Chemical Process Instrumentation
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Lecture – 04
General Principles and Representation of Instruments (Contd.)

Welcome to lecture 4 in our previous lecture we introduce the concept of functional elements in an instrument we took an example of pressure thermometer analyze the instruments function and broken down the instrument in terms of various functional elements that are present in the instrument. In this class we will again take an another example and do the same exercise.

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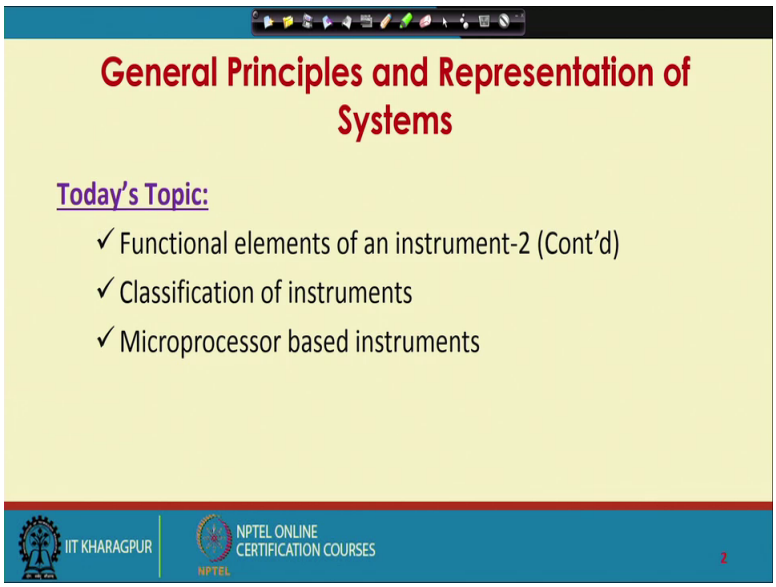

So, todays topic we will take one more example of functional elements, then we will talk about various classification of instruments and we will briefly touch upon microprocessor based instruments.

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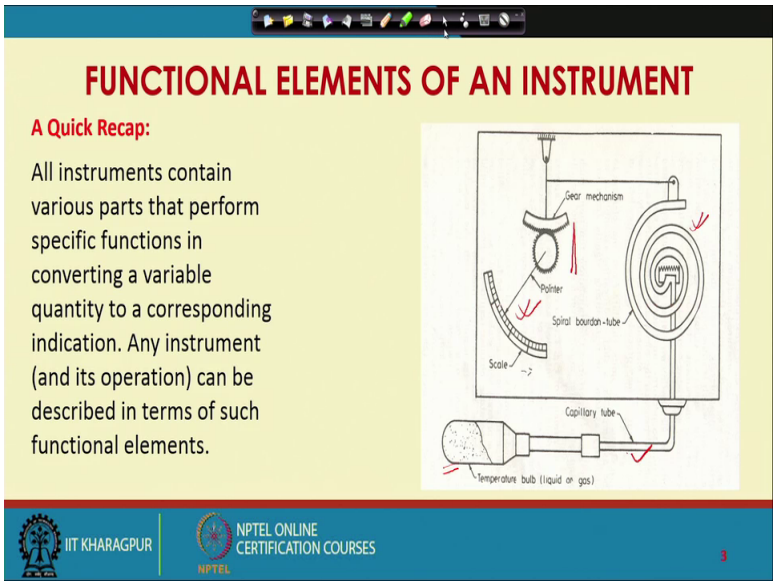

So, a quick recap of what we learnt about functional elements in our previous lecture, we said that all instruments contain various parts that perform specific functions in converting a variable quantity to a corresponding indication. Any instrument and its operation can be described in terms of such functional elements we took this example of pressure thermometer which consists of a bulb then there is a capillary tube the other end of the tube there is a bourdon tube or a spiral bourdon tube attached and other end of the bourdon tube is connected to this pointer and scale using gear and linkage mechanism.

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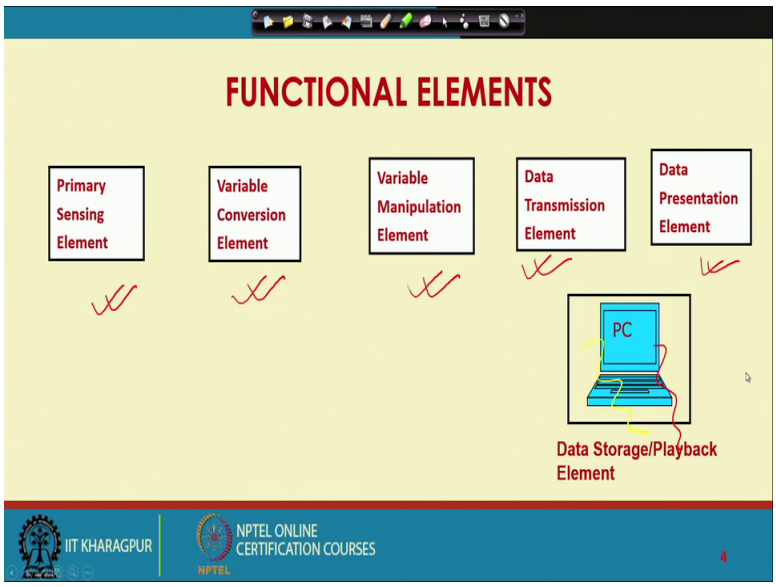

So, we identified these functional elements primary sensing element which first receives the information about the measured quantity variable conversion element converts the output of the primary sensing element to another form which may be more appropriate for purpose of measurement, variable manipulation element it changes the magnitude of the output of the variable conversion element. Data transmission element transmits data from one point to another, data presentation element presents data to the pointer and there can be data storage or data playback element as well then the data will be presented to the observer by the data presentation element.

