Engineering Metrology

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Lecture - 2A
Instruments-I

Welcome to the course on metrology in measurements. So, today, we will see the topic, role of the instruments in measurement systems.

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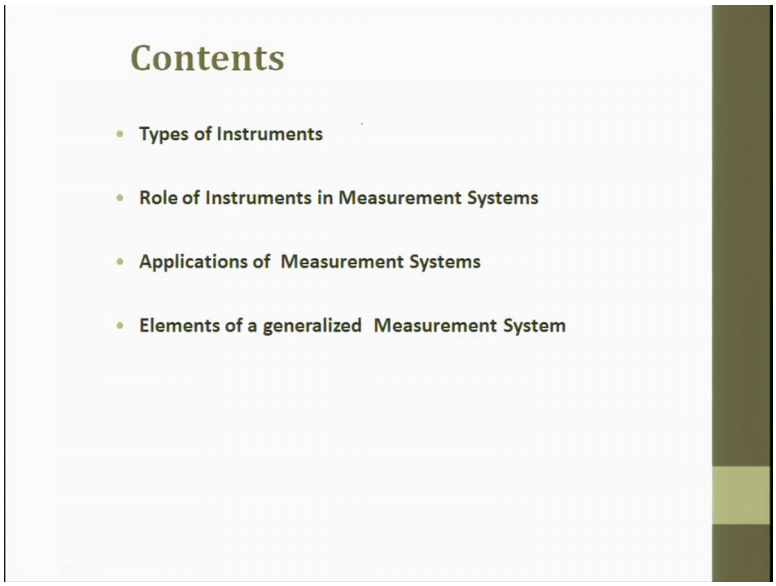

So, today we will be covering the following content; types of instruments, then role of the instruments in measuring measurement systems, applications of measurement systems and elements of a generalized measurement system. So, yesterday we saw when we had previous lecture, we saw very clearly that measurement is a very important process and this process is also used majorly one for validation, other also to control the process or control some man operations.

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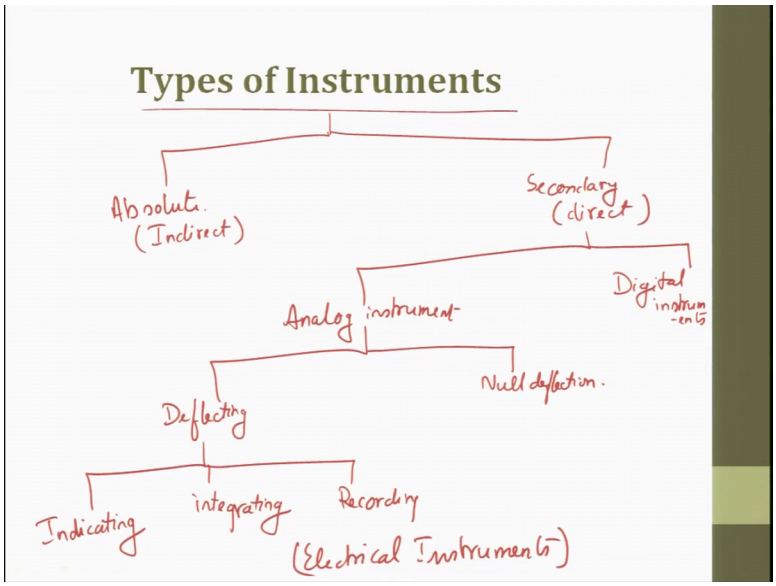

So, when we talk about type of instruments. So, the type of instruments can be classified as two; one is absolute, next is a indirect measurement and we have secondary which is a direct measurement direct instrument right. So, this direct can be classified into two which is analog instrument and this is digital instruments. Then, this analog can be divided into two; one is called as deflecting type, the other one is called as null type, null deflection right and this deflective can be further classified into two. So, first is indicating, the other one is integrating and the last one is the recording. These are generally classification of electrical instruments, ok.

So, instruments can be classified into absolute and secondary, then the secondary can be further classified in to analog and digital. Digital is today very popular and analog is basically you can discretize between even between two points; we can start doing for a analogous instrument, this analogous works on deflection, deflecting type and null deflection, then this deflecting can be further classified into Indicating, integrating and recording instruments.

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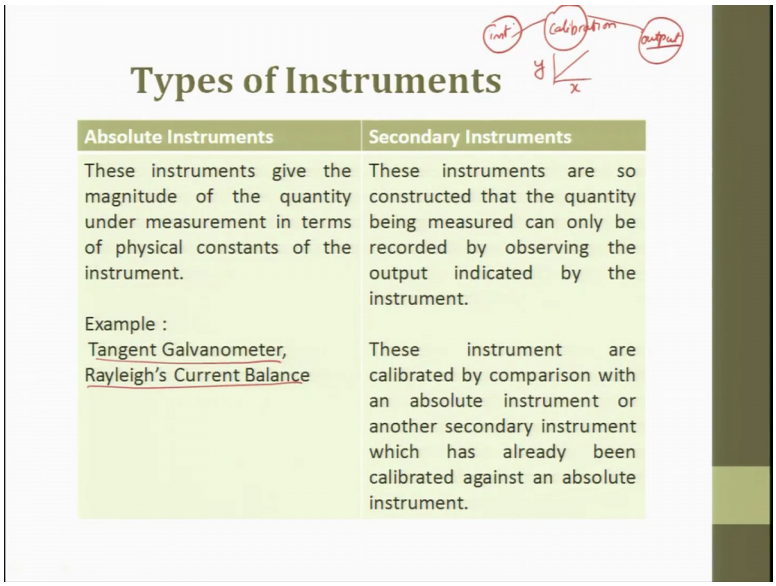

Now, let us see the difference between absolute instrument and secondary instrument. So, absolute instruments; these instruments give the magnitude of the quantities under measurement in terms of a physical constants of the instrument. For example, it can be tangent galvanometer or it can be Rayleigh's current balance. So, these are absolute instruments. When we talk about secondary instruments, these instruments are so constructed that the quantities being measured can only be recorded by observing the output indicating by the instrument. So, what is displayed there, we only see that and then we start doing the measurements these instruments are calibrated by comparison with an absolute instrument or another secondary instrument which has already been calibrated against an absolute instrument.

