Engineering Metrology

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Lecture – 21
Transducers (Part 2 of 2)

So, continuing with the lecture on Transducers.

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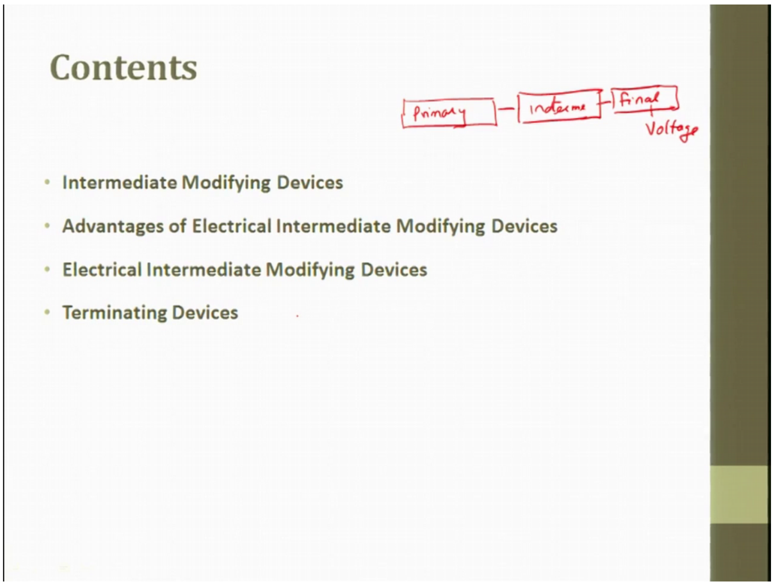

We will today try to cover intermediate modifying device. So, we saw very clearly there is a primary device, then we had an intermediate device; intermediate we had and then we had the final or secondary device or final.

So, here basically the primary signal will be recorded, then this will be converted into such a form such that the output can read it. Today predominantly what we use we always try to have an electrical output. So, as far as electrical output we look forward for voltage. So, this voltage can be easily taken back for a feedback control and the process can be controlled.

So, we will first see intermediate modifying device, then we will see advantage of electrical intermediate modifying device, then we will see electrical intermediate modifying devices, then finally, we will saw terminating devices; terminating devices are nothing, but the final devices.

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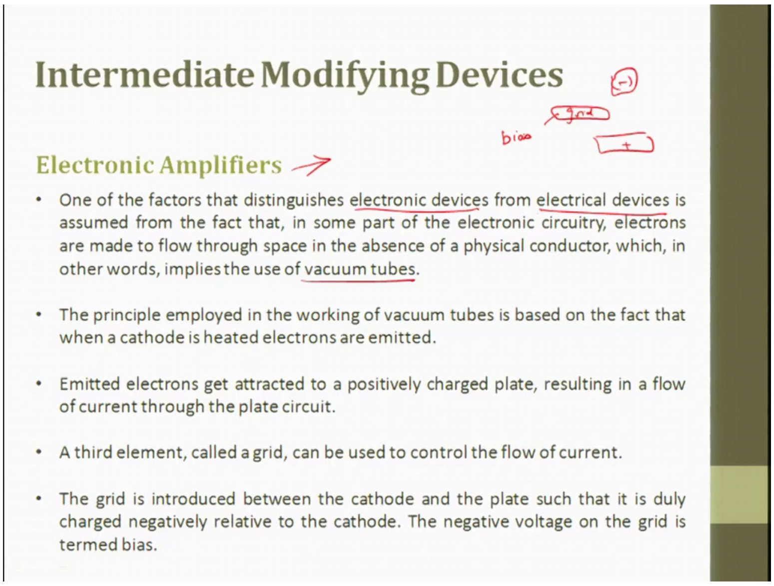

When we talk about amplification, there are two types of amplification one is mechanical amplification and the other one is electronic amplification. Mechanical amplification, over a period of time there is always a wear and tear. So, there is a backlash error or there can be deflection which is there. Mechanical for example, if you put a diaphragm there can be a deflection. So, because of that you can have some technical issues for using mechanical amplification. So, electronic amplification is easy where, wear and tear is also less. Today we always prefer to have electronic amplification.

So, electronic amplification or electronic amplifier; one of the factor that distinguishes electronic devices from electrical devices is assumed from the fact that in some part of the electronics circuit electrons are made to flow through a space in the absence of physical contact which in other words implies the use of vacuum tube, ok

So, earlier days we used vacuum tubes. So, here we are even distinguishing what is the difference of using the electronic devices and the electrical devices. Electronic devices predominantly we try to communicate in vacuum. The principle employed in the working of vacuum tubes is based on the fact that when the cathode is heated the electrons are emitted. This is vacuum tube technology; slowly this vacuum tube technology is changed and the electronic circuits have come up in a big way. So, emitted electrons get attracted towards the positive charge plate resulting in a flow of current through the plate circuit. A third element called the grid can be used to control the flow of current.

So, we had a negative we had a positive. So, negative we had positive and then we had something called grid; this is schematic diagram, a grid. The grid can be used to control the flow of current. The grid is introduced between the cathode and the plate such that it is duly charged negative relative to the cathode. The negative voltage on the grid is termed as bias ok.

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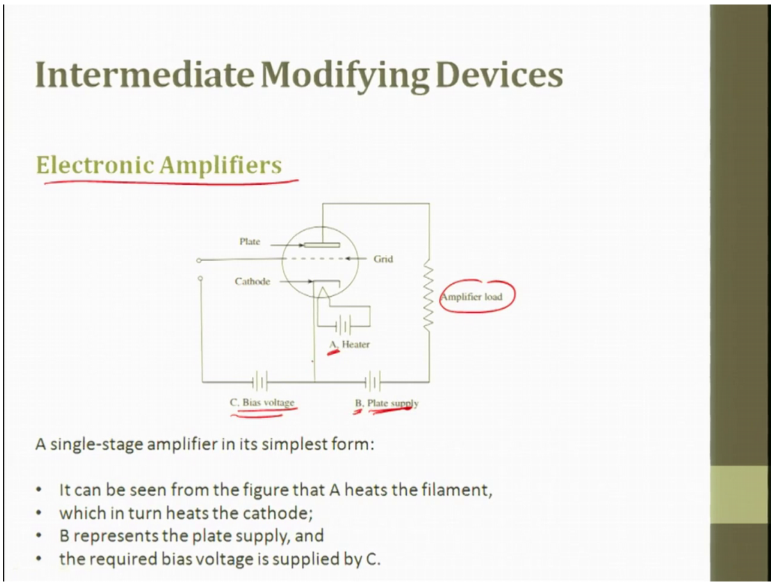

