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18/ENG04/062
Elect/Elect
EEE 319.

1) Describe briefly (with examples) sensors and Actuators for biomedical applications.

The application of sensors in biomedical diagnostics and bioinstruments has brought revolutionary changes that may already have a positive impact on the quality of life within the next century. some key current and potential applications are listed here

- sensors have enabled us to develop computer based medical imaging tools that could not be available without them, such as computer tomography, ultrasound echography, and many others
- Sensors may also bring a great development in conventional imaging tools, like x-ray photography, by getting more information with smaller radiation doses
- Portable multiparameter bedside monitoring appliances are available for intensive care
- Handy appliances are available on the market for personal and home monitoring or diagnostics
- sensor based systems can replace the function of human sensing organs, like artificial retina, hearing aids, tactile sensing on artificial limbs etc
- Rapid diagnostic tools have emerged recently based on immunosensors and DNA chips.
- There are already certain implantable self regulatory appliances, currently only for a few particular applications such as glucose monitoring and controlled insulin release. Their widespread application is prophesised for the near future

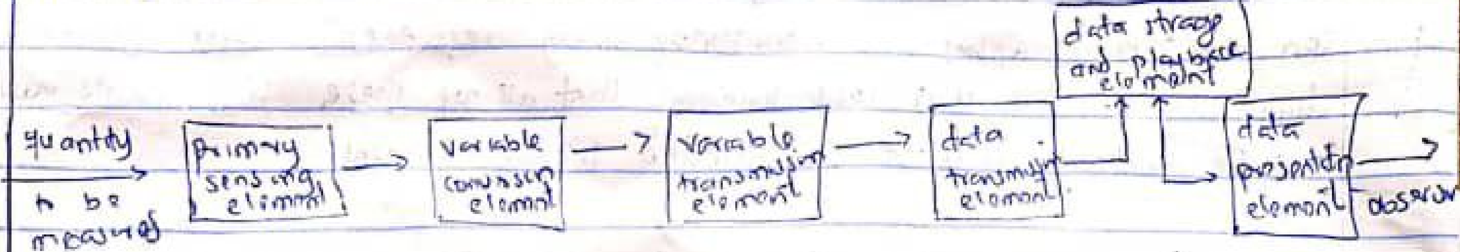
currently, digital display thermometers, ear thermometer, personal blood pressure meters and home glucose monitors are frequently used. computed tomography and ultrasonography represent well known diagnostic tools. It is less known that all of these instruments would not be available without sophisticated sensor elements.

Actuators on the other hand is a device that converts energy into motion or applies force. periodic advancement in technology have meant that the accuracy of these procedures has improved with the help of smart actuators and sensors. Different types of smart actuators are used according to the requirement and the type of actuation needed. The smart actuators are fabricated with the aid of the MEMS, which is a technology that would seem to be propitious for the future of the biomedical field.

The applications for smart actuators in the biomedical have become more advanced, such as drug delivery using a controlled micropump with which the required drug will be supplied at specific times. Microgrippers that are actuated are used to help to remove tumors. Biomedical sciences have recently become advanced in terms of making a hole or cut at a microlevel in the human body. piezo electrical actuators are used to drive a motor for drilling a hole or making a cut in surgery. They also have various applications in detection analysis, diagnosis, drug delivery and cell culture.

Examples of sensors and actuators include respiration sensor, blood pressure sensor, heart sound sensor, spring actuators, hydraulic actuators, electric actuators etc

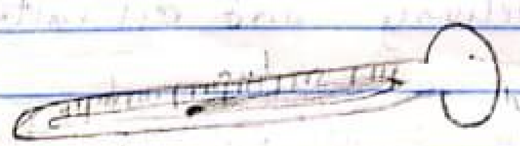
(3) Describe with sketches and examples of the components of a basic measuring instruments.



the main functional components of a measurement systems are

(i) primary sensing element
(ii) Variable conversion element.
(iii) variable manipulation element
(iv) Signal conditioning element
(v) Data transmission element
(vi) Data presentation element.