So, what we are trying to say here is in secondary, we have an instrument, this instruments has to be calibrated. So, here is the calibration so, this calibration will always try to take measurements in the linear between y and x. You establish the relationship in this calibration and then what we do is, we try to get the output. So, the instrument whatever we use over a period of time can have a warrantor or even during the first time, you have to set the machine tension or a spring tensions or the other readings in the ramp. So, what we do is we first calibrate after the calibration is over and whatever we get in the direct motion. So, that is what we said these instruments are calibrated by comparison with an absolute instrument or another secondary instrument which has

already been calibrated against an absolute instrument. For example, what we say is you try to have a measuring scale so, this scale has graduations.

So, what we do is we try to check whether the graduations in the scale are perfect. So, we try to check it to another scale or we directly try to take it with another standard which is available and measure it and see that is what we are trying to do in secondary instruments.

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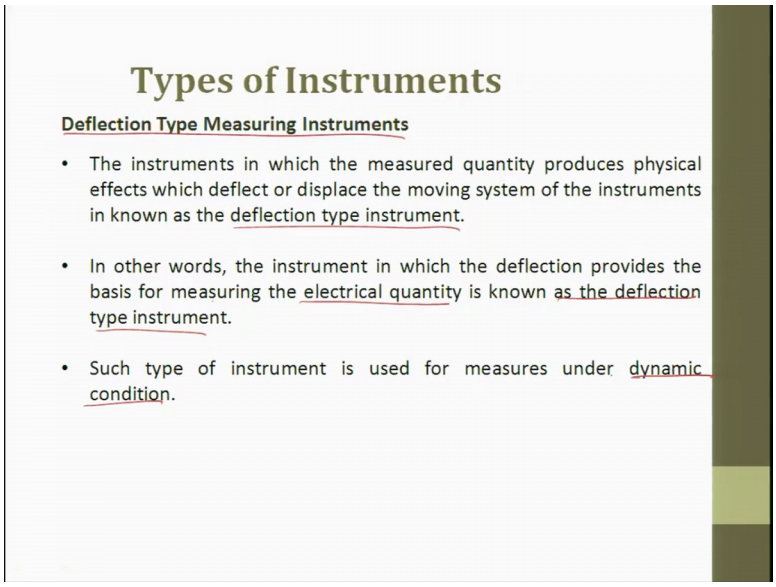

So, when we talk about deflection type measurement instruments, the instruments in which the measured quantity produces physical effects which deflects or displaces the moving system of the instruments is known as the deflecting type instruments. For example, you can take a dial gauge we will see all these equipments in the course as then when you go. So, what happens is it is spring loaded so, you have an object you want to measure the height. So, you put a dial gauge or you try to have some spring or some even scale, you try to take it just keep the move the spring.

When you try to move the spring, what happens? On this springs will inturn try to deflect a pointer which is placed against the graduation. So, you can read the graduations and then try to quantify the measurements whatever it is. So, it is basically deflection type. You have a meter, it is an analogous type; you have a meter and you will have a pointer, this pointer moves left and right whatever it is and then it tries to tell you what is the display. It can be voltage, it can be current, it can be distance whatever it is depending

upon instruments you can start doing it. So, deflection type are instruments in which the measured quantity produces physical effect right you had an object, you had a dial gauge, so dial gauge is pressed against the object.

So, the dial gauges will try to get deflection. From 0, it will try to move towards one direction I will show you what is the displacement; which deflects or displaces the moving system of the instrument is known as deflection type instruments. In other words, the instruments in which that deflection provides the basis for measuring the electrical quantity is known as deflection type instruments. So, if you want to do it for measuring the electrical quantities voltmeter, so then this is always deflection instruments such type of instruments is used to measure under dynamic conditions also; that means, to say you have to put voltmeter occurs across a wire or across as an instrument and the against that device these device are loaded. Moment it is loaded, you can see there be a fluctuation. So, it can be times statically, it can also be done dynamically.

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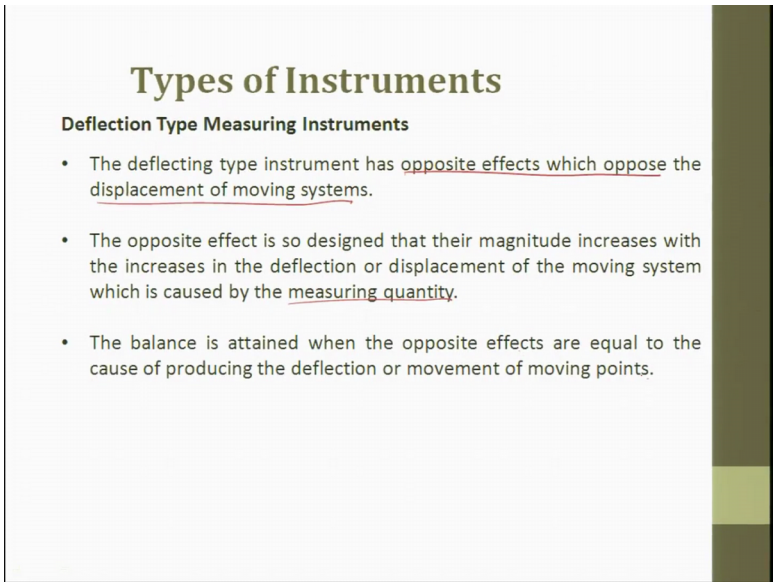

The deflection type instruments has opposite effects which opposes the displacement of a moving system. You can also have instruments like that, suppose I try to push against the spring and you can now see what is the deflection against the spring you have, you measure that deflection and that is also can be used this technique also can be used for measuring. The opposing effect is so designed, but their magnitudes increases with an

increase in the deflection or displacement of a moving system which is caused by the measuring quantity. For example, if there is a spring, the spring difference increases so, moment the spring gets compressed. So, when you see that deflection on the graduation and then you start recording it can be done for electrical, it can be done also for mechanical. The balance is attained when the opposing effects are equal ok.

