Experimental Methods in Fluid Mechanics
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Lecture 04 - Basic Concept of Dynamic Measurements Contd.

Good afternoon to you all. We will continue our discussion on Experimental Methods in Fluid Mechanics. Today, I will continue, what I was discussing in my last lecture that is the measurement system – Basic concept of dynamic measurements. In fact, I could not complete the topic of basic units, system of units and system of dimensions, so maybe I can take 10 minutes to deeply complete that part and then I will move to this topic on dynamic measurements.

So, to start with, just I will try to again say that, we have perhaps understood that we have a common system of unit that is standardized, those, that means we standardize quantities to a few system, those are used throughout the world. Today, we will see that there are primary standards.

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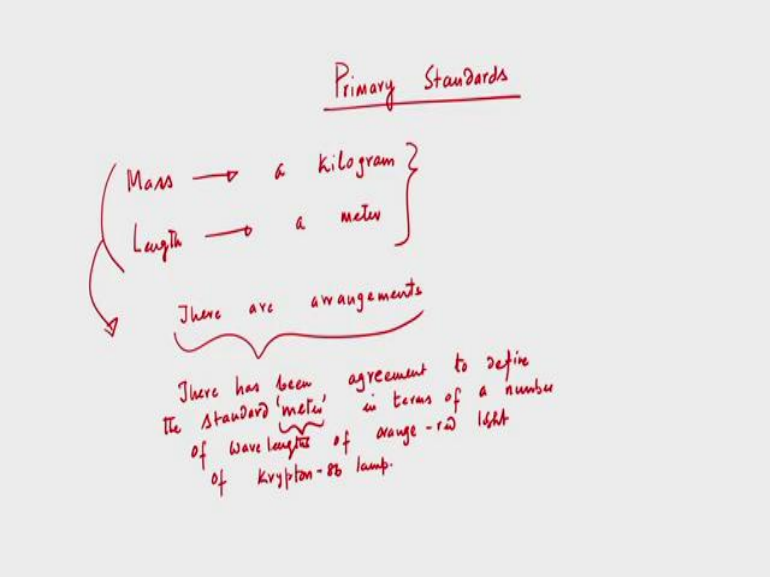

So, I am writing primary standards. There are primary standards for different unit, say for different quantities. So, primary standard for mass, so if I write mass, primary standard for mass is a kilogram, so write a kilogram. Similarly, primary standard for a length, basically why I am taking this, we have discussed that we will be, not only we that is a standardized system that is SI system.

And effort, efforts have been directed to obtain that standardized system that is SI system and that will be used, that is used throughout the world, so now I am writing length. So, the primary standard for a length is a meter, so a kilogram and a meter. Now, a kilogram, a meter, so how do we know that what is one kilogram, what is a meter? That means these are standardized.

So, that is why I would like to tell you that a kilogram, mass, a meter length those are defined in such a way that other things will be standardized with respect to this primary standards. So, I am writing what is a kilogram, to measure mass or length there are arrangement, there are arrangement to measure this.

And not only that there has been agreement between not, I am writing there has been agreement to define the standard, to define the standard meter, say meter, I am talking about meter. First, so there has been agreement to define the standard meter in terms of a number of wavelength, in terms of a number of, number of wavelengths of the orange red light, orange red light of a krypton 86 lamp.

So, these are nothing but recapitulations, I mean we have may be studied all this, all these things, but again since this is the very important part of this course, because experimental methods, when we are measuring anything, when you are estimating anything, then you need to know what are the units and if when you are, when whenever we are using unit, at least we should know whether the, those in which system we will measure this.

And as I told you that there may be situations where the quantities measured, or quantity is measured by a particular device, particular instrument are not the unit which we are looking for, so we need to know how we can have conversion of measured quantities, measured data from that unit to the unit which we are looking for.

So, this is the basically primary standard, because so the agreement is was there to define meter in terms of a number of wavelength of orange red light of Krypton 86 lamp. Similarly, that other primary standard, I mean just like kilogram, so similar definitions for standard units have been defined for all primary units. So, this is not only for the meter, that means even for a kilogram and other primary units similar definitions are defined.

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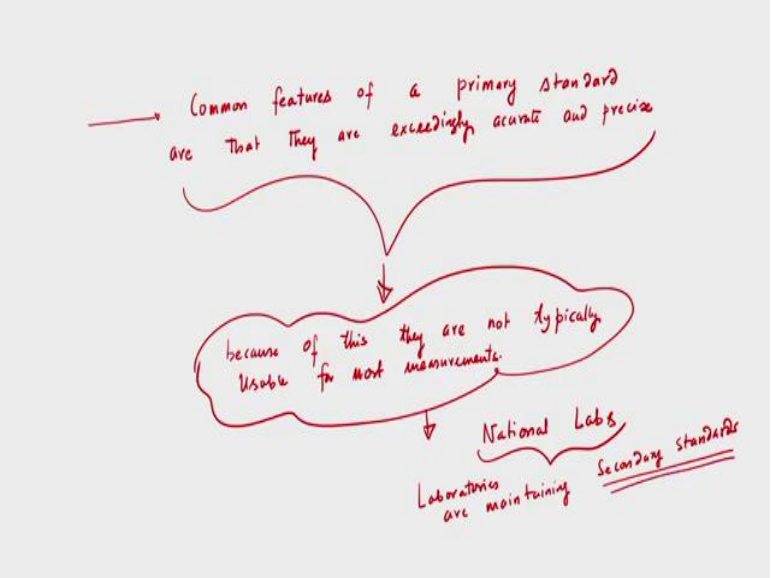

What is important that the common feature of the primary standard, say I am writing, common feature of a primary standard, common feature of a primary standard, rather I can write common features are that they are exceedingly accurate when measuring and precise, so that they are exceedingly accurate and precise and since they are exceedingly accurate and precise, they are not typically usable in most of the experiments.