Primary sensing element : this gives an output that is a function of the measurand (the input applied to it). for most but not all sensors, the function is at least approximately linear: some examples of primary sensors are a liquid in glass thermometer, a thermocouple and a strain gauge. in the case of the mercury in glass thermometer, the output reading is given in terms of the level of the mercury and so this particular primary sensor is also a complete measurement system in itself

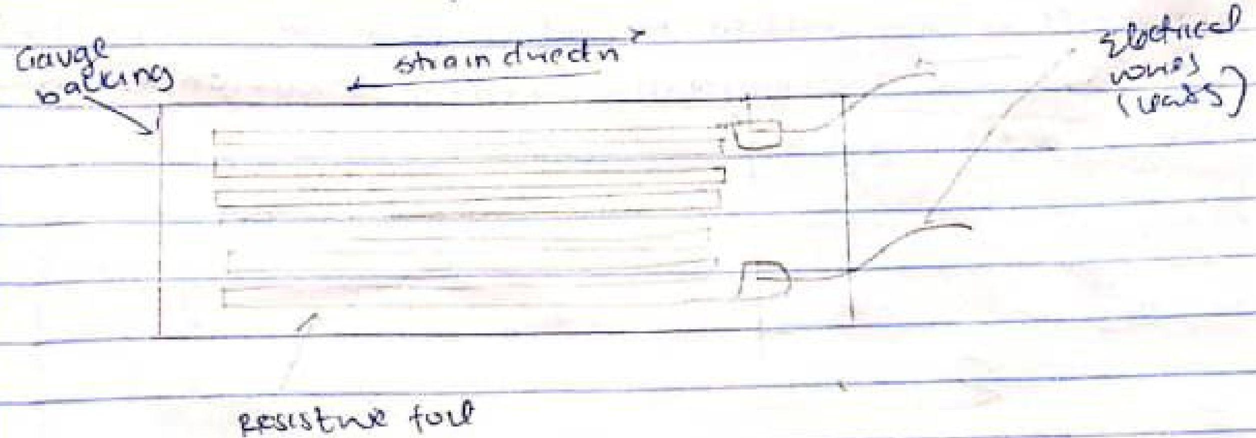


Mercury in glass thermometer

High pass (Hp) Low pass (Lp)

filtering in signal conditioning modules

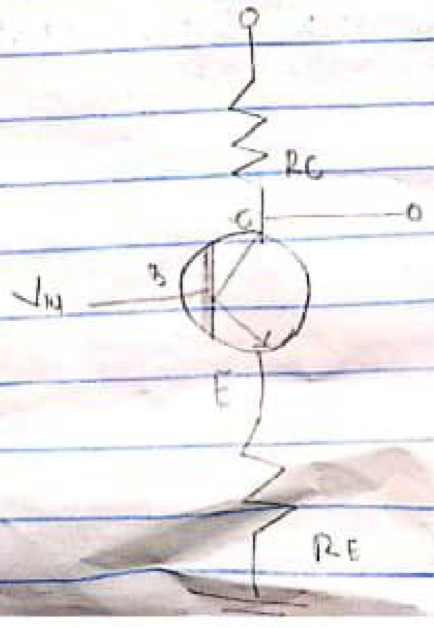
(b) Variable conversion elements are needed where the output variable of a primary transducer is in an ~~inconvent~~ inconvenient form and has to be converted to a more convenient form. For example, suppose the output from the sensing element is in the form of very small displacement which is difficult to measure mechanically, it is converted in to corresponding electrical signal with the help of transducer called strain guage for further processing.



Strain Gauge

(c) Variable manipulation element

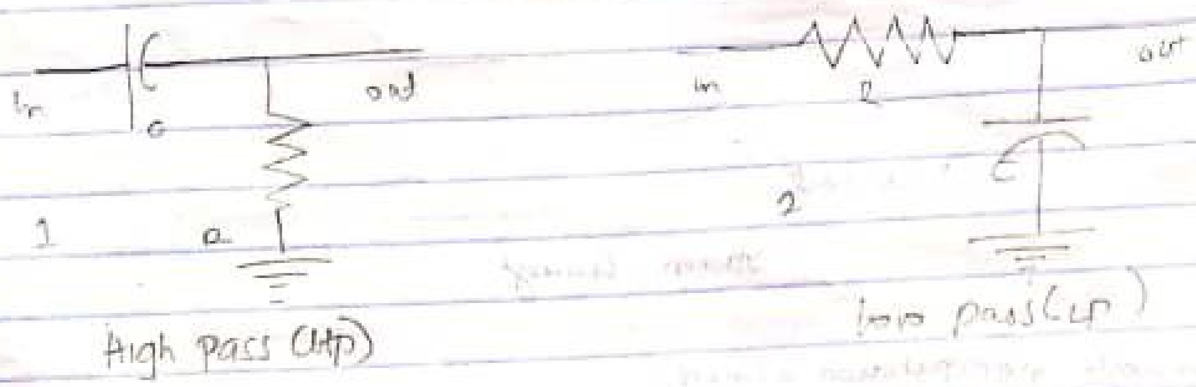
Variable manipulation element is used to manipulate the signal presented to this element while preserving the original nature of the signal. For example, a voltage amplifier act as a variable manipulation element. The amplifier accepts a small voltage signal as input and produces an output signal which is also voltage but of greater magnitude.