So, the balances what the either the static position or when you try to apply a load or when there is a movement happening, so there to balance it back to the normal position or to the 0 position, we use this instruments. The balance is obtained when the opposite effect are equal to the cause of producing the deflection or movement of a moving points. So, these are the deflection type instruments.

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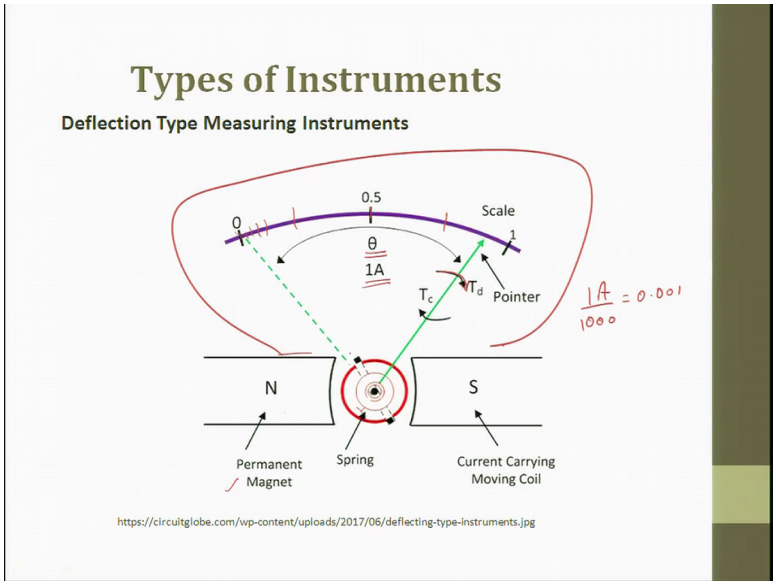

So, you can see in a deflection type instruments, you can have a permanent magnets. So, these two are a permanent magnet. So, a permanent magnet is placed, or current carrying moving coil is there. So, this is south this is north. So, if here you can see a coil the spring a partial spring is there. So and then here is a pointer you can see a pointer there right. So, at and here is the graduation scale, suppose you wanted to make it as a instrument bases on instrument you see the graduations here and this is the pointer which moves from 0 to 1. This moves 0 to 1 depending upon the current carrying moving coils response.

So, this coil swings from 0th position to the 1th position right and here they have said what is the each scale one the total reading is 1 Amperes. So, here you can see that this is T d, we will see what is T d in the next slide; T d and this is T s and you also try to make a note of the angle theta.

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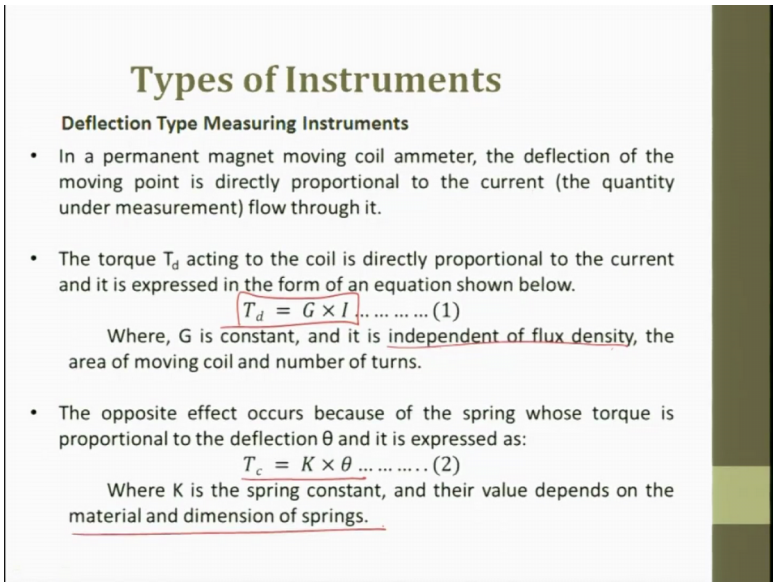

So, now let us get back to the deflection type measuring instruments. In a permanent magnet moving coil ammeter, your taking an ammeter the deflection of the moving point is directly proportional to the current.

So, as and when the current is passed the deflection happens which is seen in the equilibrium, directly proportional to the current flowing through it. The torque T d, so this is the torque; torque: force into displacement. So, the torque T d acting on the coil is directly proportion to the current and it is expressed as T d is expressed as G into I. What is G? G is a constant and it is independent of flux density the moving of the area of the moving coil and the number of turns. So, here if you see that is number of turns will be there. So, G is a constant and it is independent of the flux density and the moving and area of the moving coil and number of turns. The opposite to T d, you see opposite to T d is T c; the opposite effect across because of spring whose torque is proportional to the deflection theta and it is expressed as T c equals to K theta. So, one is T d, the T d has to be balanced by T c, right.

