very closely associated with the signal quality. The quality itself mainly depends on the attachment of the electrodes to the patient body.

- If these are not properly attached, electromagnetic disturbance can influence the ECG signal resulting in a very noisy record.
- If the patient moves rapidly, the distortion will be even bigger. Such record is then very difficult to process. Besides the attachment and quality of electrodes, there are other factors affecting the signal quality, such as muscle tremors, sampling rate and resolution of the digitized signal (high quality devices offer higher sampling frequency).

The automatic analysis commonly provides the physician with information about heart beat morphology, beat interval measurement, heart rate variability, rhythm overview and patient diary (moments when the patient pressed the patient button).

- Advanced systems also perform spectral analysis, ischemic burden evaluation, graph of patient's activity or PQ segment analysis.
- Another requirement is the ability of pacemaker detection and analysis. Such ability is useful when one wants to check the correct pacemaker function.

History

- The cardiac event monitor has been used for over twenty years. At first, these devices were not portable and had to be used only in hospital buildings.
- Advances resulted in these devices becoming smaller but were still being used only in hospitals for twenty four to forty eight hours.
- Soon portable monitors were developed weighing at first thirty pounds, then 10 pounds, and 1 pound. Modern devices are much easier to wear, weighing only a fraction of a pound.

Procedure

- Although some patients may feel uncomfortable about a Holter examination, there is nothing to worry about. No hazards are involved, and it should have little effect on one's normal daily life.
- The recording device can be worn in a case on a belt or on a strap across the chest.
- The device may be visible under light clothing, and those wearing a Holter monitor may wish to avoid shirts with a low neckline.
- Persons being monitored should not limit normal daily activities,since its purpose is to record how a heart works under various actual conditions over an extended period.
- It is an electrical device, however, and should be kept dry; showering or swimming should probably be avoided.

- Monitors can be removed for a few minutes without invalidating collected data, but proper reattachment is critical to avoid degradation of its signals.
- Beyond changing batteries, one should leave its handling to trained personnel.

PLETHYSMOGRAPHY

A **plethysmograph** is an instrument for measuring changes in volume within an organ or whole body (usually resulting from fluctuations in the amount of blood or air it contains).

ORGANS STUDIED

Lungs

- Pulmonary plethysmographs are commonly used to measure the functional residual capacity (FRC) of the lungs—the volume in the lungs when the muscles of respiration are relaxed—and total lung capacity.
- In a traditional plethysmograph, the test subject is placed inside a sealed chamber the size of a small telephone booth with a single mouthpiece.
- At the end of normal expiration, the mouthpiece is closed.
- The patient is then asked to make an inspiratory effort. As the patient tries to inhale (a maneuver which looks and feels like panting), the lungs expand, decreasing pressure within the lungs and increasing lung volume.
- This, in turn, increases the pressure within the box since it is a closed system and the volume of the box compartment has decreased to accommodate the new volume of the subject.

Methodological Approach

- Boyle's Law is used to calculate the unknown volume within the lungs. First, the change in volume of the chest is computed.
- The initial pressure and volume of the box are set equal to the known pressure after expansion times the unknown new volume.
- Once the new volume is found, the original volume minus the new volume is the change in volume in the box and also the change in volume in the chest.
- With this information, Boyle's Law is used again to determine the original volume of gas in the chest: the initial volume (unknown) times the initial pressure is equal to the final volume times the final pressure.
- Starting from this principle, it can be shown that the functional residual capacity is a function of the changes in volume and pressures as follows:

- The difference between full and empty lungs can be used to assess diseases and airway passage restrictions. An obstructive disease will show increased FRC because some airways do not empty normally, while a restrictive disease will show decreased FRC.
- Body plethysmography is particularly appropriate for patients who have air spaces which do not communicate with the bronchial tree; in such patients helium dilution would give an incorrectly low reading.
- Another important parameter, which can be calculated with a body plethysmograph is the airway resistance.
- During inhalation the chest expands, which increases the pressure within the box. While observing the so-called resistance loop (cabin pressure and flow), diseases can easily be recognized.
- If the resistance loop becomes planar, this shows a bad compliance of the lung. A COPD, for instance, can easily be discovered because of the unique shape of the corresponding resistance loop.

Limbs

- Some plethysmograph devices are attached to arms, legs or other extremities and used to determine circulatory capacity. In water plethysmography an extremity, e.g. an arm, is enclosed in a water-filled chamber where volume changes can be detected.
- Air plethysmography uses a similar principle but based on an air-filled long cuff, which is more convenient but less accurate.
- Another practical device is mercury-filled strain gauges used to continuously measure circumference of the extremity, e.g. at mid calf. Impedance plethysmography is a non-invasive method used to detect venous thrombosis in these areas of the body.

UNIT II

NEUROLOGICAL EQUIPMENT

CLINICAL SIGNIFICANCE OF EEG

A routine clinical EEG recording typically lasts 20–30 minutes (plus preparation time) and usually involves recording from scalp electrodes. Routine EEG is typically used in the following clinical circumstances:

- to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-corticalmovement disorders and migraine variants.
- to differentiate "organic" encephalopathy or delirium from primary psychiatric syndromes such as catatonia
- to serve as an adjunct test of brain death
- to prognosticate, in certain instances, in patients with coma
- to determine whether to wean anti-epileptic medications
- it can also be used to 'train' brains- particularly children's (or, I should say, find which areas of the brain require 'training' and then further EEGs are done, but only focusing on those certain areas). However this is not widely done, and many would travel to the USA for this treatment (but there are clinics in England etc. now)

At times, a routine EEG is not sufficient, particularly when it is necessary to record a patient while he/she is having a seizure.

- In this case, the patient may be admitted to the hospital for days or even weeks, while EEG is constantly being recorded (along with time-synchronized video and audio recording).
- A recording of an actual seizure (i.e., an ictal recording, rather than an inter-ictal recording of a possibly epileptic patient at some period between seizures) can give significantly better information about whether or not a spell is an epileptic seizure and the focus in the brain from which the seizure activity emanates.

Epilepsy monitoring is typically done:

- to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-cortical movement disorders and migrainevariants.

- to characterize seizures for the purposes of treatment
- to localize the region of brain from which a seizure originates for work-up of possible seizure surgery

Additionally, EEG may be used to monitor certain procedures:

- to monitor the depth of anesthesia
- as an indirect indicator of cerebral perfusion in carotid endarterectomy
- to monitor amobarbital effect during the Wada test

EEG can also be used in intensive care units for brain function monitoring:

- to monitor for non-convulsive seizures/non-convulsive status epilepticus
- to monitor the effect of sedative/anesthesia in patients in medically induced coma (for treatment of refractory seizures or increased intracranial pressure)
- to monitor for secondary brain damage in conditions such as subarachnoid hemorrhage (currently a research method)
  - If a patient with epilepsy is being considered for resective surgery, it is often necessary to localize the focus (source) of the epileptic brain activity with a resolution greater than what is provided by scalp EEG.
  - This is because the cerebrospinal fluid, skull and scalp smear the electrical potentials recorded by scalp EEG.
  - In these cases, neurosurgeons typically implant strips and grids of electrodes (or penetrating depth electrodes) under the dura mater, through either a craniotomy or a burr hole.
  - The recording of these signals is referred to as electrocorticography (ECoG), subdural EEG (sdEEG) or intracranial EEG (icEEG)--all terms for the same thing.
  - The signal recorded from ECoG is on a different scale of activity than the brain activity recorded from scalp EEG.
  - Low voltage, high frequency components that cannot be seen easily (or at all) in scalp EEG can be seen clearly in ECoG.
  - Further, smaller electrodes (which cover a smaller parcel of brain surface) allow even lower voltage, faster components of brain activity to be seen. Some clinical sites record from penetrating microelectrodes.
  - EEG may be done in all pediatric patients presenting with first onset a febrile or complex febrile seizures.
  - EEG is not indicated for diagnosing headache. Recurring headache is a common pain problem, and this procedure is sometimes used in a search for a diagnosis, but it has no advantage over routine clinical evaluation.

EVOKED POTENTIAL

- An **evoked potential** or **evoked response** is an electrical potential recorded from the nervous system of a human or other animal following presentation of a stimulus, as distinct from spontaneous potentials as detected by electroencephalography (EEG), electromyography (EMG),or other electrophysiologic recording method. Such potentials are useful for electrodiagnosis and monitoring.
- Evoked potential amplitudes tend to be low, ranging from less than a microvolt to several microvolts, compared to tens of microvolts for EEG, millivolts for EMG, and often close to a volt for ECG.
- To resolve these low-amplitude potentials against the background of ongoing EEG, ECG, EMG, and other biological signals and ambient noise, signal averaging is usually required.
- The signal is time-locked to the stimulus and most of the noise occurs randomly, allowing the noise to be averaged out with averaging of repeated responses.
- Signals can be recorded from cerebral cortex, brain stem, spinal cord and peripheral nerves.

Auditory evoked potential

- Auditory evoked potential can be used to trace the signal generated by a sound through the ascending auditory pathway.
- The evoked potential is generated in the cochlea, goes through the cochlear nerve, through the cochlear nucleus, superior olivary complex, lateral lemniscus, to the inferior colliculus in the midbrain, on to the medial geniculate body, and finally to the cortex.
- Auditory evoked potentials (AEPs) are a subclass of event-related potentials (ERP)s. ERPs are brain responses that are time-locked to some "event", such as a sensory stimulus, a mental event (such as recognition of a target stimulus), or the omission of a stimulus. For AEPs, the "event" is a sound.
- AEPs (and ERPs) are very small electrical voltage potentials originating from the brain recorded from the scalp in response to an auditory stimulus, such as different tones, speech sounds, etc.
- Brainstem auditory evoked potentials are small AEPs that are recorded in response to an auditory stimulus from electrodes placed on the scalp.

Somatosensory evoked potential

- Somatosensory Evoked Potentials (SSEPs) are used in neuromonitoring to assess the function of a patient's spinal cord during surgery.

- They are recorded by stimulating peripheral nerves, most commonly the tibial nerve, median nerve or ulnar nerve, typically with an electrical stimulus.
- The response is then recorded from the patient's scalp.
- Because of the low amplitude of the signal once it reaches the patient's scalp and the relatively high amount of electrical noise caused by background EEG, scalp muscle EMG or electrical devices in the room, the signal must be averaged.
- The use of averaging improves the signal-to-noise ratio. Typically, in the operating room, over 100 and up to 1,000 averages must be used to adequately resolve the evoked potential.
- The two most looked at aspects of an SSEP are the amplitude and latency of the peaks.
- Each peak is given a letter and a number in its name.
- For example, N20 refers to a negative peak (N) at 20ms.
- This peak is recorded from the cortex when the median nerve is stimulated.
- It most likely corresponds to the signal reaching the somatosensory cortex.
- When used in intraoperative monitoring, the latency and amplitude of the peak relative to the patient's post-intubation baseline is a crucial piece of information.
- Dramatic increases in latency or decreases in amplitude are indicators of neurological dysfunction.
- During surgery, the large amounts of anesthetic gases used can affect the amplitude and latencies of SSEPs.
- Any of the halogenated agents or nitrous oxide will increase latencies and decrease amplitudes of responses, sometimes to the point where a response can no longer be detected.
- For this reason, an anesthetic utilizing less halogenated agent and more intravenous hypnotic and narcotic is typically used.

Visual evoked potential

- In 1934, Adrian and Matthew noticed potential changes of the occipital EEG can be observed under stimulation of light.
- Ciganek developed the first nomenclature for occipital EEG components in 1961.

- Halliday and colleagues completed the first clinical investigations using VEP by recording delayed VEPs in a patient with retrobulbar neuritis in 1972.

VEP Stimuli

- The diffuse-light flash stimulus is rarely used nowadays due to the high variability within and across subjects.
- However, it is beneficial to use this type of stimulus when testing infants, animals or individuals with poor visual acuity.
- The checkerboard and grating patterns use light and dark squares and stripes, respectively.
- These squares and stripes are equal in size and are presented, one image at a time, via a computer screen.

VEP Electrode Placement

- Electrode placement is extremely important to elicit a good VEP response free of artifact.
- In a typical (one channel) setup, one electrode is placed 2.5 cm above the inion and a reference electrode is placed at Fz.
- For a more detailed response, two additional electrodes can be placed 2.5 cm to the right and left of Oz.

VEP Waves

- The VEP nomenclature is determined by using capital letters stating whether the peak is positive (P) or negative (N) followed by a number which indicates the average peak latency for that particular wave.
- For example, P50 is a wave with a positive peak at approximately 50 ms following stimulus onset.
- The average amplitude for VEP waves usually falls between 5 and 10 microvolts.

Types of VEP

- Monocular pattern reversal (most common)
- Sweep visual evoked potential
- Binocular visual evoked potential
- Chromatic visual evoked potential
- Flash visual evoked potential
- LED Goggle visual evoked potential

MEG (Magneto Encephalo Graph)

- **Magnetoencephalography** (**MEG**) is a functional neuroimaging technique for mapping brain activity by recording magnetic fieldsproduced by electrical currents occurring naturally in the brain, using very sensitive magnetometers.
- Arrays of SQUIDs(superconducting quantum interference devices) are currently the most common magnetometer, while the SERF (spin exchange relaxation-free) magnetometer is being investigated for future machines.
- Applications of MEG include basic research into perceptual and cognitive brain processes, localizing regions affected by pathology before surgical removal, determining the function of various parts of the brain, and neurofeedback.
- This can be applied in a clinical setting to find locations of abnormalities as well as in an experimental setting to simply measure brain activity.

History of MEG

- MEG signals were first measured by University of Illinois physicist David Cohen in 1968, before the availability of the SQUID, using a copper induction coil as the detector.
- To reduce the magnetic background noise, the measurements were made in a magnetically shielded room.
- The coil detector was barely sensitive enough, resulting in poor, noisy MEG measurements that were difficult to use.
- Later, Cohen built a better shielded room at MIT, and used one of the first SQUID detectors, just developed by James E. Zimmerman, a researcher at Ford Motor Company, to again measure MEG signals.
- This time the signals were almost as clear as those of EEG. This stimulated the interest of physicists who had been looking for uses of SQUIDs. Subsequent to this, various types of spontaneous and evoked MEGs began to be measured.
- At first, a single SQUID detector was used to successively measure the magnetic field at a number of points around the subject's head.
- This was cumbersome, and, in the 1980s, MEG manufacturers began to arrange multiple sensors into arrays to cover a larger area of the head.
- Present-day MEG arrays are set in helmet-shaped Vacuum flask that typically contain 300 sensors, covering most of the head. In this way, MEGs of a subject or patient can now be accumulated rapidly and efficiently.

- In 2012, it was demonstrated that MEG could work with a chip-scale atomic magnetometer (CSAM).

THE BASIC OF MEG SIGNAL

- Synchronized neuronal currents induce weak magnetic fields.
- The brain's magnetic field, measuring at 10 femtotesla (fT) for cortical activity and 10^3 fT for the human alpha rhythm, is considerably smaller than the ambient magnetic noise in an urban environment, which is on the order of 10^8 fT or 0.1 μT.
- The essential problem of biomagnetism is, thus, the weakness of the signal relative to the sensitivity of the detectors, and to the competing environmental noise.
- The MEG (and EEG) signals derive from the net effect of ionic currents flowing in the dendrites of neurons during synaptictransmission.
- In accordance with Maxwell's equations, any electrical current will produce a magnetic field, and it is this field that is measured.
- The net currents can be thought of as current dipoles, i.e. currents with a position, orientation, and magnitude, but no spatial extent.
- According to the right-hand rule, a current dipole gives rise to a magnetic field that points around the axis of its vector component.
- To generate a signal that is detectable, approximately 50,000 active neurons are needed.
- Since current dipoles must have similar orientations to generate magnetic fields that reinforce each other, it is often the layer of pyramidal cells, which are situated perpendicular to the cortical surface, that gives rise to measurable magnetic fields.
- Bundles of these neurons that are orientated tangentially to the scalp surface project measurable portions of their magnetic fields outside of the head, and these bundles are typically located in the sulci.
- Researchers are experimenting with various signal processing methods in the search for methods that detect deep brain (i.e., non-cortical) signal, but no clinically useful method is currently available.
- It is worth noting that action potentials do not usually produce an observable field, mainly because the currents associated with action potentials flow in opposite directions and the magnetic fields cancel out.
- However, action fields have been measured from peripheral nerves.

MEG USE IN THE FIELD

- In research, MEG's primary use is the measurement of time courses of activity.
- MEG can resolve events with a precision of 10 milliseconds or faster, while functional MRI (fMRI), which depends on changes in blood flow, can at best resolve events with a precision of several hundred milliseconds.
- MEG also accurately pinpoints sources in primary auditory, somatosensory, and motor areas.
- For creating functional maps of human cortex during more complex cognitive tasks, MEG is most often combined with fMRI, as the methods complement each other. Neuronal (MEG) and hemodynamic (fMRI) data do not necessarily agree, in spite of the tight relationship between local field potentials (LFP) and blood oxygenation level-dependent (BOLD) signals.
- MEG and BOLD signals may originate from the same source (though the BOLD signals are filtered through the hemodynamic response).
- MEG is also being used to better localize responses in the brain. The openness of the MEG setup allows external auditory and visual stimuli to be easily introduced.
- Some movement by the subject is also possible as long as it does not jar the subject's head. The responses in the brain before, during, and after the introduction of such stimuli/movement can then be mapped with greater spatial resolution than was previously possible with EEG.
- Psychologists are also taking advantage of MEG neuroimaging to better understand relationships between brain function and behavior.
- For example, a number of studies have been done comparing the MEG responses of patients with psychological troubles to control patients.
- There has been great success isolating unique responses in patients with schizophrenia, such as auditory gating deficits to human voices.
- MEG is also being used to correlate standard psychological responses, such as the emotional dependence of language comprehension
- Recent studies have reported successful classification of patients with multiple sclerosis, Alzheimer's disease, schizophrenia, Sjögren's syndrome, chronic alcoholism, and facial pain.
- MEG can be used to distinguish these patients from healthy control subjects, suggesting a future role of MEG in diagnostics.

Focal epilepsy

- The clinical uses of MEG are in detecting and localizing pathological activity in patients with epilepsy, and in localizing eloquent cortex for surgical planning in patients with brain tumors or intractable epilepsy.
- The goal of epilepsy surgery is to remove the epileptogenic tissue while sparing healthy brain areas.
- Knowing the exact position of essential brain regions (such as the primary motor cortex and primary sensory cortex, visual cortex, and areas involved in speech production and comprehension) helps to avoid surgically induced neurological deficits.
- Direct cortical stimulation and somatosensory evoked potentials recorded on ECoG are considered the gold standard for localizing essential brain regions.
- These procedures can be performed either intraoperatively or from chronically indwelling subdural grid electrodes. Both are invasive.
- Noninvasive MEG localizations of the central sulcus obtained from somatosensory evoked magnetic fields show strong agreement with these invasive recordings.
- MEG studies assist in clarification of the functional organization of primary somatosensory cortex and to delineate the spatial extent of hand somatosensory cortex by stimulation of the individual digits.
- This agreement between invasive localization of cortical tissue and MEG recordings shows the effectiveness of MEG analysis and indicates that MEG may substitute invasive procedures in the future.

Fetal MEG

- MEG has been used to study cognitive processes such as vision, audition, and language processing in fetuses and newborns.