Amplifier Circuit

(d) Signal conditioning element

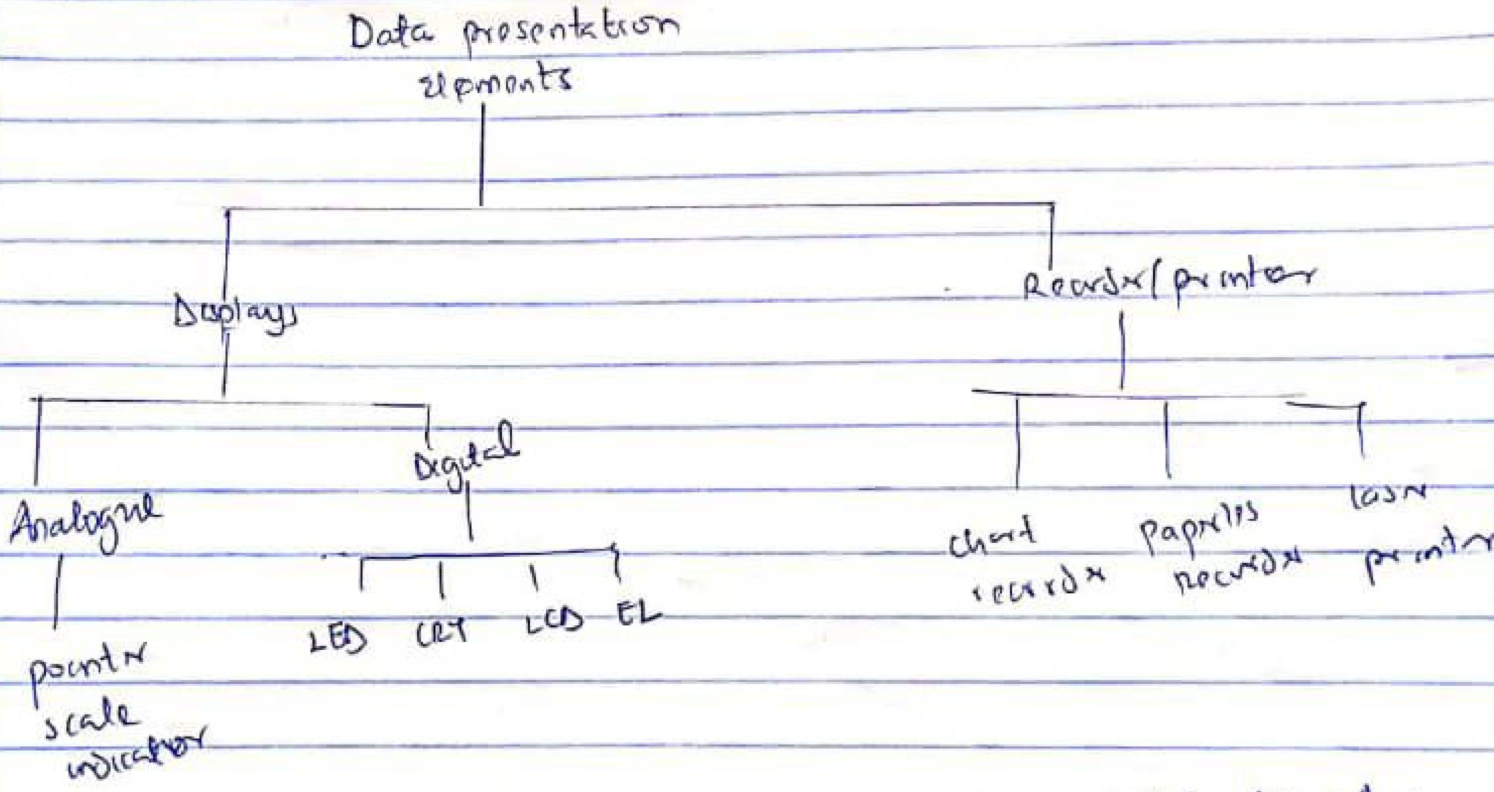
· Signal conditioning includes many other functions in addition to variable conversion and variable manipulation. Many signal conditioning processes may be linear such as amplification, attenuation, integration, differentiation, addition and subtraction. Some may be non-linear processes such as modulation, filtering, clipping. The signal conditioning processes are performed on the signal to bring it to the desired form for further transmission to next stage in the system. The element that performs the instrumentation system is known as signal conditioning element.



