**Mechanical Measurement Systems**
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**Lecture – 02**
**Functional Elements of Instruments**

Hello, I welcome you all in this course on Mechanical Measurement Systems. Today we will discuss functional elements of instruments. The topic covered in the presence lecture is classification of functional elements and I will give a few example on that.

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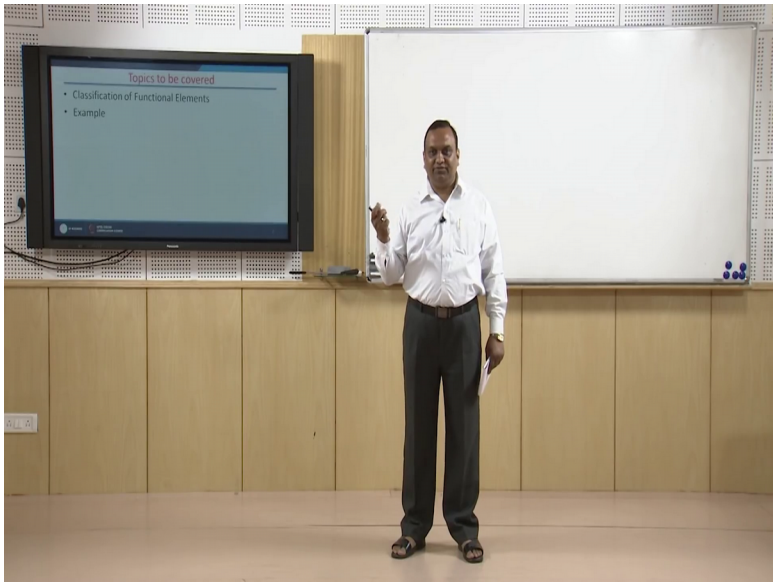


Now, I as I stated earlier for the act of measurement we need instruments without instruments we cannot do any measurement. A body human body is also a sort of measuring instrument right. We have sensors, we have sensors, we have 5 sensors right, we have skin which can sense, we have eyes which can, which can sense as a or which can work as a sensing element because every instrument must have a sensing element because without sensing element you cannot do any act of measurement.

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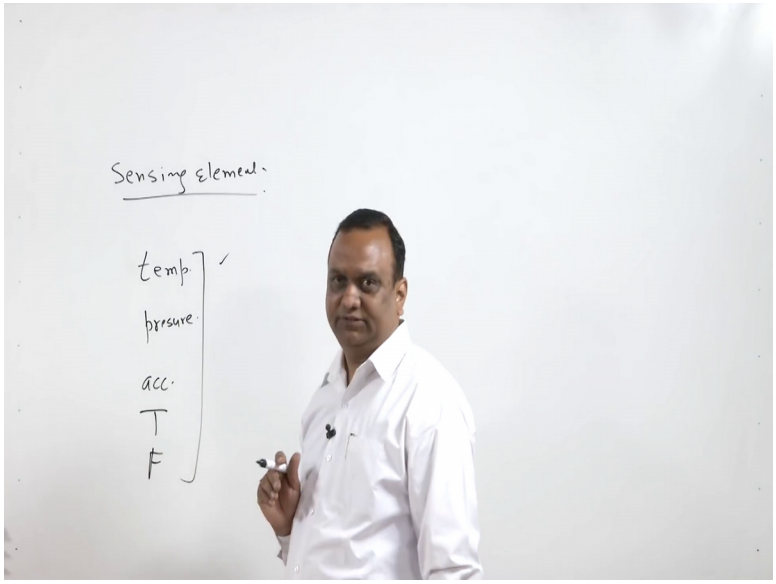


So, body is having 5 sensing elements we have skin to sense, we have eyes to sense, we have nose to sense, we have tongue to sense, we have I mean ear to sense the voice right. So, if you consider human body it is a very good example of instrumentation and very advanced instrumentation which we have not evolved as a human being artificial we could not evolve such type of measuring system. For example, our hand suppose I want to have similar type of artificial hand.

I will have to put millions of senses of the skin right, millions of the sensor of the skin and all the sensors will be passing through conductor, all the signals from these sensors will be passing through the conductor to the brain and I mean the system will be very I mean complicated right. But the nature has made this system I mean even if you destroy the sensing element the sensing element is damage it is we regenerated especially of a skin in case it is damaged it is regenerated.