EEG BIO FEEDBACK INSTRUMENTATION

- **Biofeedback** is the process of gaining greater awareness of many physiological functions primarily using instruments that provide information on the activity of those same systems, with a goal of being able to manipulate them at will.
- Some of the processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception.
- Biofeedback may be used to improve health, performance, and the physiological changes that often occur in conjunction with changes to thoughts, emotions, and behavior.

Eventually, these changes may be maintained without the use of extra equipment, for no equipment is necessarily required to practice biofeedback.

Biofeedback has been found to be effective for the treatment of headaches and migraines.

- An electroencephalograph (EEG) measures the electrical activation of the brain from scalp sites located over the human cortex.
- The EEG shows the amplitude of electrical activity at each cortical site, the amplitude and relative power of various wave forms at each site, and the degree to which each cortical site fires in conjunction with other cortical sites (coherence and symmetry).
- The EEG uses precious metal electrodes to detect a voltage between at least two electrodes located on the scalp.
- The EEG records both excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs) that largely occur in dendrites in pyramidal cells located in macrocolumns,
- several millimeters in diameter, in the upper cortical layers. Neurofeedback monitors both slow and fast cortical potentials.
- Slow cortical potentials are gradual changes in the membrane potentials of cortical dendrites that last from 300 ms to several seconds.
- These potentials include the contingent negative variation (CNV), readiness potential, movement-related potentials (MRPs), and P300 and N400 potentials.[32]
- Fast cortical potentials range from 0.5 Hz to 100 Hz.
- The main frequency ranges include delta, theta, alpha, the sensorimotor rhythm, low beta, high beta, and gamma.
- The thresholds or boundaries defining the frequency ranges vary considerably among professionals.
- Fast cortical potentials can be described by their predominant frequencies, but also by whether they are synchronous or asynchronous wave forms. Synchronous wave forms occur at regular periodic intervals, whereas asynchronous wave forms are irregular.
- The synchronous **delta rhythm** ranges from 0.5 to 3.5 Hz. Delta is the dominant frequency from ages 1 to 2, and is associated in adults with deep sleep and brain pathology like trauma and tumors, and learning disability.
- The synchronous **theta rhythm** ranges from 4 to 7 Hz. Theta is the dominant frequency in healthy young children and is associated with drowsiness or starting to sleep, REM sleep, hypnagogic imagery (intense imagery experienced before the onset of sleep), hypnosis, attention, and processing of cognitive and perceptual information.
- The synchronous **alpha rhythm** ranges from 8 to 13 Hz and is defined by its waveform and not by its frequency. Alpha activity can be observed in about 75% of awake, relaxed individuals and is replaced by low-amplitude desynchronized beta activity during movement, complex problem-solving, and visual focusing. This phenomenon is called alpha blocking.
- The synchronous **sensorimotor rhythm** (SMR) ranges from 12 to 15 Hz and is located over the sensorimotor cortex (central sulcus). The sensorimotor rhythm is associated with the inhibition of movement and reduced muscle tone.

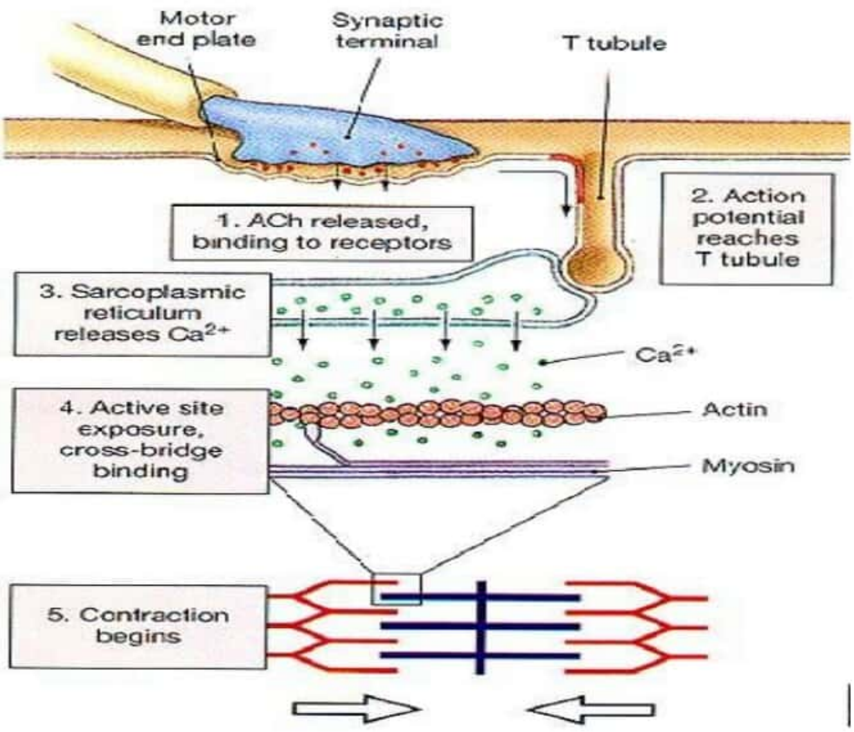
- The beta rhythm consists of asynchronous waves and can be divided into low beta and high beta ranges (13–21 Hz and 20–32 Hz). Low beta is associated with activation and focused thinking. High beta is associated with anxiety, hypervigilance, panic, peak performance, and worry.
- EEG activity from 36 to 44 Hz is also referred to as gamma. Gamma activity is associated with perception of meaning and meditative awareness.
- Neurotherapists use EEG biofeedback when treating addiction, attention deficit hyperactivity disorder (ADHD), learning disability, anxiety disorders (including worry, obsessive-compulsive disorder and posttraumatic stress disorder), depression, migraine, and generalized seizures.

UNIT III

SKELETAL MUSCULAR EQUIPMENT

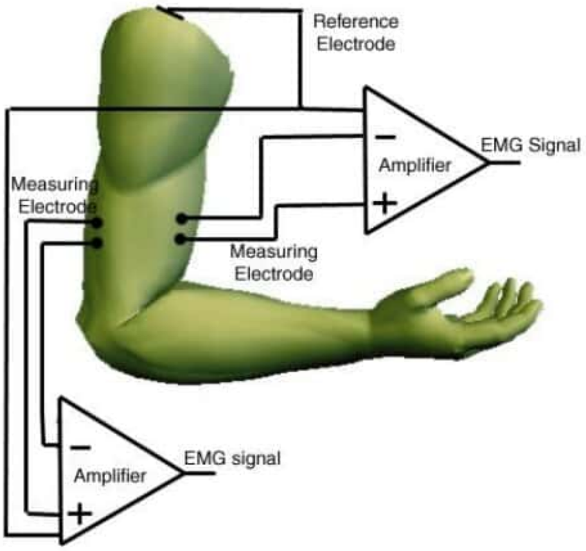
GENERATION OF EMG

- The EMG is generated when a motor neuron action potential from the spinal cord arrives at a motor end plate.
- Its arrival causes a release of ACh (Acetylcholine) at the synaptic cleft (1) which causes a depolarization (Action Potential).
- This action potential electrically travels downward from the surface in a transverse tubule (2).
- This in turn causes a release of Ca^{++} (3), causing cross-bridge binding (4) and the sarcomere of the muscle to contract (5).
- An electromyography (EMG) is a measurement of the electrical activity in muscles as a by product of contraction.
- An EMG is the summation of action potentials from the muscle fibers under the electrodes placed on the skin.
- The more muscles that fire, the greater the amount of action potentials recorded and the greater the EMG reading.

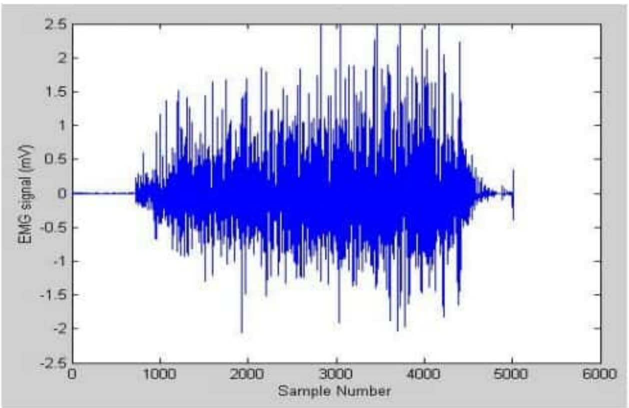


RECORDING AND ANALYSIS OF EMG WAVEFORMS

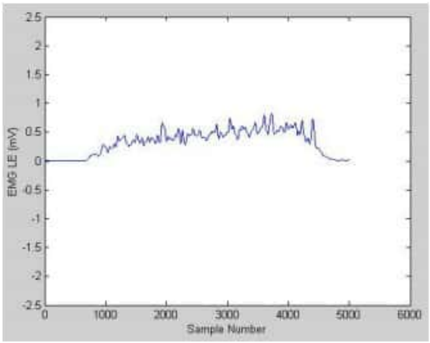
- **EMG recording:**
  The EMG is recorded by using a electrode placed on the muscle. The electrical activity measured by each muscle electrode and the ground electrode are sent to an amplifier.



- The amplifier eliminates random voltages caused by electrical noise by subtracting the signal from the ground electrode from the muscle electrode, producing the raw EMG.



- **EMG signal processing:**
  The raw EMG is processed by generating the EMG linear envelope, which is a combination of full-wave rectification (taking the absolute value) and low-pass filtering. This gives a useful result for analysis.



FATIGUE CHARACTERISTICS

- **Muscle fatigue** is the decline in ability of a muscle to generate force.
- It can be a result of vigorous exercise but abnormal fatigue may be caused by barriers to or interference with the different stages of muscle contraction.

There are two main causes of muscle fatigue:

- the limitations of a nerve's ability to generate a sustained signal (neural fatigue) and
- the reduced ability of the muscle fiber to contract (metabolic fatigue).

MUSCLE CONTRACTION

- Muscle cells work by detecting a flow of electrical impulses from the brain which signals them to contract through the release of calcium by the sarcoplasmic reticulum.
- Fatigue (reduced ability to generate force) may occur due to the nerve, or within the muscle cells themselves.

NERVOUS FATIGUE

- Nerves are responsible for controlling the contraction of muscles, determining the number, sequence and force of muscular contraction.
- Most movements require a force far below what a muscle could potentially generate, and barring pathological nervous fatigue, is seldom an issue.
- But in extremely powerful contractions that are close to the upper limit of a muscle's ability to generate force, nervous fatigue (enervation), in which the nerve signal weakens, can be a limiting factor in untrained individuals.
- In novice strength trainers, the muscle's ability to generate force is most strongly limited by nerve's ability to sustain a high-frequency signal.
- After a period of maximum contraction, the nerve's signal reduces in frequency and the force generated by the contraction diminishes.

- There is no sensation of pain or discomfort, the muscle appears to simply 'stop listening' and gradually cease to move, often going backwards.
- As there is insufficient stress on the muscles and tendons, there will often be no delayed onset muscle soreness following the workout.

METABOLIC FATIGUE

Though not universally used, 'metabolic fatigue' is a common term for the reduction in contractile force due to the direct or indirect effects of two main factors:

1. Shortage of fuel (substrates) within the muscle fiber
2. Accumulation of substances (metabolites) within the muscle fiber, which interfere either with the release of calcium (Ca^{2+}) or with the ability of calcium to stimulate muscle contraction.

Substrates

- Substrates within the muscle generally serve to power muscular contractions.
- They include molecules such as adenosine triphosphate (ATP), glycogen and creatine phosphate.
- ATP binds to the myosin head and causes the 'ratchetting' that results in contraction according to the sliding filament model.
- Creatine phosphate stores energy so ATP can be rapidly regenerated within the muscle cells from adenosine diphosphate (ADP) and inorganic phosphate ions, allowing for sustained powerful contractions that last between 5–7 seconds.
- Glycogen is the intramuscular storage form of glucose, used to generate energy quickly once intramuscular creatine stores are exhausted, producing lactic acid as a metabolic byproduct.
- Substrate shortage is one of the causes of metabolic fatigue.
- Substrates are depleted during exercise, resulting in a lack of intracellular energy sources to fuel contractions.
- In essence, the muscle stops contracting because it lacks the energy to do so.

Metabolites

- Metabolites are the substances (generally waste products) produced as a result of muscular contraction.
- They include chloride, potassium, lactic acid, ADP, magnesium (Mg^{2+}),reactive oxygen species, and inorganic phosphate.

- Accumulation of metabolites can directly or indirectly produce metabolic fatigue within muscle fibers through interference with the release of calcium (Ca^{2+}) from the sarcoplasmic reticulum or reduction of the sensitivity of contractile molecules actin and myosin to calcium.

Chloride

Intracellular chloride partially inhibits the contraction of muscles. Namely, it prevents muscles from contracting due to "false alarms", small stimuli which may cause them to contract (akin to myoclonus). This natural brake helps muscles respond solely to the conscious control or spinal reflexes but also has the effect of reducing the force of conscious contractions.

Potassium

High concentrations of potassium (K^+) also causes the muscle cells to decrease in efficiency, causing cramping and fatigue. Potassium builds up in the t-tubule system and around the muscle fiber as a result of action potentials. The shift in K^+ changes the membrane potential around the muscle fiber. The change in membrane potential causes a decrease in the release of calcium (Ca^{2+}) from the sarcoplasmic reticulum.

Lactic acid

It was once believed that lactic acid build-up was the cause of muscle fatigue. The assumption was lactic acid had a "pickling" effect on muscles, inhibiting their ability to contract. The impact of lactic acid on performance is now uncertain, it may assist or hinder muscle fatigue.

PATHOLOGY

- Muscle weakness may be due to problems with the nerve supply, neuromuscular disease (such as myasthenia gravis) or problems with muscle itself.
- The latter category includes polymyositis and other muscle disorders

MOLECULAR MECHANISMS

- Muscle fatigue may be due to precise molecular changes that occur in vivo with sustained exercise.
- It has been found that the ryanodine receptor present in skeletal muscle undergoes a conformational change during exercise, resulting in "leaky" channels that are deficient in calcium release.
- These "leaky" channels may be a contributor to muscle fatigue and decreased exercise capacity.

EFFECT ON PERFORMANCE

- Fatigue has been found to play a big role in limiting performance in just about every individual in every sport.
- In research studies, participants were found to show reduced voluntary force production in fatigued muscles (measured with concentric, eccentric, and isometric contractions), vertical jump heights, other field tests of lower body power, reduced throwing velocities, reduced kicking power and velocity, less accuracy in throwing and shooting activities, endurance capacity, anaerobic capacity, anaerobic power, mental concentration, and many other performance parameters when sport specific skills are examined.

MUSCLE STIMULATORS

- **Electrical muscle stimulation** (EMS), also known as **neuromuscular electrical stimulation** (NMES) or **electromyostimulation**, is the elicitation of muscle contraction using electric impulses.
- EMS has received increasing attention in the last few years because of its potential to serve as a strength training tool for healthy subjects and athletes, a rehabilitation and preventive tool for partially or totally immobilized patients, a testing tool for evaluating the neural and/or muscular function in vivo, and a post-exercise recovery tool for athletes.
- The impulses are generated by a device and delivered through electrodes on the skin in direct proximity to the muscles to be stimulated.
- The impulses mimic the action potential coming from the central nervous system, causing the muscles to contract.
- The electrodes are generally pads that adhere to the skin.
- The use of EMS has been cited by sports scientists as a complementary technique for sports training and published research is available on the results obtained.

HISTORY

- Luigi Galvani (1761) provided the first scientific evidence that current can activate muscle. During the 19th and 20th centuries, researchers studied and documented the exact electrical properties that generate muscle movement.
- It was discovered that the body functions induced by electrical stimulation caused long-term changes in the muscles.

- In the 1960s, Soviet sport scientists applied EMS in the training of elite athletes, claiming 40% force gains.
- In the 1970s, these studies were shared during conferences with the Western sport establishments.
- However results were conflicting, perhaps because the mechanisms in which EMS acted were poorly understood.
- Recent medical physiology research pinpointed the mechanisms by which electrical stimulation causes adaptation of cells of muscles, blood vessels and nerves

USE

- EMS can be used as a training, therapeutic, and cosmetic tool.
- In medicine, EMS is used for rehabilitation purposes, for instance in physical therapy in the prevention of disuse muscle atrophy which can occur for example after musculoskeletal injuries, such as damage to bones, joints, muscles, ligaments and tendons.
- This is distinct from transcutaneous electrical nerve stimulation (TENS), in which an electric current is used for pain therapy.
- Because of the effect that strengthened and Hypertrophied muscles have on appearance (a stronger muscle has larger cross-section, EMS is also used by a niche of practitioners for aesthetics goals.
- EMS devices cause a calorie burning that is marginal at best: calories are burnt in significant amount only when most of the body is involved in physical exercise: several muscles, the heart and the respiratory system are all engaged at once.
- However, some authors imply that EMS can lead to exercise, since a person toning his/her muscles with electrical stimulation is more likely afterwards to participate in sporting activities as the body is ready, fit, willing and able to take on physical activity.
- In EMS training few muscular groups are targeted at the same time, for specific training goals.
- The effectiveness of the devices for sport training has been debated. A number of coaches regularly use professional EMS devices as an integral part of the training of their athletes; some of these are high profile coaches, such as track coach Charlie Francis, who used the technique to supplement the training of Olympic-level athletes.
- Non-professional devices target home-market consumers with wearable units in which EMS circuitry is contained in belt-like garments (ab toning belts) or other clothing items.

NERVE STIMULATORS

ELECTRICAL NERVE STIMULATION FOR CHRONIC PAIN

- Electrical nerve stimulation is a procedure that uses an electrical current to treat chronic pain. Peripheral nerve stimulation (PNS) and spinal cord stimulation (SCS) are two types of electrical nerve stimulation.

- In either, a small pulse generator sends electrical pulses to the nerves (in peripheral nerve stimulation) or to the spinal cord (in spinal cord stimulation). These pulses interfere with the nerve impulses that make you feel pain.

Nerve stimulation is done in two steps.

- To see if it will help your pain, your doctor will first insert a temporary electrode through the skin(percutaneously) to give the treatment a trial run.

- The electrode is connected to a stimulator that the patient can control. If the trial is successful, your doctor can implant a permanent stimulator under your skin.

- This is typically done using a local anesthetic and a sedative. The stimulator itself is implanted under the skin and the small coated wires (leads) are inserted under the skin to the point where they are either connected to nerves or inserted into the spinal canal.

- After this outpatient procedure is complete, you and your doctor determine the best pulse strength.

- You are then told how to use the stimulator at home. A typical schedule for spinal cord stimulation is to use it for 1 or 2 hours, 3 or 4 times a day.

When in use, electrical nerve stimulation creates a tingling feeling.

What To Expect After Treatment

- You will have a small incision that you should keep clean and dry until it heals.

Why It Is Done

- This treatment may be done for people with severe, chronic pain who have:

- Failed back surgery syndrome.
- Severe nerve-related pain or numbness.
- Chronic pain syndromes, such as complex regional pain syndrome.

Electrical nerve stimulation is typically considered investigational for various other conditions, including multiple sclerosis, paraplegia, and intractable angina.

How Well It Works

- There isn't a lot of evidence to show how well spinal cord stimulation works. It seems to help certain types of chronic pain, such as failed back surgery syndrome and complex regional pain syndrome.

- Spinal cord stimulation may also help chronic low back pain.

- Some researchers have reported that more than half of people receiving spinal cord stimulation for chronic low back and leg pain, ischemic leg pain (for example, from peripheral arterial disease), or complex regional pain syndrome have pain reduction or relief.
- There is some evidence that peripheral nerve stimulation helps certain types of chronic pain, such as peripheral nerve pain and pain after surgery.