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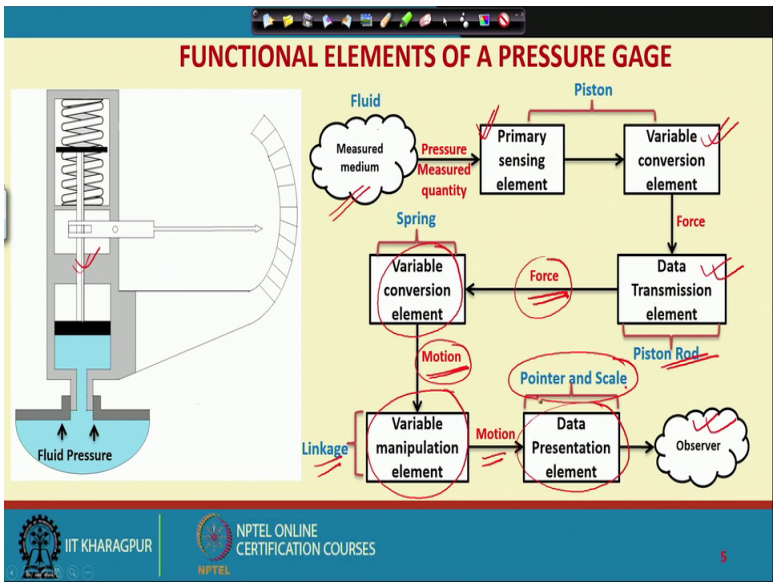

Today let us take this example, this is another example of simple pressure gauge the way to work is as follows, this is the fluid pressure that acts on this piston. So, the piston receives the fluid pressure. So, pressure acts over a surface then a force will be developed, that force is transmitted through this piston rod to this spring. So, there will be deflection of the spring and then this that deflection will be read by this pointers movement over this scale.

So, if I apply known fluid pressure and record the deflection and do a series of exercise, such exercise then it will be possible for me to calibrate the scale in terms of pressure units then when an unknown fluid pressure works from the deflection of the pointer against the scale I will be able to read the unknown pressure. So, let us now try to identify the various functional elements that are present in this instrument.

So, measured medium is fluid, piston receives first information about the fluid pressure. So, primary sensing element is piston, but piston also converts the pressure into force. So, piston also works as variable conversion element. So, piston serves the purpose of both primary sensing element as well as variable conversion element, the developed force is transmitted by this piston rod to the spring.

So, piston rod works as data presentation, data transmission element piston rod piston rod transmits the data from piston to spring. So, piston dot works as data transmission element, the output of the data transmission element of piston dot is still force this force works on spring and the spring output is motion because there will be deflection in the spring. So, the spring works as variable conversion element because there has been a change in the nature of the signal, it deceives force as input gives you motion as output.

That motion is magnified by the linkage. So, the, linkage works as variable manipulation element, output is still a motion which goes to pointer in scale which presents data to the observer. So, pointer and scale works as data presentation element.

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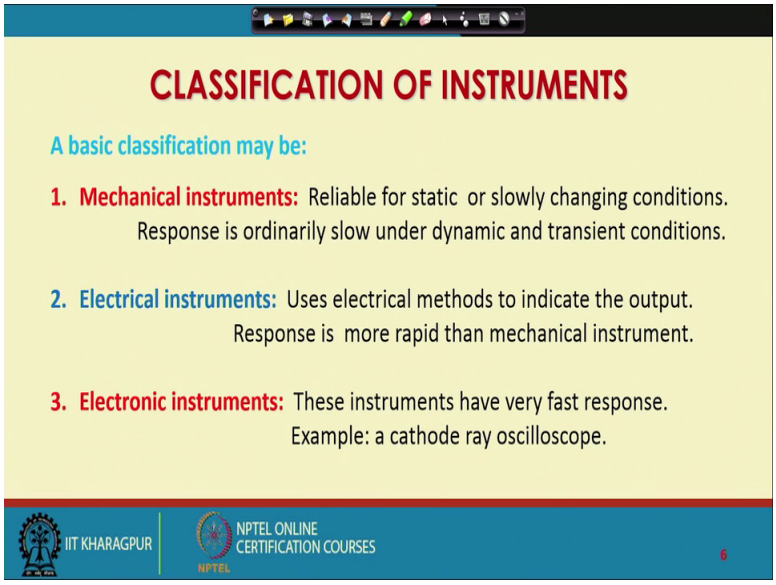

Next let us talk about classification of instruments, there are various ways of classifying instruments a very basic classification may be whether the instrument is a mechanical instrument or an electrical instrument or an electronic instrument mechanical instruments are generally reliable for static or slowly changing conditions response is ordinarily slow under dynamic and transient conditions, slow compared to electrical instruments and

electronic instruments. Electrical instruments uses electrical methods to indicate the output, response is more rapid than the mechanical instruments, electronic instruments have very fast response.