So, our body can also be considered as a very good example of measuring instrument. In engineering application there are number of variety of measuring instruments depending upon the type of application. Now in mechanical engineering most of the time we come across the instruments used for temperature, measurement instruments used for a pressure measurement, instruments used for a acceleration right and torque, force right. If you go for electrical engineering they have other type of instruments which are used

for measuring the impedance, electrical resistance, and number of parameters. So, they are I mean legs of the instruments which are used for variety of application.

Now, as an engineer our job is to improve the performance of the instrument. First of all, first of all we should understand the working of the instrument then our job is to improve the performance of the instrument, improve the reliability of the instrument right. So, every instrument some have some mandatory elements, every instrument because ultimately the ultimate aim is to develop a generalized configuration for the instruments. If we have generalized configuration for the instrument then we can think of improving the performance of the instruments.

So, in order to evolve generalized configuration of the instruments the instruments the parts of the instruments have to be classified right and so there is an effort towards that by which we can evolve a generalized configuration for the instrument and in that effort we have classified the elements of the instrument.

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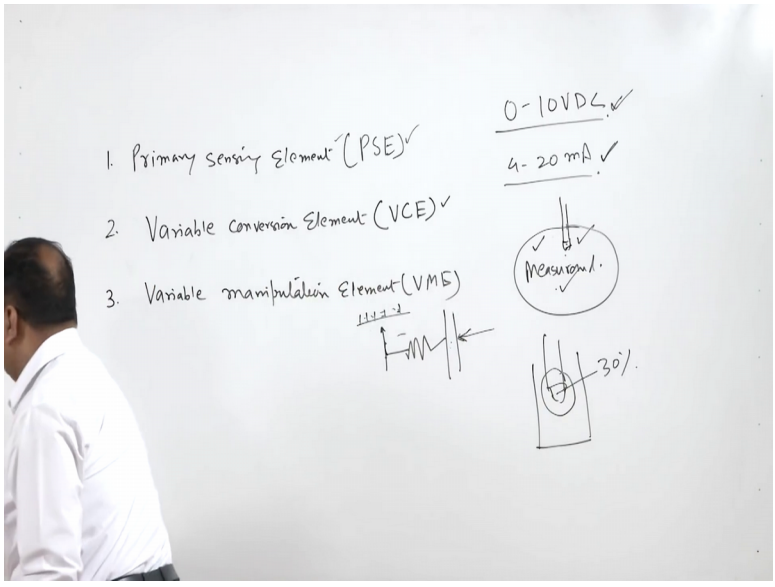


So, classified elements of the instrument the first element is primary sensing element. Now, what is primary sensing element? The primary sensing element of the instrument is the part of the instrument which first come into contact of measurant. Now what is measurant? Measurant is the object on which the measurement is being made, this room can be a measurant, my body can be measurant anything which is on which the exercise of measurement is being done is known as measurant measurant. And there is a primary

sensing element the primary sensing element of the instrument comes into the contact with the measurent.

Suppose I want to measure the temperature of this pool right and this is measurant. So, the bulb of this thermometer is primary sensing element it is known as primary sensing element. I want to measure the pressure in a vessel diaphragm of a pressure gauge is primary sensing element. So, any part of the instrument which comes into contact with the measurant is primary sensing element. For a very good music instrument the primary sensing element should withdraw minimum amount of energy.

For example, suppose in a glass I want to measure temperature with the help of a thermometer and the thermometer takes away 30 percent of energy for sensing the temperature the temperature will go down. So, glass is having water at temperature of 60 degree I put a thermometer the moment I put a thermometer thermal capacity of the thermometer is high. So, the thermal capacity is high it absorbs a lot of energy and temperature reduce from 60 to 55 degree centigrade. So, the minimum disturbance should be caused by the primary sensing element in the measurant. In fact, it should be negligible or it should be it cannot be 0, so it should be negligible.

So, primary sensing element is a very important part of any measuring instrument. But, now the primary sensing element may not come in contact with the measurant because nowadays there are contactless devices are also available. So, in contactless devices also the part of the device which picks the signal is primary sensing element.

So, nowadays it is not necessary that the primary sensing element should come into contact with the measurant, but it is the part of the instrument which picks the signal and the signal should this act of measurement should cause minimum disturbance in the measurant that is the best kind of measurement. So, while designing a primary sensing element as an engineer we have to ensure that minimum amount of energy is absorbed in this act of measurement.

