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REG NO: 18/ENG08/007
DEPT: BIOMEDICAL ENGINEERING
COURSE CODE: BME 311
COURSE TITLE: MEASUREMENT AND INSTRUMENTATION

ASSIGNMENT

1 Describe briefly (with examples) Sensors and Acutators for Biomedical Application

2 Describe with sketches and examples of the components of a basic measuring instrument

3 Describe briefly case studies of two medical measurement instruments

ANSWERS

1 SENSORS AND ACUTATORS FOR BIOMEDICAL APPLICATION

A sensor converts a physical attribute to an electrical signal while an ~~Acutat~~ Actuator does the opposite; that is it changes ~~its~~ an electrical signal to physical action

SENSORS.

Sensors are very critical components in all devices and measurement systems and to some extent, sensors are multidisciplinary of interdisciplinary field of endeavours. Sensors are classified into mechanical sensors, electrochemical sensors, biosensors, optical sensors, semiconductor sensors, magnetic sensors and thermal sensors.

Biomedical sensors are used to gain the information on body and pathology; which is a branch of biomedical engineering

Biomedical sensors are classified into physical sensor, chemical sensor and biosensor.

① Physical sensor are employed to measure blood pressure, body temperature, blood flow, blood viscosity, biological magnetic field etc

② Chemical sensors are utilized to detect the ingredient and concentration of body Liquid such as PH value, Ca^{+} conc, glucose conc. etc

③ Biosensors are used to sense enzymes, antigen, antibody

hormone, DNA, RNA and microbe.

SENSOR CHARACTERISTICS

(1)	MEASUREMENT RANGE	(7)	REPRODUCTIBILITY
(2)	SENSITIVITY	(8)	OFFSET
(3)	ACCURACY	(9)	LINEARITY
(4)	PRECISION	(10)	RESPONSE TIME
(5)	RESOLUTION	(11)	DRIFT
(6)	HYSTERESIS		

EXAMPLES OF BIOMEDICAL SENSORS.

(1) EMG SENSOR – Electromyography (EMG), is a method to evaluate motor unit action potential activity in a muscle region. as electrical signals travel through nerves to neuromuscular junctions, the change in electrical potential (voltage) can be measured.

- Some current examples of the EMG being used today are in VR and prosthetic arms.

(2) GSR SENSOR – known as galvanic skin response, it refers to changes in sweat gland activity that are reflective of the intensity of our emotional state, otherwise known as emotional arousal
- Skin conductors offers direct insights into autonomous emotional regulation as it is not under conscious control
- For example; if you are scared, happy, agitated or any emotional related response, we will experience an increase in eccrine sweat glands activity which the sensor can pick up through the electrodes and transmit to the master device, example of the use of GSR sensors currently is lie detectors.

(3) HEART RATE SENSORS – also known as heart rate monitors, is a personal monitoring device that allows a user to track and display his/her heart rate in real time for studies purposes.
- There are two ways (optical and electrical) that this sensor

monitors your heart rate which are;

· Electrical - consists of 2 elements which are a monitor and a receiver when a heartbeat is detected a radio signal or coded signal is transmitted, which the receiver uses to display / determine the current heart rate.

· Optical - uses a light that shines through a human skin which will then measures the amount of light that reflects back. the light reflections will vary as blood pulses under the skin will go past the light which are then interpreted as heart beats.

(4) FINGERPRINT SENSOR - like optical sensors, capacitive fingerprint scanners generate an image of the ridges and valleys that make up a fingerprint. However, instead of sensing the print using light, the capacitors use electrical current.

· Arrays Tiny capacitor circuits to collect data about a finger print which when connected to conductive plates on the surface of the scanner can be used to track the details of a fingerprint.

An Op-amp integrator circuit is used to track the changes when a finger's ridge is placed over the conductive plates which will change the charge slightly, while an air gap will leave the charge unchanged.

ACTUATORS.

Smart actuators utilized as a part of biomedical field can be characterized as actuators which are fit for changing over different types of energy, for example, physical energy into mechanical work in response to different natural stimuli, such as pH, heat, moisture or humidity, electric or magnetic field.