Example a cathode ray oscilloscope its response maybe in nanoseconds.

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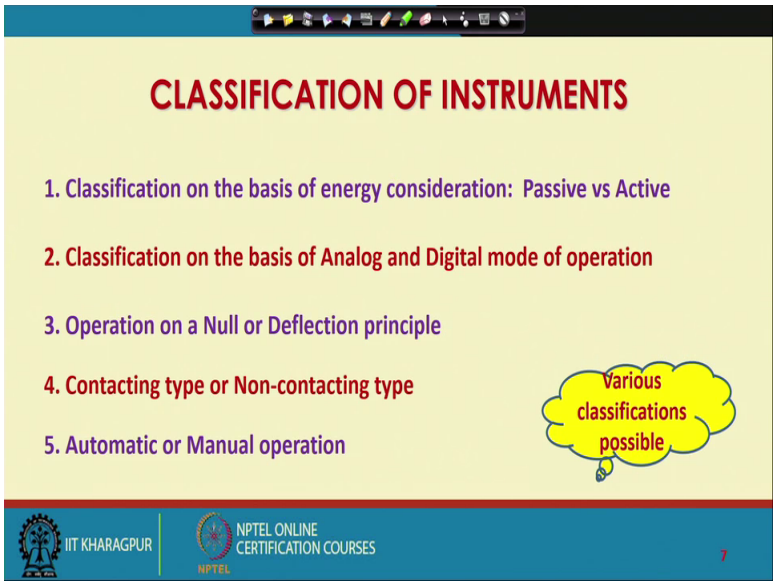

So, let us look at how in other different ways we can classify various instruments, one possible classification is on the basis of energy consideration, we classify instrument as passive instruments or active instruments another classification may be on the basis of analogue and digital mode of operation it can also be classified on the basis of whether operation is on null or deflection principle.

We can classify instruments depending on whether it is contacting type or non contacting type, we can also classify instruments depending on whether it is automatic instrument or manual instrument. Now, we will go through each of these in some detail with some examples.

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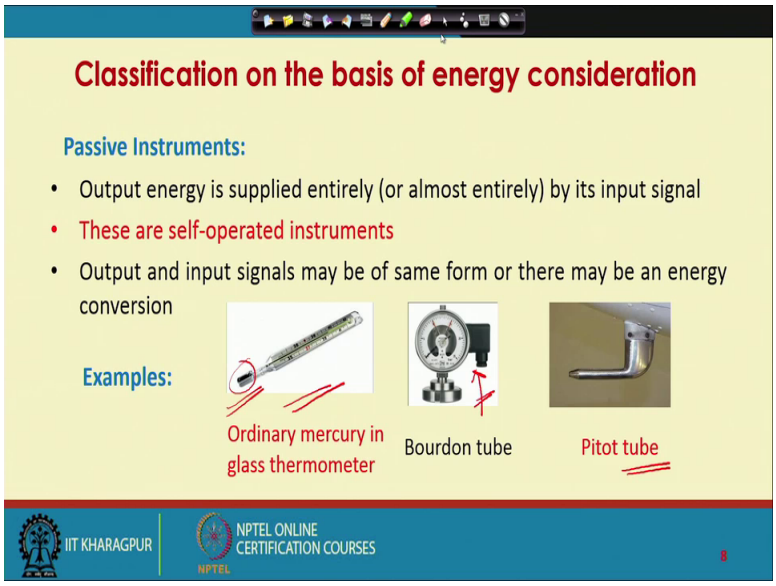

So, first let us talk about classification on the basis of energy consideration. So, on the basis of energy consideration we can classify instruments as either passive instruments or active instruments, passive instruments are those whose output energy is supplied entirely or almost entirely by its input signal.

So, the workings of passive instruments do not require any auxiliary source of power. So, these are self operated instruments output and input signals may be of same form or there may be an energy conversion for example, ordinary mercury in glass thermometer is a simple instrument, you put the thermometer bulb into medium whose temperature needs to be measured the thermometer does not need any other auxiliary source of power for its working because the energy required for measurement is extracted from the energy of the medium itself.

Similarly, bourdon tube you apply fluid pressure here and there will be deflection of the tube which is measure of pressure, again the energy comes from the energy of the medium which we are measuring. Similarly pitot tube which is another pressure measuring instrument or flow measuring instrument and we will talk about these instruments in detail in the course of time.

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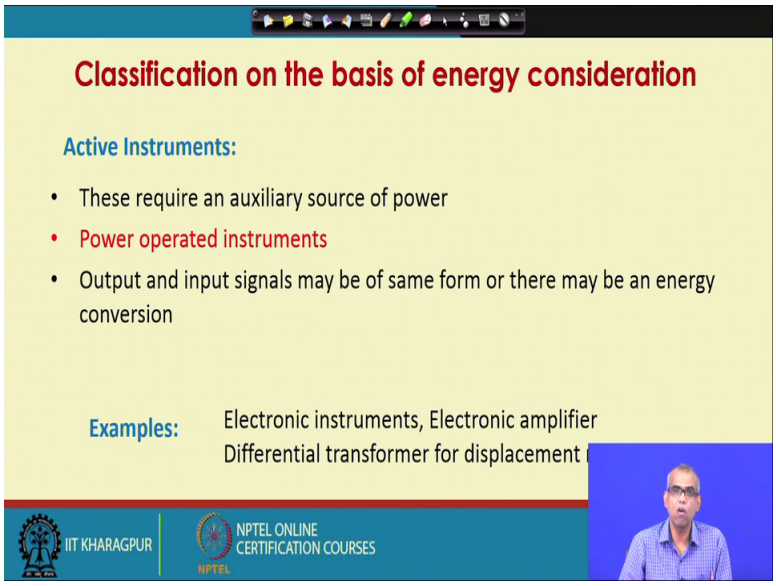

