Engineering Metrology

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Lecture – 2B
Instruments – II

Welcome, to the course on Metrology and measurements.

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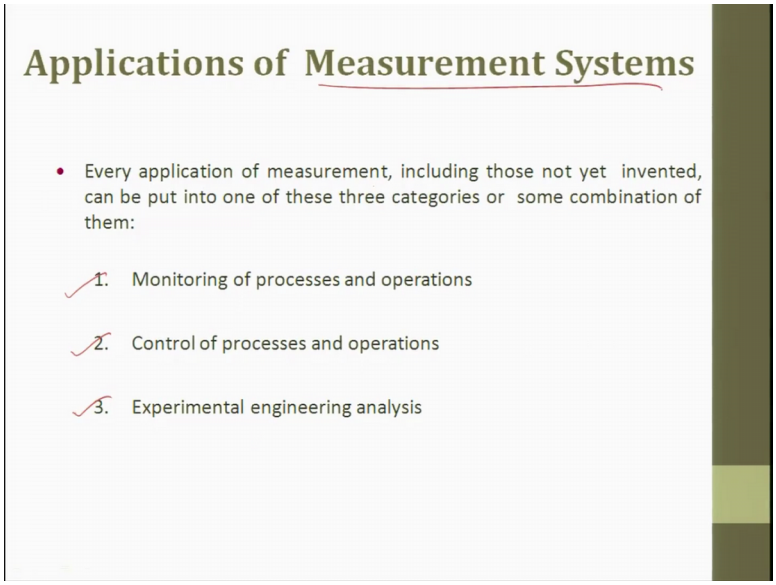

So, today we will see the application of measured system. Every application of the measurement including those not yet invented can be put in one of these three categories. 1 is monitoring of the process and operation, 2 control of the process and operation and 3 experimentally engineering analysis. So, within these three only all these measured system finds its application.

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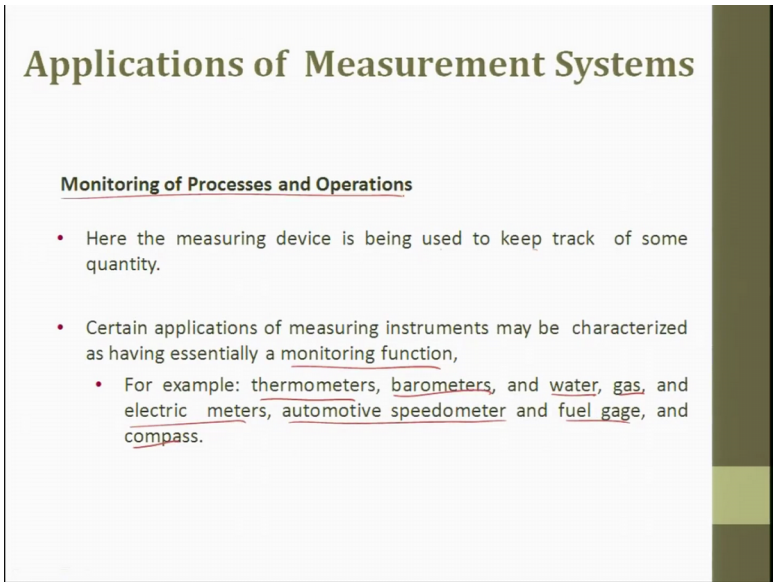

What is monitoring of a process and operation? Here the measured device is used for keep track of some quantities monitor. You keep for example, you keep on monitoring the temperature, you keep on monitoring the rainfall, you keep on monitoring the humidity. So, measure here the measuring device is used to keep a track of some quantity.

Certain applications of the measuring instrument may be characterized as having essentially a monitoring function. It can be temperature, it can be barometer pressure, water, gas, electric meter, automotive speedometer and fuel gage and compass. So, all these things are used for monitoring the process and operation.

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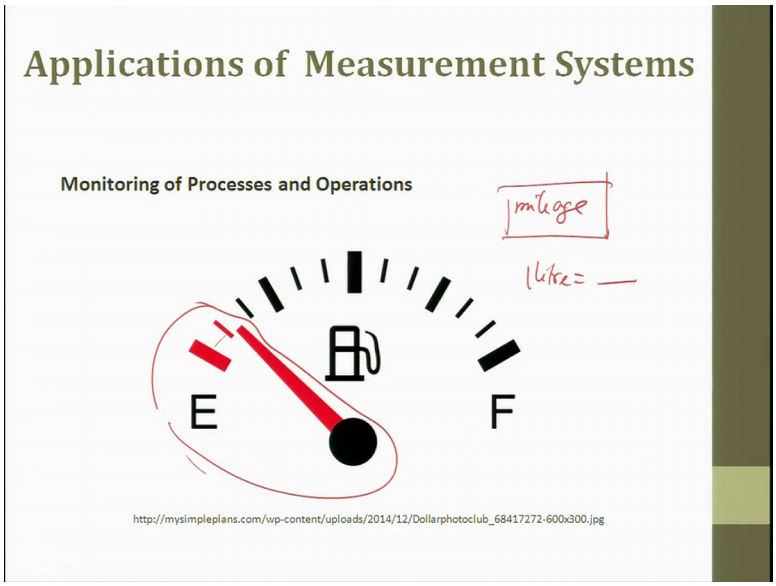

For example here this is monitoring I was talking to you about fuel. Today you can see beautiful things have come. So, see here it clearly says if the level is less than certain amount. So, it gives you a red alert and then says it is moving towards empty, ok. Here it says it is black and safe and what is this E and F? So, until you if you do not put the center image if this image is not there, so, this E and F does not make any sense. So, moment you have this center image made then by looking at the symbol people understand, this looks like a petrol pump. So, the entire device is indicating the level of fuel present in the vehicle.

And what it does? It only monitors how much it is getting sunk over a period of time. Today, interestingly you have also digital displays from the mileage the from the reduction in the fuel consumption it and the distance measured it tries to turn display the mileage per every litre or every whatever it is, every graduation it tries to tell what is the mileage it has travelled and it tries to convert this into for 1 litre, what is the distance travelled in this vehicle. So, this will try to talk about the process or the automobile.