MEDICAL ACTUATOR APPLICATIONS

MEDICA ACTUATORS are known for their accuracy and control

The following are 5 important medical industry applications which are driven by medical actuators.

(1) Hospital Beds - are specifically designed for the recovery of patients. These beds are equipped with medical actuators, which help in raising and lowering the height of bed. They also help repositioning a section of the bed at different angles for comfortable sleeping or sitting position. Electrical, electrical linear, and linear actuators are the most popular types of medical actuators used for this application

(2) Scanners - CT, MRI, PT scanning instruments are used in hospitals, clinics and palliative care units for examination and diagnosis purposes. These scanners are powered with linear actuators, which allow easy movement in any direction

(3) LASER positioning Equipment - Laser surgery is becoming popular due to various health benefits it offers. The Laser equipment needs to be positioned appropriately for desired results. The beam may cause harm if factors like position, accuracy and stability are not properly controlled. Linear actuators help control the accuracy and positioning of the beam in the Laser positioning equipment

(4) HOSPITAL LIFTS - Electrical linear and linear actuators are used in hospital lifts to control their movements. These actuators not only provide flexibility to lifts but also help pace up a patient's movements with less manual intervention.

(5) DENTAL CHAIRS - These chairs are known for their ergonomics and precision. They are equipped with actuators that allow easy adjustments of the footrest, headrest and chair height

The combination of smart sensors and actuators which are connected to the digital output, will give a clear view of the process going on the body. DNA interaction, detection of polymerase chain reaction products, dissociation of biomolecules

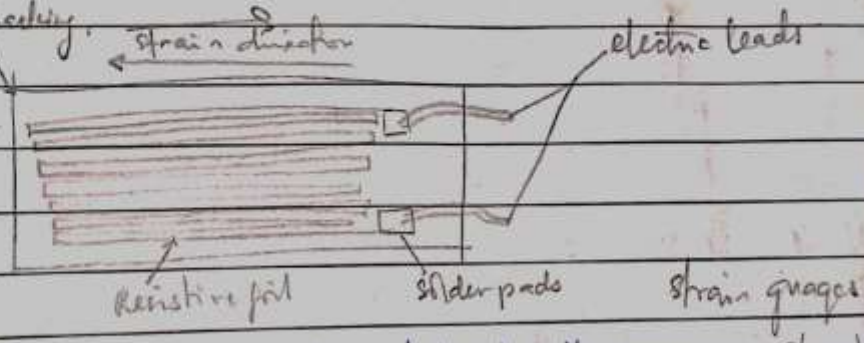
etc are carried out using a combo of smart actuators and sensors.

2. COMPONENTS OF A BASIC MEASURING INSTRUMENT

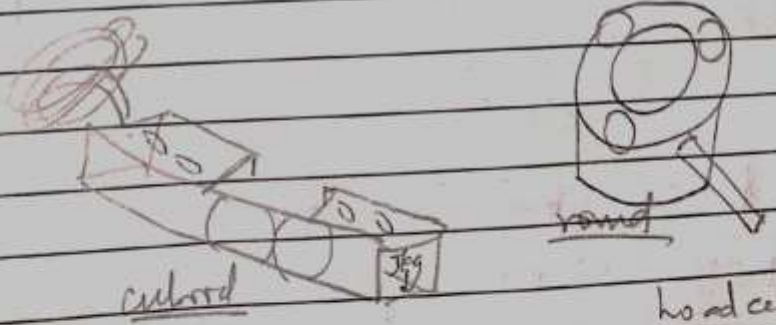
MEASURING Instruments are instruments used for measuring the physical and electric quantities. the term 'measurement' means the comparison between the two quantities of the same unit.

MEASURING COMPONENTS.

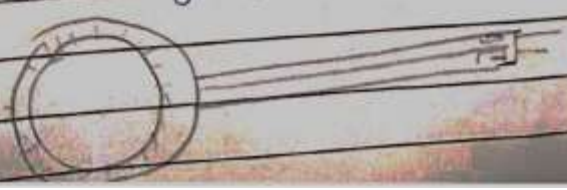
(1) STRAIN GUAGES - These consists of a very fine metallic foil etched in a grid pattern, which is bonded to a device and used to measure the strain, or amount of deformation of the device when weight or pressure is applied.