Active instruments, passive instruments do not require any auxiliary source of power, but active instruments do require an auxiliary source of power. So, they are power operated instruments, almost all electronic instruments require auxiliary source of power and they are all active instruments. Output and input signals maybe of same form or there may be an energy conversion this is common to both active instruments as well as passive instruments.

So, electronic instruments, electronic amplifier differential transformer for displacement measurement all are examples of active instruments because they all require additional sources of power for working of the instruments.

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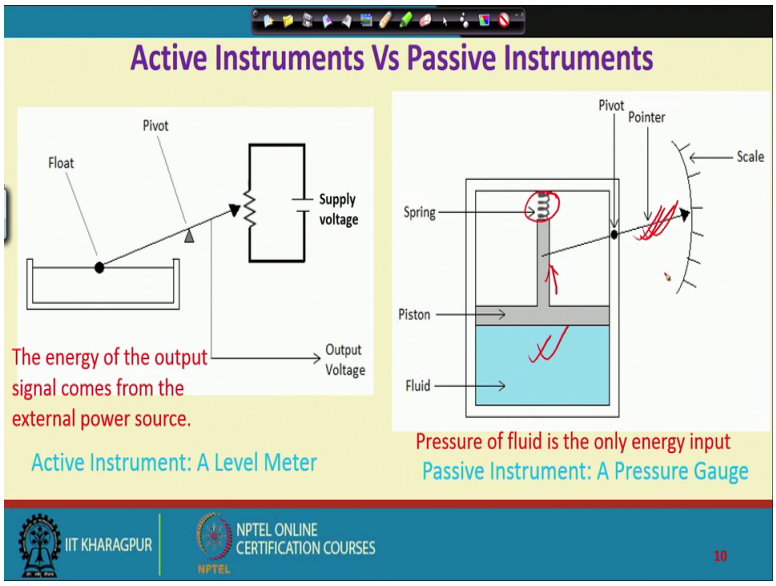

Here we have a simple example of a level meter, consider the liquid in a tank you can imagine to be petrol in fuel tank of your bike, there is a float and this potentiometer is connected to this float through the serve.

As the level goes up or comes down the float moves up or comes down and this arm touches at different points. So, depending on that the output voltage of this potentiometer will be different. So, these output voltage can be taken as a measure of the level of the liquid in this tank, note that the working of the instrument requires this voltage to be supplied. So, this is an example of active instrument.

Whereas this simple pressure gauge the fluid acts on this piston a force is generated, piston dot goes up and there is deflection of the spring because this force deflects this spring which is transmitted to this movement of the pointer against this scale, this pressure gauge does not require any auxiliary source of power. So, this is an, this is an example of passive instrument.

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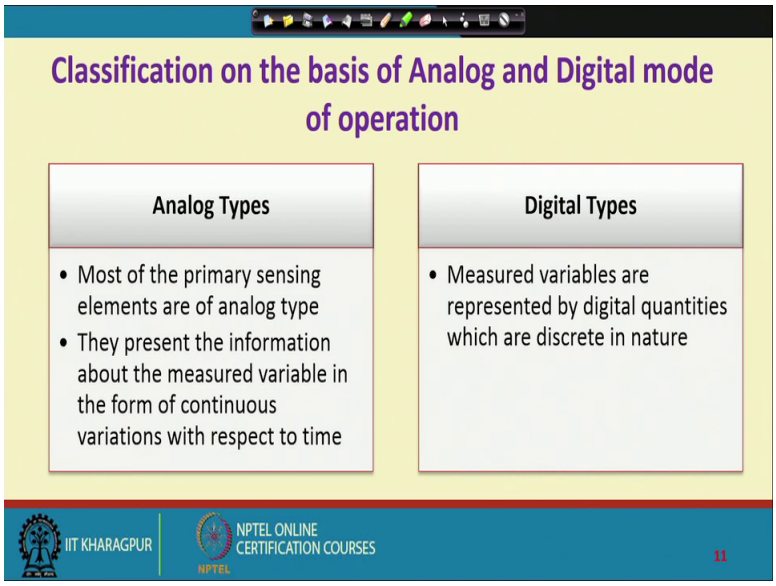

Another classification on the basis of analogue and digital mode of operation, you are all familiar with analogue types instruments and digital types instruments most of the primary sensing elements are of analog type although digital types number is increasing day by day these days. Analogue types instruments present the information about the measured variable in the form of continuous variation with respect to time.

Whereas digital types represent by digital quantities which are discrete in nature so it depends on whether the information about the measured variable is presented as an analogue signal which is a form of continuous variation with respect to time or the information about the measured variable is represented by digital quantities which are discrete in nature.