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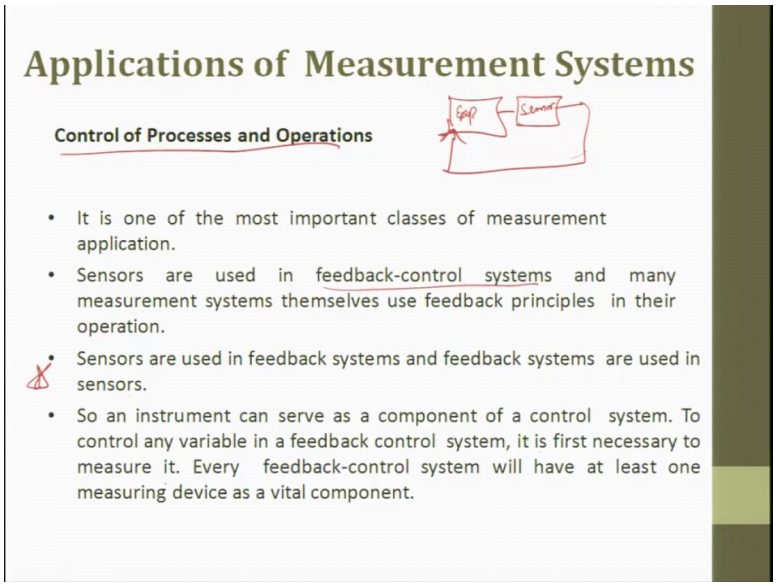

When you put in the other category of control of processes and operations it is one of the most important class of measurement applications. Here sensor are used in feedback control systems controlling of the process, right. So, how when do you control? You have an experiment going on, you measure the using sensors you measure what is going on, these are measuring systems, get the output and then come back and correct the experiment such that you get a good output.

Sensors are used in feedbacks, sensors are used in feedback control systems and many measurement systems themselves use feedback principles in their operation. Sensors are used in feedback systems and feedback systems are used in sensors. So, both can be used, very important point. So, an instrument can serve as a component of control system. To control any variable in the in the feedback control system it is first necessary to measure it every feedback control system will you have at least one measuring device as a vital component.

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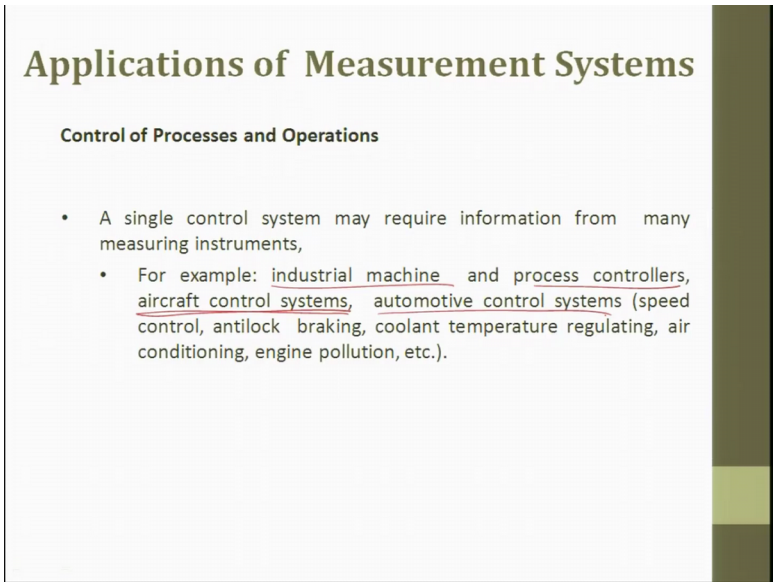

Then the signal control system may require information from many measuring instruments. So, industrial machines and process control this is useful in cement industry, sugarcane industry, sugar industry, aircraft control systems; here also there are several systems around a plane they look at all the conditions and then they try to control the system to get the output, automotive control systems all these things are available today.

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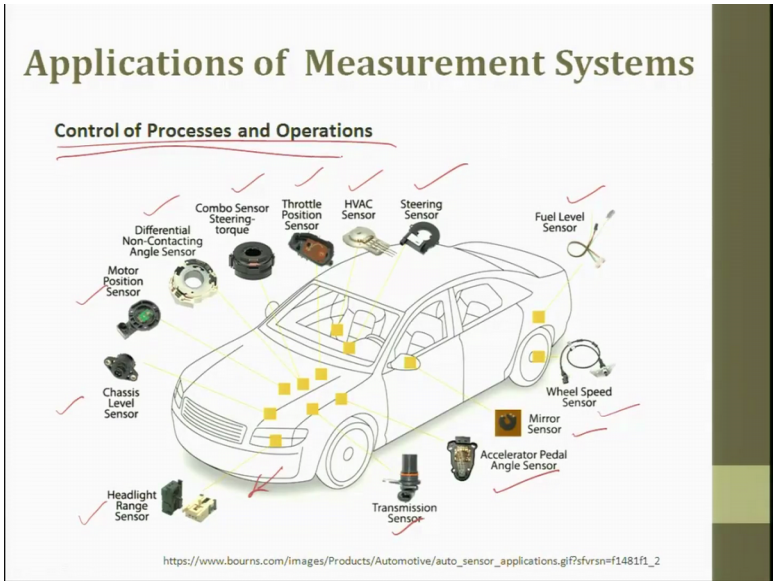

So, when we talk about different control process and operations in terms of automobile. You can see headlight range, chassis level sensor, motor position sensor, differential non-

contact angular sensor, combo sensor for steering, throttle position for fuel flow, HVAC high voltage AC sensor, then steering sensor, then fuel level sensor, wheel speed monitoring, mirror sensors, acceleration pedals and transmission systems.

Today what has happened, all these sensors are placed inside an automobile and then these sensors first measure the required quantity and then what they do is they try to control certain quantity to get the best mileage or a comfortable ride. So, here this is control of process and operation.