Risks

Possible risks related to electrical nerve stimulation include:

- Scar tissue (fibrosis) developing around the electrode.
- Pain gradually moving beyond the reach of the nerve stimulator.
- Breakage of an electrode or hardware failure.
- Infection.
- Leakage of spinal fluid during spinal cord stimulation.
- Headache from spinal cord stimulation.
- Bladder problems in spinal cord stimulation.
- Getting used to the stimulation, making it less effective.

People with an implanted stimulator can't have magnetic resonance imaging (MRI) tests.

NERVE CONDUCTION VELOCITY MEASUREMENT

- **Nerve conduction velocity** is an important aspect of nerve conduction studies.
- It is the speed at which an electrochemical impulse propagates down a neural pathway.
- Conduction velocities are affected by a wide array of factors, including age, sex, and various medical conditions.
- Studies allow for better diagnoses of various neuropathies, especially demyelinating conditions as these conditions result in reduced or non-existent conduction velocities.

NORMAL CONDUCTION VELOCITIES

- Ultimately, conduction velocities are specific to each individual and depend largely on an axon's diameter and the degree to which that axon is myelinated, but the majority of 'normal' individuals fall within defined ranges.
- Nerve impulses are extremely slow comparing to speed of electrical impulse which is in order of 50%–99% of the speed of light, however, very fast comparing to speed of blood flow, with some myelinated neurons conducting at speeds up to 120 m/s (432 km/h or 275 mph)

Motor fiber types					
Type	**Erlanger-Gasser Classification**	**Diameter**	**Myelin**	**Conduction velocity**	**Associated muscle fibers**
α	**Aα**	**13-20 µm**	**Yes**	**80–120 m/s**	**Extrafusal muscle fibers**
γ	**Aγ**	**5-8 µm**	**Yes**	**4–24 m/s** [2][3]	**Intrafusal muscle fibers**

Different sensory receptors are innervated by different types of nerve fibers. Proprioceptors are innervated by type Ia, Ib and II sensory fibers, mechanoreceptors by type II and III sensory fibers, and nociceptors and thermoreceptors by type III and IV sensory fibers.

Sensory fiber types					
Type	**Erlanger-Gasser Classification**	**Diameter**	**Myelin**	**Conduction velocity**	**Associated sensory receptors**
Ia	**Aα**	**13-20 µm**	**Yes**	**80–120 m/s**[4]	**Responsible for proprioception**
Ib	**Aα**	**13-20 µm**	**Yes**	**80–120 m/s**	**Golgi tendon organ**
II	**Aβ**	**6-12 µm**	**Yes**	**33–75 m/s**	**Secondary receptors of muscle spindle** **All cutaneous mechanoreceptors**

Peripheral Nerves	
Nerve	**Conduction velocity**
Median Sensory	**45–70 m/s**
Median Motor	**49–64 m/s**
Ulnar Sensory	**48–74 m/s**
Ulnar Motor	**49+ m/s**
Peroneal Motor	**44+ m/s**
Tibial Motor	**41+ m/s**
Sural Sensory	**46–64 m/s**

- Normal impulses in peripheral nerves of the legs travel at 40–45 m/s, and 50–65 m/s in peripheral nerves of the arms. Largely generalized, normal conduction velocities for any given nerve will be in the range of 50–60 m/s.

TESTING METHODS

- **Nerve conduction studies**

Nerve Conduction Velocity is just one of many measurements commonly made during a nerve conduction study (NCS). The purpose of these studies is to determine whether nerve damage is present and how severe that damage may be.

Nerve conduction studies are performed as follows:

- Two electrodes are attached to the subject's skin over the nerve being tested.
- Electrical impulses are sent through one electrode to stimulate the nerve.
- The second electrode records the impulse sent through the nerve as a result of stimulation.
- The time difference between stimulation from the first electrode and pick-up by the downstream electrode is known as the latency. Nerve conduction latencies are typically on the order of milliseconds.
  - Although conduction velocity itself is not directly measured, calculating conduction velocities from NCS measurements is trivial.
  - The distance between the stimulating and receiving electrodes is divided by the impulse latency, resulting in conduction velocity.
  - Many times, Needle EMG is also performed on subjects at the same time as other NCS procedures because they aid in detecting whether muscles are functioning properly in response to stimuli sent via their connecting nerves.
  - EMG is the most important component of electrodiagnosis of motor neuron diseases as it often leads to the identification of motor neuron involvement before clinical evidence can be seen.

Micromachined 3D electrode arrays

- Typically, the electrodes used in an EMG are stuck to the skin over a thin layer of gel/paste.
- This allows for better conduction between electrode and skin.
- However, as these electrodes do not pierce the skin, there areimpedances that result in erroneous readings, high noise levels, and low spatial resolution in readings.[10]
- To address these problems, new devices are being developed, such as 3-dimensional electrode arrays.
- These are MEMS devices that consist of arrays of metal micro-towers capable of penetrating the outer layers of skin, thus reducing impedance.

Compared with traditional wet electrodes, multielectrode arrays offer the following:

- Electrodes are about 1/10 the size of standard wet surface electrodes
- Arrays of electrodes can be created and scaled to cover areas of almost any size
- Reduced impedance
- Improved signal power
- Higher amplitude signals

- Allow better real-time nerve impulse tracking

CAUSES OF CONDUCTION VELOCITY DEVIATION

Anthropometric and other individualized factors

- Baseline nerve conduction measurements are different for everyone, as they are dependent upon the individual's age, sex, local temperatures, and other anthropometric factors such as hand size and height.
- It is important to understand the effect of these various factors on the normal values for nerve conduction measurements to aid in identifying abnormal nerve conduction study results.
- The ability to predict normal values in the context of an individual's anthropometric characteristics increases the sensitivities and specificities of electrodiagnostic procedures.

Age

- Normal 'adult' values for conduction velocities are typically reached by age 4. Conduction velocities in newborns and toddlers tend to be about half the adult values.
- Nerve conduction studies performed on healthy adults revealed that age is negatively associated with the sensory amplitude measures of the Median, Ulnar, and Sural nerves.
- Negative associations were also found between age and the conduction velocities and latencies in the Median sensory, Median motor, and Ulnar sensory nerves.
- However, conduction velocity of the Sural nerve is not associated with age. In general, conduction velocities in the upper extremities decrease by about 1 m/s for every 10 years of age.

Sex

- Sural nerve conduction amplitude is significantly smaller in females than males, and the latency of impulses is longer in females, thus a slower conduction velocity.
- Other nerves have not been shown to exhibit any gender biases.

Temperature

- In general, the conduction velocities of most motor and sensory nerves are positively and linearly associated with body temperature (low temperatures slow nerve conduction velocity and higher temperatures increase conduction velocity).
- Conduction velocities in the Sural nerve seem to exhibit an especially strong correlation with the local temperature of the nerve.

Height

- Conduction velocities in both the Median sensory and Ulnar sensory nerves are negatively related to an individual's height, which likely accounts for the fact that, among most of the adult population, conduction velocities between the wrist and digits of an individual's hand decrease by 0.5 m/s for each inch increase in height.

- As a direct consequence, impulse latencies within the Median, Ulnar, and Sural nerves increases with height.
- The correlation between height and the amplitude of impulses in the sensory nerves is negative.

Hand factors

- Circumference of the index finger appears to be negatively associated with conduction amplitudes in the Median and Ulnar nerves.
- In addition, people with larger wrist ratios (anterior-posterior diameter : medial-lateral diameter) have lower Median nerve latencies and faster conduction velocities.

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- Some of the processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception.
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- Biofeedback has been found to be effective for the treatment of headaches and migraines.

ELECTROMYOGRAPH

- An electromyograph (EMG) uses surface electrodes to detect muscle action potentials from underlying skeletal muscles that initiate muscle contraction.
- Clinicians record the surface electromyogram (SEMG) using one or more active electrodes that are placed over a target muscle and a reference electrode that is placed within six inches of either active.
- The SEMG is measured in microvolts (millionths of a volt).
- In addition to surface electrodes, clinicians may also insert wires or needles intramuscularly to record an EMG signal.
- While this is more painful and often costly, the signal is more reliable since surface electrodes pick up cross talk from nearby muscles.
- The use of surface electrodes is also limited to superficial muscles, making the intramuscular approach beneficial to access signals from deeper muscles.
- The electrical activity picked up by the electrodes is recorded and displayed in the same fashion as the surface electrodes.

- Prior to placing surface electrodes, the skin is normally shaved, cleaned and exfoliated to get the best signal.
- Raw EMG signals resemble noise (electrical signal not coming from the muscle of interest) and the voltage fluctuates, therefore they are processed normally in three ways: rectification, filtering, and integration.
- This processing allows for a unified signal that is then able to be compared to other signals using the same processing techniques.
- Biofeedback therapists use EMG biofeedback when treating anxiety and worry, chronic pain, computer-related disorder, essential hypertension, headache (migraine, mixed headache, and tension-type headache), low back pain, physical rehabilitation (cerebral palsy, incomplete spinal cord lesions, and stroke), temporomandibular joint dysfunction (TMD), torticollis, and fecal incontinence, urinary incontinence, and pelvic pain.
- Physical therapists have also used EMG biofeedback for evaluating muscle activation and providing feedback for their patients.

UNIT IV

PATIENT MONITORING AND BIOTELEMETRY

INTENSIVE CARE UNIT (ICU)

- An **intensive care unit** (**ICU**), also known as an **intensive therapy unit** or **intensive treatment unit** (**ITU**) or **critical care unit** (**CCU**), is a special department of a hospital or health care facility that provides intensive treatment medicine.
- Intensive care units cater to patients with severe and life-threatening illnesses and injuries, which require constant, close monitoring and support from specialist equipment and medications in order to ensure normal bodily functions.
- They are staffed by highly trained doctors and nurses who specialise in caring for critically ill patients.
- ICUs are also distinguished from normal hospital wards by a higher staff-to-patient ratio and access to advanced medical resources and equipment that is not routinely available elsewhere.
- Common conditions that are treated within ICUs include ARDS, trauma, multiple organ failure and sepsis.
- Patients may be transferred directly to an intensive care unit from an emergency department if required, or from a ward if they rapidly deteriorate, or immediately after surgery if the surgery is very invasive and the patient is at high risk of complications

Equipment and systems

- Common equipment in an ICU includes mechanical ventilators to assist breathing through an endotracheal tube or a tracheostomy tube; cardiac monitors including those with telemetry; external pacemakers; defibrillators; dialysis equipment for renal problems; equipment for the constant monitoring of bodily functions; a web of intravenous lines, feeding tubes, nasogastric tubes, suction pumps, drains, and catheters; and a wide array of drugs to treat the primary condition(s) of hospitalization. Medically induced comas, analgesics, and induced sedation are common ICU tools needed and used to reduce pain and prevent secondary infections.

Monitors in the ICU

- The intensity of the care provided in ICU requires many monitoring devices. Patients in the ICU generally have many wires attached to them for various types of monitoring.
- Monitors have alarms that notify members of the care team when a measurement is detected that is out of acceptable range.
- The constant alarming of these monitors can be frightening to patients and their families.
- It is important to remember that this highly sophisticated equipment is designed to provide the best possible care.

Some of the monitoring equipment seen in the ICU includes the following:

- **Cardiac or heart monitors:** Cardiac monitors are used to monitor the electrical activity of the heart. The monitor looks like a computer screen with lines, or tracings, moving across the screen. The monitor has electrodes that are attached to the patient's chest with sticky pads.
- **Pulse oximeter:** A pulse oximeter allows the critical care team to monitor the saturation of oxygen in the blood. It looks like a clothespin and is attached to a patient's finger, or it may be smaller and clipped onto the earlobe.
- **Swan-Ganz catheter:** A Swan-Ganz, or pulmonary artery catheter, is used to measure the amount of fluid filling the heart as well as to determine how the heart is functioning. It is inserted through the large vessels of the neck or upper chest and threaded into the heart.
- **Arterial lines (a-lines):** Arterial lines are used for continuous monitoring of blood pressure. Catheters are inserted into an artery, usually in the wrist or, less often, in the bend of the elbow (should not be the brachial artery) or groin. Arterial lines produce a tracing on a monitor that is similar to that of a heart monitor but with a different wave form. Arterial lines can also be used for drawing blood thus eliminating the need for repeated venipuntures (a surgical puncture of a vein for withdrawing blood).

Tubes & Catheters in the ICU

Central venous catheter (CVC): This type of catheter is a soft, pliable tube that is inserted into a large vessel (vein) in the neck (internal jugular vein), in the upper chest (subclavian vein), or in the groin area (femoral vein). Patients are sedated and receive a local anesthetic prior to insertion. Sutures secure the CVC, which can be left in place for days or weeks. CVCs are used:

- to administer frequent or continuous medication;
- to administer large multiple IV products that do not fit in one line; and
- to measure central venous pressure (the amount of fluid in the vessels).

CVCs carry some risk of bloodstream infection and thrombosis (tenderness and abnormal fluid collection in tissues, impaired movement, and engorged veins).

Intravenous (IV): An IV is a are plastic catheter (tube) that is inserted into the veins (peripheral IV) or a larger size catheter inserted into the larger veins of the neck. Fluids, medications, nutrition preparations, and blood products are administered through IV catheters. Patients in ICU often have multiple IVs.

Chest tubes: Chest tubes are inserted through the chest wall into the space around the lung to drain fluid or air that has accumulated and prevent the lung from being able to expand.

Urinary catheter: Urinary catheters, often referred to as Foley catheters, are inserted through the urethra into the bladder. Once in the bladder the catheter is kept in place by a balloon, which is inflated, at the end of the catheter. Urinary catheters continuously drain the bladder and allow for accurate measurement of urinary output, which is extremely important in fluid management and in assessing kidney function.

Endotracheal tubes: Endotracheal tubes are used when mechanical ventilation is necessary. The soft plastic tube is inserted either through the nose or through the mouth, between the vocal cords and into the trachea. A small soft balloon at the end of the tube in the trachea is inflated to prevent air from escaping, thus allowing adequate ventilation by the respirator. The process of having the ET tube inserted is referred to as intubation.

Patients who are intubated are unable to speak, so it is important to try to ask yes or no questions to which they can respond by shaking or nodding their head. Some patients may be able to communicate by writing. Most often patients who are intubated require sedation and may not be responsive at all.

Life Supportive Devices in the ICU

Ventilator: The ventilator, or respirator, is a breathing machine that helps patients breathe when they are too ill to breathe on their own. A patient is connected to the ventilator by an **endotracheal tube** (a flexible plastic tube that is inserted into the mouth and then down into the trachea).

It is often necessary for a patient to be sedated while on the ventilator, which may limit his or her ability to respond. This is necessary both for patient comfort and for the ventilator to be able to work effectively. As a patient's lungs recover, the amount of ventilator support is gradually decreased until it is felt a patient can breathe on his or her own.

Some patients need a ventilator to help them breathe for a prolonged period of time. If this occurs, a **tracheostomy** is often performed. This procedure involves making a small hole in the neck, just below the vocal cord. A small tube is inserted into the hole and connected to the ventilator. It is performed either in the ICU or in the operating room.

When the patient no longer requires the ventilator, the tube is removed and the hole in the neck eventually heals. A tracheostomy is comfortable for the patient and prevents damage to the trachea.

Nutrition: Nutrition is very important for the critically ill. Even though the ICU patient is immobile and does not appear to require "food" for energy, the illness or injury that has required the patient to be in the ICU increases the patient's **basal metabolic rate**(a measure of the rate of metabolism). Adequate nutrition is essential to the healing process.

Nutritional solutions can be administered through feeding tubes inserted through either the nose or the mouth into the stomach or through **central venous catheters**. The stomach route is preferred, as long as the patient's GI tract is working and able to tolerate feeding. Special nutritional preparations are available to provide the nutritional needs of the critically ill. The nutritional needs are calculated and monitored closely by the nutritionist on the critical care team and are adjusted accordingly

Informed Consent

Prior to initiating any procedure in the ICU, physicians must secure informed consent (permission) from the patient. Except in emergency situations, physicians obtain consent directly from patients.

If a patient cannot give consent, the physician seeks permission from an individual with durable power of attorney for health care. Durable power of attorney is a legal document that grants authority to make another person's health care decisions when that person is unable to make those decisions. If this is not available, a close family member can grant consent.

In some cases, patients have specific wishes that have been communicated in legal documents, such as the following:

- Advance directive: Advance directive contains instructions regarding health care decisions, especially in the case of incapacitation. It can include durable power of attorney and living wills.
- Do not resuscitate (DNR) order: A DNR is a patient's instructions not to re-start a failed heartbeat or respiration. It **does not** mean that the patient will not be treated with medications. Patients who are DNR may still receive antibiotics and sedation or medications for pain. Do not resuscitate allows for a patient to die naturally if his or her respiratory or cardiac systems stop working.

CORONARY CARE UNIT (CCU)

- A **coronary care unit** (**CCU**) or **cardiac intensive care unit** (**CICU**) is a hospital ward specialized in the care of patients with heart attacks, unstable angina, cardiac dysrhythmia and (in practice) various other cardiac conditions that require continuous monitoring and treatment.

Characteristics

- The main feature of coronary care is the availability of telemetry or the continuous monitoring of the cardiac rhythm by electrocardiography.
- This allows early intervention with medication, cardioversion or defibrillation, improving the prognosis.
- As arrhythmias are relatively common in this group, patients with myocardial infarction or unstable angina are routinely admitted to the coronary care unit.
- For other indications, such as atrial fibrillation, a specific indication is generally necessary, while for others, such as heart block, coronary care unit admission is standard.

Utilization

- In the United States, cardiac conditions accounted for eight of the eighteen conditions and procedures with high ICU utilization (ICU utilization in more than 40% of stays) in 2011.

Local differences

- In the United States, coronary care units are usually subsets of intensive care units (ICU) dedicated to the care of critically ill cardiac patients.
- These units are usually present in hospitals that routinely engage in cardiothoracic surgery.
- Invasive monitoring such as with pulmonary artery catheters is common, as are supportive modalities such as mechanical ventilation and intra-aortic balloon pumps (IABP).
- Certain hospitals, such as Johns Hopkins, maintain mixed units consisting of both acute care units for the critically ill, and intermediate care units for patients who are not critical.

Acute coronary care

- Acute coronary care units (ACCUs), also called "critical coronary care units" (CCCUs), are equivalent to intensive care in the level of service provided.
- Patients with acute myocardial infarction, cardiogenic shock, or post-operative "open-heart" patients commonly abide here.

Subacute coronary care

- Subacute coronary care units (SCCUs), also called progressive care units (PCUs), intermediate coronary care units (ICCUs), or stepdown units, provide a level of care intermediate to that of the intensive care unit and that of the general medical floor.
- These units typically serve patients who require cardiac telemetry, such as those with unstable angina.

History

- Coronary care units developed in the 1960s when it became clear that close monitoring by specially trained staff, cardiopulmonary resuscitation and medical measures could reduce the mortality from complications of cardiovascular disease.
- The first description of a CCU was given in 1961 to the British Thoracic Society by Dr. Desmond Julian, who founded the first CCU at the Royal Infirmary of Edinburgh in 1964.
- Early CCUs were also located in Sydney, Kansas City, Toronto and Philadelphia.
- The first coronary care unit in the US was opened at Bethany Medical Center in Kansas City, Kansas by Dr Hughes Day, and he coined the term.
- DF Beck performed the first successful resuscitation of a physician with myocardial infarction in 1953, and pioneered the use of open-chest defibrillation.
- The first diagnostic angiogram was discovered by Dr. Mason Sones in 1958, due to an accidental injection of dye directly into the coronary artery rather than into the entire circulation - something that was previously believed to be fatal.
- These developments led to an interest in intensive care for myocardial infarction.
- In 1967, Thomas Killip and John Kimball published a report of 250 patients with acute MI’s, who had experienced significantly better survival rates in CCUs compared to other institutions.