So, this is what is a typical circuit looks like, you apply some voltage or you apply heat. So, cathode emits. So, you have an anode. So, that is a plate. So, in between you have a grid and grid is having a bias voltage. So, this is a plate supply, you have an amplifier load. So, this is how the schematic or the basic circuit of the electronic amplifier is there. Can a cathode anode grid which is biased? So, which is used to control the flow of current and then you have a plate supply then you have an amplifier load.

The single stage amplifier in its simplest form can be seen in the figure here. It that a heater, A heats the filament which in turn heats the cathode, B represents the plate supply ok; B represents the plate supply ok, the required bias voltage is supplied by C ok; C supplies the bias voltage. So, this is A; this is B and then this is the bias voltage supply and this is for a single stage amplification or a single stage amplifier.

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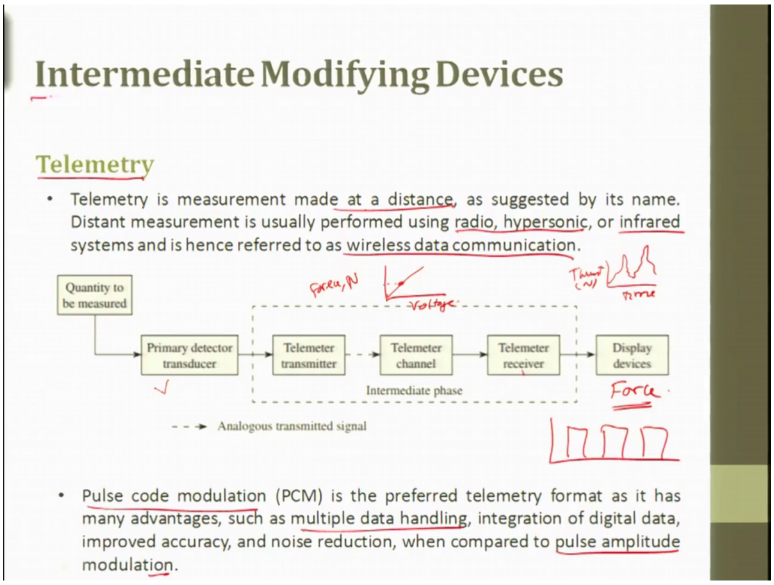

There is also a concept called as Telemetry. Today telemetry is talked about very much in terms of electronic devices ok. So, telemetry is measurement made at a distance as suggested by its name telemetry distance right. The distance measured is usually performed using radio, hypersonic or infrared systems and hence referred as a wireless data communication.

So, today we also use telemetry concept in the measurement stage. So, your measured quantity is there and this is a primary detector, then we have a telemetry transmitter and then we have a telemetry channel, then telemetry receiver and finally, you get a display. So, this entire thing is called as a intermediate phase; intermediate phase. This is converting the primary to secondary, in between it does some changes such that it tries to convert whatever is a primary reduction to the secondary reduction such that it can be recorded or visualized ok; telemetry is wireless.

So, today we are using infrared imaging. We are using radio and hypersonic for communication ok. The pulse code modulation; PCM is preferred telemetry format as it has many advantages such as multiple data handling, integration of digital data, improved accuracy and noise reduction as compared to pulsed amplitude modulator; pulsed amplitude modulator ok.

So, these are some of the techniques pulsed code modulation and pulse amplitude modulation are two different types and pulse code modulation. So, basically what are we trying to say is these are pulses ok, if you can directly amplify you will have the noise which are getting integrator. You converted into a pulse code modulation. So, you will have many data as you can handle at a given point.

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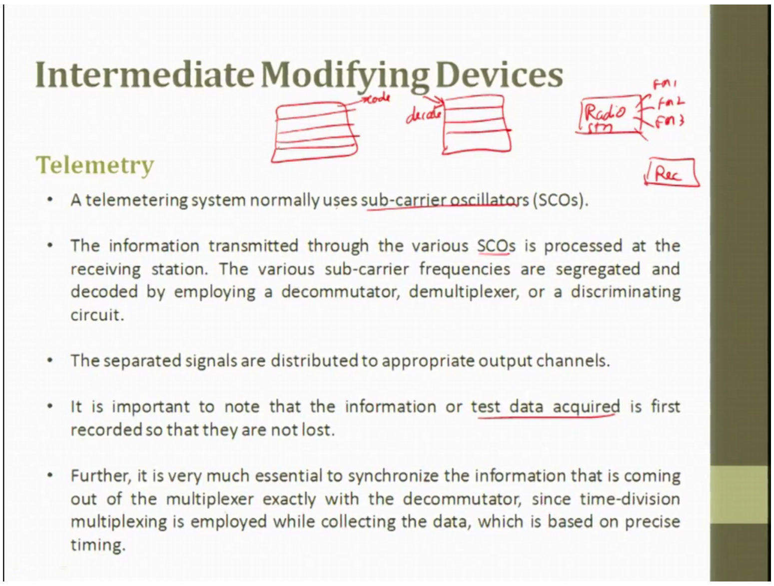

A telemetering system normally uses a subcarrier oscillator. The information transmitter through various oscillators is processed at receiving station. So, if you see here it is the receiving station ok. So, if you cannot visualize, it is something like your radio station. You have a radio station, radio station you have multiple FM's right, FM 1, FM 2, FM 3 right and then when you have a this is a station and when you have a receiver, we try to receive set frequencies and we can jump from one frequency to the another frequency and start getting. So, you can have data's which is multiple data's handled at the receiving end.