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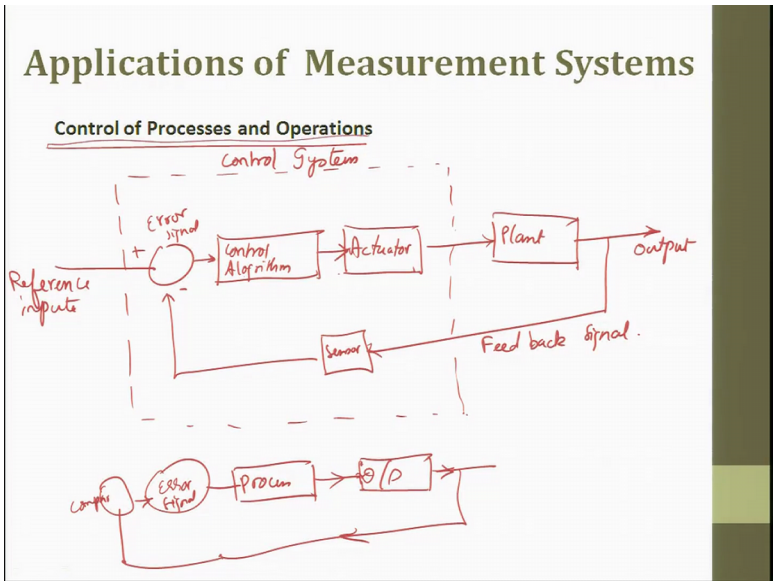

So, if you want to talk little bit more about control of processes and automation let me make a schematic diagram. So, we have, this is the reference signal input and then we have a control algorithm, then we have an actuator, then we have a plant and that will give output right. So, this is going to be feedback signal and a. So, this is a control system ok, and here is a feedback system you if see the control of the process, this is how it is.

Reference input is given. So, here there is error signal which is error signal which is generated and then this is taken to the control algorithm. Control algorithm does the modification or understands what is it then it actuates. What is an actuator? Actuator is just a change of certain variables or parameters which are involved, so an actuator comes. So, these actuators do the job after going through the control algorithm then this

is given information to the plant and plant starts working as per the control algorithms error signal whatever it is getting generated, it works and then it produces an output.

Now, what we see is we take the output and then we take it as a feedback signal give it to the sensor and then ask this sensor to understand what is going on and that is error signal is given. If you want to put it in crude terms you have a error signal, there is a process which is going on then the output is taken and then this output is brought back, and then it is compared then the error signal is given. So, accordingly the process is monitored. So, the output parameter the output can be even a shaft which is missing the product which comes out of a bread which is coming out of a bakery microwave oven, pizza coming out of a oven, it can be there or a finger chips coming out. So, all are processed.

So, after the process is over so, the output comes. Now, the output is measured and then if there are corrections to be made immediately it goes sends the output whatever is it, it measures the output and gives it back and then in the comparator it checks the value then error signal, corrections made. So, it keeps on continuing. So, this is generally the measured value is used to control the process.

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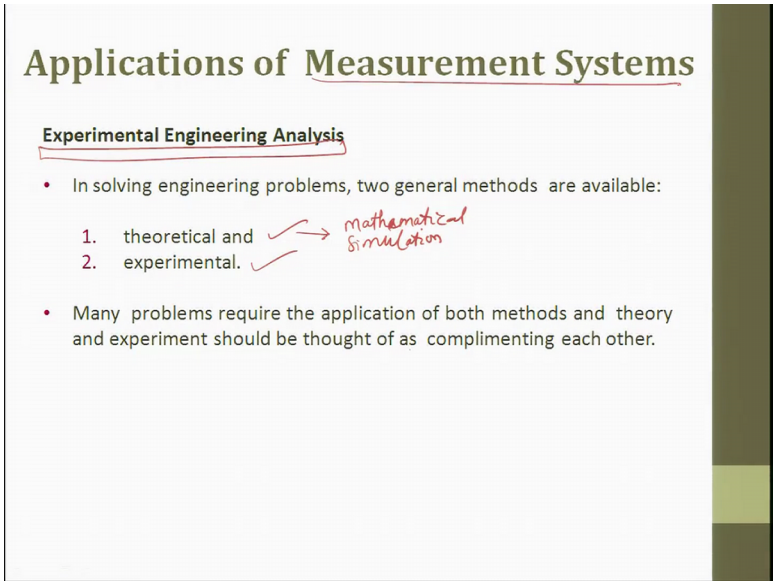

Engineering experimental engineering analysis in solving engineering problems two general methods are available, theoretical and experimental. Many problems require the application of both methods and theory and experiment should be thaught of an as an compliment due to each other. What we are trying to say is in engineering analysis we do

theory. Theory is we mathematically solve the problem the mathematically we solve the problem or we do simulation and understand the process completely. After understanding the process whatever we have understood we execute it in the experiments and see whether it is coming.

So, here this is experimental engineering analysis where the application of a measuring systems come in a big way.

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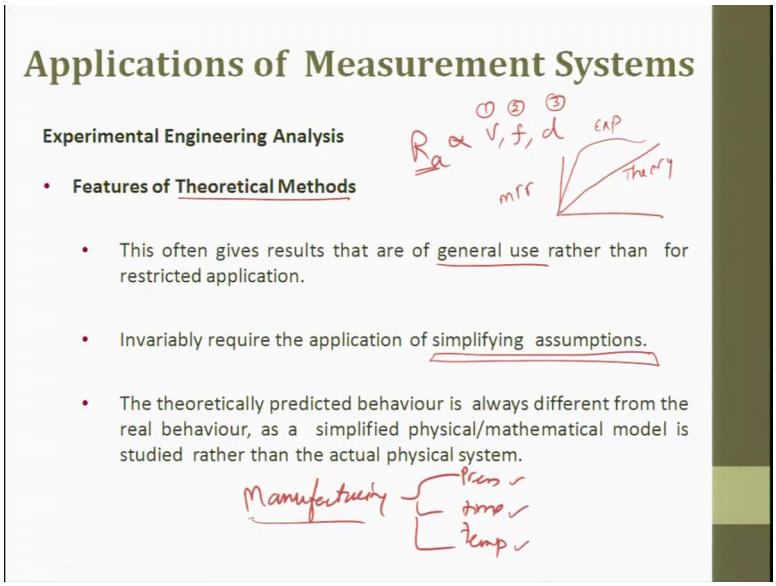

So, what are the features of a theoretical method? This often gives result that are general use rather than a restricted application. It gives for example, you have speed feed depth of control in a in a lathe machine we know feed plays an important role followed by may be a depth of cut may then follow the cutting speed. So, this relationship is known. I am just giving you an example this relationship is known. So, the magnitude of individual responses depends upon tool work piece interactions, right. So, the general use is given by the theory, but when I try to take the general use and tweak it to my requirements so then that is customization happening

So features of theoretical method is a general understanding is given. So, for example, R a is directly proportion to V, f and d in a lathe machine. So, now, you can it the theoretical one can even come out with the formulas and this is the first major influence, this is the second and this is the third. So, this general is given, but what value of V, what

value of f and what value of d you have to choose such that you get a better R a, but should come for the experiments.