- This, along with other reports, led to an increase in coronary care units. Now catheterization units are commonplace in large cities.

INFUSION PUMP

- An **infusion pump** infuses fluids, medication or nutrients into a patient's circulatory system.
- It is generally used intravenously, although subcutaneous, arterial and epidural infusions are occasionally used.
- Infusion pumps can administer fluids in ways that would be impractically expensive or unreliable if performed manually by nursing staff.
- For example, they can administer as little as 0.1 mL per hour injections (too small for a drip), injections every minute, injections with repeated boluses requested by the patient, up to maximum number per hour (e.g. in patient-controlled analgesia), or fluids whose volumes vary by the time of day.
- Because they can also produce quite high but controlled pressures, they can inject controlled amounts of fluids subcutaneously (beneath the skin), or epidurally (just within the surface of the central nervous system – a very popular local spinal anesthesia for childbirth).

Types of infusion

The user interface of pumps usually requests details on the type of infusion from the technician or nurse that sets them up:

- **Continuous infusion** usually consists of small pulses of infusion, usually between 500 nanoliters and 10 milliliters, depending on the pump's design, with the rate of these pulses depending on the programmed infusion speed.
- **Intermittent infusion** has a "high" infusion rate, alternating with a low programmable infusion rate to keep the cannula open. The timings are programmable. This mode is often used to administer antibiotics, or other drugs that can irritate a blood vessel.
- **Patient-controlled** is infusion on-demand, usually with a preprogrammed ceiling to avoid intoxication. The rate is controlled by a pressure pad or button that can be activated by the patient. It is the method of choice for patient-controlled analgesia (PCA), in which repeated small doses of opioid analgesics are delivered, with the device coded to stop administration before a dose that may cause hazardous respiratory depression is reached.
- **Total parenteral nutrition** usually requires an infusion curve similar to normal mealtimes.

Some pumps offer modes in which the amounts can be scaled or controlled based on the time of day. This allows for circadian cycles which may be required for certain types of medication.

Types of pump

There are two basic classes of pumps.

- Large volume pumps can pump nutrient solutions large enough to feed a patient.
- Small-volume pumps infuse hormones, such as insulin, or other medicines, such as opiates.

Within these classes, some pumps are designed to be portable, others are designed to be used in a hospital, and there are special systems for charity and battlefield use.

Large-volume pumps usually use some form of peristaltic pump. Classically, they use computer-controlled rollers compressing a silicone-rubber tube through which the medicine flows. Another common form is a set of fingers that press on the tube in sequence.

Small-volume pumps usually use a computer-controlled motor turning a screw that pushes the plunger on a syringe.

- Some of the smallest infusion pumps use osmotic power.
- Basically, a bag of salt solution absorbs water through a membrane, swelling its volume. The bag presses medicine out.
- The rate is precisely controlled by the salt concentrations and pump volume. Osmotic pumps are usually recharged with a syringe.
- Spring-powered clockwork infusion pumps have been developed, and are sometimes still used in veterinary work and for ambulatory small-volume pumps.
- They generally have one spring to power the infusion, and another for the alarm bell when the infusion completes.

Specialized infusion pumps have been designed for this purpose, although they have not been deployed.

- Many infusion pumps are controlled by a small embedded system.
- They are carefully designed so that no single cause of failure can harm the patient. For example, most have batteries in case the wall-socket power fails.
- Additional hazards are uncontrolled flow causing an overdose, uncontrolled lack of flow, causing an underdose, reverse flow, which can siphon blood from a patient, and air in the line, which can cause an air embolism.

Safety features available on some pumps

The range of safety features varies widely with the age and make of the pump. A state of the art pump in 2003 may have the following safety features:

- Certified to have no single point of failure. That is, no single cause of failure should cause the pump to silently fail to operate correctly. It should at least stop pumping and make at least an audible error indication. This is a minimum requirement on all human-rated infusion pumps of whatever age. It is not required for veterinary infusion pumps.
- Batteries, so the pump can operate if the power fails or is unplugged.

- Anti-free-flow devices prevent blood from draining from the patient, or infusate from freely entering the patient, when the infusion pump is being set up.
- A "down pressure" sensor will detect when the patient's vein is blocked, or the line to the patient is kinked. This may be configurable for high (subcutaneous and epidural) or low (venous) applications.
- An "air-in-line" detector. A typical detector will use an ultrasonic transmitter and receiver to detect when air is being pumped. Some pumps actually measure the volume, and may even have configurable volumes, from 0.1 to 2 ml of air. None of these amounts can cause harm, but sometimes the air can interfere with the infusion of a low-dose medicine.
- An "up pressure" sensor can detect when the bag or syringe is empty, or even if the bag or syringe is being squeezed.
- A drug library with customizable programmable limits for individual drugs that helps to avoid medication errors.
- Mechanisms to avoid uncontrolled flow of drugs in large volume pumps (often in combination with a giving st based free flow clamp) and increasingly also in syringe pumps (piston-brake)
- Many pumps include an internal electronic log of the last several thousand therapy events. These are usually tagged with the time and date from the pump's clock. Usually, erasing the log is a feature protected by a security code, specifically to detect staff abuse of the pump or patient.
- Many makes of infusion pump can be configured to display only a small subset of features while they are operating, in order to prevent tampering by patients, untrained staff and visitors.

Safety issues

- Infusion pumps have been a source of multiple patient safety concerns, and problems with such pumps have been linked to more than 56,000 adverse event reports from 2005 to 2009, including at least 500 deaths.
- As a result, the U.S. Food and Drug Administration (FDA) has launched a comprehensive initiative to improve their safety, called the Infusion Pump Improvement Initiative.
- The initiative proposed stricter regulation of infusion pumps. It cited software defects, user interface issues, and mechanical or electrical failures as the main causes of adverse events.

BED SIDE MONITORING

- In medicine, **monitoring** is the observation of a disease, condition or one or several medical parameters over time.
- It can be performed by continuously measuring certain parameters by using a **medical monitor** (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests (such as blood glucose monitoring with a glucose meter in people with diabetes mellitus).
- Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry.

Classification by target parameter

Monitoring can be classified by the target of interest, including:

- **Cardiac monitoring**, which generally refers to continuous electrocardiography with assessment of the patients condition relative to their cardiac rhythm. A small monitor worn by an ambulatory patient for this purpose is known as a Holter monitor. Cardiac monitoring can also involve cardiac output monitoring via an invasive Swan-Ganz catheter.
- **Hemodynamic monitoring**, which monitors the blood pressure and blood flow within the circulatory system. Blood pressure can be measured either invasively through an inserted blood pressure transducer assembly, or noninvasively with an inflatable blood pressure cuff.
- **Respiratory monitoring**, such as:
  - Pulse oximetry which involves measurement of the saturated percentage of oxygen in the blood, referred to as SpO2, and measured by an infrared finger cuff
  - Capnography, which involves CO_2 measurements, referred to as EtCO2 or end-tidal carbon dioxide concentration. The respiratory rate monitored as such is called AWRR or airway respiratory rate)
  - Respiratory rate monitoring through a thoracic transducer belt, an ECG channel or via capnography
- **Neurological monitoring**, such as of intracranial pressure. Also, there are special patient monitors which incorporate the monitoring of brain waves (electroencephalography), gas anesthetic concentrations, bispectral index (BIS), etc. They are usually incorporated into anesthesia machines. In neurosurgery intensive care units, brain EEG monitors have a larger multichannel capability and can monitor other physiological events, as well.
- **Blood glucose monitoring**
- **Childbirth monitoring**
- **Body temperature monitoring** through an adhesive pad containing a thermoelectric transducer.

Vital parameters

- Monitoring of vital parameters can include several of the ones mentioned above, and most commonly include at least blood pressure and heart rate, and preferably also pulse oximetry and respiratory rate.
- Multimodal monitors that simultaneously measure and display the relevant vital parameters are commonly integrated into the bedside monitors in critical care units, and the anesthetic machines in operating rooms.
- These allow for continuous monitoring of a patient, with medical staff being continuously informed of the changes in general condition of a patient.

- Some monitors can even warn of pending fatal cardiac conditions before visible signs are noticeable to clinical staff, such as atrial fibrillation or premature ventricular contraction (PVC).

Medical monitor

- A medical monitor or physiological monitor is a medical device used for monitoring.
- It can consist of one or more sensors, processing components, display devices (which are sometimes in themselves called "monitors"), as well as communication links for displaying or recording the results elsewhere through a monitoring network.

Components

Sensor

Sensors of medical monitors include biosensors and mechanical sensors.

Translating component

The translating component of medical monitors is responsible for converting the signals from the sensors to a format that can be shown on the display device or transferred to an external display or recording device.

Display device

- Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis,
- They may be accompanied by numerical readouts of computed parameters on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on.
- Modern medical display devices commonly use digital signal processing (DSP), which has the advantages of miniaturization, portability, and multi-parameter displays that can track many different vital signs at once.
- Old analog patient displays, in contrast, were based on oscilloscopes, and had one channel only, usually reserved for electrocardiographic monitoring (ECG).
- Therefore, medical monitors tended to be highly specialized. One monitor would track a patient's blood pressure, while another would measure pulse oximetry, another the ECG.
- Later analog models had a second or third channel displayed in the same screen, usually to monitor respiration movements and blood pressure.
- These machines were widely used and saved many lives, but they had several restrictions, including sensitivity to electrical interference, base level fluctuations and absence of numeric readouts and alarms.

Communication links

- Several models of multi-parameter monitors are networkable, i.e., they can send their output to a central ICU monitoring station, where a single staff member can observe and respond to several bedside monitors simultaneously.
- Ambulatory telemetry can also be achieved by portable, battery-operated models which are carried by the patient and which transmit their data via a wireless data connection.
- Digital monitoring has created the possibility, which is being fully developed, of integrating the physiological data from the patient monitoring networks into the emerging hospital electronic health record and digital charting systems.
- This newer method of charting patient data reduces the likelihood of human documentation error and will eventually reduce overall paper consumption.
- In addition, automated ECG interpretation incorporates diagnostic codes automatically into the charts.
- Medical monitor's embedded software can take care of the data coding according to these standards and send messages to the medical records application, which decodes them and incorporates the data into the adequate fields.
- Long-distance connectivity can avail for telemedicine, which involves provision of clinical health care at a distance.

Other components

A medical monitor can also have the function to produce an alarm (such as using audible signals) to alert the staff when certain criteria are set, such as when some parameter exceeds of falls the level limits.

Mobile appliances

An entirely new scope is opened with mobile carried monitors, even such in sub-skin carriage. This class of monitors delivers information gathered in body-area networking (BAN) to e.g. smart phones and implemented autonomous agents.

Examples and applications

The development cycle in medicine is extremely long, up to 20 years, because of the need for U.S. Food and Drug Administration (FDA) approvals, therefore many of monitoring medicine solutions are not available today in conventional medicine.

Blood glucose monitoring

In vivo blood glucose monitoring devices can transmit data to a computer that can assist with daily life suggestions for lifestyle or nutrition and with the physician can make suggestions for further study in people who are at risk and help prevent diabetes mellitus type 2 .

Stress monitoring

Bio sensors may provide warnings when stress levels signs are rising before human can notice it and provide alerts and suggestions

Serotonin biosensor

Future serotonin biosensors may assist with mood disorders and depression.

Continuous blood test based nutrition

In the field of evidence-based nutrition, a lab-on-a-chip implant that can run 24/7 blood tests may provide a continuous results and a coumputer can provide nutritaion suggestions or alerts.

Psychiatrist-on-a-chip

In clinical brain sciences drug delivery and in vivo Bio-MEMS based biosensors may assist with preventing and early treatment of mental disorders

Epilepsy monitoring

In epilepsy, next generations of long-term video-EEG monitoring may predict epileptic seizure and prevent them with changes of daily life activity like sleep, stress, nutrition and mood management.

Toxicity monitoring

Smart biosensors may detect toxic materials such mercury and lead and provide alerts.

UNIT V
EXTRA CORPOREAL DEVICES AND SPECIAL DIAGNOSTIC TECHNIQUES

ENDOSCOPY

- Endoscopy means looking inside and typically refers to looking inside the body for medical reasons using an endoscope, an instrument used to examine the interior of a hollow organ or cavity of the body.
- Unlike most other medical imaging techniques, endoscopes are inserted directly into the organ.
- There are many different types of endoscope, and depending on the site in the body and the type of procedure, endoscopy may be performed by a doctor or a surgeon, and the patient may be fully conscious or anaesthetised.
- Most often the term endoscopy is used to refer to an examination of the upper part of the gastrointestinal tract, known as an esophagogastroduod enoscopy.

For non-medical use, similar instruments are called borescopes.

MEDICAL USES

A health care provider may use endoscopy for any of the following:

- investigation of symptoms, such as symptoms in the digestive system including nausea, vomiting, abdominal pain, difficulty swallowing and gastro intestinal bleeding.
- confirmation of a diagnosis, most commonly by performing a biopsy to check for conditions such as anemia, bleeding, inflammation, and cancers of the digestive system.
- giving treatment, such as cauterization of a bleeding vessel, widening a narrow esophagus, clipping off a polyp or removing a foreign object.

Specialty professional organizations which specialize in digestive problems advise that many patients with Barrett's esophagus are too frequently receiving endoscopies. Such societies recommend that patients with Barrett's esophagus and no cancer symptoms after two biopsies receive biopsies as indicated and no more often than the recommended rate.

APPLICATIONS

Health care providers can use endoscopy to review any of the following body parts:

The gastrointestinal tract (GI tract):

- oesophagus, stomach and duodenum (esophagogastroduod enoscopy)
- small intestine (enteroscopy)
- large intestine/colon (colonoscopy, sigmoidoscopy)
- Magnification endoscopy
- bile duct
  - endoscopic retrograde cholangiopancreatography (ERCP), duodenoscope-assisted cholangiopancreatoscopy, intraoperative cholangioscopy
- rectum (rectoscopy) and anus (anoscopy), both also referred to as (proctoscopy)

- The respiratory tract
  - The nose (rhinoscopy)
  - The lower respiratory tract (bronchoscopy)
- The ear (otoscope)
- The urinary tract (cystoscopy)
- The female reproductive system (gynoscopy)
  - The cervix (colposcopy)
  - The uterus (hysteroscopy)
  - The fallopian tubes (falloposcopy)
- Normally closed body cavities (through a small incision):
  - The abdominal or pelvic cavity (laparoscopy)
  - The interior of a joint (arthroscopy)
  - Organs of the chest (thoracoscopy and mediastinoscopy)

Endoscopy is used for many procedures:

- During pregnancy
  - The amnion (amnioscopy)
  - The fetus (fetoscopy)
- Plastic surgery
- Panendoscopy (or triple endoscopy)
  - Combines laryngoscopy, esophagoscopy, and bronchoscopy
- Orthopedic surgery
  - Hand surgery, such as endoscopic carpal tunnel release
  - Knee surgery, such as anterior cruciate ligament reconstruction
  - Epidural space (Epiduroscopy)
  - Bursae (Bursectomy)
- Endodontic surgery
  - Maxillary sinus surgery
  - Apicoectomy
- Endoscopic endonasal surgery
- Endoscopic spinal surgery

An Endoscopy is a simple procedure which allows a doctor to look inside human bodies using an instrument called an endoscope. A cutting tool can be attached to the end of the endoscope, and the apparatus can then be used to perform surgery. This type of surgery is called Key hole surgery, and usually leaves only a tiny scar externally.

RISKS

- The main risks are infection, over-sedation, perforation, or a tear of the stomach or esophagus lining and bleeding.

- Although perforation generally requires surgery, certain cases may be treated with antibiotics and intravenous fluids.
- Bleeding may occur at the site of a biopsy or polyp removal.
- Such typically minor bleeding may simply stop on its own or be controlled by cauterisation. Seldom does surgery become necessary.
- Perforation and bleeding are rare during gastroscopy.
- Other minor risks include drug reactions and complications related to other diseases the patient may have.
- Consequently, patients should inform their doctor of all allergic tendencies and medical problems.
- Occasionally, the site of the sedative injection may become inflamed and tender for a short time. This is usually not serious and warm compresses for a few days are usually helpful.
- While any of these complications may possibly occur, it is good to remember that each of them occurs quite infrequently.

AFTER THE ENDOSCOPY

- After the procedure the patient will be observed and monitored by a qualified individual in the endoscopy room or a recovery area until a significant portion of the medication has worn off.
- Occasionally the patient is left with a mild sore throat, which may respond to saline gargles, or chamomile tea.
- It may last for weeks or not happen at all.
- The patient may have a feeling of distention from the insufflated air that was used during the procedure. Both problems are mild and fleeting.
- When fully recovered, the patient will be instructed when to resume their usual diet (probably within a few hours) and will be allowed to be taken home.
- Where sedation has been used, most facilities mandate that the patient be taken home by another person and that he or she not drive or handle machinery for the remainder of the day.
- Patients who have had an endoscopy without sedation are able to leave unassisted.

LAPROSCOPY

- **Laparoscopy** (from Ancient Greek (lapara), meaning "flank, side", and (skopeo), meaning "to see") is an operation performed in the abdomen or pelvis through small incisions (usually 0.5–1.5 cm) with the aid of a camera.

- It can either be used to inspect and diagnose a condition or to perform surgery.

TYPES

- There are two types of laparoscope:

  (1) a telescopic rod lens system, that is usually connected to a video camera (single chip or three chip), or

  (2) a digital laparoscope where a miniature digital video camera is placed at the end of the laparoscope, eliminating the rod lens system.

- The mechanism mentioned in the second type is mainly used to improve the image quality of flexible endoscopes replacing traditional fiberscopes.
- Nevertheless, laparoscopes are rigid endoscopes. The rigidness is required in clinical practice.
- The rod lens based laparoscopes are highly dominant in practice, due to their fine optical resolution (50 µm typically, dependant on the aperture size used in the objective lens), and the image quality can be better than the digital cameras if necessary.
- The second type is very rare in the laparoscope market and hospitals.

SURGERY

- The laparoscope allows doctors to perform both minor and complex surgeries with a few small cuts in the abdomen.
- There are a number of advantages to the patient with laparoscopic surgery versus an open procedure.
- These include reduced pain due to smaller incisions and hemorrhaging, and shorter recovery time.

GYNECOLOGICAL DIAGNOSIS

- In gynecology, diagnostic laparoscopy may be used to inspect the outside of the uterus, ovaries and fallopian tubes, for example in the diagnosis of female infertility.
- Usually, there is one incision near the navel and a second near to the pubic hairline.
- For gynecological diagnosis, a special type of laparoscope can be used, called a fertiloscope.
- A fertiloscope is modified to make it suitable for trans-vaginal application.
- A dye test may be performed to detect any blockage in the reproductive tract, wherein a dark blue dye is passed up through the cervix and is followed with the laparoscope through its passage out into the fallopian tubes to the ovaries.

ELECTRONIC MONITORING OF FUNCTIONAL PARAMETER

- In medicine, **monitoring** is the observation of a disease, condition or one or several medical parameters over time.
- It can be performed by continuously measuring certain parameters by using a **medical monitor** (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests (such as blood glucose monitoring with a glucose meter in people with diabetes mellitus).
- Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry.