So, when T c has to be balanced. So, we always talk about the spring constant and their values depend on the material on the dimension of the spring. So, the sensitivity of the spring is directly proportion to the dimensions and the material in which we choose.

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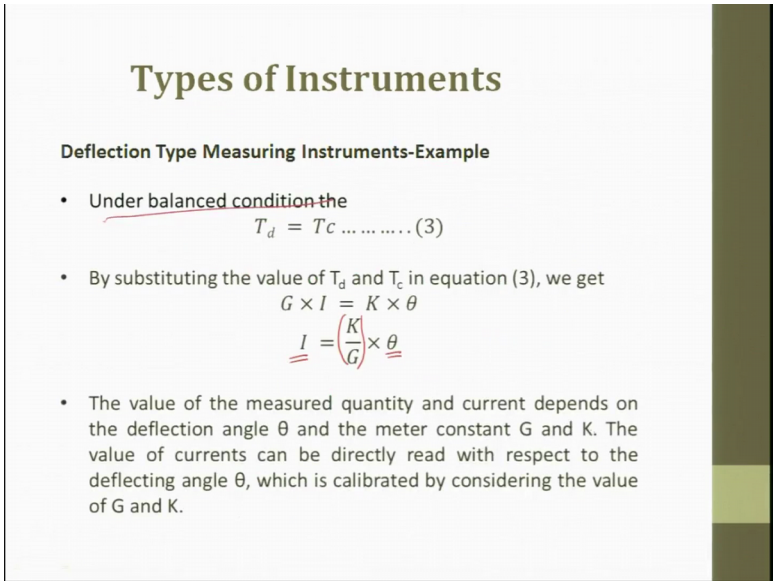

So, under the balancing condition now, T d should be equal to T s. So, now, when we try to substitute all those things G into I equal to K into theta, so now, we know for the current whatever is carrying to the coil this is a constant parameter and this is an angle. K by G is a constant parameter K is depends on material G is independent of flux density. The value of the measured quantity current depends on the deflection theta and the meter constant G and K.

The value of the current can be directly read in this instrument. This is nothing but a deflection type measuring instrument. The value of the current can be directly read with respect to the deflecting angle theta which is calibrated by considering the values of G and K. So, this one if you see this meter, this because suppose let us assume you buy it for the first time that time also what they do is, they try to apply load and then they try to adjust that stiffness or the spring the makes your that the instrument is sensitive. Then since it has a moving mechanical part over a period of time, it gets wear and tear. So, again it has to be calibrated and then it has to be brought down. Calibration is basically periodically you check what whether the instrument is working properly. So, how do we check that; for a known current, what is the deflection we try to get.

If there is error here, we start adjusting the error during the calibration, set the system right on this. So, how do we do it? Spring constant and G; what is G? G is nothing but a constant we it is independent of flux density the area of the moving coil and the number of turns right.

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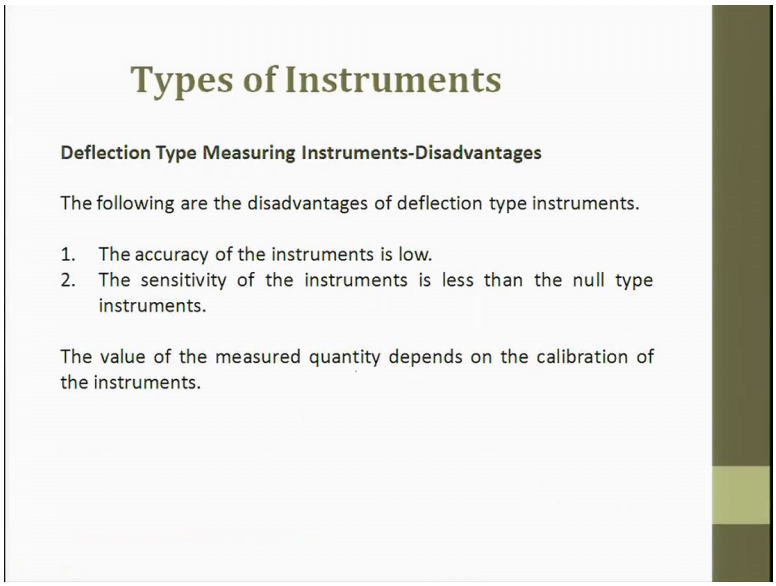

So, the deflection type measuring instrument. So, this is deflection type. So, if you go back and see whatever we have discussed we have told you many things, opposite the deflecting type instrument has opposite effects which opposes the displacement of a moving system. So, here you now you can understand the moving system is a spring ok. So, the disadvantageous of deflection type measuring instrument, the following are the disadvantageous of the deflection type instrument, the accuracy of the instrument is very low because here basically what we do is it is the graduation between these two. Say for example, from here if you can set this theta if it is around about 60 degrees right, 60 degrees what is happening is you are dividing in to may be 6 or 8 divisions.

So, if you divide it into 6 or 8 divisions, so here the sub divisions will be 2 hard to you to see. So, the sensitivity and accuracy are two different terminologies. We will see the difference while the course is going on. Sensitivity of the instrument is also less, accuracy is less and sensitivity is less because, the sensitivity in turn depends upon this spring constant. The spring constant you cannot vary very small steps. So, if you cannot

vary very small steps, then basically the pointer shows the displacement. So, the displacement also cannot show in very small step.

For example, you can invest equipments suppose you talk about one as the graduation. So, there it can be divided into 100 parts. So, 1 Amp can be divided into 100 parts. So, you will 1000 parts. So, what you get is the 0.001 will be the resolution. And suppose, if you want to have 10000, then so many lines have to be drawn which is not possible and second thing the spring constant a spring which is used also does not has sensitivity. So, basically, the sensitivity is not there, the accuracy is not there.