Invariably requires the application of simplified assumptions. See, in manufacturing there are only three parameters, they are pressure, time and temperature these are the three parameters. So, in there are processes where only one is involved, there are processes where two thing two process variables are involved, there are where are all the three is involved. When more than one variable is involved the we do not know exactly what is the weightage of individual parameters. If we know the exact weightage then we can quickly go do manufacturing modeling, process modelling of any process, but this is very a trickier situation. So, what we generally do is we make lot of assumptions. So, this assumptions tries to generalize the model. So, moment we generalize model what we get an output is generic output.

The theoretically predicted behavior is always different from the real times. So, generally suppose you try to take away the material loop or rate, this will be the theoretical response their experimental response can be something like this. This can be experimentally response, this can be theory. Why theory it is almost a straight line? Because you have made assumptions and the model is made in such a fashion, such that it always leads you to the theoretical one. So, when we do in real time experiments there is always an error. The theoretical production behavior is always different from a real time behavior, as simplified physical mathematical models because many a times to simplify the model and working of some manufacturing process we tried to take variable relationship as linear. So, it is studied rather than the actual physical system.

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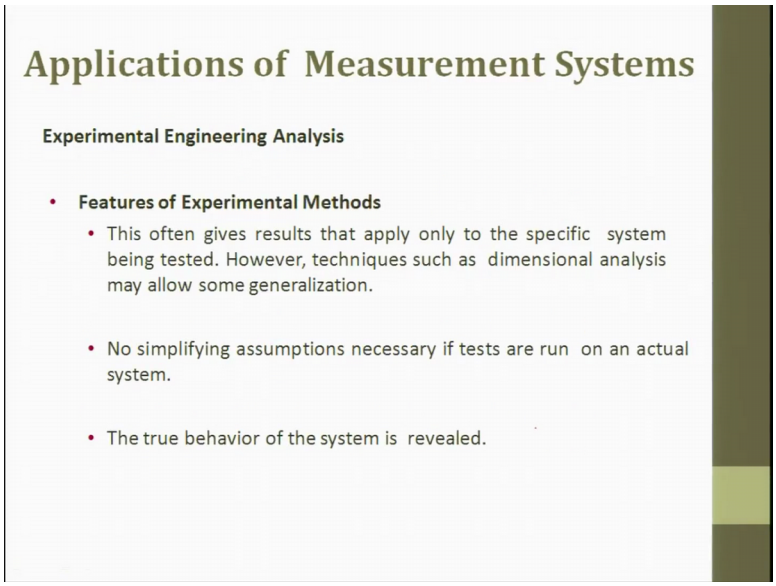

In some cases, it may lead to complicated mathematical problems. So, for example, if we want to do a laser simulation, laser welding or laser hole making similar process simulation, it is extremely difficult. Why? Because you are supposed to take heat, you are supposed first is heat, you are supposed to take material property and you are also supposed to take a time dependent variable for this, it is a very complicated process.

So, in some cases it may lead to complicated mathematical modeling. Sometimes it requires only it requires only pen, pencil, computer etcetera, but extensive facilities it is not necessary for theoretical one. So, the time no time delay when engendered in building modelling and assembly is all there.

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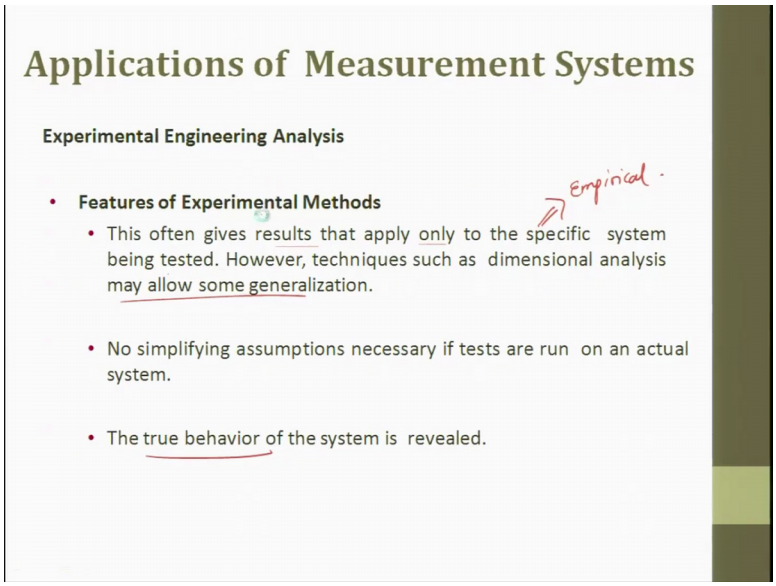

So, when we talk about features of experimental modelling it is often it often gives the results that apply only to a specific system that is what I said you remember in the previous lecture empirical modeling, (Refer Time: 14:17) specific system being tested. However, the techniques can be dimensional analysis may allow some generalization. So, but here what happens in the experiments the true behavior is realized.