Monitoring can be classified by the target of interest, including:

- **Cardiac monitoring**, which generally refers to continuous electrocardiography with assessment of the patients condition relative to their cardiac rhythm. A small monitor worn by an ambulatory patient for this purpose is known as a Holter monitor. Cardiac monitoring can also involve cardiac output monitoring via an invasive Swan-Ganz catheter.
- **Hemodynamic monitoring**, which monitors the blood pressure and blood flow within the circulatory system. Blood pressure can be measured either invasively through an inserted blood pressure transducer assembly, or noninvasively with an inflatable blood pressure cuff.
- **Respiratory monitoring**, such as:
  - Pulse oximetry which involves measurement of the saturated percentage of oxygen in the blood, referred to as SpO2, and measured by an infrared finger cuff
  - Capnography, which involves CO_2 measurements, referred to as EtCO2 or end-tidal carbon dioxide concentration. The respiratory rate monitored as such is called AWRR or airway respiratory rate)
  - Respiratory rate monitoring through a thoracic transducer belt, an ECG channel or via capnography
- **Neurological monitoring**, such as of intracranial pressure. Also, there are special patient monitors which incorporate the monitoring of brain waves (electroencephalography), gas anesthetic concentrations, bispectral index (BIS), etc. They are usually incorporated into anesthesia machines. In neurosurgery intensive care units, brain EEG monitors have a larger multichannel capability and can monitor other physiological events, as well.
- **Blood glucose monitoring**
- **Childbirth monitoring**
- **Body temperature monitoring** through an adhesive pad containing a thermoelectric transducer.

VITAL PARAMETERS

- Monitoring of vital parameters can include several of the ones mentioned above, and most commonly include at least blood pressure andheart rate, and preferably also pulse oximetry and respiratory rate.

- Multimodal monitors that simultaneously measure and display the relevant vital parameters are commonly integrated into the bedside monitors in critical care units, and the anesthetic machines in operating rooms.
- These allow for continuous monitoring of a patient, with medical staff being continuously informed of the changes in general condition of a patient.
- Some monitors can even warn of pending fatal cardiac conditions before visible signs are noticeable to clinical staff, such as atrial fibrillation or premature ventricular contraction (PVC).

MEDICAL MONITOR

- A medical monitor or physiological monitor is a medical device used for monitoring. It can consist of one or more sensors, processing components, display devices (which are sometimes in themselves called "monitors"), as well as communication links for displaying or recording the results elsewhere through a monitoring network.

COMPONENTS

Sensor

Sensors of medical monitors include biosensors and mechanical sensors.

Translating component

The translating component of medical monitors is responsible for converting the signals from the sensors to a format that can be shown on the display device or transferred to an external display or recording device.

Display device

- Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis, They may be accompanied by numerical readouts of computed parameters on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on.
- Besides the tracings of physiological parameters along time (X axis), digital medical displays have automated numeric readouts of the peak and/or average parameters displayed on the screen.
- Modern medical display devices commonly use digital signal processing (DSP), which has the advantages of miniaturization, portability, and multi-parameter displays that can track many different vital signs at once.
- Old analog patient displays, in contrast, were based on oscilloscopes, and had one channel only, usually reserved for electrocardiographic monitoring (ECG).
- Therefore, medical monitors tended to be highly specialized. One monitor would track a patient's blood pressure, while another would measure pulse oximetry, another the ECG.
- Later analog models had a second or third channel displayed in the same screen, usually to monitor respiration movements and blood pressure.

- These machines were widely used and saved many lives, but they had several restrictions, including sensitivity to electrical interference, base level fluctuations and absence of numeric readouts and alarms.

Communication links

- Several models of multi-parameter monitors are networkable, i.e., they can send their output to a central ICU monitoring station, where a single staff member can observe and respond to several bedside monitors simultaneously.
- Ambulatory telemetry can also be achieved by portable, battery-operated models which are carried by the patient and which transmit their data via a wireless data connection.
- Digital monitoring has created the possibility, which is being fully developed, of integrating the physiological data from the patient monitoring networks into the emerging hospital electronic health record and digital charting systems, using appropriate health care standards .
- This newer method of charting patient data reduces the likelihood of human documentation error and will eventually reduce overall paper consumption.
- In addition,automated ECG interpretation incorporates diagnostic codes automatically into the charts.
- Medical monitor's embedded software can take care of the data coding according to these standards and send messages to the medical records application, which decodes them and incorporates the data into the adequate fields.
- Long-distance connectivity can avail for telemedicine, which involves provision of clinical health care at a distance.

Other components

- A medical monitor can also have the function to produce an alarm (such as using audible signals) to alert the staff when certain criteria are set, such as when some parameter exceeds of falls the level limits.

Mobile appliances

- An entirely new scope is opened with mobile carried monitors, even such in sub-skin carriage. This class of monitors delivers information gathered in body-area networking (BAN) to e.g. smart phones and implemented autonomous agents.

THERMOGRAPHY– APPLICATION

- **Infrared thermography (IRT)**, **thermal imaging**, and **thermal video** are examples of infrared imaging science.

- Thermographic cameras usually detect radiation in the long-infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 µm) and produce images of that radiation, called **thermograms**.
- Since infrared radiation is emitted by all objects with a temperature above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination.
- The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature.
- When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night.
- As a result, thermography is particularly useful to the military and other users of surveillance cameras.
- Some physiological changes in human beings and other warm-blooded animals can also be monitored with thermal imaging during clinical diagnostics.
- Thermography is used in allergy detection and veterinary medicine.
- It is also used for breast screening, though primarily by alternative practitioners as it is considerably less accurate and specific than competing techniques.
- Government and airport personnel used thermography to detect suspected swine flu cases during the 2009 pandemic.
- Thermography has a long history, although its use has increased dramatically with the commercial and industrial applications of the past fifty years.
- Firefighters use thermography to see through smoke, to find persons, and to localize the base of a fire.
- Maintenance technicians use thermography to locate overheating joints and sections of power lines, which are a sign of impending failure.
- Building construction technicians can see thermal signatures that indicate heat leaks in faulty thermal insulation and can use the results to improve the efficiency of heating and air-conditioning units.
- The appearance and operation of a modern thermographic camera is often similar to a camcorder. Often the live thermogram reveals temperature variations so clearly that a photograph is not necessary for analysis.

Advantages of thermography

- It shows a visual picture so temperatures over a large area can be compared
- It is capable of catching moving targets in real time
- It can be used to find defects in shafts, pipes, and other metal or plastic parts
- It can be used to detect objects in dark areas
- It has some medical application, essentially in kinesiotherapy

Limitations and disadvantages of thermography

- Many models do not provide the irradiance measurements used to construct the output image; the loss of this information without a correct calibration for emissivity, distance, and ambient temperature and relative humidity entails that the resultant images are inherently incorrect measurements of temperature

- Images can be difficult to interpret accurately when based upon certain objects, specifically objects with erratic temperatures, although this problem is reduced in active thermal imaging
- Accurate temperature measurements are hindered by differing emissivities and reflections from other surfaces.
- Most cameras have ±2% accuracy or worse in measurement of temperature and are not as accurate as contact methods
- Only able to directly detect surface temperatures

Applications

- Condition monitoring
- Digital infrared thermal imaging in health care
- Medical imaging
- Neuro musculo skeletal disorders.
- Thyroid gland abnormalities.
- Various other neoplastic, metabolic, and inflammatory conditions.
- Night vision and Targeting
- UAV Surveillance.
- Research
- Surveillance in security, law enforcement and defence

MEDICAL IMAGING Application

- Primarily used for breast imaging. There are three approaches: tele-thermography, contact thermography and dynamic angiothermography.
- These digital infrared imaging thermographic techniques are based on the principle that metabolic activity and vascular circulation in both pre-cancerous tissue and the area surrounding a developing breast cancer is almost always higher than in normal breast tissue.
- Cancerous tumors require an ever-increasing supply of nutrients and therefore increase circulation to their cells by holding open existing blood vessels, opening dormant vessels, and creating new ones (neo-angiogenesis theory).

Tele-thermography and contact thermography supporters claim this process results in an increase in regional surface temperatures of the breast, however there is little evidence that thermography is an accurate means of identifying breast tumours.

- Thermography is not approved for breast cancer screening in the United States or Canada, and medical authorities have issued warnings against thermography in both countries.

- Dynamic angiothermography utilizes thermal imaging but with important differences with the tele-thermography and contact thermography, that impact detection performance.
- First, the probes are improved over the previous liquid crystal plates; they include better spatial resolution, contrastive performance, and the image is formed more quickly.
- The more significant difference lies in identifying the thermal changes due to changes in vascular network to support the growth of the tumor/lesion.
- Instead of just recording the change in heat generated by the tumor, the image is now able to identify changes due to the vascularization of the mammary gland. It is currently used in combination with other techniques for diagnosis of breast cancer. This diagnostic method is a low cost one compared with other techniques.
- The angiothermography is not a test that substitutes for other tests, but stands in relation to them as a technique that gives additional information to clarify the clinical picture and improve the quality

Electronic and LC (liquid crystal) contact thermography

- Also by contact measurement the temperatures of the skin can be recorded. There have been electronic thermometers (thermistor or thermo couple devices for punctual registration in use as well as plates including encapsuled LC (liquid cholesterol crystals)for two -dimensional area covering.
- These devices are of historic interest and have been used as long as infrared cameras were extremely expensive and in early stages of development.
- They have a lot of disadvantages such as interfering with the measured object by contact.

Recently used infrared cameras for medical examinations:

- Together with the advanced microelectronic development infrared cameras recently achieve major advantages.
- While still the cooled MCT scanner must be called the gold standard, it is a slowly recording (1 Hz) and therefore not a real time imaging system.
- Modern scanners like the Jenoptik VarioScan HR have brilliant, clear, noise and pixel error free images with a high resolution and best stability, reproducibility, sensitivity (better than 30 mK) and avoidance of any thermal drift.

PRINCIPLES OF CRYOGENIC TECHNIQUE AND APPLICATION

- Cryogenics is the study and use of materials at extremely low temperatures.
- Such low temperatures cause changes in the physical properties of materials that allow them to be used in unusual engineering, industrial, and medical applications.

- For example, in the cryogenic temperature range, air becomes a liquid or even a solid and living tissue freezes instantly.
- Matter behaves strangely at the lowest temperatures of the cryogenic range.
- Electric currents never stop flowing, liquids run uphill, and rubber becomes as brittle as glass.
- In medicine, cryogenic cooling is used in some diagnostic techniques, such as **magnetic resonance imaging** (MRI).
- Cryosurgery uses liquid nitrogen to kill unhealthy tissue by freezing it.
- Cryogenics is expected to play an important role in the development of better procedures for preserving human organs for **transplant.**

The Cooling Process

- A substance is normally cooled by placing it next to something colder.
- To make the substance supercold, however, heat must also be removed and the substance must be insulated (encased).
- An important method of cryogenic supercooling involves liquefying gases and using these gases to cool other substances.
- One technique is to convert to liquid form a gas that can be liquefied by pressure alone.
- Then a gas requiring a lower temperature to become a liquid is placed in a container and immersed (dipped) in the first.
- The gas that is already liquefied cools the second and converts it to a liquid.
- After several repetitions of this process, the targeted gas is liquefied.
- A Dewar flask is normally used to store such very low temperature liquefied gases.
- If the disorderly spin of electrons in a substance could be slowed down, then the substance would cool down.
- In cooling by demagnetization, a strong magnetic force is used to give the outside energy required to line up the molecules of a paramagnetic substance (one made up of paramagnetic ions). This also raises the temperature. At the same time the substance is cooled in liquid helium. When the substance cools down to its starting temperature, the magnetic field is removed.
- This causes the ions to resume their disorderly alignment (order). The energy the ions use to move comes from the heat energy of the substance, which causes the temperature of the substance to drop.
- Liquid nitrogen is one of the safest cooling agents available. In medicine it is used to kill unhealthy tissues by freezing them. Cryogenic processes are also used to supply "banks" storing eye corneas, blood, and sperm for future surgical procedures. Some embryos have also been frozen and stored for later implantation (surgical placement) in women.

Cryosurgery

- Cryosurgery is relatively bloodless because the low temperatures used constrict the blood vessels, stemming the flow.
- Special instruments are used that have freezing tips to kill the damaged tissue and shields to protect surrounding tissue.
- Cooper used cryosurgery to freeze and destroy damaged tissue in the brains of patients with Parkinson's disease (a degenerative illness).
- Since then, cryosurgery has found many applications. It is used to repair detached retinas and to remove cataracts.
- It is also used to treat liver cancer and prostate cancer.
- Cryosurgery is also widely used in the fields of dermatology, gynecology, plastic surgery, orthopedics, and podiatry.
- Cryosurgery has also been used successfully for more than 30 years in veterinary medicine.

OPHTHALMIC INSTRUMENTS

- A **retractor** is a surgical instrument with which a surgeon can either actively separate the edges of a surgical incision or wound, or can hold back underlying organs and tissues, so that body parts under the incision may be accessed.
- The two are each available in many shapes, sizes, and styles.
- The general term retractor usually describes a simple handheld steel tool possessing a curved, hooked, or angled blade fitted with a comfortable handle, that when in place maintains the desired position of a given region of tissue.
- These simple retractors may be handheld, clamped in situ, or suspended at the end of a robotic arm.
- Retractors can also be self retaining and not need to be held once inserted by having two or more opposing blades or hooks which are separated via spring, ratchet, worm gear or some other method and pull on opposite sides of a wound.
- The term retractor is also used to describe the distinct, hand-cranked devices such as rib spreaders (also known as thoracic retractors, or distractors) with which surgeons may forcefully drive tissues apart to obtain the exposure.
- For specialized situations such as spinal surgery retractors have been fitted both with suction and with fiberoptic lights to keep a surgical wound dry and illuminated.

Retinoscopy (Ret) is a technique to obtain an objective measurement of the refractive error of a patient's eyes. The examiner uses a **retinoscope** to shine light into the patient's eye and observes the reflection (reflex) off the patient's retina.

- While moving the streak or spot of light across the pupil the examiner observes the relative movement of the reflex or manually places lenses over the eye (using a trial frame and trial lenses) to "neutralize" the reflex.
- Static retinoscopy is a type of retinoscopy used in determining a patient's refractive error. It relies on Foucault's principle, which states that the examiner should simulate optical infinity to obtain the correct refractive power.
- Hence, a power corresponding to the working distance is subtracted from the gross retinoscopy value to give the patient's refractive condition, the working distance lens being one which has a focal length of the examiner's distance from the patient (e.g. +1.50 dioptre lens for a 67 cm working distance).
- Myopes display an "against" reflex, which means that the direction of movement of light observed from the retina is a different direction to that in which the light beam is swept.
- Hyperopes, on the other hand, display a "with" movement, which means that the direction of movement of light observed from the retina is the same as that in which the light beam is swept.
- Static retinoscopy is performed when the patient has relaxed accommodative status.
- This can be obtained by the patient viewing a distance target or by the use of cycloplegic drugs (where, for example, a child's lack of reliable fixation of the target can lead to fluctuations in accommodation and thus the results obtained).
- Dynamic retinoscopy is performed when the patient has active accommodation from viewing a near target.
- Retinoscopy is particularly useful in prescribing corrective lenses for patients who are unable to undergo a subjective refraction that requires a judgement and response from the patient (such as children or those with severe intellectual disabilities or communication problems).
- In most tests however, it is used as a basis for further refinement by subjective refraction. It is also used to evaluate accommodative ability of the eye and detect latent hyperopia

Intraocular lens (IOL) is a lens implanted in the eye used to treat cataracts or myopia.

- The most common type of IOL is the pseudophakic IOL. These are implanted during cataract surgery, after the cloudy crystalline lens (otherwise known as a cataract) has been removed.
- The pseudophakic IOL replaces the original crystalline lens, and provides the light focusing function originally undertaken by the crystalline lens.
- The second type of IOL, more commonly known as a phakic intraocular lens (PIOL), is a lens which is placed over the existing natural lens, and is used in refractive surgery to change the eye's optical power as a treatment for myopia, or nearsightedness.
- IOLs usually consist of a small plastic lens with plastic side struts, called haptics, to hold the lens in place within the capsular bag inside the eye.
- IOLs were conventionally made of an inflexible material (PMMA), although this has largely been superseded by the use of flexible materials.Most IOLs fitted today are fixed monofocal lenses matched to distance vision.
- However, other types are available, such as multifocal IOLs which provide the patient with multiple-focused vision at far and reading distance, and adaptive IOLs which provide the patient with limited visual accommodation.
- Insertion of an intraocular lens for the treatment of cataracts is the most commonly performed eye surgical procedure.
- Surgeons annually implant more than 6 million lenses.
- The procedure can be done under local anesthesia with the patient awake throughout the operation.
- The use of a flexible IOL enables the lens to be rolled for insertion into the capsule through a very small incision, thus avoiding the need for stitches, and this procedure usually takes less than 30 minutes in the hands of an experienced ophthalmologist.
- The recovery period is about 2–3 weeks. After surgery, patients should avoid strenuous exercise or anything else that significantly increases blood pressure.
- They should also visit their ophthalmologists regularly for several months so as to monitor the implants.
- IOL implantation carries several risks associated with eye surgeries, such as infection, loosening of the lens, lens rotation, inflammation and night time halos, but a systematic review of studies has determined that the procedure is safer than conventional laser eye treatment. Though IOLs enable many patients to have reduced dependence on glasses, most patients still rely on glasses for certain activities, such as reading.

UNIT I

CARDIAC EQUIPMENT

HEART RATE MONITOR

- A **heart rate monitor** is a personal monitoring device that allows one to measure one's heart rate in real time or record the heart rate for later study.
- It is largely used by performers of various types of physical exercise.

History

- Early models consisted of a monitoring box with a set of electrode leads which attached to the chest.
- The first wireless EKG heart rate monitor was invented in 1977 by Seppo Säynäjäkangas, founder of Polar Electro, as a training aid for the Finnish National Cross Country Ski team.
- As 'intensity training' became a popular concept in athletic circles in the mid-80s, retail sales of wireless personal heart monitors started from 1983.

Composition

- Modern heart rate monitors usually comprise two elements: a chest strap transmitter and a wrist receiver (which usually doubles as a watch) or mobile phone.
- In early plastic straps, water or liquid was required to get good performance. Later units have used conductive smart fabric with built-in microprocessors that analyze the EKG signal to determine heart rate.
- More recent devices utilise optics to measure heart rate using Infrared light.This is achieved by production of infrared light by an internal bulb, as Infrared light is absorbed by the blood, a sensor measures the amount that the infrared light is darkened by.
- If it is significantly darker, due the pulse causing a temporary increase in the amount of blood that is travelling through the measured area, that is counted as a pulse.
- Strapless heart rate monitors (often referred to as "wearables") now allow the user to just touch two sensors on a wristwatch display for a few seconds to view heart rate data.
- These are popular for comfort and ease of use, though they don't give as much detail as monitors that use a chest strap.
- Some models of these variations of heart rate monitors utilise an infrared sensor to measure the heart rate, as opposed to two electrodes.

- More advanced models offer measurements of heart rate variability, activity, and breathing rate to assess parameters relating to a subject's fitness. Sensor fusion algorithms allow these monitors to detect core temperature and dehydration.
- Another style of heart rate monitor replaces the plastic around-the-chest strap with fabric sensors - the most common of these is a sports bra for women that includes sensors in the fabric.

In old versions, when a heart beat is detected a radio signal is transmitted, which the receiver uses to determine the current heart rate.