The value of the measured quantity depends on the calibration of the instrument. Suppose if the calibration is wrong, so then whatever data we get the result is also not clear.

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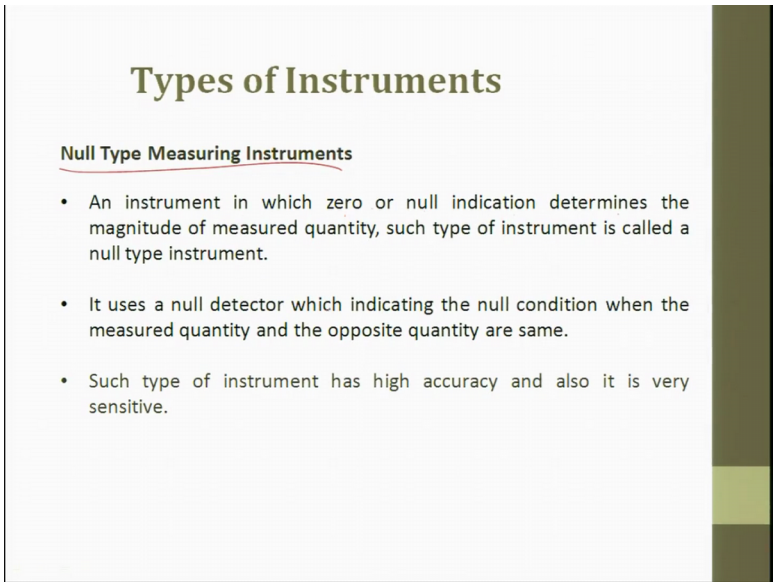

The other type of classification in analogous is null type measurement instrument. Here in null type, the instrument is the word null itself says it has something to be related to 0 and instrument in which 0 or null in indication determines the magnitude of the measured quantity such that such type of instrument is called as null type instruments.

So, I repeat an instrument in which 0 or null indication determines the magnitude of the measured quantity. It uses a null detector which indicates the null condition when the measured quantity and the opposite quantities are the same. This type of instruments are

highly accurate and also it is very sensitive. So, compared to the previous condition, whatever we have seen in deflection type, the null is much more accurate and sensitive. So, wherever we want, we would like to prefer null.

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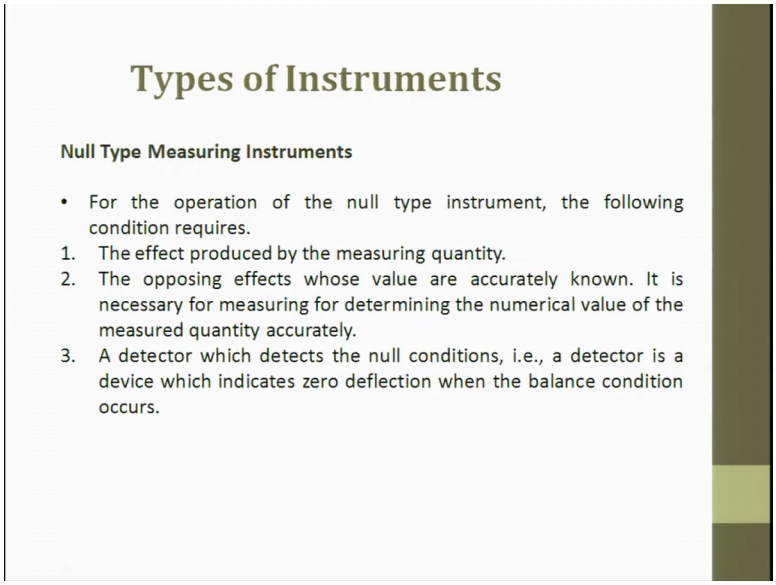

For the operation of the null type instrument; where is the difference coming from? So, that is what we are going to next. For the operation of the null type instruments, the following conditions are required.

The effect produced by the measuring quantity the opposing effects whose values are accurately known, it is necessary for measuring of for determining the numerical values of the measured quantity accurately, a detector which detects the null condition; that is a detector is the device which indicates 0 deflection when the balance condition is occurred. So, these are the conditions required for null.

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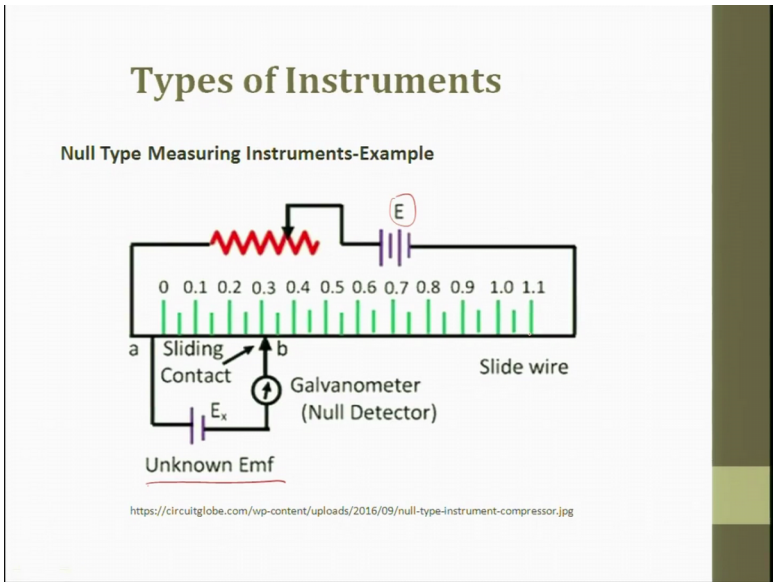

So, this is how it this schematic diagram looks like. So, null type deflector. So, here you will have a main scale you have a sliding contact ok. So, sliding contact is the here, there is the galvanometer so, this is a wire sliding wire, this is the sliding contact which is here and here you will have a resistance which is added and then you will have voltage which is applied E. So, here are graduations. So, unknown EMF is applied here. So, if the galvanometer does and then it slides over a sliding wire, so, if you look at it, if you wanted to do comparison measurement, if you want to do displacement measurement, so we can always at this can be a sliding bar and this can be a stationary bar or it can be a stationary scale and there is a sliding contact which moves on a stationary scale.