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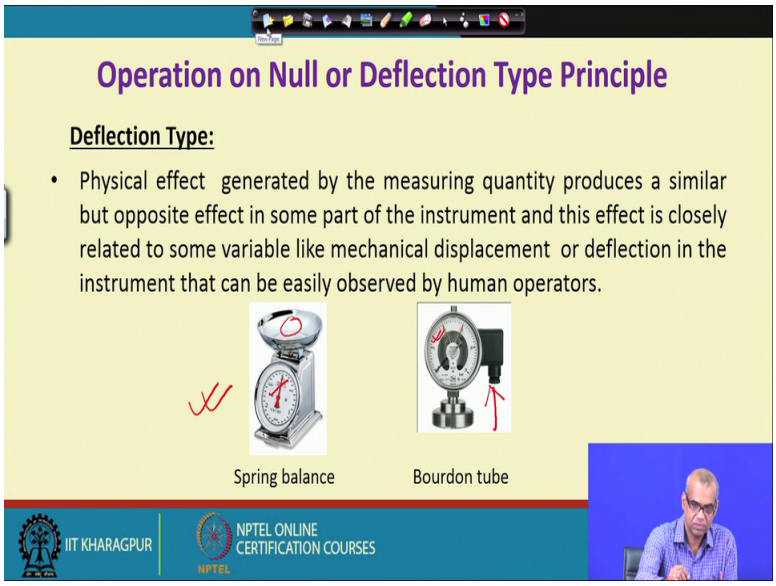

Operation on null or deflection type principle, what do you mean by deflection type principal is as follows. Physical effect generated by the measuring quantity produces a similar, but opposite effect in some part of the instrument and this effect is closely related to some variable like mechanical displacement of deflection in the instrument that can be easily observed by human operators.

Look at the spring balance when you put weight on this span the information about the measurement is represented by the deflection of this pointer. Similarly the bourdon tube when you apply fluid pressure here the information about the measured pressure is indicated by the pointer against this scale. So, deflection type instrument indicates the information about measured quantity by a deflection, whereas, in case of null types attempt is made to maintain deflection at 0.

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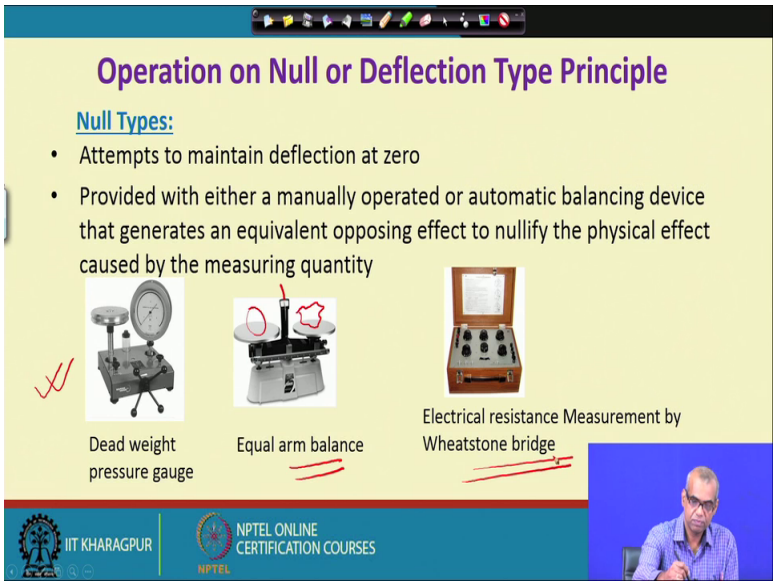

So, when the instrument indicates the information about the measured quantity a null point is maintained. So, deflection is made 0 at that point. So, the null types instruments are provided with either a manually operated or automatic balancing device that generates an equivalent opposing effect to nullify the physical effect caused by the measuring quantity.

An example is a dead weight pressure gauge, equal arm balance you weight use, let us I put 500 gram weight here. So, when I put 500 gram commodity here there would not be any deflection of this pointer there will be 0 deflection or it will be at null position similarly electrical resistance measurement by Wheatstone bridge you maintain a null point.

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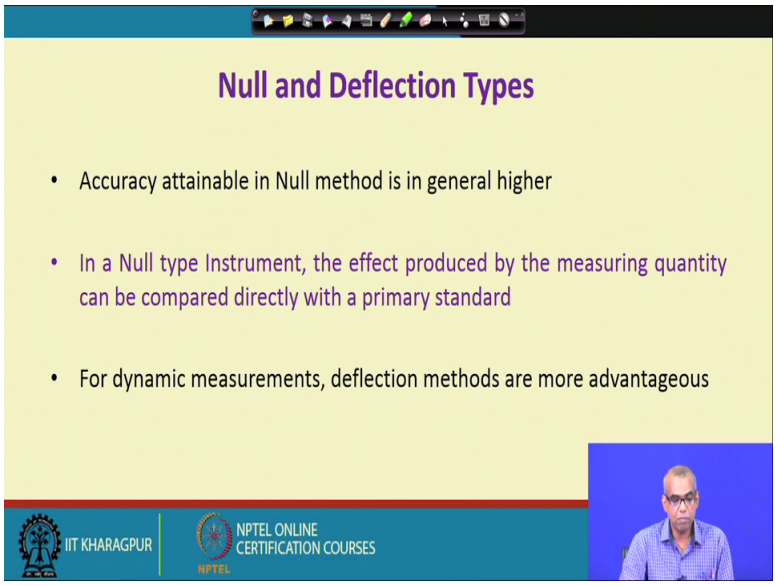

So, these are all null type instruments, some more points about null and deflection types instruments, accuracy attainable in null methods is in general higher than that of deflection type instruments in a null type instrument the effect produced by the measuring quantity can be compared directly with a primary standard, imagine the example of balance, for dynamic measurements deflection methods are of course, much more advantageous because null type instruments requires operators assistance to get the null point, in principle it can be made automatic, but you have to make arrangements. So, that you can get the null point in that while the instrument is indicating the information about the measured quantity.

