Mechanical Measurement Systems
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Lecture – 03
Classification of Measuring Instruments

Hello, I welcome you all in this course on mechanical measurement systems, today, we will discuss classification of measuring instrument, in today's lecture, we will be covered we will be covering classification of measuring instruments we will take some examples.

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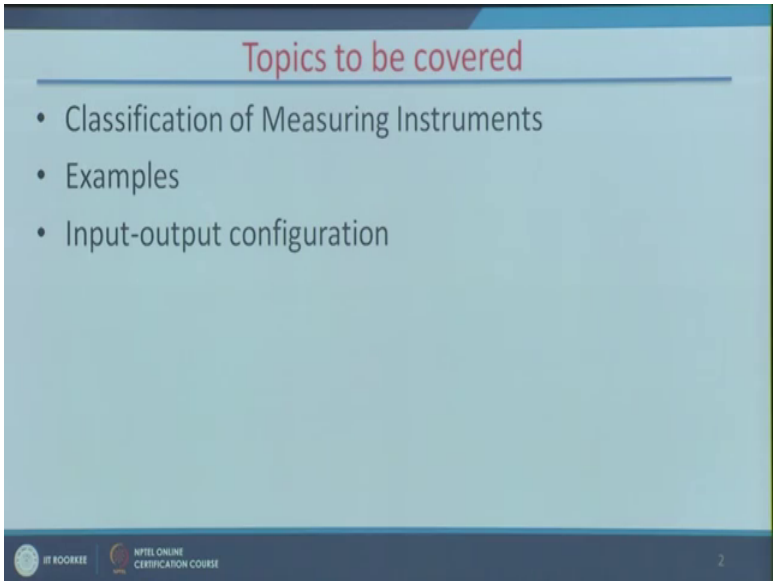

And we will discuss input output configuration of measuring instruments, now we have in previous lecture we discussed about the functional elements of the instruments and because there are number of instruments there are n number of instruments which are used for the purpose of measurement. And we will like to here we will like to classify those measuring instruments.

And the first classification is null and deflection type null.

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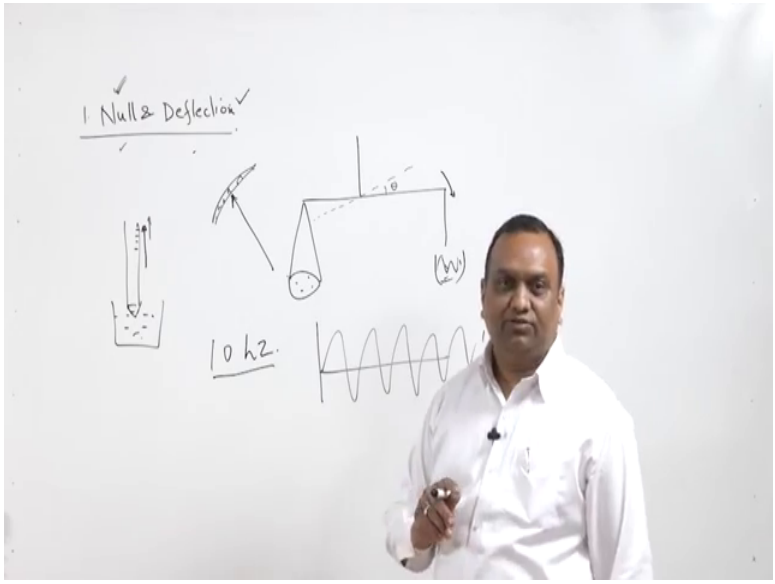

And deflection, null and deflection type of instrument. When an instrument is loaded I means let us take example of a thermometer, when a thermometer is dipped in water right the primary sensing element comes into the contact with the measurement and we say that a instrument is loaded.

And loading of instrument produces some effect in case of thermometer it is increase in the volume of the mercury, which ultimately leads to movement of level of mercury in the thermometer and that is how we measure the temperature. So, when an instrument is loaded it produces some effect right, and that affect is noted this type of instrument is known as defection type of instrument.