So, at the information transmitted through various SCOs oscillators is processed at the receiving station. The various subcarrier frequencies are segregated and decoded by employing a decommutator, demultiplexer or a discriminating circuit. So, what we are trying to say is you have a bundle of data which is coming. So, this data is now discretized and then the discretized data is coded and then you communicate.

After it is communicated, when you receive it, all these things are this is coded and then here you decode it; decode it and then you start using the data. The segregated signal, the separated signals are distinguished to appropriate output channels. It is important to note the information or the test data acquired is first recorded so that they are not last. Further, it is very much essential to synchronize the information that is coming out of the multiplexer exactly with the decommutator, since the time division multiplexing is employed while collecting the data which is based on the precise timing.

So, what are we trying to do? If you go back to this you will understand measured can be mechanical or see, now I will tell you the research which I am also trying to do we have drilling machine. So, we measure the forces. So, what do we measure? We measure voltage ok.

Now, the interesting problem is if I have a wire to communicate, for example, in drilling I put my dynamometer and the spindle and the spindle records the forces that is thrust and torque and if there is a wire, the wire will get entangled. So, now, what we do is we try to communicate the signal whatever has got acquired on in the dynamometer, it is transmitted it is transmitted directly to receiving station and in the receiving station what I have done is I have converted the force; that means, to say voltage data into force data.

What I have done? I have calibrated for this for this force of N what will be the voltage I have calibrated already. So, I have taken the linear zone. So, now, I know if I have got this voltage, so, I correspondingly try to get the forces on it and interestingly I also try to make it dynamic. So, as and when it starts machining the torque or the thrust keeps increasing and decreasing with respect to time. So, this may be thrust and this may be time ok, this is Newton. So, I get this output.

So, here I am telemetrically communicating the voltage into a force signal which is displayed outside. This communication can be done by telemetry method. In telemetry method, first I have to acquire the data, discretize the data, I have to transmit the data. So, I transmit. So, when I transmit I also have multiple channels and then. So, I discretize it to various frequencies or various time signals and then I try to acquire them. So, here I try to code them and here I try to decode them, here I try to do pulse code modulation and then I receive everything where the noise is reduced and then I convert the data. So, this is how telemetry which is used in intermediate modifying device which is used in transducers.

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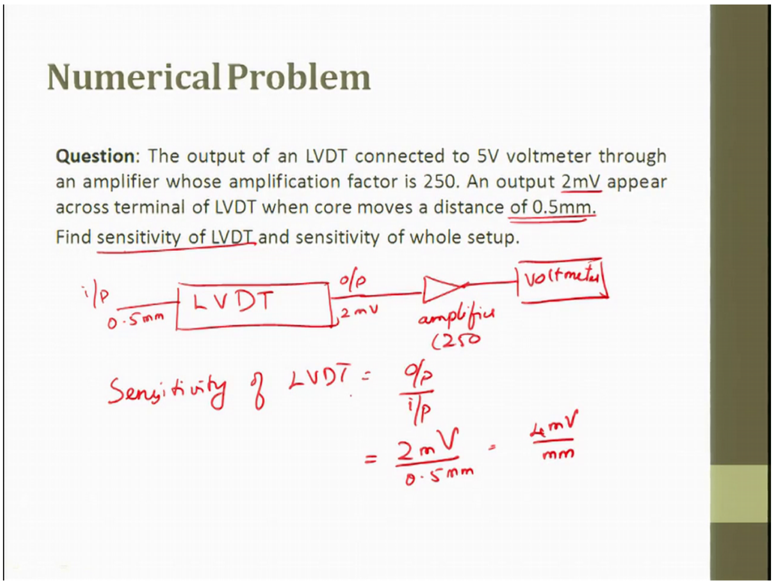

So, let us try a simple problem; the output of an LVDT connected to a 5 volt voltmeter through an amplifier whose amplification factor is 250 and output of 2 millivolt appears across terminals of LVDT, when core moves at a distance of 0.5. LVDT please go back and remember we had a primary coil, we had a core and then we have 2 secondary coils. So, that is what the output 2 millivolt appears across terminal of LVDT when the core moves at a distance of 0.5.

Find the sensitivity of the LVDT. So, what we are trying to say? We are trying to say that there is a LVD; Linear Variable Differential transformer. So, here is an input which is nothing, but 0.5 millimeter and here this is output which is 2 millivolt right. I am attaching it to an amplifier, amplifier which is 250 times and then I am trying to get the voltmeter, voltmeter reading.

So, if I have to calculate the sensitivity of LVDT, which is nothing but output by input. So, this is nothing but 2 millivolt divided by 0.5 millimeter. So, this is 4 millivolt per millimetre this will be the sensitivity of LVDT.

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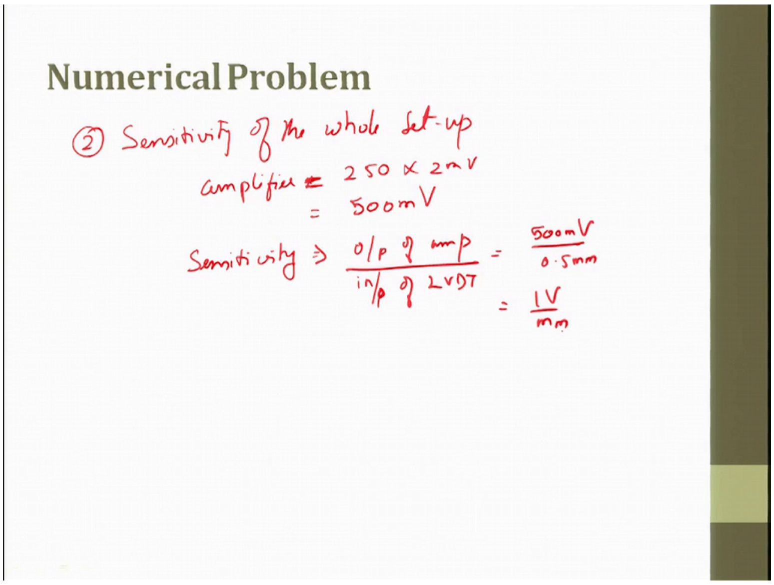

So, now if I have to find out the sensitivity of the whole setup, sensitivity of the whole setup; so, it will be amplify amplifier in to oh amplifier it is 250 into 2 millivolt that is going to be 500 millivolt right. So, sensitivity is nothing, but output of amplifier divided by input of LVDT which is nothing but 500 millivolt divided by 0.5 millimeter. So, this is nothing, but 1 volt per millimetre; this will be the sensitivity of the whole system.