Now, second is variable conversion element. The variable conversion element convert converts one form of single into the another form of signal. For example, if we take a spring right the spring can convert force into distance, but variable converts an element should not I mean should maintain variable conversion element should maintain the original nature of the signal original nature of the signal should not be disturbed right.

So, there is a variable conversion element and the variable a system can have a number of variable conversion element not only one, a system can have a number of variable conversion elements and the purpose of variable conversion element is to convert one form of signal into another form of signal plus force we cannot see, but displacement we can see. Because if I put a indicator here then displacement I can measure, but force I cannot see right.

So, for the act of measurement at least the observer it should observer should be able to see the change in the units or if it a I mean nowadays most of the data are required by the data equation system or they are electronically stored. So, all the signals nowadays they are converted into the digital signals right and output of nowadays transducers are used in most of the applications. The transducers by definition, the transducers are the devices which convert one form of energy into the other form of energy.

The output of these electronic devices whether you want to measure the pressure even the temperature transducers are there, pressure transducers are there and you find number of measuring instruments, they are giving output in the form 0 to 10 volt DC the output of the transducers either it is in the form of 0 to 10 volt DC or 4 to 20 milli ampere. It depends it is the choice of the consumer whether you want to have this one or you want to have this one right. Now if the signal has to be transmitted for a for of place normally this type of output is preferred, but when we are after the accuracy and the data acquisition system is very close or the to the to the measurent then we can go for 0 to 10 volt DC system in details these things will be discussing when we will discuss about the data acquisition.

Now, here will focus on variable conversion element, so the purpose of the variable conversion element is to convert one form of signal into the another form of signal and it maintains the basic nature of the signal.

Now third is variable manipulation element, variable manipulation element. Now variable manipulation element does not change the nature of the signal I mean if it is displacement it will continue to be displacement if the signal is in current it will continue to be in current or signal is in form of angle then it will continue to be angle, but in this case the original still the original nature of the signal is not disturbed. Suppose the output deflection is 2 degree, 2 degree is difficult to read. So, it will be amplified to say let us

say 20 degree. So, that will increase the accuracy of the measurement also suppose displacement is 0.4 mm, 0 to 0.4 mm. So, displacement will be change to 0 to 40 mm right. So, this type of elements are known as variable manipulation element.

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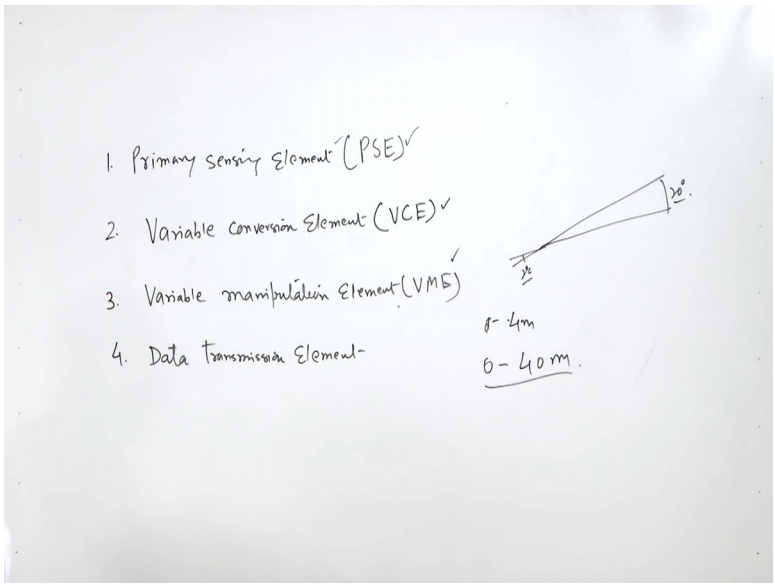


A third one is, sorry the fourth one is data transmission element, a data transmission element means transmission data from one point to another point ah. Cables, cables are a data transmission element, but here also during data transmission original a nature of the signal should not change. So, cables are data transmission element a shaft, shafts are data transmission element because at one place, suppose there a rotary motion at one place it can be transmitted to another place using a shaft. Belts can also be a belts can also be a sort of data transmission element.