Let us take an example of pressure gauge when a pressure gauge is fixed to a vessel the gas or the fluid which is inside the vessel exerts pressure on the pressure gauge, or it is a diaphragm it may be a diaphragm type or piezoelectric type of pressure gauge and then the signal. So, let us take diaphragm type of pressure gauge and the signal is transmitted to the spring and the finally, the spring gives deflection to the indicator and that is how we measure pressure through a pressure gauge.

So, there are n number of devices and all device in some of the devices the measurement is done by defection type of method in this method the primary sensing element comes into the contact with the measuring, it takes signal and this effect of measurement causes some counter effect somewhere, in some part of the instrument and this counter effect is

seen on a scale and I mean normally it is a displacement normally, it is displacement because displacement can be sensed by the eyes right.

There are null type of instruments also the best example of null type of instrument is a balance in a balance, we simply put some weights right on the other side of the balance because if we do not put a counter weight here, a counter weight is put here. If you don't put a counter weight this lever will deflect and occupy some position theta, right.

So, we provide another, another let us say another force or another input to the instrument which neutralizes this effect. So, this neutralizing effect leads to the null type of instrument. So, grossly we can classify instrument as null type of instrument and deflection type of instruments.

Now, if we compare null type of and deflection type of instruments definitely in the null type of instruments, we avoid losses due to friction or losses due to movement of the parts. So, they tend to be more accurate the null type of instruments tend to be more accurate, but on the other side if the signal is dynamic. Suppose signal has a frequency of 10 hertz, and it is a I mean reciprocating like this signal is like this.

So, these type of signals are a difficult to measure with the null type of instruments. So, dynamic signals are difficult to measure with the help of null type of instruments. So, for those purposes deflection type of instruments are preferred.

Second thing is if we take the let us take one example, will take let us take example of dead weight pressure gauge in a dead weight pressure gauge suppose there is a vessel.

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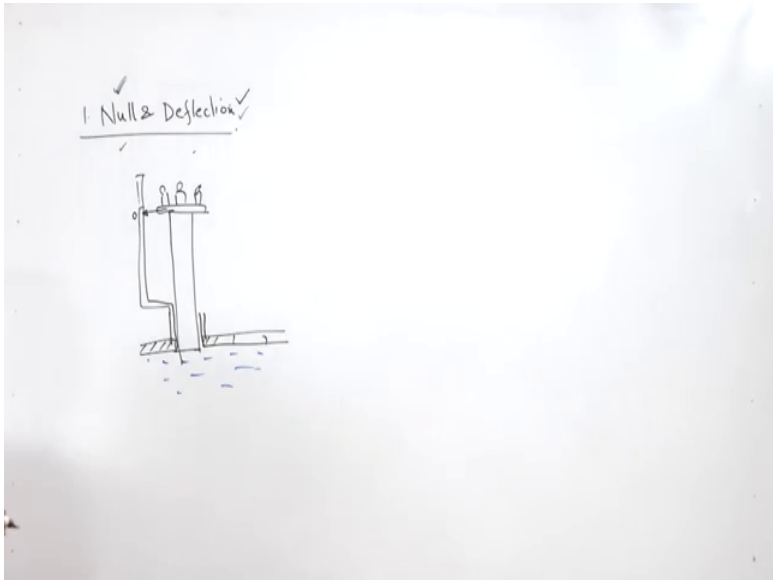

And in the vessel a pressure gauge dead weight type of pressure gauge is fixed, there is a shaft this shaft is in contact with fluid which is occupying this vessel. And the shaft has a platform and on platform we put some dead weights right, and these dead weights are and this platform is connected with a indicator.

So, one thing is though this type of instrument can be null type or deflection type. We can have a constant weight and we can calibrate this weight with this pressure and then with rise in pressure we can take reading with the help of this indicator, second thing is we just keep it in a null position and keep on increasing the weight and we can do the measurement.