- This signal can be a simple radio pulse or a unique coded signal from the chest strap (such as Bluetooth, ANT, or other low-power radio link); the latter prevents one user's receiver from using signals from other nearby transmitters (known as cross-talk interference).

Newer versions include a microprocessor, which is continuously monitoring the EKG and calculating the heart rate, and other parameters.

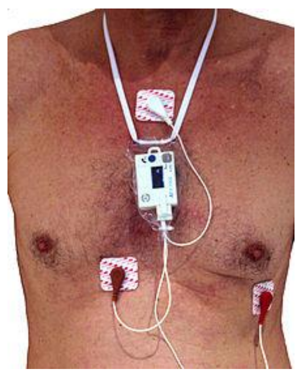
- These may include accelerometers that can detect speed and distance, eliminating the need for foot worn devices.
- There are a wide number of receiver designs, with various features.
- These include average heart rate over exercise period, time in a specific heart rate zone, calories burned, breathing rate, built-in speed and distance, and detailed logging that can be downloaded to a computer.
- The receiver can be built into a smartwatch or smartphone. Wrist bands with integrated sensor work optically, and have poor accuracy.

HOLTER MONITOR

- In medicine, a **Holter monitor** (often simply "Holter" or occasionally **ambulatory electrocardiography device**) is a portable device for continuously monitoring various electrical activity of the cardiovascular system for at least 24 hours (often for two weeks at a time).
- The Holter's most common use is for monitoring heart activity (electrocardiography or ECG). Its extended recording period is sometimes useful for observing occasional cardiac arrhythmias which would be difficult to identify in a shorter period of time.
- For patients having more transient symptoms, a cardiac event monitor which can be worn for a month or more can be used.

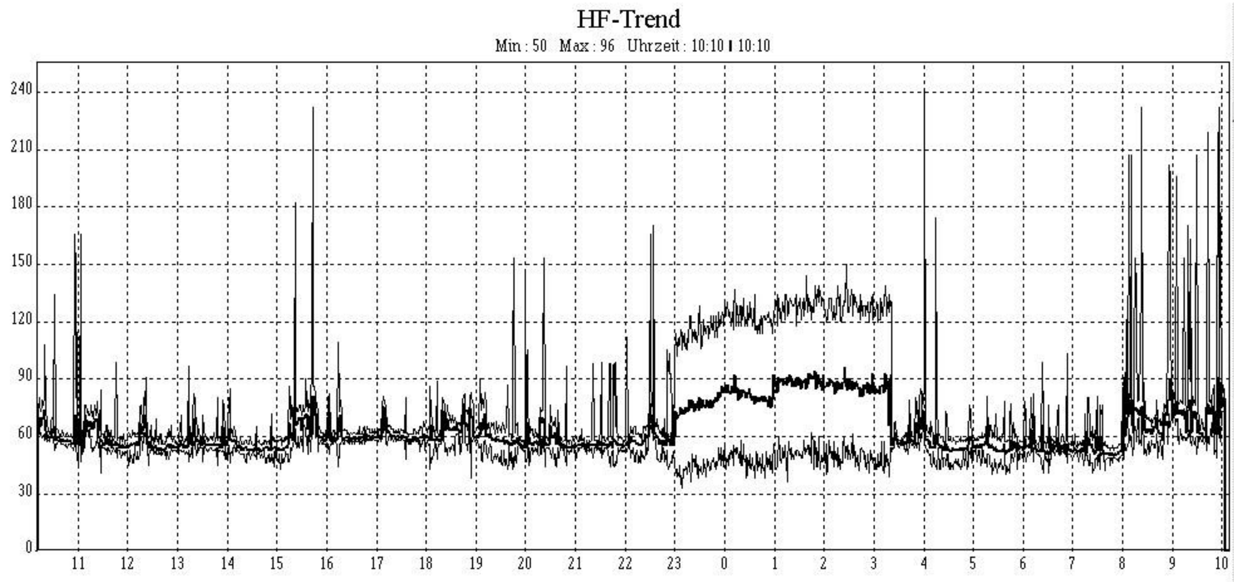
The Holter monitor was developed at the Holter Research Laboratory in Helena Montana by experimental physicists Norman J. Holter and Bill Glasscock, who started work on radio telemetry in 1949.

- When used to study the heart, much like standard electrocardiography, the Holter monitor records electrical signals from the heart via a series of electrodes attached to the chest. Electrodes are placed over bones to minimize artifacts from muscular activity.
- The number and position of electrodes varies by model, but most Holter monitors employ between three and eight.
- These electrodes are connected to a small piece of equipment that is attached to the patient's belt or hung around the neck, keeping a log of the heart's electrical activity throughout the recording period.



Inventor	Norman Holter and Bill Glasscock at Holter Research Laboratory

Atrial fibrillation recorded by a Holter monitor



Data storage

- Older devices used reel to reel tapes or a standard C90 or C120 audio cassette and ran at a 1.7 mm/s or 2 mm/s speed to record the data.
- Once a recording was made, it could be played back and analyzed at 60x speed so 24 hours of recording could be analyzed in 24 minutes.
- More modern units record an EDF-file onto digital flash memory devices. The data is uploaded into a computer which then automatically analyzes the input, counting ECG complexes,
- calculating summary statistics such as average heart rate, minimum and maximum heart rate, and finding candidate areas in the recording worthy of further study by the technician.

Components

- Each Holter system consists of two basic parts – the hardware (called monitor or recorder) for recording the signal, and software for review and analysis of the record.
- Advanced Holter recorders are able to display the signal, which is very useful for checking the signal quality.
- Very often there is also a “patient button” located on the front site allowing the patient to press it in specific cases such as sickness, going to bed, taking pills…. A special mark will be then placed into the record so that the doctors or technicians can quickly pinpoint these areas when analyzing the signal.

Recorder

- The size of the recorder differs depending on the manufacturer of the device. The average dimensions of today's Holter monitors are about 110x70x30 mm but some are only 61x46x20 mm and weigh 99 g.
- Most of the devices operate with two AA batteries. In case the batteries are depleted, some Holters allow their replacement even during monitoring.
- Most of the Holters monitor the ECG just in two or three channels. Depending on the model (manufacturer), different counts of leads and lead systems are used.
- Today's trend is to minimize the number of leads to ensure the patient's comfort during recording. Although 2/3 channel recording has been used for a long time in the Holter monitoring history, recently 12 channel Holters have appeared.
- These systems use the classic Mason-Likar lead system, thus producing the signal in the same representation as during the common rest ECG and/or stress test measurement.
- These Holters then allow to substitute stress test examination in cases the stress test is not possible for the current patient.
- They are also suitable when analyzing patients after myocardial infarction. Recordings from these 12-lead monitors are of a significantly lower resolution than those from a standard 12-lead ECG and in some cases have been shown to provide misleading ST segment representation, even though some devices allow setting the sampling frequency up to 1000 Hz for special-purpose exams like the late potential.
- Another interesting innovation is the presence of a triaxial movement sensor, which records the patient physical activity, and later shows in the software three different statuses: sleeping, standing up, or walking.
- This helps the cardiologist to better analyze the recorded events belonging to the patient activity and diary. Holter monitoring is a very useful part of an ECG.
- Some modern devices also have the ability to record a vocal patient diary entry that can be later listened to by the doctor.

Analyzing software

- When the recording of ECG signal is finished (usually after 24 or 48 hours), it is up to the physician to perform the signal analysis.
- Since it would be extremely time demanding to browse through such a long signal, there is an integrated automatic analysis process in the software of each Holter device which automatically determines different sorts of heart beats, rhythms, etc.
- However the success of the automatic analysis is very closely associated with the signal quality. The quality itself mainly depends on the attachment of the electrodes to the patient body.

- If these are not properly attached, electromagnetic disturbance can influence the ECG signal resulting in a very noisy record.
- If the patient moves rapidly, the distortion will be even bigger. Such record is then very difficult to process. Besides the attachment and quality of electrodes, there are other factors affecting the signal quality, such as muscle tremors, sampling rate and resolution of the digitized signal (high quality devices offer higher sampling frequency).

The automatic analysis commonly provides the physician with information about heart beat morphology, beat interval measurement, heart rate variability, rhythm overview and patient diary (moments when the patient pressed the patient button).

- Advanced systems also perform spectral analysis, ischemic burden evaluation, graph of patient's activity or PQ segment analysis.
- Another requirement is the ability of pacemaker detection and analysis. Such ability is useful when one wants to check the correct pacemaker function.

History

- The cardiac event monitor has been used for over twenty years. At first, these devices were not portable and had to be used only in hospital buildings.
- Advances resulted in these devices becoming smaller but were still being used only in hospitals for twenty four to forty eight hours.
- Soon portable monitors were developed weighing at first thirty pounds, then 10 pounds, and 1 pound. Modern devices are much easier to wear, weighing only a fraction of a pound.

Procedure

- Although some patients may feel uncomfortable about a Holter examination, there is nothing to worry about. No hazards are involved, and it should have little effect on one's normal daily life.
- The recording device can be worn in a case on a belt or on a strap across the chest.
- The device may be visible under light clothing, and those wearing a Holter monitor may wish to avoid shirts with a low neckline.
- Persons being monitored should not limit normal daily activities,since its purpose is to record how a heart works under various actual conditions over an extended period.
- It is an electrical device, however, and should be kept dry; showering or swimming should probably be avoided.

- Monitors can be removed for a few minutes without invalidating collected data, but proper reattachment is critical to avoid degradation of its signals.
- Beyond changing batteries, one should leave its handling to trained personnel.

PLETHYSMOGRAPHY

A **plethysmograph** is an instrument for measuring changes in volume within an organ or whole body (usually resulting from fluctuations in the amount of blood or air it contains).

ORGANS STUDIED

Lungs

- Pulmonary plethysmographs are commonly used to measure the functional residual capacity (FRC) of the lungs—the volume in the lungs when the muscles of respiration are relaxed—and total lung capacity.
- In a traditional plethysmograph, the test subject is placed inside a sealed chamber the size of a small telephone booth with a single mouthpiece.
- At the end of normal expiration, the mouthpiece is closed.
- The patient is then asked to make an inspiratory effort. As the patient tries to inhale (a maneuver which looks and feels like panting), the lungs expand, decreasing pressure within the lungs and increasing lung volume.
- This, in turn, increases the pressure within the box since it is a closed system and the volume of the box compartment has decreased to accommodate the new volume of the subject.

Methodological Approach

- Boyle's Law is used to calculate the unknown volume within the lungs. First, the change in volume of the chest is computed.
- The initial pressure and volume of the box are set equal to the known pressure after expansion times the unknown new volume.
- Once the new volume is found, the original volume minus the new volume is the change in volume in the box and also the change in volume in the chest.
- With this information, Boyle's Law is used again to determine the original volume of gas in the chest: the initial volume (unknown) times the initial pressure is equal to the final volume times the final pressure.
- Starting from this principle, it can be shown]that the functional residual capacity is a function of the changes in volume and pressures as follows:

- The difference between full and empty lungs can be used to assess diseases and airway passage restrictions. An obstructive disease will show increased FRC because some airways do not empty normally, while a restrictive disease will show decreased FRC.
- Body plethysmography is particularly appropriate for patients who have air spaces which do not communicate with the bronchial tree; in such patients helium dilution would give an incorrectly low reading.
- Another important parameter, which can be calculated with a body plethysmograph is the airway resistance.
- During inhalation the chest expands, which increases the pressure within the box. While observing the so-called resistance loop (cabin pressure and flow), diseases can easily be recognized.
- If the resistance loop becomes planar, this shows a bad compliance of the lung. A COPD, for instance, can easily be discovered because of the unique shape of the corresponding resistance loop.

Limbs

- Some plethysmograph devices are attached to arms, legs or other extremities and used to determine circulatory capacity. In water plethysmography an extremity, e.g. an arm, is enclosed in a water-filled chamber where volume changes can be detected.
- Air plethysmography uses a similar principle but based on an air-filled long cuff, which is more convenient but less accurate.
- Another practical device is mercury-filled strain gauges used to continuously measure circumference of the extremity, e.g. at mid calf. Impedance plethysmography is a non-invasive method used to detect venous thrombosis in these areas of the body.

UNIT II

NEUROLOGICAL EQUIPMENT

CLINICAL SIGNIFICANCE OF EEG

A routine clinical EEG recording typically lasts 20–30 minutes (plus preparation time) and usually involves recording from scalp electrodes. Routine EEG is typically used in the following clinical circumstances:

- to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-corticalmovement disorders and migraine variants.
- to differentiate "organic" encephalopathy or delirium from primary psychiatric syndromes such as catatonia
- to serve as an adjunct test of brain death
- to prognosticate, in certain instances, in patients with coma
- to determine whether to wean anti-epileptic medications
- it can also be used to 'train' brains- particularly children's (or, I should say, find which areas of the brain require 'training' and then further EEGs are done, but only focusing on those certain areas). However this is not widely done, and many would travel to the USA for this treatment (but there are clinics in England etc. now)

At times, a routine EEG is not sufficient, particularly when it is necessary to record a patient while he/she is having a seizure.

- In this case, the patient may be admitted to the hospital for days or even weeks, while EEG is constantly being recorded (along with time-synchronized video and audio recording).
- A recording of an actual seizure (i.e., an ictal recording, rather than an inter-ictal recording of a possibly epileptic patient at some period between seizures) can give significantly better information about whether or not a spell is an epileptic seizure and the focus in the brain from which the seizure activity emanates.

Epilepsy monitoring is typically done:

- to distinguish epileptic seizures from other types of spells, such as psychogenic non-epileptic seizures, syncope (fainting), sub-cortical movement disorders and migrainevariants.

- to characterize seizures for the purposes of treatment
- to localize the region of brain from which a seizure originates for work-up of possible seizure surgery

Additionally, EEG may be used to monitor certain procedures:

- to monitor the depth of anesthesia
- as an indirect indicator of cerebral perfusion in carotid endarterectomy
- to monitor amobarbital effect during the Wada test

EEG can also be used in intensive care units for brain function monitoring:

- to monitor for non-convulsive seizures/non-convulsive status epilepticus
- to monitor the effect of sedative/anesthesia in patients in medically induced coma (for treatment of refractory seizures or increased intracranial pressure)
- to monitor for secondary brain damage in conditions such as subarachnoid hemorrhage (currently a research method)

  - If a patient with epilepsy is being considered for resective surgery, it is often necessary to localize the focus (source) of the epileptic brain activity with a resolution greater than what is provided by scalp EEG.
  - This is because the cerebrospinal fluid, skull and scalp smear the electrical potentials recorded by scalp EEG.
  - In these cases, neurosurgeons typically implant strips and grids of electrodes (or penetrating depth electrodes) under the dura mater, through either a craniotomy or a burr hole.
  - The recording of these signals is referred to as electrocorticography (ECoG), subdural EEG (sdEEG) or intracranial EEG (icEEG)--all terms for the same thing.
  - The signal recorded from ECoG is on a different scale of activity than the brain activity recorded from scalp EEG.
  - Low voltage, high frequency components that cannot be seen easily (or at all) in scalp EEG can be seen clearly in ECoG.
  - Further, smaller electrodes (which cover a smaller parcel of brain surface) allow even lower voltage, faster components of brain activity to be seen. Some clinical sites record from penetrating microelectrodes.
  - EEG may be done in all pediatric patients presenting with first onset a febrile or complex febrile seizures.
  - EEG is not indicated for diagnosing headache. Recurring headache is a common pain problem, and this procedure is sometimes used in a search for a diagnosis, but it has no advantage over routine clinical evaluation.

EVOKED POTENTIAL

- An **evoked potential** or **evoked response** is an electrical potential recorded from the nervous system of a human or other animal following presentation of a stimulus, as distinct from spontaneous potentials as detected by electroencephalography (EEG), electromyography (EMG),or other electrophysiologic recording method. Such potentials are useful for electrodiagnosis and monitoring.
- Evoked potential amplitudes tend to be low, ranging from less than a microvolt to several microvolts, compared to tens of microvolts for EEG, millivolts for EMG, and often close to a volt for ECG.
- To resolve these low-amplitude potentials against the background of ongoing EEG, ECG, EMG, and other biological signals and ambient noise, signal averaging is usually required.
- The signal is time-locked to the stimulus and most of the noise occurs randomly, allowing the noise to be averaged out with averaging of repeated responses.
- Signals can be recorded from cerebral cortex, brain stem, spinal cord and peripheral nerves.

Auditory evoked potential

- Auditory evoked potential can be used to trace the signal generated by a sound through the ascending auditory pathway.
- The evoked potential is generated in the cochlea, goes through the cochlear nerve, through the cochlear nucleus, superior olivary complex, lateral lemniscus, to the inferior colliculus in the midbrain, on to the medial geniculate body, and finally to the cortex.
- Auditory evoked potentials (AEPs) are a subclass of event-related potentials (ERP)s. ERPs are brain responses that are time-locked to some "event", such as a sensory stimulus, a mental event (such as recognition of a target stimulus), or the omission of a stimulus. For AEPs, the "event" is a sound.
- AEPs (and ERPs) are very small electrical voltage potentials originating from the brain recorded from the scalp in response to an auditory stimulus, such as different tones, speech sounds, etc.
- Brainstem auditory evoked potentials are small AEPs that are recorded in response to an auditory stimulus from electrodes placed on the scalp.

Somatosensory evoked potential

- Somatosensory Evoked Potentials (SSEPs) are used in neuromonitoring to assess the function of a patient's spinal cord during surgery.

- They are recorded by stimulating peripheral nerves, most commonly the tibial nerve, median nerve or ulnar nerve, typically with an electrical stimulus.
- The response is then recorded from the patient's scalp.
- Because of the low amplitude of the signal once it reaches the patient's scalp and the relatively high amount of electrical noise caused by background EEG, scalp muscle EMG or electrical devices in the room, the signal must be averaged.
- The use of averaging improves the signal-to-noise ratio. Typically, in the operating room, over 100 and up to 1,000 averages must be used to adequately resolve the evoked potential.
- The two most looked at aspects of an SSEP are the amplitude and latency of the peaks.
- Each peak is given a letter and a number in its name.
- For example, N20 refers to a negative peak (N) at 20ms.
- This peak is recorded from the cortex when the median nerve is stimulated.
- It most likely corresponds to the signal reaching the somatosensory cortex.
- When used in intraoperative monitoring, the latency and amplitude of the peak relative to the patient's post-intubation baseline is a crucial piece of information.
- Dramatic increases in latency or decreases in amplitude are indicators of neurological dysfunction.
- During surgery, the large amounts of anesthetic gases used can affect the amplitude and latencies of SSEPs.
- Any of the halogenated agents or nitrous oxide will increase latencies and decrease amplitudes of responses, sometimes to the point where a response can no longer be detected.
- For this reason, an anesthetic utilizing less halogenated agent and more intravenous hypnotic and narcotic is typically used.

Visual evoked potential

- In 1934, Adrian and Matthew noticed potential changes of the occipital EEG can be observed under stimulation of light.
- Ciganek developed the first nomenclature for occipital EEG components in 1961.

- Halliday and colleagues completed the first clinical investigations using VEP by recording delayed VEPs in a patient with retrobulbar neuritis in 1972.

VEP Stimuli

- The diffuse-light flash stimulus is rarely used nowadays due to the high variability within and across subjects.
- However, it is beneficial to use this type of stimulus when testing infants, animals or individuals with poor visual acuity.
- The checkerboard and grating patterns use light and dark squares and stripes, respectively.
- These squares and stripes are equal in size and are presented, one image at a time, via a computer screen.