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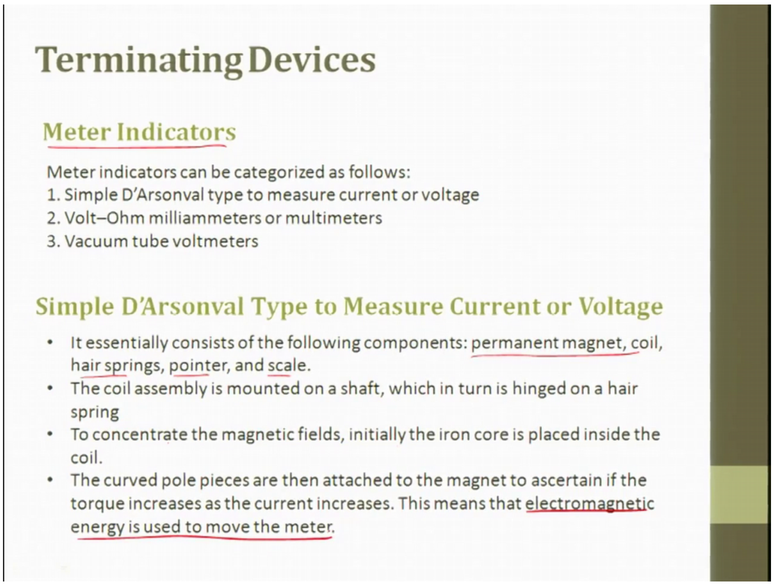

So, we have finished that the intermediate device. So, now let us look into terminating devices. So, the terminating devices are it is they are classified into meter indicators.

Meter indicators can be categorized as follows; simple D'Aarsonval type of measure current or voltage type of measure current or voltage.

Next will be volt ohm milliammeter or multimeter or then the last one is going to be vacuum tube voltmeter. So, meter indicators can be classified into three. So, they are simple D'Arsonval type to measure current or voltage volt ohm milliammeter or multimeter vacuum type voltmeter.

So, when we talk about simple D'Arsonval type to measure current or voltage, it essentially consist of the following components one is called as a permanent magnet, coil hair spring, pointer and scale. The coil assembly is mounted on a shaft which in turn is hinged on your hair spring. To concentrate the magnetic field, initially the iron core is placed inside the coil.

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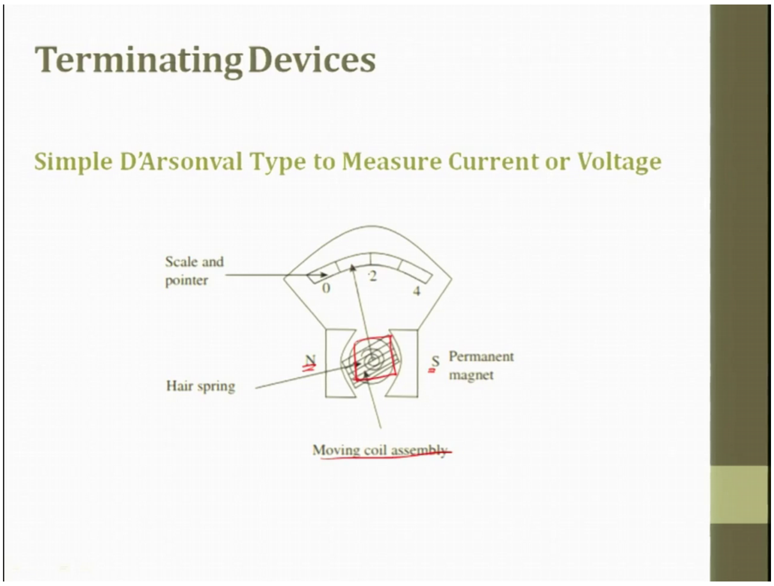

So, we can see the figure and then you will understand. So, this is the scale pointer which I said; this is the moving coil assembly, this is the hair spring which we have; there are the two permanent magnets north pole and south pole moving coil assembly is this is the moving coil assembly ok.

So, if you go back, it essentially consist of the following components; permanent magnet, coil, hair spring, pointer and scale. All these things are here; pointer, scale, then permanent magnets, moving coil assembly, then you have a hair spring. So, the coil assembly is mounted on a shaft which in turn is hinged on a hair spring.

So, what is it? So, we are talking about this part. To concentrate the magnetic field, initially the iron core is placed inside the coil. Where is the coil? Here is the coil. So, the coil spring hinged and they place it here. The curved pole piece is then attached to the magnet to ascertain if the torque increases as the current increases. This means that electromagnetic energy is used to move the meter. So, here, this is used for moving the meter ok; like dial gauge we studied dial gauge we had coiled spring then we had a leaf spring attached. So, in the similar way here it is electromagnetically, we are trying to move.