So, this type of instrument I mean we can modify this instrument for both type of measurement null type of measurement and deflection type of measurement; however, when we go for the deflection type of measurement then friction automatically will come into the picture the losses due to friction will automatically come due to picture, that is why it is always preferred to have null type of instrument if the system is not dynamic. Another classification can be for this measuring instrument.

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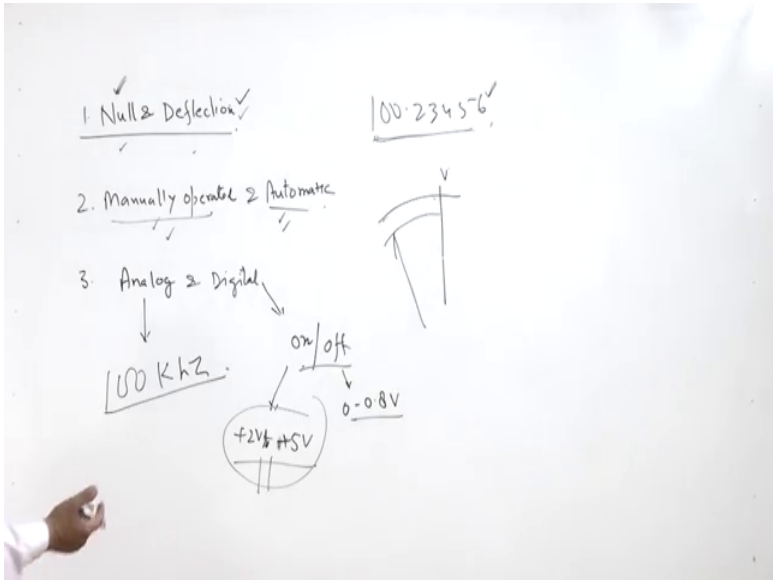

That is manually operated and automatic type. So, all the instruments can further be broadly classified as manually operated instrument and automatic instrument, nowadays with emergence of computers and p l cs and modern electronic devices, there is a shift from manually operated instruments to automatic instruments, but the importance of manually operated instruments can also not be denied right.

So, all the instruments available can be classified amongst them manually operated instrument or automatic instruments. Third type which is very interesting this is analogue and digital right. In past many of the instruments almost all the instruments were analogue type of instruments. So, in analogue type of instrument the output carries the output of the analogue instrument carries the information certain information about the input to the instrument.

And analogue type of instrument the output is continuous right. Let us take example of voltmeter, if we put a voltmeter in a circuit and you want to measure the voltage the needle of the voltmeter will shift continuously move and will attain a certain position and that will give the voltage of the line.

Now, digital type of instrument because nowadays data has most of the data is stored in the digital form. So, digital type of instrument they work in binary mode on and off digital type of instrument they work in binary mode on and off. Normally the it is off when 0 to 0.8 volt voltage is there for example, it is off and plus 2, 2 plus 5 plus 5 volt, it

is on right. So, the digital instrument this is very important to understand the digital instruments they work in on and off mode.

So, 0 to 0.8 volt of let us say 0.2 volt to 5 volt it is on volt weather voltage is 3 volt or 4 volts it will remain on. So, there is a measure which conception that a digital instruments are very accurate if you want to go for high accuracy, why should go for analogue type of instruments because they give continuous output digital type of instruments in many of the instruments you will find that output is 100.23456 volts and people say that is very accurate it is not accurate it is just display of the volt of some or output of some calculations.

It does not mean that if you want to have instrument accurate after 6 decimal place, then it has to be calibrated, against a known standard then instrument has to be calibrated against the known standard. So, digital is to be digital signals are important because nowadays all the data are stored in the computer.

And sometimes sampling rate is very high, sampling rate you can have let us say 10 kilohertz, sorry 100 kilohertz for some 100 kilohertz sample, you have digital data and data can directly go to the computer for this sampling rate the analogue or suppose the, the input is also varying input is not constant it is also varying it becomes difficult to take data with the analogue instruments, because that is I mean we are not very convenient in storing data analogue data we are convenient in storing digital data.