VEP Electrode Placement

- Electrode placement is extremely important to elicit a good VEP response free of artifact.
- In a typical (one channel) setup, one electrode is placed 2.5 cm above the inion and a reference electrode is placed at Fz.
- For a more detailed response, two additional electrodes can be placed 2.5 cm to the right and left of Oz.

VEP Waves

- The VEP nomenclature is determined by using capital letters stating whether the peak is positive (P) or negative (N) followed by a number which indicates the average peak latency for that particular wave.
- For example, P50 is a wave with a positive peak at approximately 50 ms following stimulus onset.
- The average amplitude for VEP waves usually falls between 5 and 10 microvolts.

Types of VEP

- Monocular pattern reversal (most common)
- Sweep visual evoked potential
- Binocular visual evoked potential
- Chromatic visual evoked potential
- Flash visual evoked potential
- LED Goggle visual evoked potential

MEG (Magneto Encephalo Graph)

- **Magnetoencephalography** (**MEG**) is a functional neuroimaging technique for mapping brain activity by recording magnetic fieldsproduced by electrical currents occurring naturally in the brain, using very sensitive magnetometers.
- Arrays of SQUIDs(superconducting quantum interference devices) are currently the most common magnetometer, while the SERF (spin exchange relaxation-free) magnetometer is being investigated for future machines.
- Applications of MEG include basic research into perceptual and cognitive brain processes, localizing regions affected by pathology before surgical removal, determining the function of various parts of the brain, and neurofeedback.
- This can be applied in a clinical setting to find locations of abnormalities as well as in an experimental setting to simply measure brain activity.

History of MEG

- MEG signals were first measured by University of Illinois physicist David Cohen in 1968, before the availability of the SQUID, using a copper induction coil as the detector.
- To reduce the magnetic background noise, the measurements were made in a magnetically shielded room.
- The coil detector was barely sensitive enough, resulting in poor, noisy MEG measurements that were difficult to use.
- Later, Cohen built a better shielded room at MIT, and used one of the first SQUID detectors, just developed by James E. Zimmerman, a researcher at Ford Motor Company, to again measure MEG signals.
- This time the signals were almost as clear as those of EEG. This stimulated the interest of physicists who had been looking for uses of SQUIDs. Subsequent to this, various types of spontaneous and evoked MEGs began to be measured.
- At first, a single SQUID detector was used to successively measure the magnetic field at a number of points around the subject's head.
- This was cumbersome, and, in the 1980s, MEG manufacturers began to arrange multiple sensors into arrays to cover a larger area of the head.
- Present-day MEG arrays are set in helmet-shaped Vacuum flask that typically contain 300 sensors, covering most of the head. In this way, MEGs of a subject or patient can now be accumulated rapidly and efficiently.

- In 2012, it was demonstrated that MEG could work with a chip-scale atomic magnetometer (CSAM).

THE BASIC OF MEG SIGNAL

- Synchronized neuronal currents induce weak magnetic fields.
- The brain's magnetic field, measuring at 10 femtotesla (fT) for cortical activity and 10^3 fT for the human alpha rhythm, is considerably smaller than the ambient magnetic noise in an urban environment, which is on the order of 10^8 fT or 0.1 µT.
- The essential problem of biomagnetism is, thus, the weakness of the signal relative to the sensitivity of the detectors, and to the competing environmental noise.
- The MEG (and EEG) signals derive from the net effect of ionic currents flowing in the dendrites of neurons during synaptictransmission.
- In accordance with Maxwell's equations, any electrical current will produce a magnetic field, and it is this field that is measured.
- The net currents can be thought of as current dipoles, i.e. currents with a position, orientation, and magnitude, but no spatial extent.
- According to the right-hand rule, a current dipole gives rise to a magnetic field that points around the axis of its vector component.
- To generate a signal that is detectable, approximately 50,000 active neurons are needed.
- Since current dipoles must have similar orientations to generate magnetic fields that reinforce each other, it is often the layer of pyramidal cells, which are situated perpendicular to the cortical surface, that gives rise to measurable magnetic fields.
- Bundles of these neurons that are orientated tangentially to the scalp surface project measurable portions of their magnetic fields outside of the head, and these bundles are typically located in the sulci.
- Researchers are experimenting with various signal processing methods in the search for methods that detect deep brain (i.e., non-cortical) signal, but no clinically useful method is currently available.
- It is worth noting that action potentials do not usually produce an observable field, mainly because the currents associated with action potentials flow in opposite directions and the magnetic fields cancel out.
- However, action fields have been measured from peripheral nerves.

MEG USE IN THE FIELD

- In research, MEG's primary use is the measurement of time courses of activity.
- MEG can resolve events with a precision of 10 milliseconds or faster, while functional MRI (fMRI), which depends on changes in blood flow, can at best resolve events with a precision of several hundred milliseconds.
- MEG also accurately pinpoints sources in primary auditory, somatosensory, and motor areas.
- For creating functional maps of human cortex during more complex cognitive tasks, MEG is most often combined with fMRI, as the methods complement each other. Neuronal (MEG) and hemodynamic (fMRI) data do not necessarily agree, in spite of the tight relationship between local field potentials (LFP) and blood oxygenation level-dependent (BOLD) signals.
- MEG and BOLD signals may originate from the same source (though the BOLD signals are filtered through the hemodynamic response).
- MEG is also being used to better localize responses in the brain. The openness of the MEG setup allows external auditory and visual stimuli to be easily introduced.
- Some movement by the subject is also possible as long as it does not jar the subject's head. The responses in the brain before, during, and after the introduction of such stimuli/movement can then be mapped with greater spatial resolution than was previously possible with EEG.
- Psychologists are also taking advantage of MEG neuroimaging to better understand relationships between brain function and behavior.
- For example, a number of studies have been done comparing the MEG responses of patients with psychological troubles to control patients.
- There has been great success isolating unique responses in patients with schizophrenia, such as auditory gating deficits to human voices.
- MEG is also being used to correlate standard psychological responses, such as the emotional dependence of language comprehension
- Recent studies have reported successful classification of patients with multiple sclerosis, Alzheimer's disease, schizophrenia, Sjögren's syndrome, chronic alcoholism, and facial pain.
- MEG can be used to distinguish these patients from healthy control subjects, suggesting a future role of MEG in diagnostics.

Focal epilepsy

- The clinical uses of MEG are in detecting and localizing pathological activity in patients with epilepsy, and in localizing eloquent cortex for surgical planning in patients with brain tumors or intractable epilepsy.
- The goal of epilepsy surgery is to remove the epileptogenic tissue while sparing healthy brain areas.
- Knowing the exact position of essential brain regions (such as the primary motor cortex and primary sensory cortex, visual cortex, and areas involved in speech production and comprehension) helps to avoid surgically induced neurological deficits.
- Direct cortical stimulation and somatosensory evoked potentials recorded on ECoG are considered the gold standard for localizing essential brain regions.
- These procedures can be performed either intraoperatively or from chronically indwelling subdural grid electrodes. Both are invasive.
- Noninvasive MEG localizations of the central sulcus obtained from somatosensory evoked magnetic fields show strong agreement with these invasive recordings.
- MEG studies assist in clarification of the functional organization of primary somatosensory cortex and to delineate the spatial extent of hand somatosensory cortex by stimulation of the individual digits.
- This agreement between invasive localization of cortical tissue and MEG recordings shows the effectiveness of MEG analysis and indicates that MEG may substitute invasive procedures in the future.

Fetal MEG

- MEG has been used to study cognitive processes such as vision, audition, and language processing in fetuses and newborns.

EEG BIO FEEDBACK INSTRUMENTATION

- **Biofeedback** is the process of gaining greater awareness of many physiological functions primarily using instruments that provide information on the activity of those same systems, with a goal of being able to manipulate them at will.
- Some of the processes that can be controlled include brainwaves, muscle tone, skin conductance, heart rate and pain perception.
- Biofeedback may be used to improve health, performance, and the physiological changes that often occur in conjunction with changes to thoughts, emotions, and behavior.

Eventually, these changes may be maintained without the use of extra equipment, for no equipment is necessarily required to practice biofeedback.

Biofeedback has been found to be effective for the treatment of headaches and migraines.

- An electroencephalograph (EEG) measures the electrical activation of the brain from scalp sites located over the human cortex.
- The EEG shows the amplitude of electrical activity at each cortical site, the amplitude and relative power of various wave forms at each site, and the degree to which each cortical site fires in conjunction with other cortical sites (coherence and symmetry).
- The EEG uses precious metal electrodes to detect a voltage between at least two electrodes located on the scalp.
- The EEG records both excitatory postsynaptic potentials (EPSPs) and inhibitory postsynaptic potentials (IPSPs) that largely occur in dendrites in pyramidal cells located in macrocolumns,
- several millimeters in diameter, in the upper cortical layers. Neurofeedback monitors both slow and fast cortical potentials.
- Slow cortical potentials are gradual changes in the membrane potentials of cortical dendrites that last from 300 ms to several seconds.
- These potentials include the contingent negative variation (CNV), readiness potential, movement-related potentials (MRPs), and P300 and N400 potentials.[32]
- Fast cortical potentials range from 0.5 Hz to 100 Hz.
- The main frequency ranges include delta, theta, alpha, the sensorimotor rhythm, low beta, high beta, and gamma.
- The thresholds or boundaries defining the frequency ranges vary considerably among professionals.
- Fast cortical potentials can be described by their predominant frequencies, but also by whether they are synchronous or asynchronous wave forms. Synchronous wave forms occur at regular periodic intervals, whereas asynchronous wave forms are irregular.
- The synchronous **delta rhythm** ranges from 0.5 to 3.5 Hz. Delta is the dominant frequency from ages 1 to 2, and is associated in adults with deep sleep and brain pathology like trauma and tumors, and learning disability.
- The synchronous **theta rhythm** ranges from 4 to 7 Hz. Theta is the dominant frequency in healthy young children and is associated with drowsiness or starting to sleep, REM sleep, hypnagogic imagery (intense imagery experienced before the onset of sleep), hypnosis, attention, and processing of cognitive and perceptual information.
- The synchronous **alpha rhythm** ranges from 8 to 13 Hz and is defined by its waveform and not by its frequency. Alpha activity can be observed in about 75% of awake, relaxed individuals and is replaced by low-amplitude desynchronized beta activity during movement, complex problem-solving, and visual focusing. This phenomenon is called alpha blocking.
- The synchronous **sensorimotor rhythm** (SMR) ranges from 12 to 15 Hz and is located over the sensorimotor cortex (central sulcus). The sensorimotor rhythm is associated with the inhibition of movement and reduced muscle tone.

- The beta rhythm consists of asynchronous waves and can be divided into low beta and high beta ranges (13–21 Hz and 20–32 Hz). Low beta is associated with activation and focused thinking. High beta is associated with anxiety, hypervigilance, panic, peak performance, and worry.
- EEG activity from 36 to 44 Hz is also referred to as gamma. Gamma activity is associated with perception of meaning and meditative awareness.
- Neurotherapists use EEG biofeedback when treating addiction, attention deficit hyperactivity disorder (ADHD), learning disability, anxiety disorders (including worry, obsessive-compulsive disorder and posttraumatic stress disorder), depression, migraine, and generalized seizures.

Questions

Polarization occurs due to

In a dry cell, polarization

In electrochemical cell movement of ions is inhibited by a

Conventionally, electrode potential refers to

In non-metals, half cells electricity is conducted via solution by

Standard electrode potential for any half-cell is measurement of

Which of the following cannot be used as secondary reference electrode?

Which of the following is known as calomel?

The biocatalytic membrane is attached to the glass electrode using which of the following materials?

Biocatalytic membrane electrode cannot be used for the measurement of which of the following gases?

Which of the following gas permeable membrane is used for ammonia gas sensing electrode?

Which of the following gas permeable membrane is used for carbon dioxide gas sensing electrode?

Which of the following is not the characteristic of a reference electrode?

Why is Standard hydrogen electrode called as the primary reference electrode?

Which of the following is the simple and most convenient hydrogen electrode?

More negative electrons (e^-) are attracted by more

Negative electrode in half cell is made up of

It is easier to reduce ion on left if electrode is

In carbon dioxide electrode, the membrane separates which of the following?

The biocatalytic membrane used in ammonia selective electrode is which of the following?

Which of the following is not the disadvantage of hydrogen electrode?

In Hydrogen electrode, the electrode is placed in a solution of ____ M Hcl. Fill in the blank.

Pure copper (Cu) rod in a solution of copper(II) sulfate ($CuSO_4$) solution constitutes the

Ordinary dry cells are used in

Half cells contain two ions of same element with different

1 mole of Cl_2 requires electricity of

Hydrogen electrode which is the reference electrode can be used as which of the following?

The composition of glass membrane in glass electrode cannot have which of the following?

Cells with a size of button are used in

Types of half cell includes

Composition of a standard hydrogen electrode is

Species with higher oxidation are always written in an equation on

In non-metals, half cells electricity is conducted via solution by

Part of platinum electrode in a reaction is

Nickel cadmium cells are

Ions discharged in electrolysis depends on

Production of energy in fuel cell as compare to petrol engine is considerably

Species gaining electrons will be reduced and act as

Electrochemical cell is achieved by connecting two

Half-cell which is used to refer different electrode is standard

Number of specified particles in 1 mole is

Cells with a size of button are used in

1 faraday is equal to

Effect of high voltage needed to discharge OH^- ion is called

Flow of electrons (e^-) through external circuit in cars provides energy to

In button cells, negative pole is made up of
Light weight batteries which produce high voltage are
Oxidation of chloride ions (Cl^-) to chlorine (Cl_2) is done by
Number of faradays required to discharge 1 mole of an ion is equal to charge on that ion is
It is easier to reduce ion on left if electrode is
Half reaction occur in fuel cell of
A secondary cell used in car battery is composed of plates of
More negative electrons (e^-) are attracted by more
Negative electrode in half cell is made up of
In electrolysis of silver nitrate solution, silver is deposited at
Half-cell which is used to refer different electrode is standard
Faraday has proposed two laws of
When rate of gain of electrons will be equal to loss of electrons state obtained will be
Part of platinum electrode in a reaction is
In Hydrogen electrode, the electrode is placed in a solution of ____ M Hcl. Fill in the blank.

opt1	**opt2**
rapid dissolving of magnesium in dilute acid	slow dissolving of magnesium in conc. Acid
cannot be prevented	is prevented through ammonium nitrate mixture
salt bridge	electrode
oxidation	reduction
platinum wire	platinum foil
voltage	ions apart
Calomel electrode	Silver-silver chloride electrode
Silver chloride	Mercury chloride
Nylon mesh	Teflon
Ammonia	Carbon dioxide
Silicon rubber	Microporous Teflon membrane
Silicon rubber	PVC membrane
It must have a known output potential	It must have a constant output potential
It has a known output potential	It has a constant output potential
Pascal Hydrogen electrode	Bourne Hydrogen electrode
positive pole	cathode
hydrogen	zinc
more positive	less negative
Sodium carbonate, magnesium chloride	Magnesium hydrogen carbonate, sodium chloride
Urea	Urease
Platinum can be easily poisoned	Presence of oxidising agents alters the potential
0.5	1
half cell	electrode
toys	torches
atomic mass	oxidation state
2 faraday	1 faraday
Anode only	Cathode only
Sodium silicate	Calcium silicate
heart pacemakers	hearing aids
metal/metal ion	non-metal/non-metal
hydrogen gas	H+ ions
left hand side	right hand side
platinum wire	platinum foil
more	less
smaller	low voltage supplier
relative electrode potential	concentration of ions
high	low
reducing agent	oxidizing agent
ions	electrodes
carbon electrode	hydrogen electrode
Avogadro constant	L
heart pacemakers	hearing aids
96500°C	12700°C
over voltage effect	hydroxyl effect
drive	ignite

zinc	lithium
nickel cadmium cells	aluminum air batteries
nitric acid	acidified MnO^{-4}
Faraday's first law	Faraday's second law
more positive	less negative
oxygen	hydrogen
lead	lead oxide
positive pole	cathode
hydrogen	zinc
anode	cathode
carbon electrode	hydrogen electrode
electrolysis	hydrolysis
Redox equilibrium	neutral
more	less
0.5	1

opt3
copper electrode gets covered with bubbles of hydrogen gas
is prevented through magnese oxide
solution
neutralization
both A and B
radii of ions
Mercury-mercury sulphate electrode
Potassium chloride
Silicon rubber
Hydrogen
Fluorocarbon
Fluorocarbon
Its output potential is dependent on the composition of the solution
Its output potential is independent of the composition of the solution
Hilderbant Hydrogen electrode
negative pole
copper
both A and B
Sodium hydrogen carbonate, sodium chloride
Acrylamide
It gives salt error
2
ions
both A and B
nucleon number
4 faraday
Anode or Cathode
Lithium silicate
stomach ulcers
ion/ion
platinum electrode
middle
both A and B
neutral
high voltage supplier
relative electrode charge
same
neutralizing agent
half cells
copper electrode
Leonardo's number
stomach ulcers
987690°C
high effect
combustion

both A and B
lead(II) sulfate batteries
sulfuric acid
Lenz's first law
both A and B
hydrogen -oxygen
lead sulfate
negative pole
copper
inert electrode
copper electrode
electromagnetism
constant
neutral
2

opt4	opt5	opt6
copper electrode gets covered with bubbles of oxygen gas		
is prevented through a NaOH mixture		
all of them		
charge potential		
none		
deposited ions		
Glass electrode		
Mercury sulphate		
Polythene		
Nitrogen		
Polythene		
Polythene		
It is employed in conjunction with the indicator or working electrode		
Its output potential is zero volts		
West Hydrogen electrode		
anode		
tungsten		
neutral		
Magnesium carbonate, magnesium chloride		
Polyacrylamide		
H_2 gas at 1 atmospheric pressure is difficult to set up and transport		
3		
all of them		
car		
electronic configuration		
3 faraday		
Salt bridge		
Barium silicate		
both A and B		
all of them		
all of them		
nowhere		
aluminum foil		
often		
a and c		
density of electrolyte		
constant		
reagent		
all of them		
zinc electrode		
both A and B		
both A and B		
96000°C		
all of them		
all of them		

silver
lead(II) oxide batteries
acidified ClO_2^{-3}
Lenz's second law
neutral
nitrogen
both A and B
anode
tungsten
charged electrode
zinc electrode
gravity
unstable
often
3

Answer
copper electrode gets covered with bubbles of hydrogen gas
is prevented through magnese oxide
salt bridge
reduction
both A and B
voltage
Glass electrode
Mercury chloride
Nylon mesh
Nitrogen
Fluorocarbon
Silicon rubber
Its output potential is dependent on the composition of the solution
Its output potential is zero volts
Hilderbant Hydrogen electrode
positive pole
zinc
both A and B
Magnesium hydrogen carbonate, sodium chloride
Urease
It gives salt error
1
half cell
both A and B
oxidation state
2 faraday
Anode or Cathode
Barium silicate
both A and B
all of them
all of them
middle
both A and B
less
a and c
relative electrode charge
high
oxidizing agent
half cells
hydrogen electrode
both A and B
both A and B
96500°C
over voltage effect
drive

both A and B
aluminum air batteries
acidified MnO^{-4}
Faraday's second law
both A and B
hydrogen -oxygen
both A and B
positive pole
zinc
cathode
hydrogen electrode
electrolysis
Redox equilibrium
less
1