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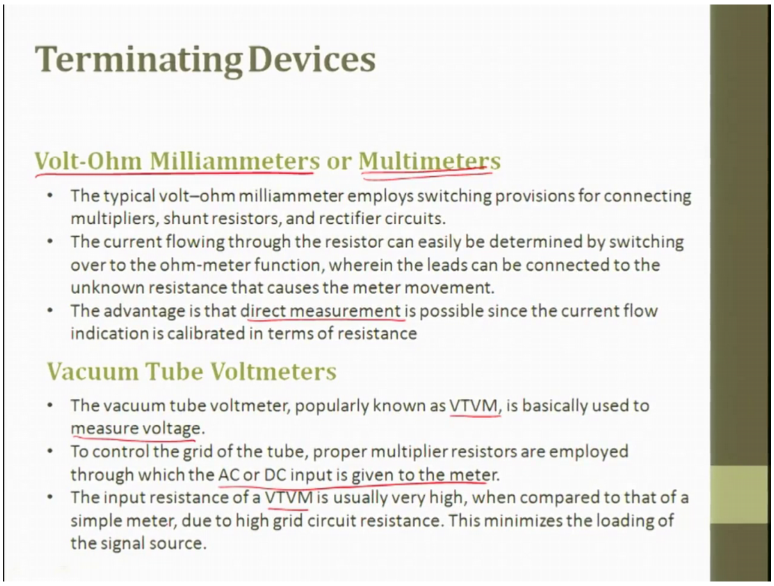

Next one is Volt Ohm Multiammeter or Multimeters; a typical volt ohm milliammeter employs switching provision for connecting multipliers, stunt resistors and rectifier circuits. The current flowing through the resistor can easily be determined by switching over to the ohm meter function, wherein, the leads can be connected to the unknown resistance that causes the meter movement.

The advantage is that the direct measurement is possible since the current flow indication is calibrated in terms of resistance. You can call it as volt ohm milliammeter or it is otherwise called as multimeter. Multimeter is use you have two probes these two probes are put into the socket for connecting multipliers; stunt resistors and rectifiers you can connect it and then what we do is we try to measure the output. So, the advantage is it directly gives the measurement.

The vacuum tube voltmeter; the vacuum tube voltmeter popularly known as VTVM is basically used to measure the voltage to control the grid of the tube; you remember the grid what we saw there. Proper multiplier resistors are employed through which the AC or DC input is given to the meter. The input resistance of VTVM is usually very high when compared to that of simple meter due to high grid circuit resistance. This minimizes the loading of the signal source.

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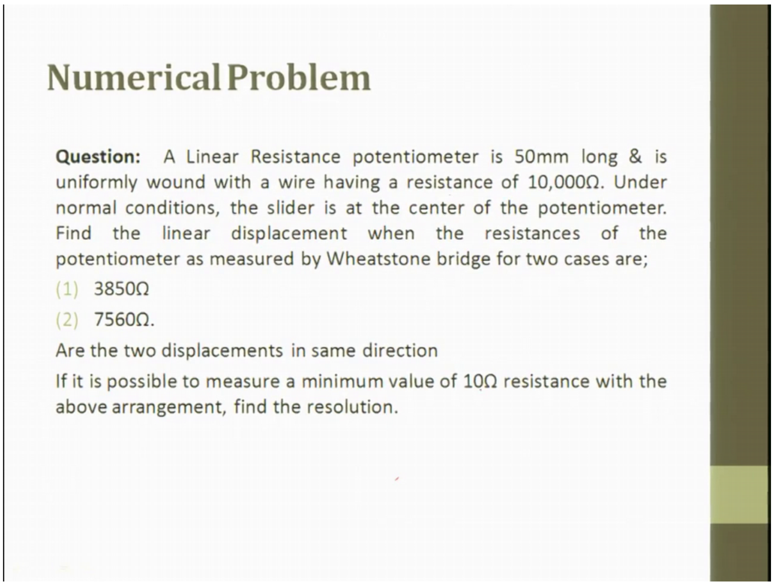

So, now let us try one more simple question; a linear resistance potentiometer is 50 millimeter long and is uniformly wound with a wire having a resistance of so many ohms. Under normal condition, the slider is at the center of the potentiometer. With the linear displacement, when the resistance of the potentiometer as measured by wheatstone bridge for two cases are 3850 ohms, 7560 ohms. Are the two displacements in the same direction? If it is possible to measure a minimum value of 10 ohm resistance with the above arrangement find the resolution.

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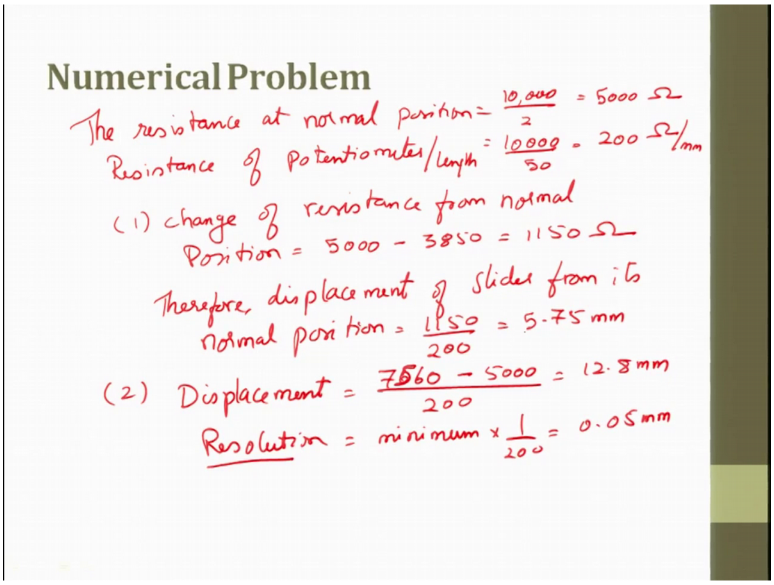

So, let us try to solve the problem. The resistance at normal position is which is 5000 ohms. So, the resistance of potentiometer per unit length is equal to 10000 divided by 50 which is 200 ohm per millimetre.

First, what are we asking? We are trying to find out change of resistance, change of resistance from normal position which is nothing but 5000 minus 3850 gives you 1150 ohms, change of resistance from normal position. Therefore, displacement of slider from its normal position is going to be 1150 divided by 200 which is nothing but 5.75 millimeter.

You want to have this resistance, measure this is the displacement you have. Second thing, displacement is going to be 7560 minus 5000 divided by 200, which is going to be 12.8 millimeter. So, the resolution is going to be minimum into 1 by 200 that is 0.05 millimeter. So, we have found out the resolution, we have also found out the displacement ok.