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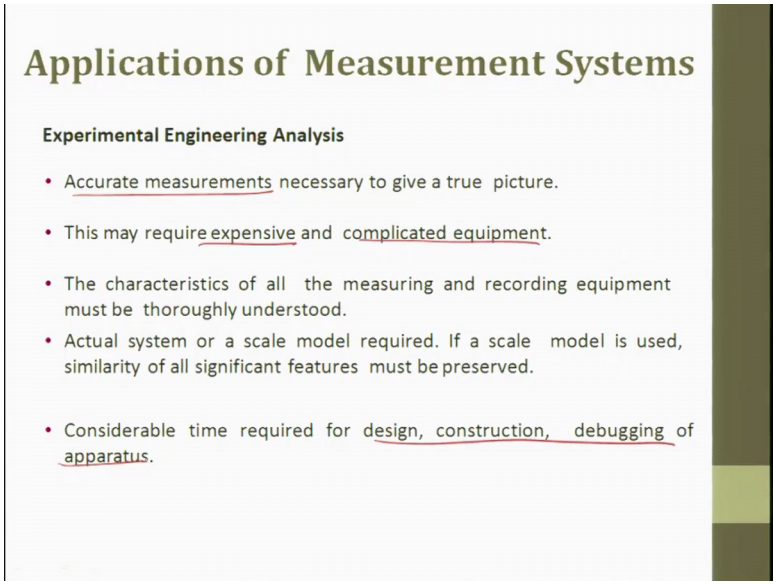

The accurate measurement; measurements necessary to give a true picture it the experiments are always expensive and the device what you what it is complicated in

nature. So, it is considerable time is required for designing construction and debugging that apparatus before doing the final version of it.

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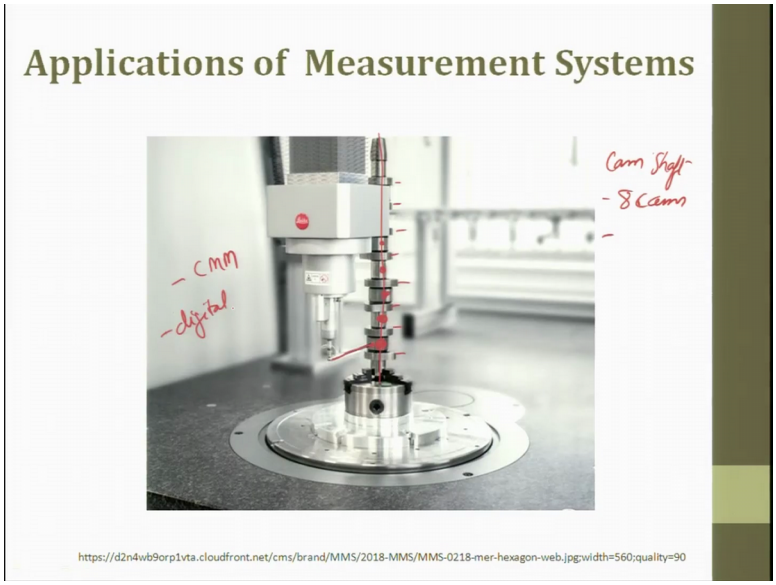

So, here is a instrument which is here is a shaft which is a cam shaft you can see these are cams 1 2 3 4 5 6 7 and 8, it is a cam shaft with a maybe 8 cam; cams are always given for timer it is something like a timer are timely release of fluid or whatever it is so, it is there. So, here it all these cams are attached to your shaft or it is a integral part of a shaft. So, now, what is happening your; you can see these are the areas where it will be in contact with the housing or some place. So, we are trying to measure the individual values of this, ok. This is done on a CMM machine Coordinate Measuring Machine and here is a stylus. The stylus comes in contact with it so we try to get a digital display of the value at any given point of time.

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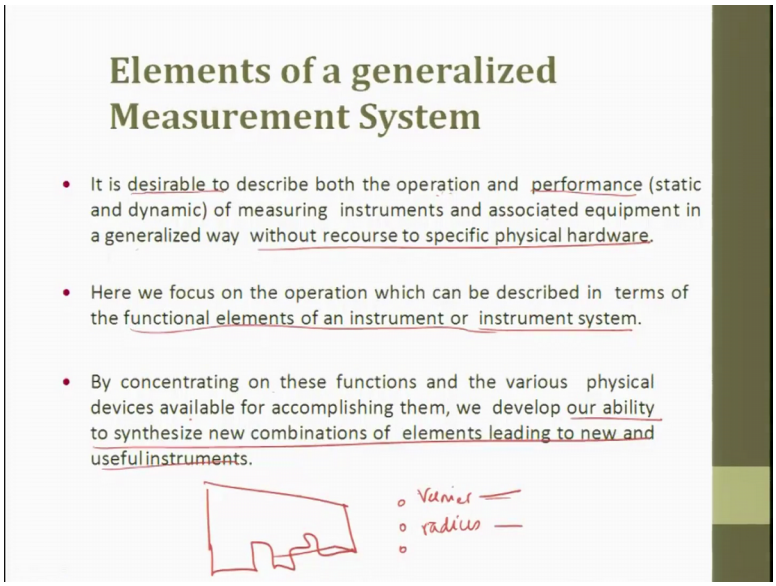

So the elements of generalized measured system it is desirable to do describe both the operation and performance of measuring instrument and associated equipments in a generalized way without recourse of specific hardware.

So, what we are trying to say here is whenever we try to give requirements for developing a measuring system we should try to may get very generic. So, it is desirable to describe both the operation; that means, to say rather than saying please give me that x instrument, you say that is say so, here is a part in which is manufactured and this undergoes these operations and this is what is the criticality of this part in terms of performance. For this I would like to design or I would like to have I would need an instrument.

So, it is very clearly describes to the opponent person or the next person what instruments to pick rather than exactly saying please give me back. So, it is desirable to describe both the operation how the manufacture and the performance or the measuring instrument and associated equipments in a generalized way rather than a specific. Here we focus on operations which can be described in terms of functional elements of an instrument or we used to be these instrument system.

So, try they say here is an instrument which has to be this this this this this measurement we should not talk about what should be the shape size how does it look like or those things we have to say what is the functions which should be there in the system and what

should be there you need a functions it should measure. By concentrating on this functions and various physical devices and the various physical device of are available for accomplishing them we develop our ability to synthesize new combination of instruments. For example, you can say a dial gauge is required or you say that here is a component which is something like this to measure.

So, what I will do is I cannot measure the internal of these grooves and all. So, what I will do? I will try to say please give me a Vernier; please give me a device where it can measure the radius. So, here what I am doing is I am trying to split into various functions and then am trying to assimilate these functions, try to develop my own device for the requirement.