Questions
The biosignal frequency from various section of human body are in the
The EEG signal originated from the
The ranges of frequency a voltage related to EEG are
The bundle ofmuscle fibers in amuscle supplied by a single motor nerve fiber is called a
The bio electric generator of heart is situated at
The most abundant negative ions in our body are
Among the following electrode which have high Zi
in case of ERG what types of electrodes used to pickup signal
Loud speaker is also used in the recorder of
Pressure transducer for measuring blood pressure is from
The hydrogen ion concentration of the blood is most easily determined with a
To obtain good contact between the electrode and the skin the gapis filled with an electrode paste containing
Among the contact media like alcohol ,Electrode pastes ,saline and multipoint electode,which has the lowest imped
The magnitude of the polaristion for a given electrode material is dependent primarily on the
The active tranducer in the measurement of pressure is
The amplifier which has no drift is
The improper response time of the amplifier in the biomedical records
To reduce common mode interference during recording of bio signals one can use
Resistively generated interference arises through incorrect
CMRR is more in
For biomedical applications,the most used amplifier is
The use of notch filter in signal conditioning system is
EMG deals with the
minographs are connected with
The heart sounds are recorded by
The heart's dipole field is measured by lead system called
Arrthymia can be diagoned by
In ECG the calibration signal amplitude is
artifacts are
bicycle ergometer is related with
The obstruction of blood flow is known as
The normal pH of the blood is
Inflammation of the kidneys is called
The level of conscious can be followed by means of the

opt1
RF frequency range
Glia cells
0.5Hz -100Hz and 10micro v -100micro.v
Motor unit
Aortic value
sulphates
surface electrodes
Disc electodes
EMG
strain gauge transducers only
surface electrodes
Electrolytes
Alcohol
shape of electrode
Piezo-electric transducers
D.C amplifier
affects the gain of the amplifier
buffer amplifier
Grounding
single ended amplifier
single ended amplifier
to filter R.F noise
study of brain activity
EEG
electro cardiography
wilson lead system
EEG
1 Mv
skin crafts
ECG
cyanosis
7
otitis
EEG.

opt2
microwave range
motor unit
Dc to 10Kz and 10micro v-1000micro v
Purkinje fiber system
SA node
borates
Needle electrode
Retinal electode
ECG
Strain gauge or capative tranducer
Needle electrode
wax
electrode paste
Current density at the surface of contact between electrode and tissue
capacitive transducers
differential amplifier
delays the signals
Differential amplifier
current density at the electrode
Diffrential amplifier
Differential amplifier
TO filter 50Hz noise from mains
study of myocardial activity
ECG
endoscope
Orthogonal lead system
ECG
1V
Time varying half cell potentials
EMG
edema
7.4
hepatitis
ECG

opt3	opt4
zero to few KHz.	few kilo hz to few MHz
sino atrial node	acetyelcholine
0-1000KHz and 0.1milli v - few milli v	20Hz -100Hz and zero -few milli volt
Bundle of His	muscle spindle
AV node	The brain
chlordes	chlorates
Micro electrode	disc electode
vacuum type electrode	pH electrode
EOG	EEG
resistive transducers	Fiber optic sensor
differential amplifier	Glass electrode
glycerene	iodine
saline	Multipoint electrode
impedance of the electrode	Half cell potential
strain gauge	inductive transducers
single ended amplifier	Chopper amplifier
Changes the shape of the waveforms of the signal	attenuates the signal
single ended amplifier	chopper amplifier
supply voltage	input impedance
Inverting operational amplifier	chopper amplifier
inverting operational amplifier	chopper amplifier
To filter the signal from	to attenuate the evoked response potential
Study of muscular activity	study of central nervous system
ERG	EMG
Phono cardiography	angio cardiography
vector lead system	32 electrode system
Vector cardiogram	phono cardiography
1 micro volt	0.5 Mv
radio capsules	radio noise
ERG	EEG
hyperemia	stasis
6.6	7.8
rephritis.	toxemia
EMG	ERG

opt5	opt6	Answer
		zero to few KHz
		Glia cells
		0.5Hz -100Hz and 10micro v -100micro.v
		Motor unit
		SA node
		chlordes
		Micro electrode
		Retinal electode
		EMG
		strain gauge or capative tranducer
		glass electrode
		electrolytes
		multipoint electrode
		current density at the surface of contact between electrode and tissue
		Piezo-electric transducers
		chopper amplifier
		Changes the shape of the waveforms of the signal
		differential amplifier
		grounding
		Diffrential amplifier
		differential amplifier
		to filter 50Hz noise from mains
		study of muscular activity
		ECG
		phono cardiography
		orthogonal lead system
		ECG
		1 Mv
		time varying half cell potentials
		ECG
		stasis
		7.4
		rephritis
		EEG

Questions
Which of the following is the formula for pH calculation?
Pure water is known to be which of the following?
Which of the following is the value of hydrogen ion concentration of pure water?
Which of the following is the value of hydroxyl ion concentration of pure water?
Which of the following is the relation between hydrogen and hydroxyl ion concentration of pure water?
The Nernst equation is given by which of the following statements?
Which of the following is the relation between concentration of hydrogen and hydroxyl ions in an acidic solution?
Which of the following is the relation between concentration of hydrogen and hydroxyl ions in a basic solution?
The measurement of hydrogen ion concentration can be made by measuring the potential developed in an electroche
Slope factor is independent of temperature.
Which of the following is not the characteristic of a reference electrode?
Why is Standard hydrogen electrode called as the primary reference electrode?
Which of the following is the simple and most convenient hydrogen electrode?
Which of the following is not the disadvantage of hydrogen electrode?
In Hydrogen electrode, the electrode is placed in a solution of ____ M Hcl. Fill in the blank.
Hydrogen electrode which is the reference electrode can be used as which of the following?
If hydrogen electrode acts as cathode, hydrogen is reduced
Given below is a diagram of hydrogen electrode. Identify the unmarked component
The composition of glass membrane in glass electrode cannot have which of the following?
Which of the following is the purpose of added membranes in the glass membrane of the glass electrode?
Which of the following cannot form the inner reference electrode in glass electrodes?
The pH response of glass electrode is limited entirely to the area of the special glass membrane bulb.
Which of the following is not the advantage of glass electrodes?
Which of the following is not the disadvantage of glass electrodes?
Given below is the diagram of glass electrode. Identify the unmarked component.

opt1
a) log10[H+]
a) Weak electrolyte
a) 1×107 moles/litre
a) 1×107 moles/litre
a) Value of hydrogen ion concentration is greater
a) E=Eo + 2.303 RT/F log CH
a) Value of hydrogen ion concentration is greater
a) Value of hydrogen ion concentration is greater
a) True
a) True
a) It must have a known output potential
a) It has a known output potential
a) Pascal Hydrogen electrode
a) Platinum can be easily poisoned
a) 0.5
a) Anode only
a) True
a) Hydrogen at 1 atm
a) Sodium silicate
a) They act as tightners
a) Silver electrode
a) True
a) It gives accurate results for high as well as low pH values
a) Poor readings are obtained in buffered or unbuffered solutions
a) Platinum leads

opt2

b) -log10[H+]

b) Strong electrolyte

b) 1×105 moles/litre

b) 1×105 moles/litre

b) Value of hydroxyl ion concentration is greater

b) E=Eo – 2.303 RT/F log CH

b) Value of hydroxyl ion concentration is greater

b) Value of hydroxyl ion concentration is greater

b) false

b) False

b) It must have a constant output potential

b) It has a constant output potential

b) Bourne Hydrogen electrode

b) Presence of oxidising agents alters the potential

b) 1

b) Cathode only

b) False

b) Hydrogen at 10 atm

b) Calcium silicate

b) They act as filters

b) Copper electrode

b)false

b) It is simple to operate

b) The electrode must be washed thoroughly with distilled water to obtain proper results

b) Silver wire coated with silver chloride

opt3

c) log2[H+]

c) Neither weak nor strong

c) 1×106 moles/litre

c) 1×106 moles/litre

c) They are both always the same

c) E=Eo + 2.303 RT×F log CH

c) They are both always the same

c) They are both always the same

c) Its output potential is dependent on the composition of the solution

c) Its output potential is independent of the composition of the solution

c) Hilderbant Hydrogen electrode

c) It gives salt error

c) 2

c) Anode or Cathode

c) Helium at 1 atm

c) Lithium silicate

c) They act as conditioners

c) Calomel electrode

c) It has no salt error

c) Materials suspended on glass should be wiped out neatly to obtain proper results

c) Copper wire

opt4	opt5	opt6
d) -log2[H+]		
d) Not an electrolyte		
d) 1×108 moles/litre		
d) 1×108 moles/litre		
d) The concentrations keep changing		
d) E=Eo – 2.303 RT×F log CH		
d) The concentrations keep changing		
d) The concentrations keep changing		
d) It is employed in conjunction with the indicator or working electrode		
d) Its output potential is zero volts		
d) West Hydrogen electrode		
d) H2 gas at 1 atmospheric pressure is difficult to set up and transport		
d) 3		
d) Salt bridge		
d) Helium at 10 atm		
d) Barium silicate		
d) They act as collectors		
d) Silver chloride electrode		
d) Modern electrodes can withstand severe treatment		
d) It is affected by oxidation reduction potentials in the solution		
d) Platinum reference electrode		

Answer

b) -log10[H+]

a) Weak electrolyte

a) 1×107 moles/litre

a) 1×107 moles/litre

c) They are both always the same

a) E=Eo + 2.303 RT/F log CH

a) Value of hydrogen ion concentration is greater

b) Value of hydroxyl ion concentration is greater

a) True

b) False

c) Its output potential is dependent on the composition of the solution

d) Its output potential is zero volts

c) Hilderbant Hydrogen electrode

c) It gives salt error

b) 1

c) Anode or Cathode

a) True

a) Hydrogen at 1 atm

d) Barium silicate

a) They act as tightners

b) Copper electrode

a)true

a) It gives accurate results for high as well as low pH values

d) It is affected by oxidation reduction potentials in the solution

b) Silver wire coated with silver chloride

Questions

Air conduction, by definition, is the transmission of sound through the external and middle ear to the inter
The hearing threshold is an invariable fixed intensity above which sound is always heard and below which
Unit of sound intensity ________
Sound intensity is proportional to the _________ of sound pressure
Decibel expresses the logarithm of the ratio between two sound _________
What is the unit of dB?
If I1 and I2 are two intensities in watts per square centimetre, then the number of decibels with which they
__________ is a specialized equipment, which is used for the identification of hearing loss in individuals.
Which threshold of hearing is measured by a pure-tone audiometer ?
Speech audiometers are normally used to determine ______________
Pure-tone audiometers usually generate test tones in octave steps from ___________
Speech audiometry normally allows measurements to be made within the frequency range of _____
The signal intensity of Pure-tone audiometers ranging from ______
The frequency range of pure-tone audiometer is more than that of speech audiometer.
___________ amplifier circulatory is employed to reduce the hum noise generated by the power supply in
The unit of sensitivity of an electrocardiograph is ________
The volume of blood out side the dialyzer is known as priming volume.
The range of CMRR of Foetal electrocardiogram is ______________
Power Line Hum is responsible for most of common-mode interfering signal.
What is the role of Cupraphan in haemodialysis?
Which of the following is the property of instrumentational amplifier?
Foetal ECG signal detected via electrodes placed on mother's abdomen is complex and requires attenuatic
The blood is a good conductor of electricity.
The range of FHR measurement due to substitution logic is between __________ bpm.
Which of the following is the technique of analyzing the electrical activity of heart by obtaining ECG's?
Vectorcardiogram displays the electrical events in __________perpendicular axes.
___________ is a vectorial representation of the distribution of electric potentials generated by heart.
How many loops each vectorcardiogram exhibits?
Which of the following instrument is used for recording the sounds connected with the pumping action of
Which instrument is used for clinical detection of heart sounds?
Who provides a recording of waveforms of heart sounds?
What is the frequency range of sound generated from the closure of mitral and tricuspid valve?
Which of the following microphone is used for recording phonocardiograms?
What is the frequency range of sound produced at the closure of aortic and pulmonic valves?
What is the thickness of new acoustic sensor?
Who described about new acoustic sensor?
Acoustic sensor principal sensing component is made up of which polymer ?
What is the frequency range of amplifier used for a phonocardiograph?
PCG amplifiers usually have gain compensation circuits to increase amplification of high frequency signa

opt1
a) True
a) True
a) joules per sq. cm
a) cube
a) intensities
a) watts per sq cm
a) N = 10 log I1/I2
a) gaugemeter
a) air-conduction thresholds of hearing
a) speech reception thresholds for diagnostic purposes
a) 125 to 800 Hz
a) 300–3000 Hz
a) 10 dB to +100 dB
a) True
a) low pass filters
a) m/mV
a) True
a) 0-120 dB
a) True
a) used to check conductivity of dialyzer
a) Extremely low input impedance
a) True
a) True
a) 20-220
a) VCG
a) one
a) EEG
a) one
a) ECG
a) Stethoscope
a) Electrocardiograph
a) 0 to 30 Hz
a) Contact Microphone
a) less than 0 Hz
a) 0.25 mm
a) Golden et al
a) PEO(Poly-ethylene oxide)
a) less than 0 Hz
a) True

opt2
b) False
b) False
b) watt per sq. cm
b) square
b) powers
b) dyne per sq cm
b) N = 10 log I2/I1
b) tachometer
b) bone-conduction thresholds of hearing
b) air-conduction and bone-conduction thresholds of hearing
b) 125 to 8000 Hz
b) 30–300 Hz
b) –10 dB to -100 dB
b) False
b) high pass filters
b) mm/V
b) False
b) 0-200 dB
b) False
b) used as membrane
b) high bias and offset currents
b) False
b) False
b) 60-260
b) EEG
b) two
b) ECG
b) two
b) VCG
b) Endoscope
b) Vectorcardiograph
b) 30 to 100 Hz
b) Shotgun Microphone
b) 0 to 30 Hz
b) 0.5 mm
b) Rijn et al
b) PET(Poly-ethylene tetraphthalate)
b) 0 to 20 Hz
b) False

opt3

c) joules per cm
c) inverse square
c) pressures
c) unit less
c) N = -10 log I1/I2
c) manometer
c) speech reception thresholds for diagnostic purposes
c) bone-conduction thresholds of hearing
c) 25 to 8000 Hz
c) 300–3000 KHz
c) –10 dB to +100 dB

c) band pass filters
c) mm/mV

c) 0-150 dB

c) used to check blood leakage
c) low slew rate

c) 40-240
c) EMG
c) three
c) PCG
c) three
c) PCG
c) Anoscope
c) Phonocardiograph
c) 100 to 1000 Hz
c) Handheld Microphone
c) 30 to 100 Hz
c) 1.0 mm
c) Levkov et al
c) PVDF(Poly-vinylidene fluoride)
c) 20 to 2000 Hz

opt4 **opt5 opt6**

d) watt per cm
d) inverse square root
d) intensities, powers and pressures.
d) watts pr cm
d) N = log I1/I2
d) audiometer
d) air-conduction and bone-conduction thresholds of hearing
d) air-conduction thresholds of hearing
d) 15 to 800 Hz
d) 3–30K Hz
d) –10 dB to +10 dB

d) notch filters
d) m/V

d) 0- 130 dB

d) not at all used
d) Very high CMRR

d) 0-200
d) PCG
d) four
d) VCG
d) four
d) EEG
d) Proctoscope
d) Electromyograph
d) above 1000 Hz
d) Lapel Microphone
d) above 100 Hz
d) 1.5 mm
d) Kassal et al
d) PS(Poly-styrene)
d) above 2000 Hz

Answer
a) True
a) True
b) watt per sq. cm
b) square
d) intensities, powers and pressures.
c) unit less
a) N = 10 log I1/I2
d) audiometer
d) air-conduction and bone-conduction thresholds of hearing
a) speech reception thresholds for diagnostic purposes
b) 125 to 8000 Hz
a) 300–3000 Hz
c) –10 dB to +100 dB
a) True
d) notch filters
c) mm/mV
b) False
a) 0-120 dB
a) True
b) used as membrane
d) Very high CMRR
a) True
b) False
c) 40-240
a) VCG
b) two
d) VCG
c) three
c) PCG
a) Stethoscope
c) Phonocardiograph
b) 30 to 100 Hz
a) Contact Microphone
d) above 100 Hz
d) 1.5 mm
d) Kassal et al
c) PVDF(Poly-vinylidene fluoride)
c) 20 to 2000 Hz
a) True

Questions
The filter used to reject the 50Hz noise picked up from power lines or machinery is called?
Devices that pass the signal from its source to the measurement device without a physical or galvanic con
Which of the following technique is not employed in isolation devices?
To achieve the low frequency response for medical applications, the amplifier configuration must contain
Besides breaking ground loops, isolation blocks high voltage surges and rejects high common mode volta
Strain gauges are resistance devices in a Wheat stone bridge configuration _________
Which of the following voltage regulator IC gives a variable positive voltage?
_______ IC is a variable negative voltage regulator.
Digital filters are sensitive to temperature as compared with analog filters.
Signal conditioning is not of much importance in the measuring and recording system.
Which amplifier will reject any common mode signal that appears simultaneously at both amplifier input t
Which amplifier has a limited frequency response?
_____________ are used with transducers which require an external source of excitation.
DC amplifiers are employed with _______ feedback type.
DC amplifiers are mostly used for very low level applications because they offer very less dc drift and hig
Chopper stabilized dc amplifiers are complex amplifiers having ________ amplifiers incorporated in the r
Which of the following amplifier is employed with resistive transducers which require an external source
When two wires of different material are joined together at either ends, forming two junctions which are n
Chopper input dc amplifiersare preferred for low level inputs to instrumentation systems because of their l
The junction at higher temperature in thermocouple is termed as measuring junction.

opt1
a) band reject filter
a) filters
a) resistance
a) higher resistance
a) True
a) which does not requires bridge completion circuitry and an excitation source
a) LM317
a) 7912
a) True
a) True
a) ac coupled amplifiers
a) differential amplifier
a) carrier amplifiers
a) positive
a) True
a) 1
a) differential amplifier
a) thermo-motive
a) True
a) True

opt2
b) band stop filter
b) rectifiers
b) optical
b) higher capacitance
b) False
b) which requires bridge completion circuitry and an excitation source
b) LM337
b) 7905
b) False
b) False
b) differential amplifiers
b) dc amplifiers
b) dc amplifiers
b) negative
b) False
b) 2
b) ac coupled amplifier
b) electro-motive
b) False
b) False

opt3
c) notch filter
c) bridges
c) inductance
c) lower resistance

c) which neither requires bridge completion circuitry nor an excitation source
c) 7805
c) LM337

c) carrier amplifiers
c) ac coupled amplifiers
c) ac coupled amplifiers
c) depends on the application

c) 3
c) carrier amplifier
c) chemical reactive

opt4	opt5	opt6
d) all reject filter		
d) isolaters		
d) capacitance		
d) lower capacitance		
d) which requires bridge completion circuitry but does not an excitation source		
d) 7812		
d) LM317		
d) dc amplifiers		
d) carrier amplifiers		
d) differential amplifier		
d) can be any positive or negative does't matter		
d) 4		
d) dc bridge amplifier		
d) mechanical		

Answer
c) notch filter
d) isolaters
a) resistance
b) higher capacitance
a) True
b) which requires bridge completion circuitry and an excitation source
a) LM317
c) LM337
b) False
b) False
b) differential amplifiers
b) dc amplifiers
a) carrier amplifiers
b) negative
b) False
c) 3
d) dc bridge amplifier
a) thermo-motive
a) True
a) True