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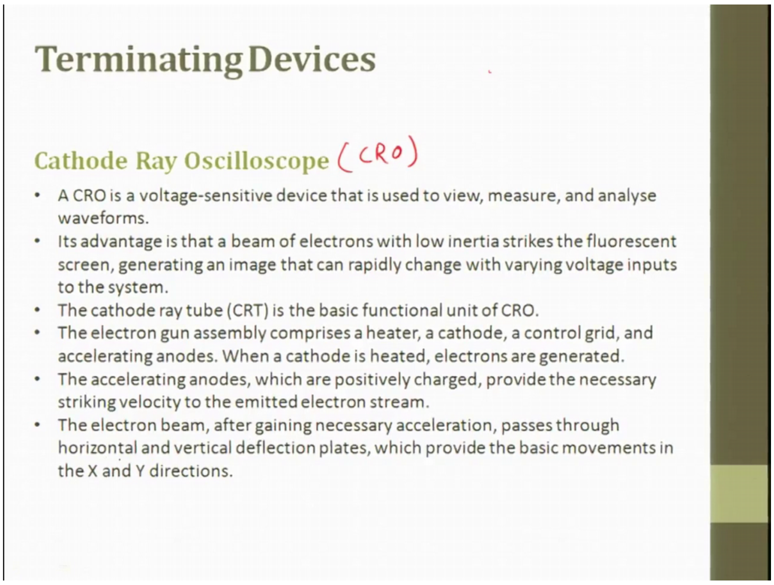

So, CRO, Cathode Ray which is also an output device wherein which you can monitor; so, you can monitor through coil you can simple coil output with the pointer. You can measure it with the multimeter, then you can measure it with a vacuum tube you can also measure it with CRO, Cathode Ray Oscilloscope or CRO is a is a voltage sensitive device that is used to view measure and analyze waveform. Its advantage is that a beam of electron with low inertial strikes the fluorescent screen, generates an image that can rapidly change with varying voltage input to the system.

The CRT is the basic function unit of CRO; Cathode Ray Tube is the basic function of CRO. Electron gun assembly comprising a heater cathode control grid and accelerating anodes are there. When the cathode is heated, if you go back and see cathode heating anode there grid are generated. The axial rate at anode which are positively charged provides the necessary striking voltage to the emitted electron stream. The electron beam after draining necessary acceleration passes through horizontal and vertical deflecting plates which provide them the basic moment in the X and Y direction.

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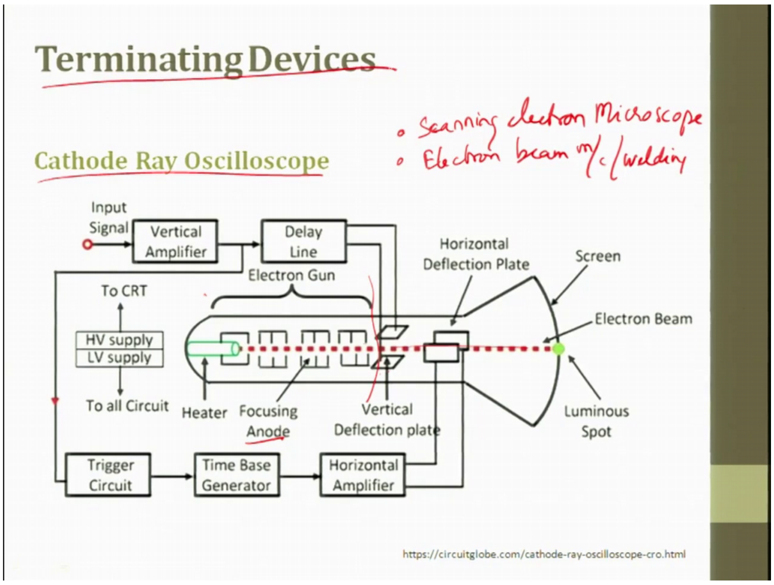

So, this is a CRO, you have a heater. So, then you have this heater tries to eject electrons. So, here is focusing anode; so that the electrons which are dispersed are focused onto a single line. So, then you have deflecting plates, these are called as vertical deflecting plates. Then you will all have horizontal deflecting plates, the electron moves through this to the screen ok; this is the electron beam. Electron beam passes it heated, it is thermions it is heated ejected and once these ions are to be focused passes through this focusing anodes and then goes through deflecting plates vertical, horizontal and then hits on the screen, then when it hits it illuminates.

So, if you look at it this portion is called the electron gun. Then you have vertical plates, horizontal plates; horizontal plates are connected to horizontal amplifier, then time based generator trigger circuits you are have ok. When you look at the horizontal amplifier you also have vertical amplifier you also have delay lines. So, here is an input which is given and then this vertical amplifier takes. So, basically this will try to push back the electrons electron beam to that is or it can try to take the deviation.

Then here delay line. So, this is given us inputs. So, heating, focusing, vertical plates, horizontal plates, screen, luminous happen; so, this is the schematic diagram of a CRO. So, a CRO will have a CRT. So, it is high voltage supply low voltage supply to the circuit, this is how the electron works the electron the gun works, electron gun. The same electron gun is used to for your scanning electron microscope, scanning electron microscope. Almost the same thing, the only thing is you will have a the gun will the electron beam will have higher currents. If you want to go on the higher side you can also use it for electron beam machining or welding; we use the same electron gun source. The only thing is the energy which is there in the electrons is higher ok.

So, you this is displace or terminating device these are the displaying devices.

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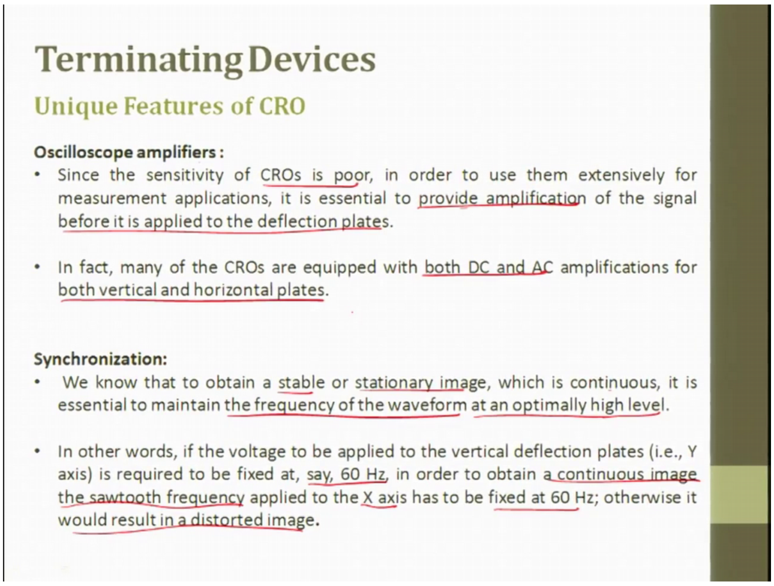

Unique feature of a CRO; so, you have oscilloscope amplifiers. Since the sensitivity of CRO is very poor, in order to use them extensively for measurement application, it is essential to provide amplification of the signal before it is applied to the deflecting plates. So, that is why we have a amplifier vertical amplifiers.