So, what happens based upon the lines and the distance here, there is difference in the voltage displayed and so, you can get the output.

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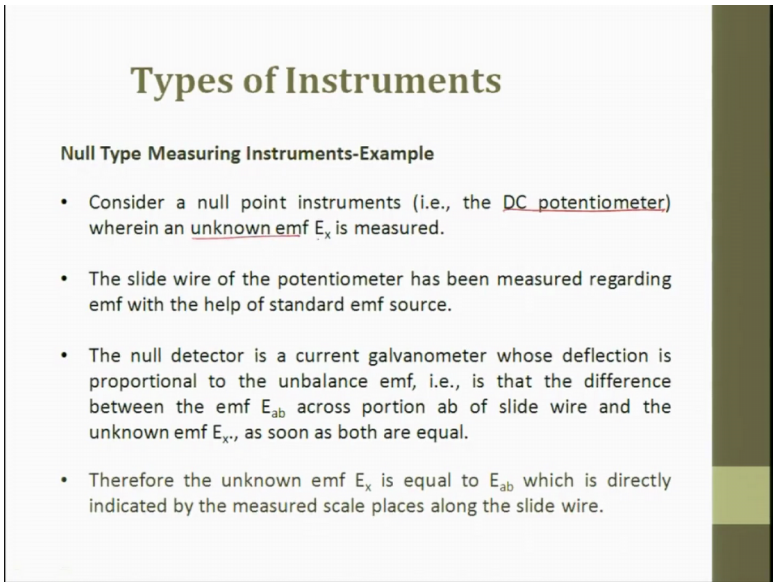

So, consider a point ah, consider here a null point instrument that is the DC potentiometer which is an unknown emf E x is measured. A slide wire of a potentiometer has been measured regarding emf with the help of a standard emf source ok, potentio is nothing but we try to rotate and try to balance a circuit or balance a bridge. The null detector is a current galvanometer whose deflection is proportional to unbalanced emf that is that difference between the emf absolute across portion ab of sliding wire and the unknown emf E x as soon as both are equal. So, if you go back and see where is E, E x, E ab.

Therefore, the unknown emf is equal to E ab which is directly which is directly indicated by the measured scale placed along the sliding wire. So, here if you see this sliding wire which moves the sliding contact moves on a sliding wire and with that we try to see the displacement and then we try to balance it between E x and E eb, E ab and we try to find out if you want to balance it. So, what are you to adjust so, we adjust it in the red resistance given here and then we try to find out.

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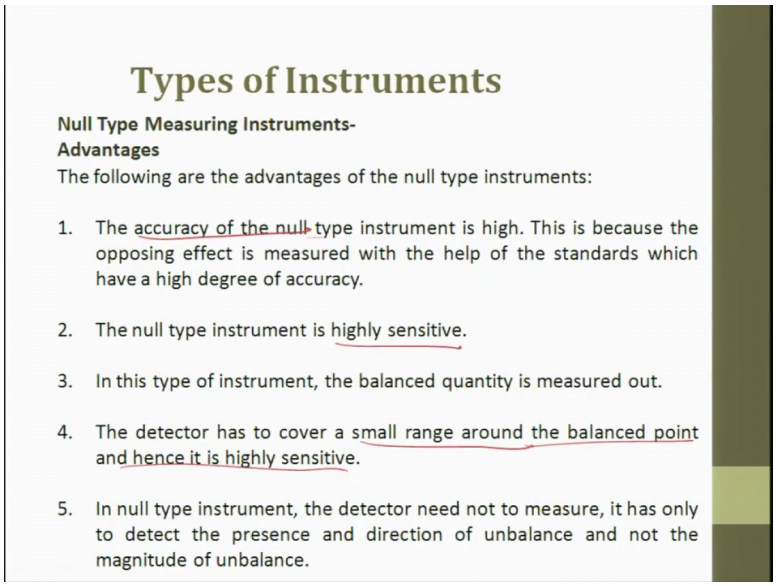

So, the advantageous are going to be the accuracy of a type of instrument present extremely high, the null type instrument is highly sensitive. So, it is accuracy is high, it is highly sensitive the; so, here there is if you see here there is no mechanical moving parts. For example, there you had a spring to balance in this you do not have spring to balance.

So, the detector to cover a small range around a balance point and hence it is highly sensitive, so, this instrument null type instrument measurements are very well appreciated.