Next we can also classify the instruments on the basis of whether they are contacting type or non contacting type.

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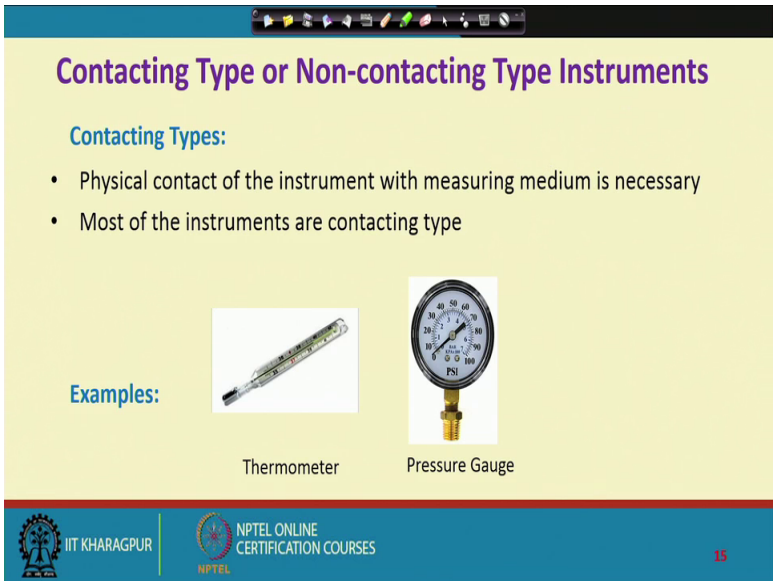

As the name suggest the contacting type instruments are those where you have to bring the instrument in direct contact with the medium whose value or quantity you are measuring. So, of direct physical contact of the instrument with the measuring medium is necessary for contacting types instruments most of the instruments are contacting type.

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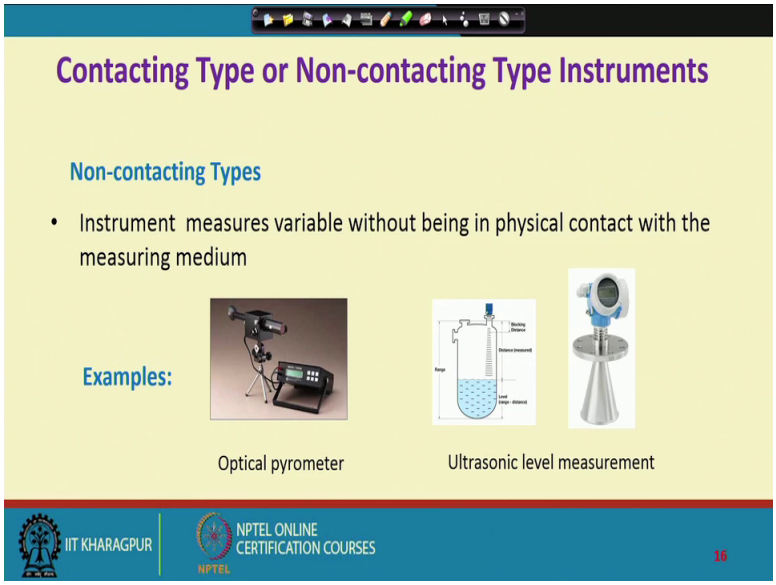

Example a thermometer, a pressure gauge and there are several other examples we will see as we move along. Non contact, non contacting type instruments here instrument measures variable without being in physical contact with the measuring medium. So, you

do not have to bring the instrument in direct contact with the medium whose quantity your value whose quantity or value are measuring, imagine you want to measure the temperature of furnace, the temperature may be extremely high. So, it may not be possible for you to bring a sensor or a instrument in direct contact with the medium will rely on principles of non contacting type instruments.

An optical pyrometer is an example of non contacting type instrument, is the temperature in measuring instrument it is used to measure temperature of objects, hot objects and it is not necessary that we bring the instrument in contact with each other, we will learn more about optical pyrometer when we talk about temperature measuring instruments in detail.

Similarly, ultrasonic level measurements it works on the principle of reflection of ultrasound again it is a non contacting type instruments. So, non contacting type instruments have certain advantages, but most of the instruments that we have use in laboratories or industry are contacting type, we have seen we have seen infrared thermometer which measures your body temperature without touching you, it is there in several airports which screens human body temperature for fever it is an non contacting type instruments.