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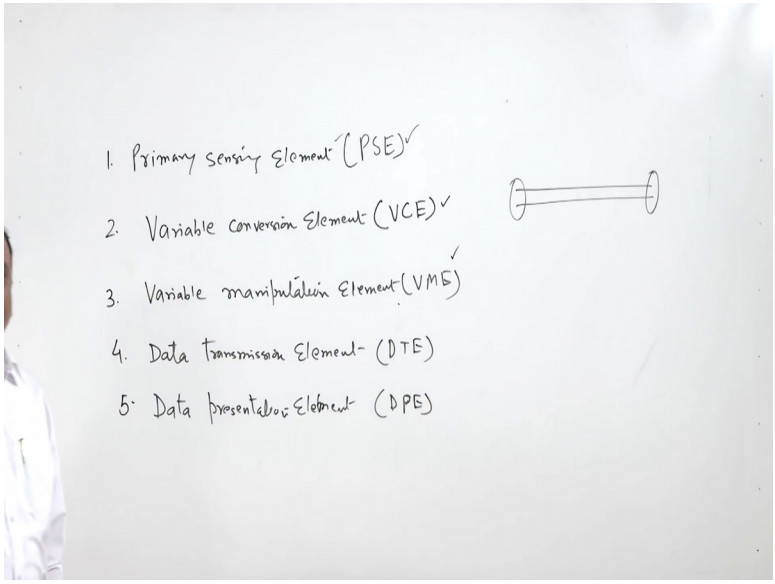


And fifth is data presentation element data transmission element and data presentation element. Obviously, the data presentation element is the dial of the dial gauge or computer screen, computer screen can be a or the video screen can be a data presentation element. So, much advance has been taken place recently in this data transmission element and data presentation element and, but the primary sensing element is very important, because through primary sensing element the sense the signal is coming into the measuring instrument and act of measurement is being done.

If there is a problem with the primary sensing element the entire process of measurement will be disturbed right. So, we will take one example how we can break an instrument into different type of ah components of a measuring instrument. So, we will take one pressure gauge very old type of pressure gauge rudimentary, which is rudimentary pressure gauge, so rudimentary pressure gauge.

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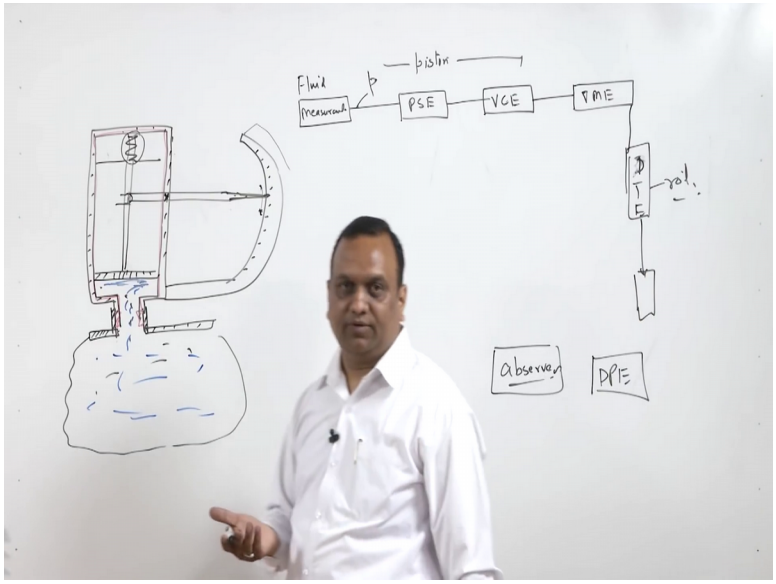


Earlier suppose there is a vessel which is filled with some fluid right and a pressure gauge is fitted in this vessel, the pressure gauge is fitted in this vessel, in this the housing of a pressure gauge. And it is a piston type of where is a piston type of arrangement there is a piston here and it is the fluid is exerting pressure this fluid is exerting pressure on the piston right. And this piston is connected with spring, there is a spring here with the help of a stylus is connected with a spring it is pressing the spring and in between there is an indicator and there is a data presentation element also. So, this indicator is indicating the pressure of this dial and it is it has divisions.

So, when this piston is lifted when the piston is lifted this is stylus is move this stylus will move right and it is healed here. So, it will, it will act as a liver and it will indicate the pressure in the vessel. So, this is rudimentary type of pressure gauge.