So, analogue instruments have their own importance normally secondary standards I will discuss later on, they are all analogue instruments through which the calibration is made, but normally the nowadays the measuring instruments more and more we are having digital instruments.

So, we are moving from analogue to digital instrumentation due to high due to due to the storage facilities in the computers; however, for the purpose of accuracy and calibration analogue instruments are used.

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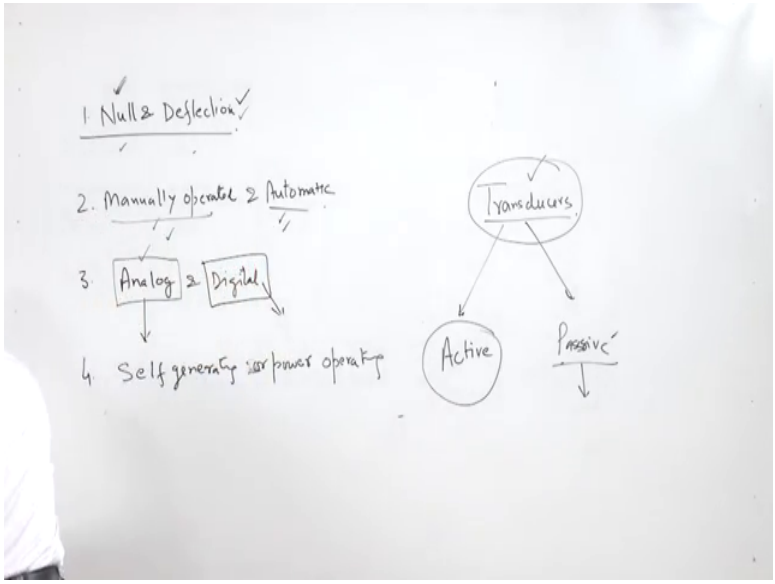

Now, the third is the instrument now the forth one, now the forth one is self-generating and power operated or power operated operating, now what does this mean self-generating or power operated, self-generating means the, the act of measurement does not require external power, you must be or you may be familiar with the term transducers.

The transducers are the devices which convert a signal into electrical signal or one form of energy into the another form of energy another form of signal. So, this is the definition of transducers, but now a days if electrical signals are acquired an electrical signals are also output that case that that device is also known as transducer so there is a.

So, the scope of transducers has widen, earlier the function of transducer it was defined as to convert one form of signal to another converted into another form of signal. And normally it was electrical signals because now we look for electrical signals earlier, when the analogue devices were there we were looking for the displacement, all the inputs were converted into the displacement.

If the input is pressure output has to be displacement because displacement we can see, but now a days we are using transducers all the inputs are converted into the electrical signals, because electrical signals they are digital signals they go directly go to the computer for the purpose of a storage. So, there are types of transducers active and passive.

Now, passive transducers are those transducers which do not take any external energy right for example, let us take the example of thermometer. So, thermometer is sort of a passive transducer the primary sensing element takes certain amount of energy from the measurand and this energy is used for increasing the volume of mercury in the thermometer and which ultimately leads to rise in the level of mercury in thermometer. So, it is a sort of a passive transducer.

Now, some transducers are active transducers where external. So, because the signal is weak, signal is weak and external source of energy is required to amplify the signal, and a good design of a measuring instrument is that design where minimum amount of energy is drawn from the measurand, right. So, I will give you an example of sorry, electronic amplifier.