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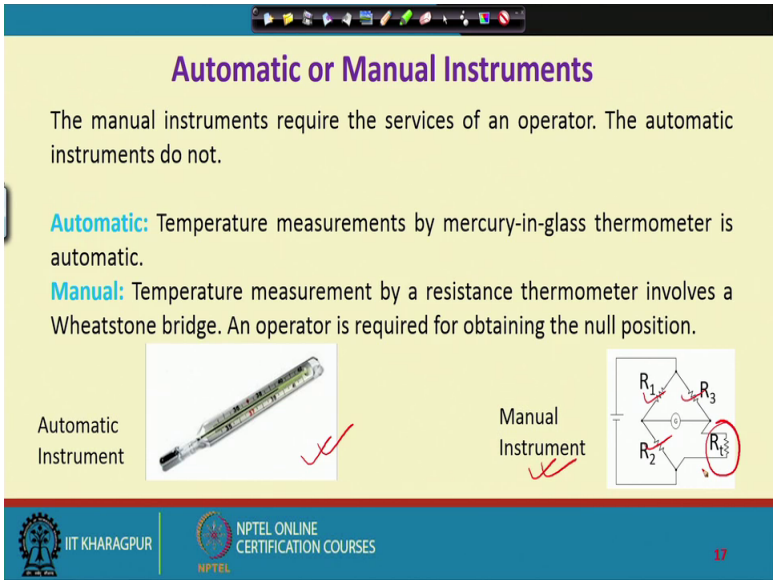

Finally we can also classify instruments on the basis of automatic or manual instruments, the manual instruments required the service of an operator the automatic instruments do not require the service of an operator.

Let us say temperature measurements by mercury in glass thermometer, is an automatic instrument because it does not require any service of the operator, you just have to put the thermometer in contact with the medium whose temperature were measuring temperature will be indicated by the position of the mercury in the scale. manual temperature measuring instrument we learn later about a resistance thermometer, it works on the principle of change of resistance of a way with change in temperature, we know the temperature we know the resistance of a resistance were change changes with change in temperature.

So, by measuring the change in resistance I will be able to measure the temperature, now this measurement involves a Wheatstone bridge. So, we have seen just few slides before that Wheatstone bridge requires a null point to be established. So, the measurement of temperature by a resistance temperature device is a manual instrument because it requires operated assistance to obtain the null point.

So, this is an example of ordinary mercury in glass thermometer which is automatic instrument and this is a manual instrument, here this is the Wheatstone bridge 3 ms and this 4 term is connected to the resistance where or resistance thermometer we will learn more about this in detail when we talk about temperature measuring instruments in temperature measuring instruments in detail.

One point to be noted here is this that automatic instrument does not necessarily have to be very complex with respect to manual instruments, for this given example in hand when you talk about temperature measurement by mercury in glass thermometer which is a very ordinary and simple looking thermometer it is an automatic instrument, but temperature measurement by resistance thermometer with help of a Wheatstone bridge is more complex looking instrument, but a manual instrument. So, it depends on whether operator assistance is required or not of force automatic instruments have distinct advantages.

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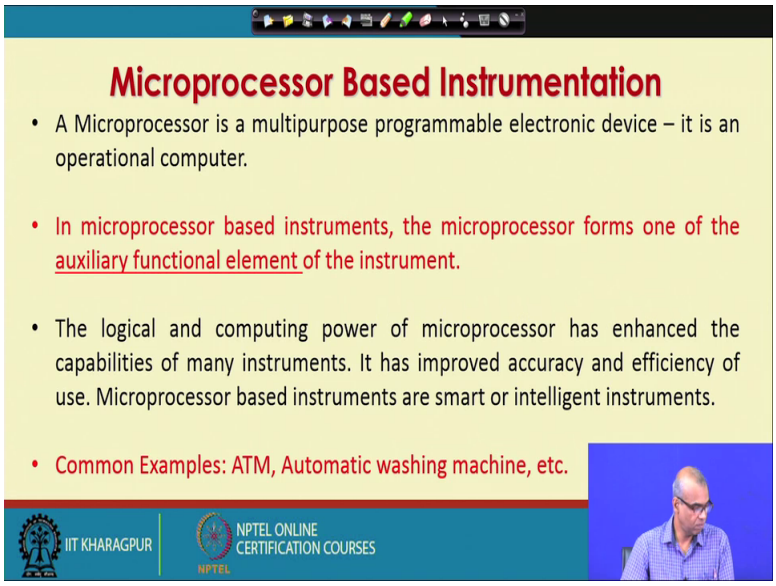

Let us now very briefly talk about microprocessor based instruments, a microprocessor is the multipurpose programmable electronic device it is actually an operational computer in microprocessor based instruments the microprocessor forms one of the auxiliary functional element of the instrument. We have talked about various functional elements of an instrument, in microprocessor based instruments the microprocessor will be one of the auxiliary functional element of the instrument, the logical and computing power of microprocessor has enhanced the capabilities of many instruments, it has improved accuracy and efficiency of use.

Microprocessor based instruments are known as smart or intelligent instruments, common examples are ATM, automatic washing machines etcetera.