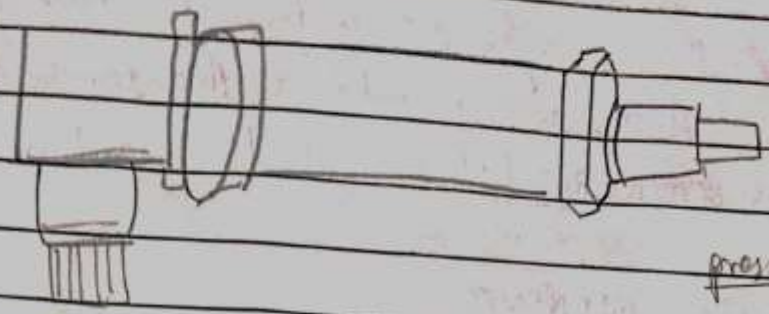
(2) LOAD CELLS - manufactured load cells ~~are~~ use strain gages to convert weight into electrical output.



(3) FORCE SENSORS - These are sensors for mass product that uses strain gages

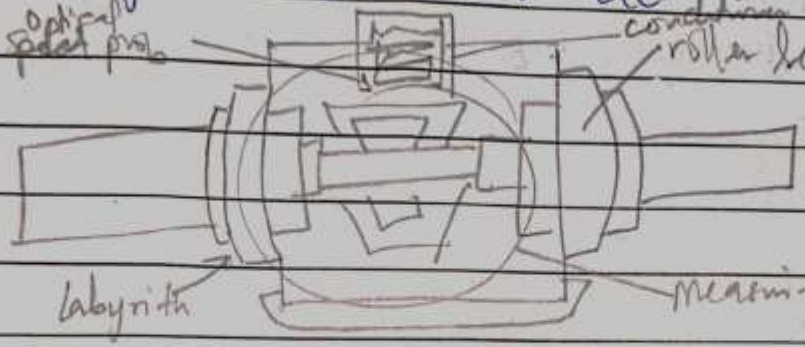


5 PRESSURE SENSORS — Using strain-gages, these pressure sensors are sensors that measure pressure as electric signals

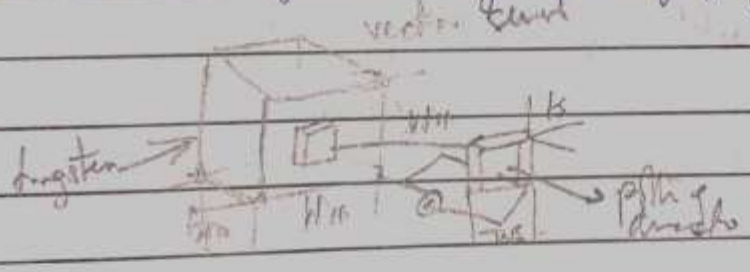


pressure Sensor

6. TORQUE TRANSDUCERS — the sensors for torque measurement measure the twist with a strain gauge in various driving parts like the engine and transmission etc

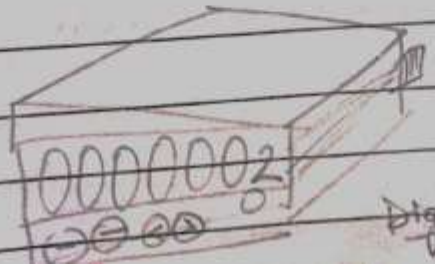


7. VECTOR SENSORS — A sensor that detects the translation power in the directions. this sensor can miniaturize because of a simple structure and is the best for the usage of the gripping force detection, etc



Vector Sensor

8. Digit Indictors — ~~Minebea produ~~ digital indicators are produced for use in its load cells, transducers and measuring components