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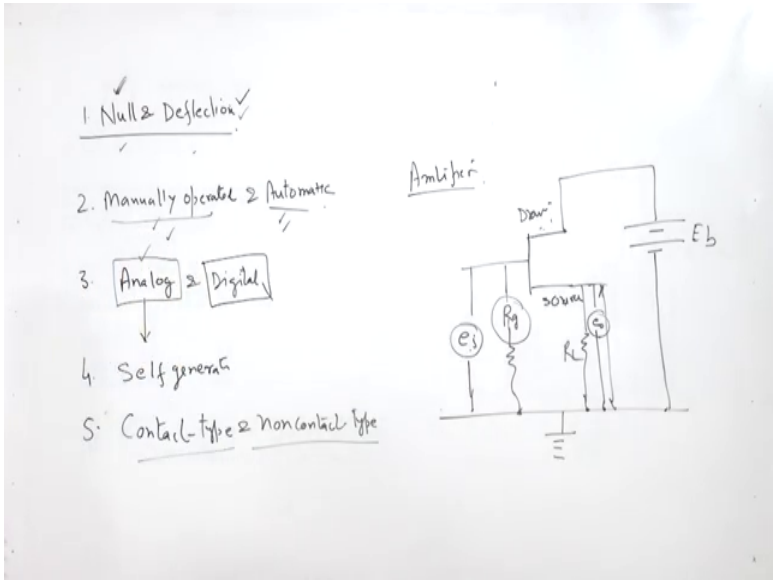

There is an electronic amplifier the function of amplifier is to increase the output right so there is a field effect transistor. So, here drain this is source and there is a input voltage this is resistance, then this is a battery the battery is and here we get output and this is r l.

The input signal is this they are all grounded, input signal is feeble it is very weak, this resistance is also high this drain here the current is almost 0 right. And then we get entire power from this battery, and we get amplified signal output, but input output relationship remain same the moment I change e i the e o will change the e o will change, and in this

type of instruments the input controls the output, but it does not supply power to the output .

So, power of the output is much larger than the power of input there are certain drawbacks also in this type of systems. So, input controls the output, but it does not supply power to the output.

So, after this the active and passive transducers the last one is contact type, type and non-contact type right. Contact type of instrument non-contact type of instrument nowadays again there is a shift from contact type to non-contact type, but it does not mean that non-contact type of instruments are highly accurate.

If we talk about the accuracy either of these type of instruments can be accurate more accurate, but the contact type of instrument the primary sensing element comes into the physical contact with the measurand, where in non-contact type of instrument the primary sensing element does not come in physical I mean physical contact with the instrument, but it senses.

The signals from the measurement, it senses the signal from the measurement and for example, infrared thermometer infrared thermometer does not come into the contact with a measurand, but its senses signals from the measurand.

So, further the all the instruments can be classified into the category contact type and non-contact type of instruments, now regarding the yes one thing I forgot to tell you that analogue and digital suppose the signal is analogue and we want to convert into the digital it is very easy in nowadays in the market analogue to digital converter analogue to.

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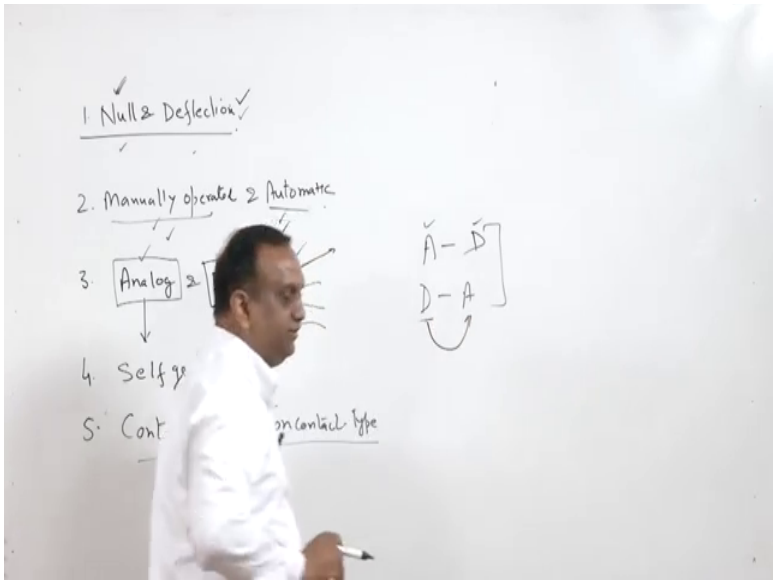

Analogue to digital converter or digital to analogue converter both are available. So, simply in the signals in the lines of the signals we just simply put analogue to digital converter, all analogue signals will be converted into digital form or if their digital signals you just put digital to analogue converter all the digital signals will be converted into the analogue form.