In fact, many CRO's are equipped with both DC and AC amplification for both vertical and horizontal plates. Synchronization, we know that to obtain a stable and a stationary image which is continuous, it is essential to maintain the frequency of the waveform at an optimal high level. In other words, if the voltage to be applied to the vertical deflecting plates that is Y axis is required to be fixed at say 50 hertz, in order to obtain a continuous image, the sawtooth frequency applied to X axis has to be fixed at 60 hertz, otherwise, this would distort the images.

So, what they are trying to say is you have these deflecting plates. So, these deflecting plates must be synchronized in terms of frequency; so that you get a output.

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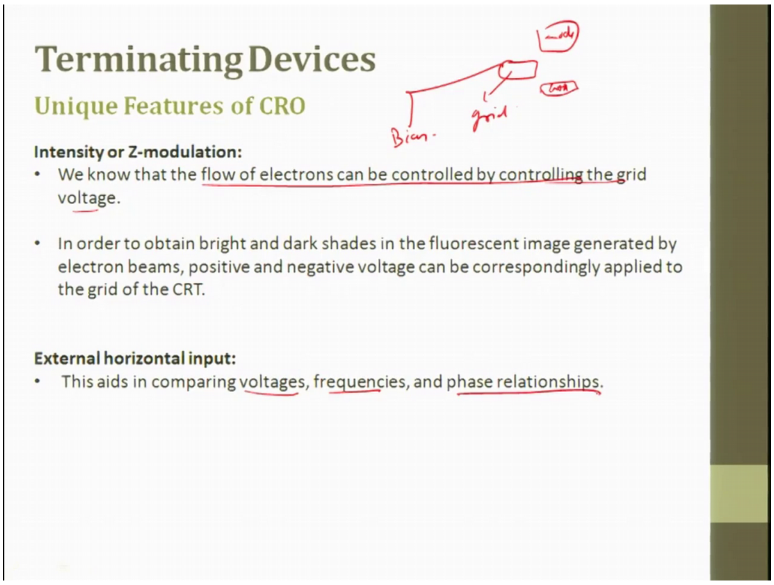

So, intensity or Z-modulation; we know that the flow of current can control can be controlled by controlling the grid voltage ok. So, what is the grid voltage we are talking about? These are the grid voltages ok.

So, same way if you see that it is cathode, anode this is anode, this is cathode and then you have a grid. This grid will always be given a bias ok. In order to obtain a bright and a dark shades in the fluorescent image generated by the electron beam, positive and negative voltages correspondingly applied to the grid portion. So, the external horizontal inputs are also applied which compares with the voltage, frequency and phase relationship, we can try to get the output.

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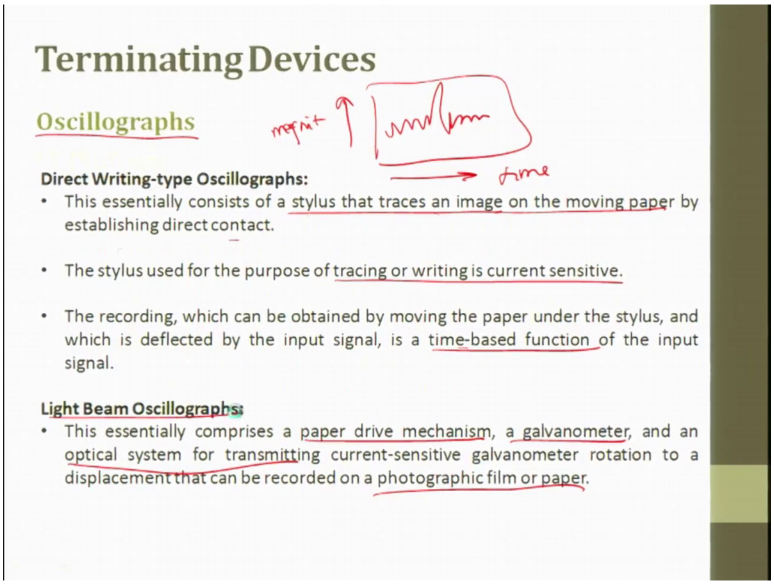

Direct writing type Oscillographs are there. So, this essentially consists of a stylus that traces the image on a moving paper. So, from the oscilloscope, you can converted it into a reading form. So, it will have X axis might be time and Y axis can be anything as magnitude. So, the essentially it consists of a stylus that traces the image of the moving paper by establishing a direct contact. The stylus used for this purpose for tracing and writing is current sensitive. The recording, which can be obtained by moving the paper under the stylus and which is deflected by the input signal as a time-based function for the input.

So, you can also have oscillographs. So, what we saw was oscilloscope, this is oscilloscope; display it can be recorded separately. This can also be converted into a hardcore reading output light beam oscillographs are also there this essentially comprises a paper driven mechanism, a galvanometer and an optical system for transmitting current sensitive galvanometric rotation to a displacement that can be recorded on a photographic film paper. So, a light beam oscillograph is also used.