Digital Indicator

9 Tensile and compression testing machines - Used to measure the amount of stretch and contraction of devices.

3. Medical measuring instruments - Sphygmomanometer and Electrocardiograph

A SPHYGMOMANOMETER

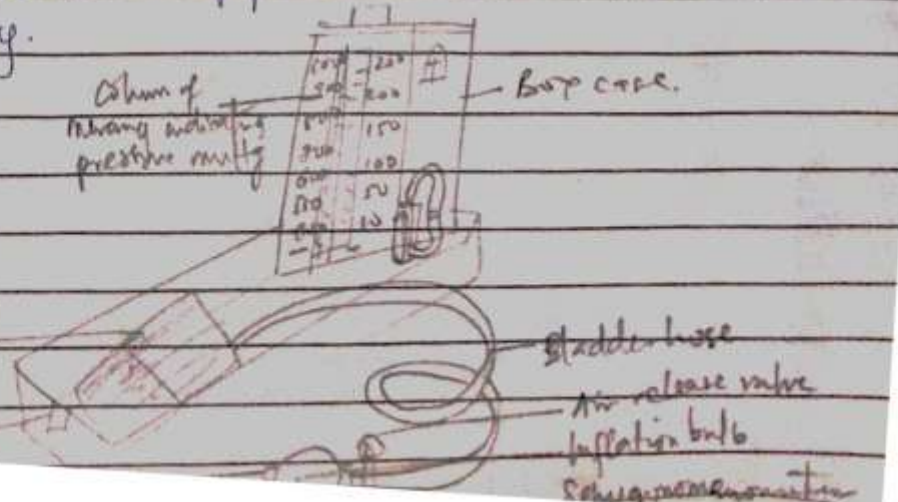
A Sphygmomanometer, also known as a blood pressure monitor, or blood pressure gauge, is a device used to measure blood pressure, composed of an inflatable cuff to collapse and then release the artery under the cuff in a controlled manner, and a mercury or aneroid manometer to measure the pressure.

Manual Sphygmomanometers are used with a stethoscope when using the auscultatory technique.

We have different types of Sphygmomanometers, Manual which is classified to mercury Sphygmomanometer and Aneroid and Digital, ~~which is classified to~~ Digital Sphygmomanometer.

Measurement of the blood pressure is carried out in the diagnosis and treatment of hypertension (high blood pressure) and in many other healthcare scenarios.

The Sphygmometer was invented by Samuel Siegfried Karl Ritter von Basch in 1881 while Scipione Riva-Rocci introduced a more easily used version in 1896; In 1901 neurosurgeon Dr Harvey Cushing brought an example of it to the US, modernized it and popularized it within the medical community.

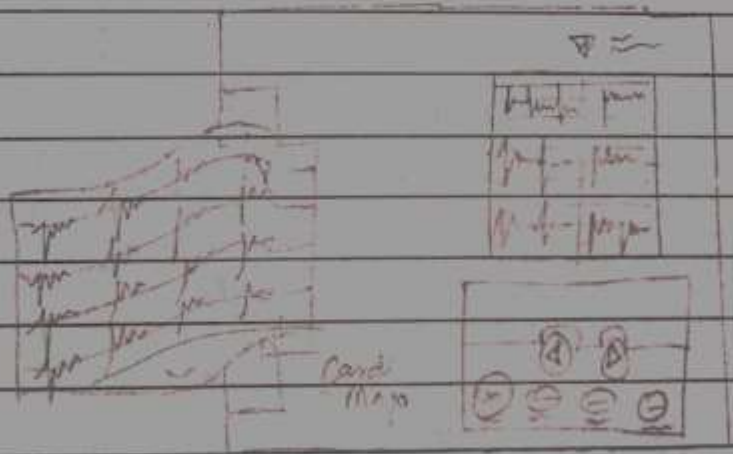


b ELECTROCARDIOGRAPH

This is a machine used for electrocardiography, electrocardiography is the process of producing an electrocardiogram (ECG or EKG). It is a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin. These electrodes detect the small electrical changes that are a consequences of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat). changes in normal ECG pattern are usually indicators of heart and blood flow problems; in other words issues with the circulatory system.

A lot of Scientist and contributors involved in the creation and evolution of devices between the years 1872 - 1942 which are Alexander Muirhead, John Burdon-Sanderson, Augustus Waller, Willem Einthoven, Engineer Clement Ader, Tanaka Takeomi and Emanuel Goldberger.

The overall goal of performing an ECG is to obtain information about the electrical function of the heart.



AN ELECTROGRAPH