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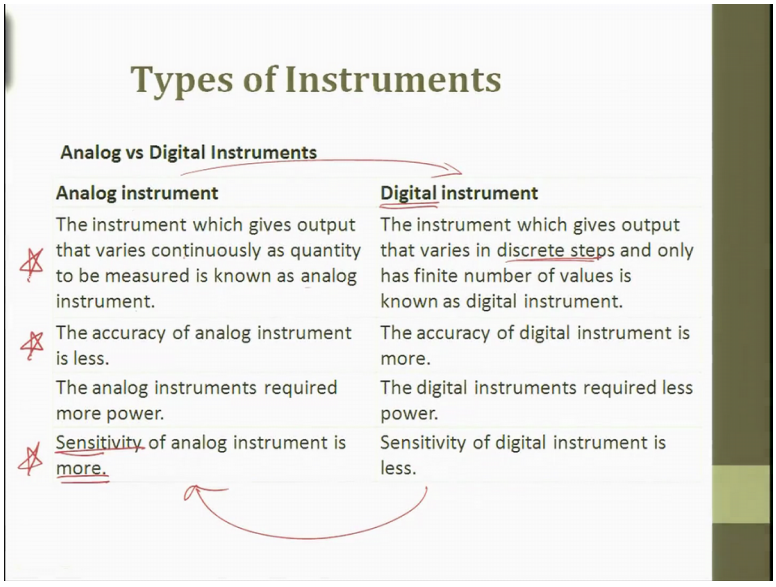

So, when you try to see the difference between analog instrument and digital instrument. Today everything has become digital, earlier it was an all analogous. So, the analogous in which gives output that varies continuously as quantities to be measured is known as analogous instrument whereas, in digital it will be in discrete steps. It will first start at moving from first used analog, from analog they went to digital and they said while if you go the digital we have more options to play with the signal and the output. And now what they realize is if we use it by digital, further classification between the two discrete iteration steps becomes very difficult.

So, people are trying to go back from digital to analogous now and see how to balance the data. The accuracy of the analog instrument is very less, the accuracy is high the analog instrument requires more power because, lot of moving parts are there digital is less power. Sensitivity is of the analogous case is very high the sensitivity for the digital is very less ok, sensitivity is one term it is more analog. So, that is why people are moving back to analog to see what they can do with the signals.

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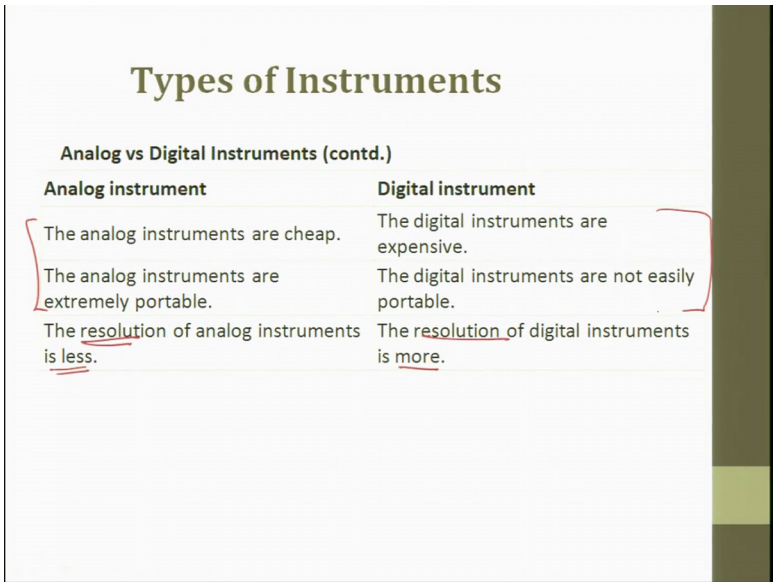

Analog instruments are very economical, digital are expensive, but now it has also become economical because lot of mass production of digital equipments have started coming in to the market. The analog instruments are extremely portable, the digital instruments are not easily portable, we are talking about in totality, but it is now also become portable.

The resolution of the analog instrument is less, resolution of the digital is more. So, this is also very important resolution. See these two points are secondary points, please do not try to take this in the examination point of view. The most important points are going to be this one, this one, this one and this one right. Rest all points are secondary points. These four are primary points to distinguish analogous and digital.

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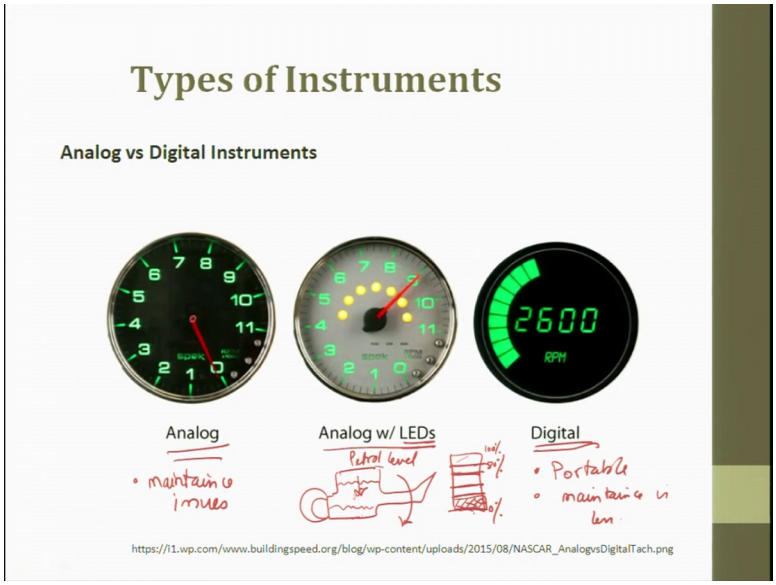

So, if you see analogous, this is analogous. Earlier in the bikes and all we used to see the graduation is continuous and there used to be a pointer which moves along around it and then it tries to show the speed whatever it is right. So, now, then later it became analogous with led right and now it has become completely digital. It has become completely digital. So, today if you see the analogous where there are springs and other things which are involved, so it always has maintenance issues. But here it was portable and maintenance were less here ok. Today, there is a blind of led also getting and so, it becomes easy. So, I recently saw a dial instrument wherein which they had a display and this was basically nothing but to tell about the petrol level and here was the display which said.