Now, I will do the analysis of this pressure gauge will start with the primary sensing element. So, here obviously, the piston which is it is piston which is coming in contact with the fluid right and it is exerting pressure on the piston. So, when the fluid is. So, the measurant is here measurant, so measurant is fluid the fluid is exerting pressure on the piston and so the primary sensing element is piston primary sensing element and the signal is in the form of pressure on the piston.

Now, this pressure is converted into force by piston itself. So, not only acting as a primary sensing element, piston is also working as variable conversion element, so

because it is converting pressure into the force. So, piston is converting is also working as a variable conversion element because it is this is piston, because the force the pressure which is exerted because we are measuring the pressure the primary signal is pressure. So, pressure which is being exerted on the piston is being converted into the force, right. So, this is not only primary sensing element. So, one element can act as a primary sensing element and variable conversion element as well right.

A system can have number of, should have one primary sensing element, but it can have number of a variable conversion element, a system can have a number of variable manipulation element, a system can have number of data transmission element because it is it is possible that a data may be required to be transmitted from one position to the other position.

A system can have different data presentation element, you can have suppose there is a pressure gauge, you are fixing pressure gauge on a vessel the display can be on the near the pressure gauge also you can have display on your computer, you can store data in a cassette. So, nowadays with the modern technology you can have n number of data presentation element, but this is a very rudimentary type of pressure gauge, so here the piston is working as a primary sensing element and variable conversion element.

Then the piston is exerting force on this rod, this is variable, piston is exerting force in this rod. At the same time the force is converted into the displacement because the rod is being lifted with the act of pressure. So, this here it is also working as, it is also working as data manipulation element. So, data manipulation element is here and after data manipulation the rod is pushing the spring, rod is pushing the spring. So, rod is transmitting data from piston to spring.

Since rod is being is transmitting data from piston to the spring. So, this is known as data transmission element this is rod, rod is acting as a data transmission element and data transmission element. And then what is happening here is spring is getting compressed or depending upon the direction of the motion or it is getting expanded right; and here there is a indicator right, and this indicator what is it is doing small displacement it is multiplying right. When the displacement it is multiplying then it is known as variable manipulation element.

So, data manipulation element, data transmission element and variable manipulation, variable manipulation element, variable transmission element, data transmission element and then again manipulation element because the signal is being manipulated. And after that we have observer, after we have this is data presentation element this skill is data presentation element and then I am standing before it I am an observer, so data presentation element and then observer.

So, this is how we can break the number of this measuring instrument in a number of elements and we can do the analysis of each element as well. So, this is how we can break this pressure gauge into the number of elements ah. In a nutshell I will explain again this is pressure, pressure is being converted into the force by the piston, this is by variable conversion element is piston is also working as a primary sensing element and variable conversion element, this force is transmitted to the spring, here the force is converted into the displacement and this displacement is again manipulated for the indication on the dial gauge right.

Now, in old days I will give you another example also regarding this.

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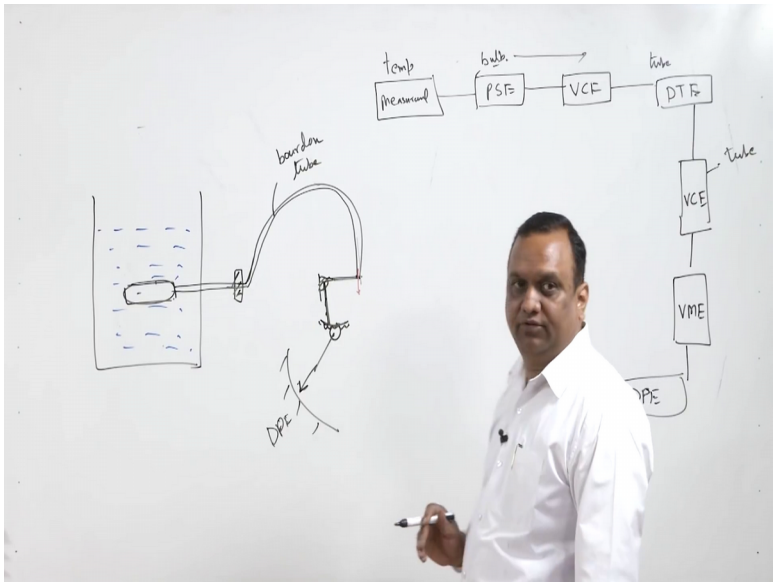


Suppose there is a vessel I want to measure temperature in this vessel because these are the instrument there are very old instrument nowadays they are not used, but they are the very good to understand the elements of function elements of any instrument.