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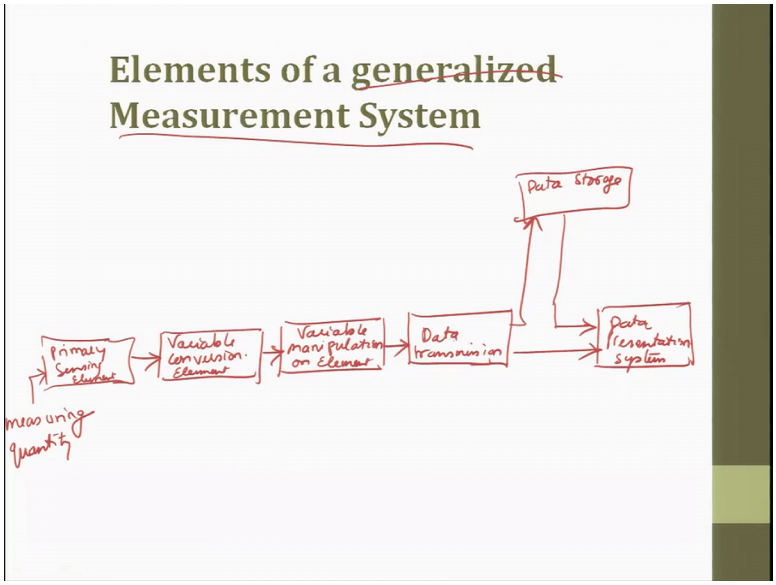

So, when you talk about the elements of generalized measuring systems. So, it will be like this so you will have measuring quantity, then you will have primary sensing element measure it and then what we have is we will have variable conversion element then we will try to have variable manipulation on element, then we will have data acquisition or a data transmission right and then what we do is data presentation system. So, if you see here these are the different elements which are present in generalized measuring system.

So, first we will have a measuring quantity. So, we will have a primary sensor to measure and then this primary sensor elements whatever is there it then it is sent to a variable

conversion element. So, we will try to convert some of the primary data into a secondary data, then what we do is we try to take those conversion data variable manipulation of elements we try to do and then what we try to do is we try to have to have data transmission system. This data transmission system communicates to a data storage and then the this signal is further sent to data presentation system. It without going to a data storage it can directly come to the presentation or it can go to store. So, that means, to say I am measuring a data then I am trying to convert the data and then trying to develop manipulation for the elements and then I am trying to record the am trying to take the final data in my hand and that data can be used for displaying presentation systems directly.

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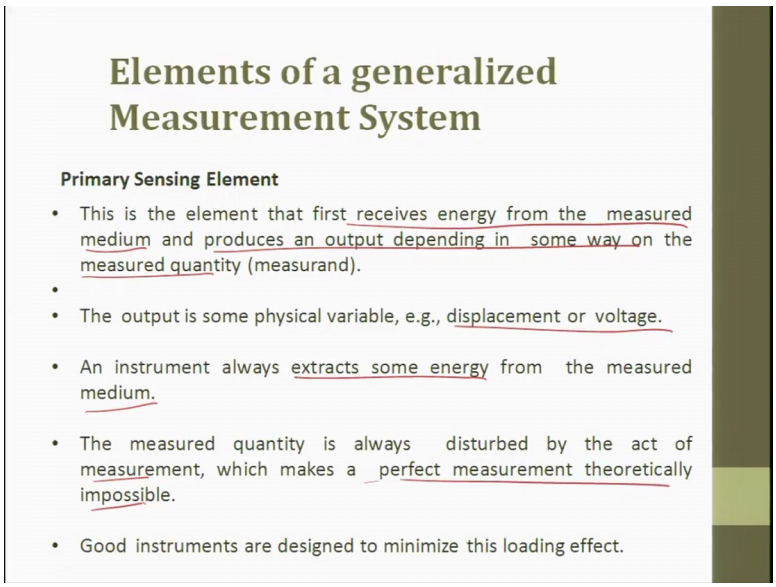

So, what are the primary elements? These are the elements that first receives energy from the measured media and produce an output depending in some way of the measured quantity. The output is some physical variable example it can be displacement and voltage. An instrument always extract some energy from the measured media. The measured quantity is always disturbed by the art of measurement, which makes a perfect measurement theoretically impossible. Good instruments are designed to minimize the load effect.

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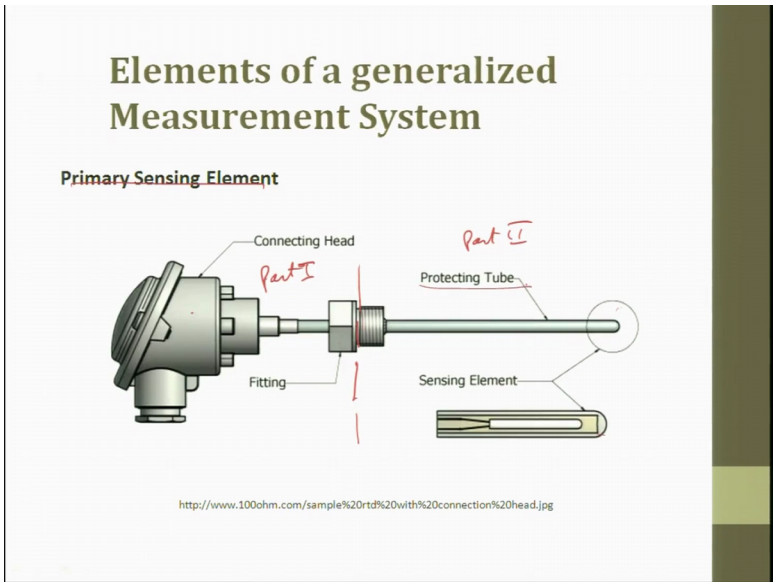

For example this is a primary device. This is a primary sensing device, ok. So, here is a fitting. So, here is a connecting head this can be this is at a protecting tube then sensing this can be an LVDT or this can be a sensor which is used for deducting gas, whatever it is, right. So, here if you see that so, this is the connecting head; connecting head connecting head of fitting. So, here this is a till this it will be an independent and this will be one part; part I and this will be part II and here depending upon this the sensitivity these devices can be changed. For example, the protecting tube can be changed the sensing element whatever it is there this can be changed, so that we try to get the data more accurate.