Now, let us talk about input output configuration of measuring instruments input output configuration means the relation of input and output.

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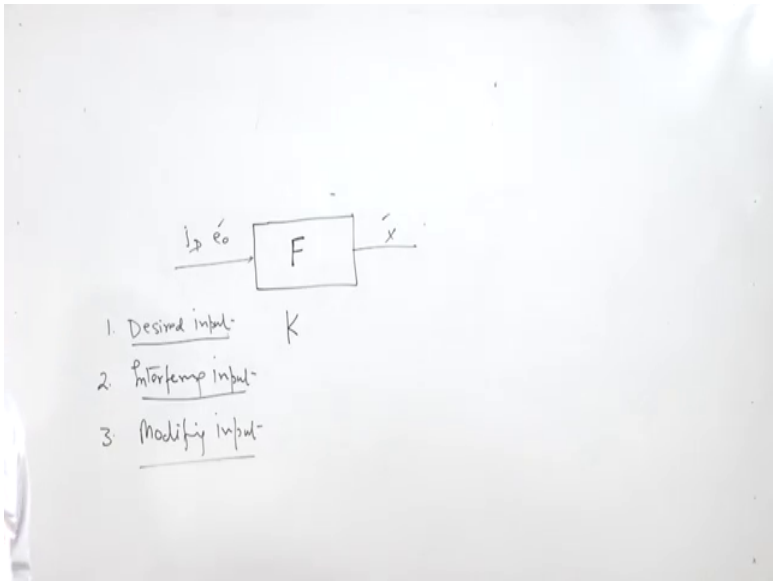

There is a measuring instrument right its opposite senses some input desired input, desired there are three types of inputs one is desired input, for desired input is that signal for which the instrument is designed to be sensitive. So, an instruments response response to this type of signal and this is known as desired input.

So, an instrument so desired input to the instrument is that input for which the instrument is designed, second thing is interfering input. Now interfering input is that input for which the instrument is unintentionally sensitive, suppose there is magnetic field and your measuring voltage with the help of a voltmeter.

So, when there is a magnetic field that magnetic field may cause additional deflection in the needle or reduce or restrict the deflection of the needle. So, you may not get the correct reading. So, your voltmeter is unintentionally responsive to that magnetic field. So, this type of input is known as interfering input, now third one is modifying input modifying input is that input which changes the input output relationship, for example, there is a change in the density of the fluid.

So, in a damper when a damping fluid you are using if the density of the damping fluid changes with time, sorry with temperature then input output relationship will change and. So, the modifying input is that input to the instrument which alters the, the input output relationship interfering input that input to the instrument for which the instrument is unintentionally for which the instrument is not designed, but it is responding always sensitive to this input desired input is that input for which the instrument is designed.

Now input may be in the form of let us say some, some voltage let us say some voltage and output of the instrument is some form of displacement right.

So, there is a function so this function transforms or transfers voltage into displacement, it is not a constant of proportionality it is a constant of proportionality k in the case when there is a linear relationship then it is a constant of proportionality, but when there is a non-linear relationship between output and input we have to go for a function not for a constant. So, if we want to depict the arrangement of an instrument with the help of diagrams.