So, there is a pressure thermometer. So, there is a bulb. So, there is a bulb and the bulb is connected to a bourdon tube b o u r bourdon tube and bourdon tube and then there is a linkage, and then there is a indication this is. This vessel is filled with water for example, right. So, here what happens when the temperature of water changes it rise or false correspondingly the pressure it is filled with a fluid, this tube is filled with a field. And the characteristic of the bourdon tube is when the pressure in the bourdon tube increases, there is only literal increase in the dimension of the bourdon tube there is no increase in the diameter of the bourdon tube right.

So, this tube is being used here in this vessel or in this capsule the fluid is filled the moment the temperature in the vessel changes the pressure in the bulb will also change. The moment the pressure in the bulb changes the pressure in the bourdon tube will change; the tube will get elongated. Suppose there is a rise in temperature suppose there is a rise in temperature here the tube will get elongated, the moment the tube will get elongated it will exert force on this lever and there is going to be movement in the arm of this lever right, and there is a linkage and finally, there is a moment in the pointer of this pressure gauge sorry this temperature gauge temperature measuring instrument.

Now we will again, here the measurant is temperature measurant temperature because we are measuring the temperature. And when there is a change in the temperature in this case the bulb is it is obvious and it is visible also that the bulb is in contact with the measurant. So, bulb is the primary sensing element, bulb, bulb is primary sensing element and it is also variable conversion element. Why it is variable conversion element? Because the bulb is converting the primary signal is temperature here primary signal is temperature here.

So, what the bulb is doing? The bulb is converting temperature into the pressure because it is a constant volume, volume is constant, the movement the temperature increases the pressure will increase it is a constant volume process.

So, bulb is increasing the pressure. So, it is also acting as variable conversion element bulb. So, here bulb is primary sensing element because it is taking signals from the measurant and it is also variable conversion element because it is converting temperature into pressure.

Now, this is tube at the signal through this tube the signal is transmitted to this place this is a tube. So, this tube is transmitting signal to this place right. So, the tube is data transmission element, data transmission element tube and at the same time data is transmitted and the tube is elongated, So, in addition to the data transmission element the tube is also working as variable conversion element tube, bourdon tube. So, bourdon tube here is doing two functions, one is it is working as a data transmission element and the second is it is also working as variable conversion element.

Now, motion starts the movement this tube is elongated suppose this is there is a rise in pressure. So, the tube will be elongated, tube will be elongated right and then this linkage will come into the action right. And this linkage what this linkage is doing entire linkage I will not deal it individually this linkage is just manipulating the motion right. Since this linkage is manipulating the motion, so the linkage will be called a variable manipulating element because it is not changing the basic nature of the signal.

The job the linkage is doing is it is simply manipulating the signal, but because original signal is in the form of displacement the linkage is also maintaining it to be displacement right. And then this displacement is displayed on the this data presentation element. So, here data presentation element is the dial of the temperature gauge and then there is observer.

So, likewise we can to the break any measuring instrument in a number of elements the benefit of this exercise is first of all we can understand the working of the instrument and the second thing is we can find a scope for the improvement. If we make a number of elements and then we do the analysis of the elements then we can find scope for the improvement in the performance of element.

And the basic objective is in instrumentation the basis basic objective is to develop a generalized configuration of the instrument because if we want to study the characteristics of the instrument, instruments have two types of characteristics. One is static characteristics another is dynamic characteristics a static characteristics means the signal does not vary with time.

Suppose temperature is in a pool the temperature is constant suppose in this room temperature is constant it does not change with time and then we do the measurement right and measurement the process of measurement may take I mean substantial time

maybe one minute or two minute, but a signal will not change signal will remain same that is known as static acquisition of the data or and characteristics for such type of signals is known as static characteristics of the instrument.

Now if signal is changing with time I mean the temperature in this room is varying let us say 0.1 degree centigrade per second right. Then we will then the response of the instrument will be known as the dynamic characteristics of the instrument. That is all for today.

Thank you very much.