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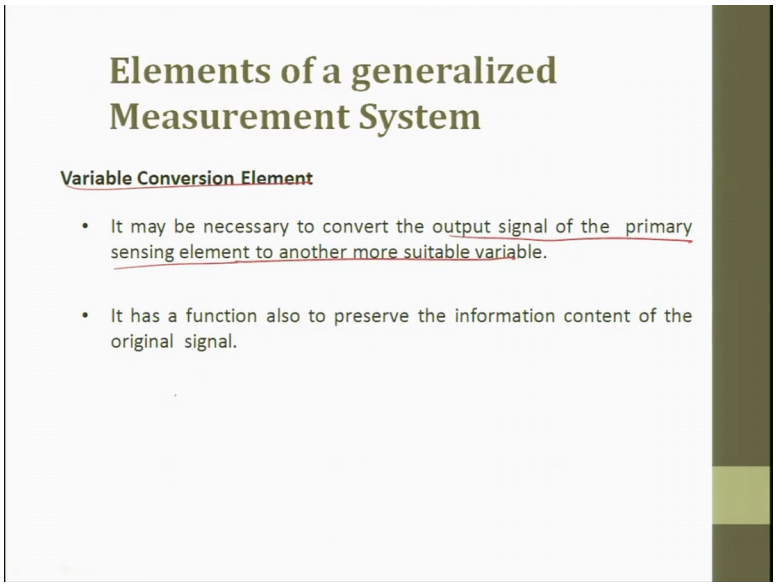

The variable conversion element so, I am trying to take an individual block diagram and am trying to tell primary variable. I am trying to talk about various block diagrams it may be necessary to convert the outputs signal of the primary sensing elements on another more suitable variable.

So, instead of trying to take only displacement I will try to convert this in to a voltage parameter. It has a function also to preserve the information content to the original form. So, it is always like that displacement you always converted into a into a voltage signal, so that this voltage can be used for very other measurements.

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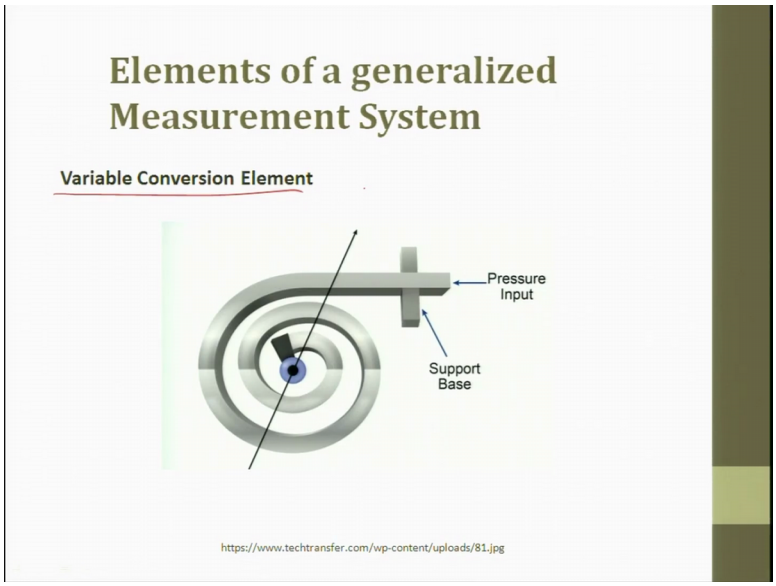

So, variable conversion element if you see these are pressure inputs and you can say this is the supporting tube here is a coiled spring. This when it tries to push this will pointer will try to improve. So, this is this displacement is converted into this motion.

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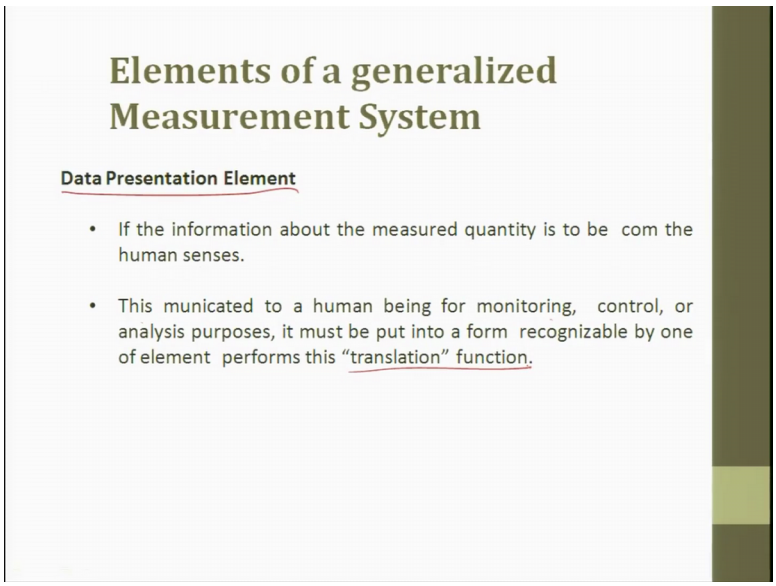

So, then the data presentation element; if the information about the measured quantity is to be computerized or is to be stored somewhere so, then is to human sense it is always there. Then this munication to the human being for monitoring, control and analysis process, it must be put into the form of recognizable by one of the element performs the

translation function. So, the data presentation element tries to convert the data in and helps us to understand what is it.

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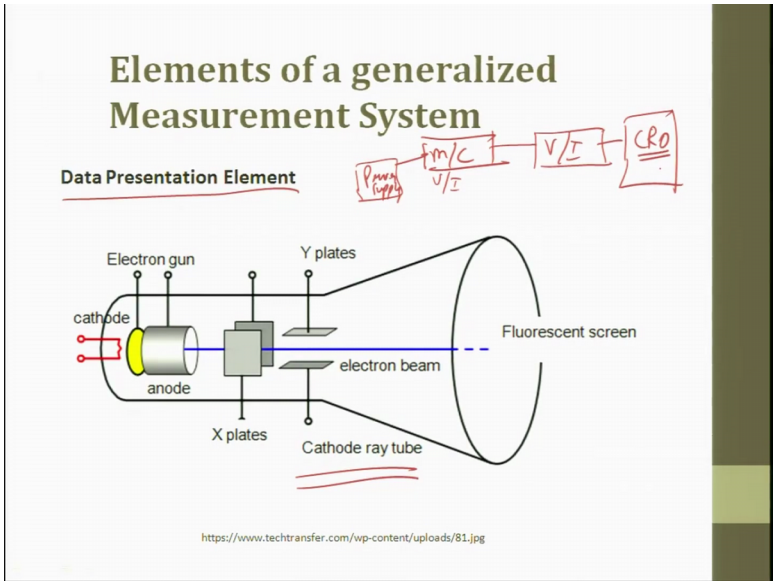