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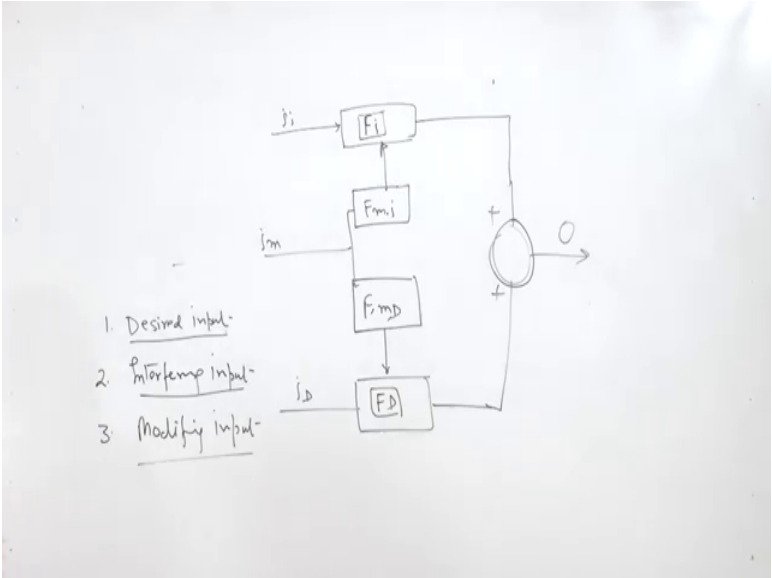

So, there is a desired input, some transfer function FD and FD is and there is i D desired input.

There is one interfering input this is interfering input, it is coming and there is one modifying input, modifying input it will contribute to both modifying input will contribute to both it will contribute to interfering input and it will contribute to desired input right.

So, modified input desired and function modified interfering it is it will contribute to the interfering. It will compute contribute to desired input right, and this will go to the summing device and here we will get the output.

So, this is how the arrangement of different signals can be depicted with the help of a block diagram this block diagram is very helpful, in showing the in depicting the functioning of instrument I am repeating this block diagram this is desired input coming to the instrument interfering input coming to the instrument, modifying input will contribute to both interfering and desired. And then these two signals they will go to this summing device and will get the output. Now, I will give you an example for this very good example is manometer.

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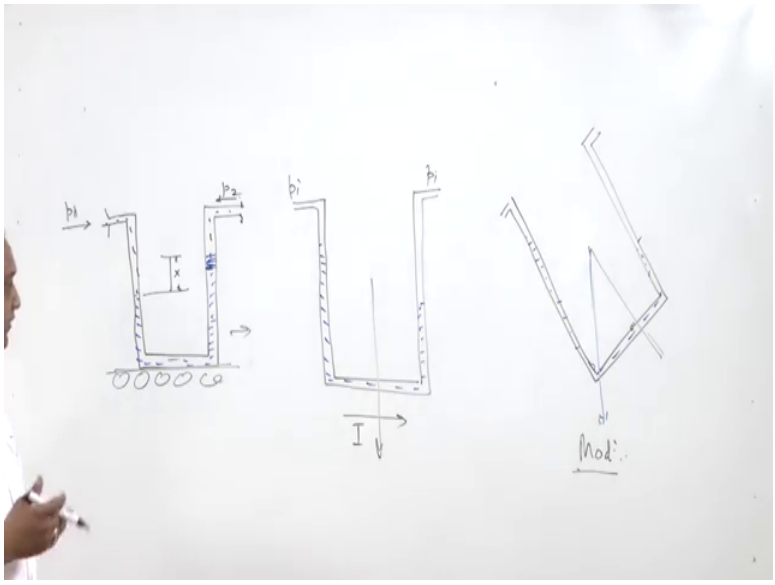

Let us take case of a manometer. So, in a manometer there is a tube right, and normally they are there is a base fluid and this is p 1 and this is p i initial pressure.

And then p or p 1 and p 2 right, pressure is exerted this is pressure is exerted here this is this is connected to p 2 and this is connected to p 1 right. And there is some different in scale difference in scale there is some difference in the column, and by just measuring this x we get the pressure difference.