Data transmission element

There are several situations where the elements of an instrument are actually physically separated. In such situations, it becomes necessary to transmit data from one element to another. The element that performs this function is called a data transmission element. For example satellites or the air planes are physically separated from the control stations & earth.

e. Data presentation element :- The function of data presentation element is to convey the information about the quantity under measurement to the personnel handling the instrument or the system for monitoring control or analysis purposes. The information conveyed must be in a convenient form. In case data is to be monitored, visual display devices are needed. These devices may be analogue or digital indicating instruments like ammeters, voltmeters etc.



Classification of Data presentation element.

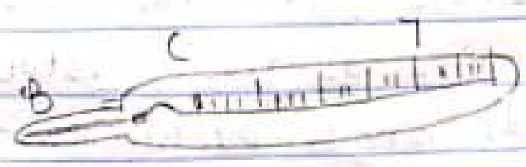
(3) Describe briefly case studies of two medical measurement instruments

① A clinical thermometer:

It consist of a cylindrical bulb B which is filled with mercury. The normal temprature in a clinical thermometer is from about 35 degrees to 42 degrees. The temprature of a healthy human body is approximately 98.6° f. To determine the temprature a person has to hold the tip of the thermometer either under the armpit or in the mouth under his tongue for a minute. Then we monitor the number against the point at which the mercury line stop growing further indicates the body temprature of the person.

Working principle:

The thermometer is thoroughly shaken before measuring the temprature of the body. Then the mercury level drops and remains inside the bulb. In this condition, if the thermometer is placed under the tongue or under the arms, the temprature and consequently the volume of the thermometer increases. As a result, some mercury flows through the capilary tube from the bulb. When the thermometer is taken out of the body, the mercury level contracts. Consequently, the mercury above level C goes back to the bulb. But since the mercury level ~~C goes bac~~ above C cannot come back to the bulb through the fine capillary tube, it remains above C. So the upper level of the mercury surface indicates the temprature of the body. Before using the thermometer again it should be shaken thoroughly so that mercury level goes back to the bulb. Even after the thermometer is removed from the body, the temprature can be read. Since it is measured the highest temprature of a body, so it is called maximum thermometer.



A clinical thermometer

Sphygmomanometer:

A sphygmomanometer is a device that measures blood pressure. It is composed of an inflatable rubber cuff which is wrapped around the arm. A measuring device indicates the cuff's pressure. A bulb inflates the cuff and a valve releases pressure.

Working Principle

In humans, the cuff is normally placed smoothly and snugly around an upper arm at roughly the same vertical height as the heart while the subject is seated with the arm supported. Other sites of placement depend on species and may include the flipper or tail. It is essential that the correct size of cuff is selected for the patient. Too small a cuff results in too high a pressure, while too large a cuff results in too low a pressure. For clinical measurements it is usual to measure and record both arms in the initial consultation to determine if the pressure is significantly higher in one arm than the other. A difference of 10 mmHg may be a sign of coarctation of the aorta. If the arms read differently, the higher reading arm would be used for later readings. The cuff is inflated until the artery is completely occluded.

With a manual instrument, listening with a stethoscope to the brachial artery, the examiner slowly releases the pressure in the cuff at a rate of approximately 2 mm per heart beat. As the pressure in the cuffs falls, a "whooshing" or pounding sound is heard (see korotkoff sounds) when blood flow first start again in the artery. The pressure at which this sound began is noted and recorded as the systolic blood pressure. The cuff pressure is further released until the sound can no longer be heard. This is recorded as the diastolic blood pressure. In noisy environments where auscultation is impossible (such as the scenes often encountered in emergency medicine), systolic blood pressure alone may be read by releasing the pressure until a radial pulse is palpated