So, it showed like almost if the petrol is filled, it showed something like this and as and when the petrol level goes to down, it goes like this. And slowly this instrument this display started rotating and the neck came down and this whatever data we see here is also seen as a graduation here. So, they said 100 percent may be 80 percent and it had 0

percent. So, as and when the petrol level goes down, so you can see here also the colour will be switched off and finally, when it comes to this portion it will start displaying it in that colour. So, it will give you a feel for the driver to go fill it. So, here more than what is the level showing, it also indicates and it also indicates an alerts the driver that petrol has to be filled. So, this is completely digital ok.

You can also have led attached with analogous, but today exhaustively what we use is digital.

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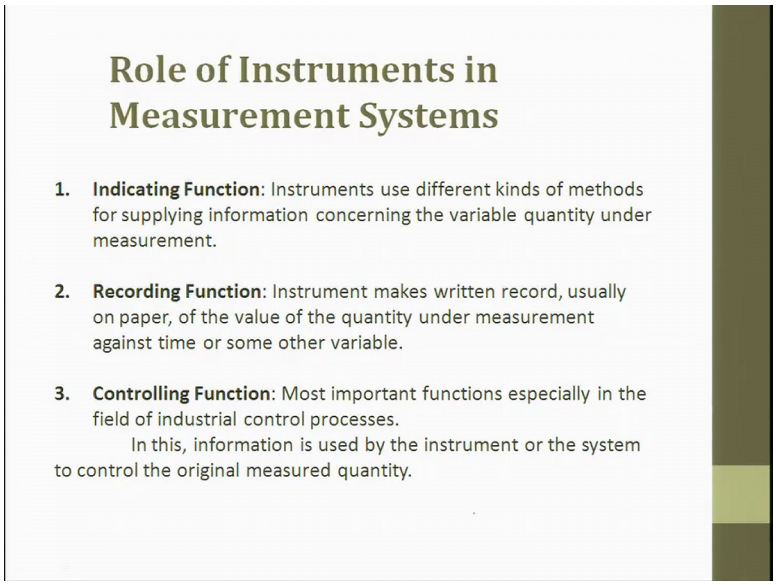

So, when we talk about the role of instruments in measuring system indicating function, the instruments use different kinds of method for supplying information concerning the variable quantities under measurements. These are indicating which indicates, recording is which record. For example, the most challenging risk indicating. So, indicating is it only shows. So, what do we do with the shown data? So, the shown data suppose if you want to record the data at 6 o clock in the morning, 7, 8, 9, 10 and this has to be given to you at the evening shift or at the evening hours or with working style for 24 hours. So, then first it indicates, then whatever it indicates should have a phenomena of recording. So, the data is recorded so and then it if from the recorded data if you want to control the entire process then the last one is the control function.

So, indicating is just to show what is the measurements going on. Recording these instruments make written record usually on paper it can be a stylus moving or it can be a

excel file or it can be darts getting plugged or the values of the quantity in measured under various kinds scales and some other variables. Control functions most important function, especially in the field of in industrial control process. So, whatever is indicated, it tries to take the data looks into a base function and then it tries to verify and if there is an error, it does a correction.

So, control function is most important function especially in the field of industrial control process. In this, information is used by the instrument or a system to control the original measured quantities. So, next let us see the role of instruments in measuring systems. So, here this can be represented by a schematic diagram.

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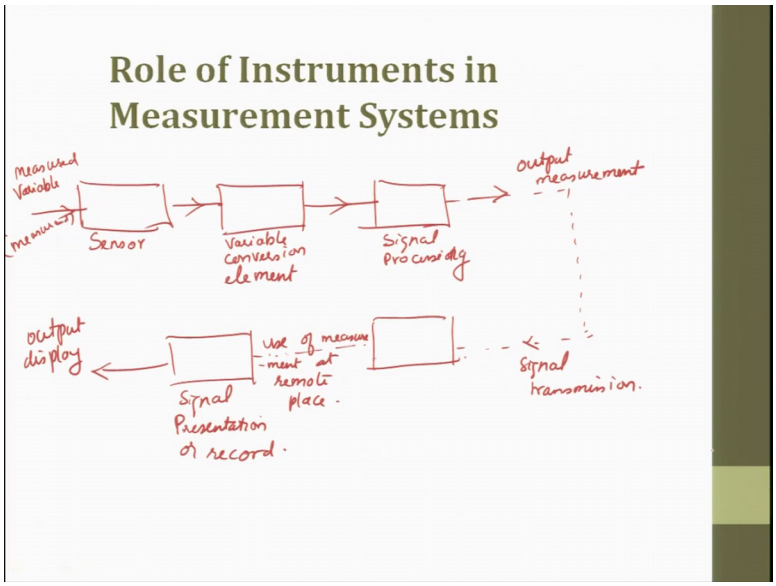

So, first let me make the diagram and then name it. So, this is a measured variable ok, this is given here. So, here is a sensor to measure it. Then here what we do is it is a variable conversion element, the next one is going to be the signal is getting processed ok, then here you what we have is output measurement, then signal this transmission and then here we use of at remote place and this is signal presentation or record, then this is the output display ok.

So, if you look into the role of instruments in measured system, you will try to have a measured variable which is otherwise called as measurand ok. Then you will have a sensor. So, from the sensor, it will be various conversion elements, then it will be a signal processing signal is getting processed, then you get an output. So whatever output is

there it is getting retransmitted. So, it into retransmitted and then here what we do is we try to use the measurand at remote places, you try to take this signal and then you try to get these things.

Suppose this is just to give you a simulation of your control room which is there in a processing industry. So, the sensor will measure it. Whatever it measures, it gets converted variable conversion elements are there. So, then what we get is a signal. So, whatever signal we get we process the signal to control the process. So, it is transmitted. So, and then it is also recorded and finally, what you see on the display board is the output which is measured ok. So, with this, we will come to an end of this lecture.

Thank you.