Now, suppose this platform, now this platform it does is not moving at all. Suppose, I make this platform to move it starts moving with a certain velocity, in this direction. Now when it starts moving with certain velocity in this direction, then we can have configuration like this even though the pressure is both side is p 1.

So, when it is accelerating in this direction right, when it is accelerating if feel it is moving with a uniform velocity it will not make any change, but when there is a change in inertia it is accelerating with certain velocity with certain acceleration in this direction there will be difference in columns though the pressure on the both side is same now if we connect this to p 1 and p 2 this is p i, initial pressure.

Now if I connect this p 1 and p 2 this value of x will be altered right. So, this type of input is known as interfering input. So, this acceleration is spurious input that is interfering signals in the instrument.

Now, second thing is instead of acceleration, suppose I tilt this manometer if I tilt this manometer then the direction of force with respective to the instrument direction of gravitational force with respect to the instrument will change, gravitational force will remain same, but the direction of the gravitational force with respect to this instrument will change because here it is in this direction this passing through the centre of the base.

Now it is passing from here and this will also change input output relationship and this type of input is modifying input, because I am giving you the mechanical engineering examples because we are dealing with the mechanical systems. Another example can be a strain gauge, a strain gauges are used for measuring the strain in a surface or in a body or in an entity.

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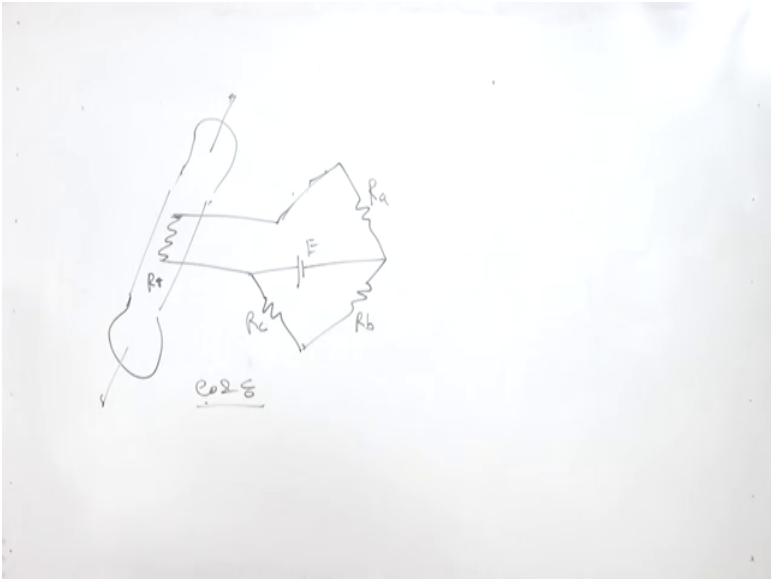

So, the principle of a strain gauge is the change in the resistance with the application of a stress, when the when the wire is pulled, when a wire is pulled its cross section area reduces and the length increases. Both the cases, lead to the increase in the resistance of wire, right.

So, we develop a relation between the strain develop in the wire, and change in electrical resistance and that is how the stream is measured with the help of this is the working principle of a strain gauge and that is how the strain is measured with the help of a strain gauge.

So, suppose there is a fixed body right and we put a strain gauge here, a strain gauge is normally it makes one of the arm of a (Refer Time: 31:07) stone bridge right and this is. So, this is resistance a let us say R b R c and this is not a resistance because this is this arm a strain gauge.

So, initially I mean there is no bridge is balanced bridge is balanced, when this element is put under stress or in a stretch this wire which is pasted on the surface shall also get stretched this will change the resistance of the wire and we will get net e m f right. Now we can have relation between output and strain develop in the strain gauges.

So, when there is a change in the strain we will developed an e m f and we can have relation between output and strain. Now this can have this arrangement can have some interfering input also interfering, input maybe the temperature if there is a change in the temperature or uneven expansion of this strain gauge and this base with change in temperature.

So, this can be an interfering input to the signal right. So, this is another example for different type of signals input output configuration that is all for today.

Thank you very much.