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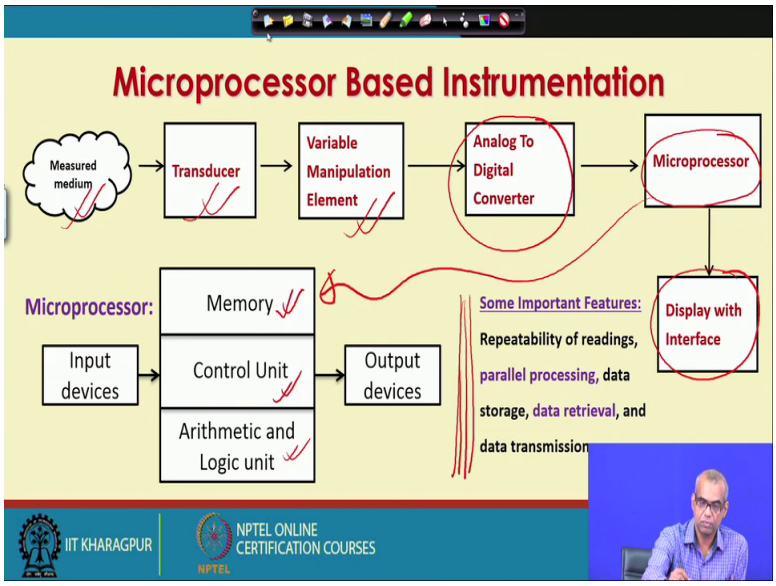

So, in case of microprocessor based instruments the information from measured in medium can go to transducer for the time being you can think of it as a primary sensing element plus a variable conversion element. Output goes to variable manipulation element for amplification or reducing the strength of signal as necessary been an analogue to digital converter will be there. So, analogue signal will be converted to a digital signal, microprocessor will receive this digital signal and microprocessor will display with interface.

Since the microprocessor is essentially an operational computer, you will see the memory unit, the control unit and the arithmetic and logic unit in a microprocessor, some important features of microprocessor based instruments repeatability of readings parallel processing, data storage, data retrieval and data transmission. So, these operations are much easier for a microprocessor based instruments.

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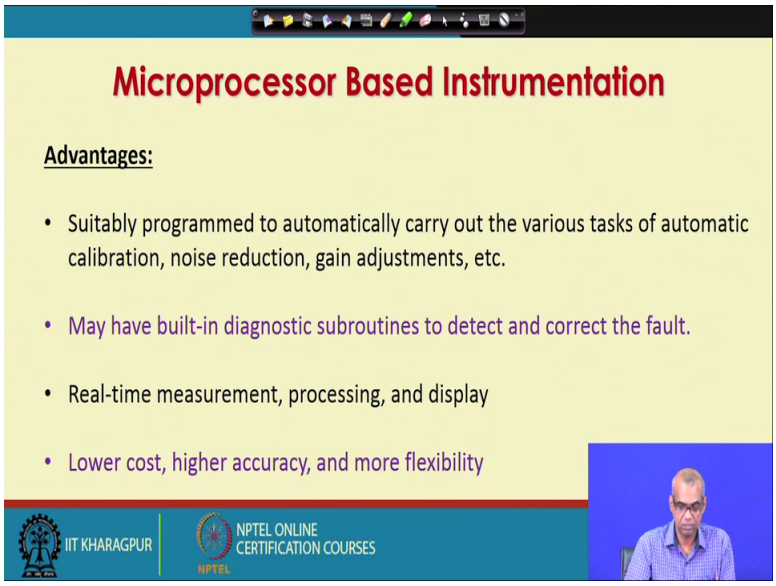

Some of the advantages of microprocessor based instrumentation; it can be suitably program to automatically carry out various tasks such as automatic calibration, noise reduction, gain adjustment etcetera. It may have built in diagnostic subroutines to detect and correct the fault in the instrument or fault in the measurement, real time measurement real time processing and real time display is easily available, lower cost higher accuracy and more flexibility.

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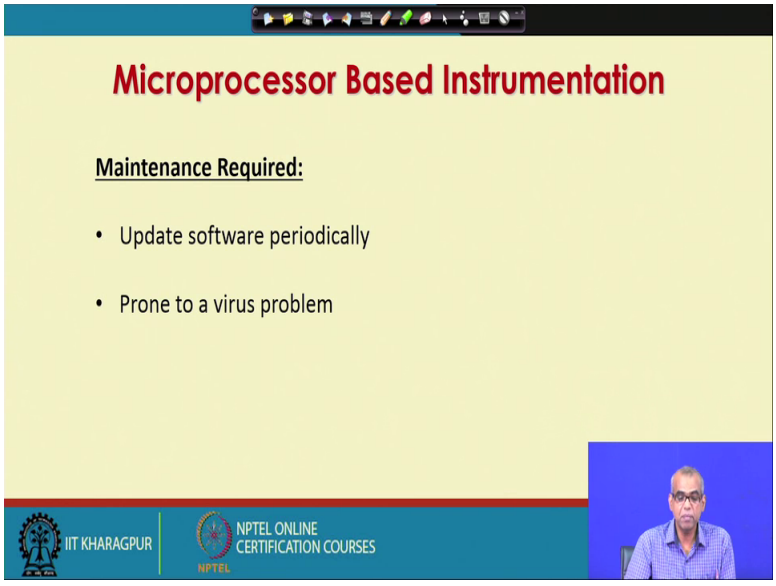

But certain maintenance or certain care is required, we need to update software periodically with time and it is also prone to virus problem, otherwise microprocessor based instruments are much more advanced user friendly accurate. So, we stop our lecture 4 here.