So, the data presentation element can be like a CRO which is there for example, you had a circuit a power supply. So, the power supply had and then this is attached to a machine. So, the power supply gave some data to the machine voltage it gave, current it gave. So, voltage and current signals have been given. So, now, what I do is I try after this thing machine to measure the voltage same and then I, voltage and current parameter to find out the load what is there or resistance what is been getting developed. So, then this signal I wanted to connect it one oscilloscope CRO and see the displacement to see that the data the presentation which is happening in a CRO.

So, this is a; it can be called as a TV or it can be a CRO which is used to see the displacement. So, primary so, first we saw primary so, then we saw where primary element system, then variable conversion system I gave an example, then the data presentation happens in the CRO.

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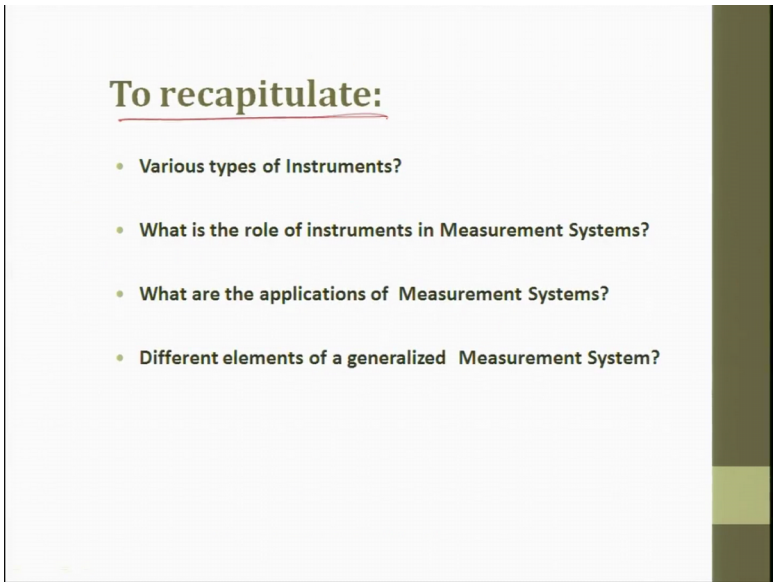

So, in this lecture so, what all did we see? We saw various types of instruments, then the role of instruments in measurements. Then what are the different type of applications of measurement and what are the different elements of a generalized measuring system.

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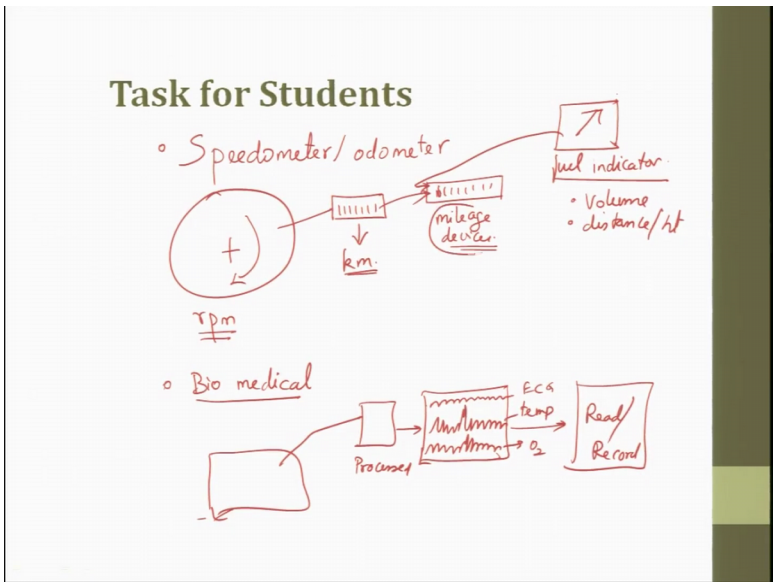

So, task for students: So, let us take two tasks, the first task is let us take a speedometer; speedometer is a device which is used to measure the speed which is used or we can we call it as odometer which is used in bikes. So, basically you will have a wheel which rotates at some rpm, it rotates at some rpm and this data is getting converted on the

screen you will see kilometers, you will see kilometers and then this in turn is linked with a mileage showing device or mileage device, ok. So, again here it is a data. So, now, what I want to you guys to see is how is the data of rpm getting converted finally, into a mileage data. So, here if you see data to cover distance so, a single measured data is converted into some other data form and this data is used to find out the mileage and here you also need an input of fuel consumption. So, in here you have a device which is which is showing the few fuel indicator, ok.

So, this data has also to be linked with this and you will have go get the data and here please understand it does it look for volume, does it look for distance that we used to say height of the tank what how does this fuel indicator measure the level of a fuel. So, please try to understand and now you see varying data points you get varying measurements. So, for measuring individual physical parameters you have varying measurement devices. These devices will have varying units and they do single or that is primary or secondary data item is taken and then it is processed and then you can see multiple sensors also getting linked.

The next thing what I want you guys to look at it is please look at medical device, biomedical device wherein which you can see in an oscilloscope or in a monitor you see the data which is getting displayed this can be a temperature data, this can be the oxygen content data, this whatever it is this can be your ECG data, whatever it is you see look at it. So, how are these see you have a human body from here you have different sensors, all these sensors are preprocessed or processed and then you get the data displayed and this data you can read as well as record this data for patient to understand the patient history try to look at this real time application.

So, here you will see patient is monitored through multiple sensors and this sensors whatever it is the data is getting displayed and then this data is intern recorded and retrieved as and when it is required. Please try to look at these two examples what I have given here how measurements are important, how different different measurements sensors are involved to get a different data for processing. So, with this we will come to an end of this lecture.

Thank you.