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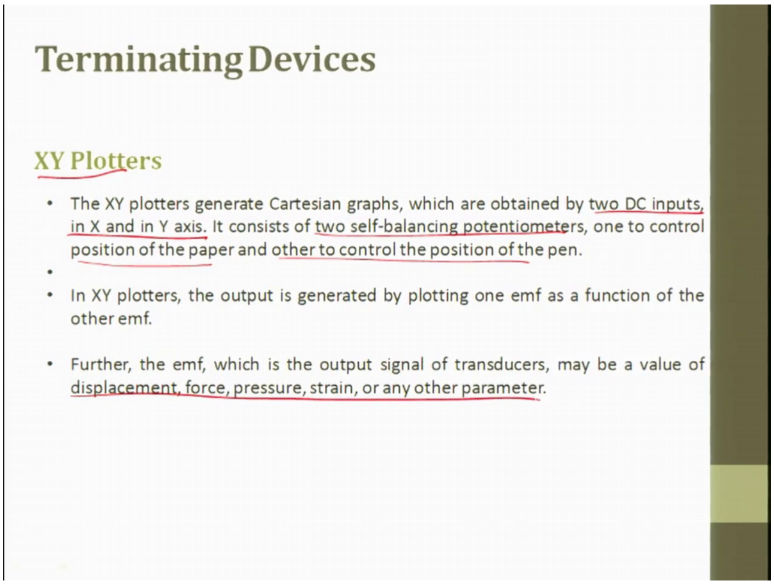

You also have an XY plotter; it is the same like the direct right oscilloscope. These are all terminating devices oscilloscope oscillographs, this is used in light beam oscillograph directorate oscillograph. You also have XY plotters to same way to plot, the output which are obtained by two DC inputs that is X and Y axis. It consist of self balancing potentiometer; one to control the position of the paper and the other to control the position of the pen. This operates and you try to get further the EMF, which is the output signal of transducer maybe the value of displacement force pressure strain and other parameters.

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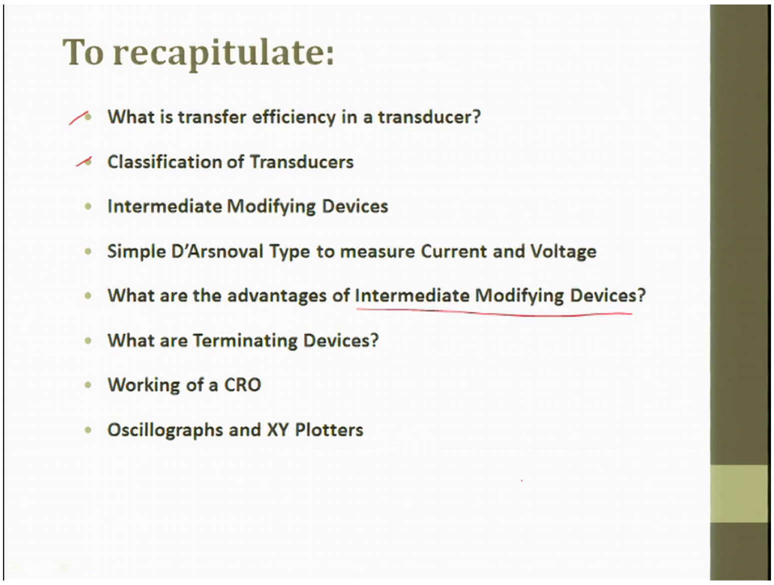

So, in this chapter of transducers what all did we cover we were trying to cover what is the transfer efficiency in transducers? What are the various classification of transducers, intermediate modifying devices simple well type of measure current and voltage, then what are the advantages of intermediate modifying devices, then terminating devices, then we saw a working of a CRO finally, oscillographs and XY plotter.

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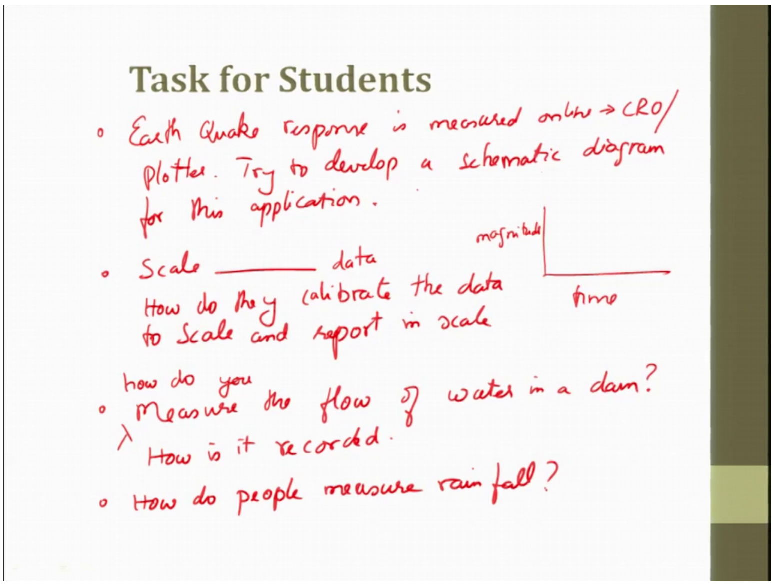

Task to student is try to look at the seismic or we can try to say earthquake response is measured online it can be through a CRO or it can be through a plotter try to develop a schematic diagram for this application. So, how do they do it right?

So, for example, they do it on riche scales and then they also do it with respect to time. So, please understand what they measure. First, you should understand that and then how it is intermediately getting transferred finally, what is the display you see and how is the display in terms of plotter. So, what I am more interested is what is your time scales they talk about what is the magnitude and second thing we always talk in terms of a scale.

So, a riche scale riche a scale is used let me not even give the specification. So, generally what we report is a dash scale. So, try to understand a schematic diagram of the application, then there is a scale by which they represent the data. So, try to understand how they calibrate, calibrate the data to scale and report in scale ok.

The next question is how do people measure the flow of water flow of water in a dam ok? For measure how do you measure the flow of water in a dam? Second thing is how is it recorded last is how do people measure rainfall ok? These are some of the things which you will have to look forward for data and understand how is it plotted how does it work ok. These are all tasks for yourself learning ok, in the examination you can have questions based on these tasks, whatever I have been giving tasks to students and more than that if you start understanding all these tasks ok, then you will start appreciating the measurement science ok.

Thank you very much.