So, problem is that we have defined meter, similar definitions are available or similar definitions are there even for others primary standards and fine, maybe we have defined all those, but the common feature is that they are exceedingly accurate and precise and because of this, because of this, very important is that they are not typically usable for most of the experiments.

So, because of this, because of this they are not typically usable, they are not typically usable for most of the experiments or most of, most of the measurements, most measurements I can write, most measurements. So, this is very important. And so what we do, so primary standards are exceedingly accurate and precise because of this they are not typically usable in most of the experiments or most of the measurement methods and techniques.

So, what do we do? Rather there are national laboratories where secondary standards are there maintained, they are maintaining secondary standards, which are calibrated against these primary standards. So, basically because of this problem, we cannot typically use; what do we do?

I am writing here, there are national laboratories, national labs where these labs are maintaining secondary standard. So, basically laboratories are maintaining secondary standards and I am underlining these two words, secondary standards where the secondary standards are calibrated against those primary standards.

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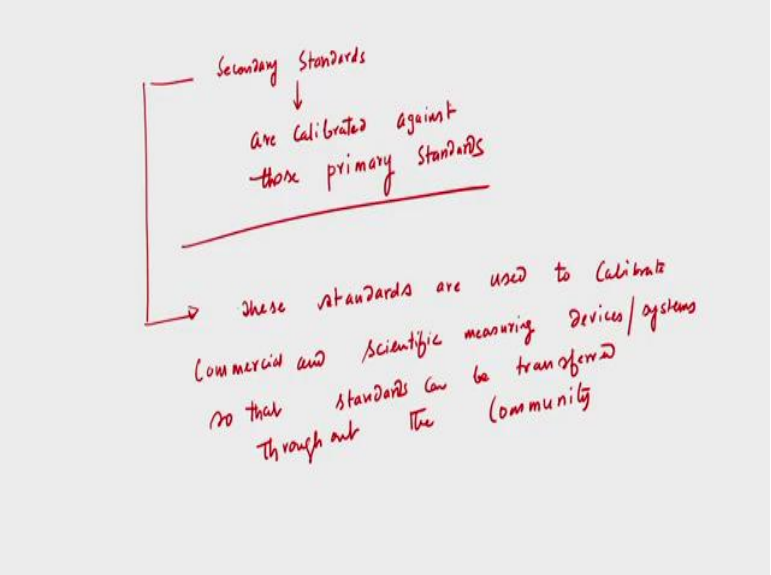

So, these secondary standards are calibrated against those primary standards. So, that means since we cannot use primary standards, national laboratories are there who are meant, where the secondary standards are maintained and secondary standards are calibrated against this primary standard. Now, not only we are using primary standards, again what we do?

So, national laboratories are having, I mean they are maintaining these primary standards. Now, what do we do? These secondary standards, the secondary standards they are again used, because we have understood what do we mean by calibration and what we, what do you need to have this process, I mean this process, like I mean calibration.

So, secondary standard again, these standards are used further to calibrate, to further to calibrate commercial and scientific, scientific measuring devices, devices, systems so that standards can be transferred throughout the community. So, basically we have understood primary standards are very accurate, precise, they are not typically used.

Secondary standards which are there in the national laboratories are calibrated against these primary standards. These primary standards are not also used, they are also used to

calibrate commercial or scientific equipments, devices, systems, which are largely used in our experimental research and also, I mean experimental research and these are used to transfer these standards throughout the community.

So, basically, these are, this is secondary standard and then commercial scientific measuring devices. A ternary standard and higher level standards are kept, is very important, we started with primary, secondary, then we had ternary. Now, these ternary standards which are against kept and used to calibrate RI instrument.

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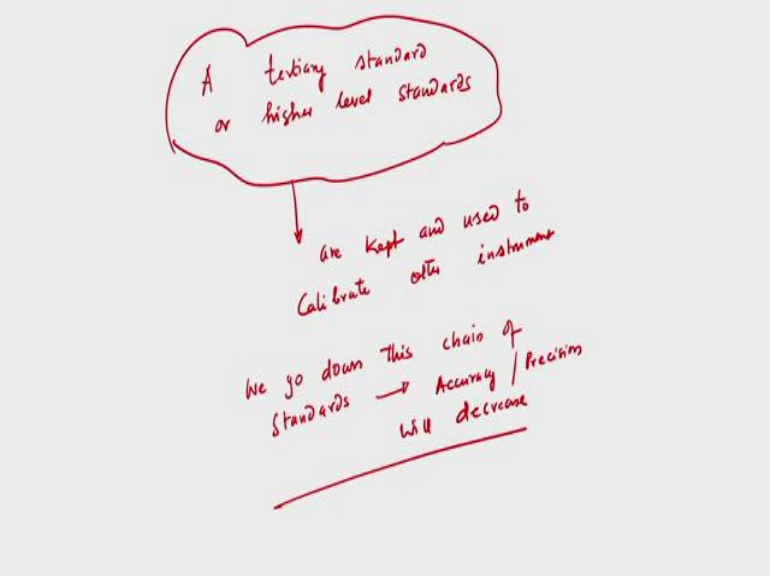

A tertiary standard or even higher level or higher level standards, these standards are kept and used to calibrate other instrument. So, from this discussion what we can understand that if we go down further, this chain of standard, I mean through the chains of the standard, then what will happen? So, we started with primary, then secondary, then tertiary or even higher level, quaternary standards.

So, basically there are kept and used to calibrate RI instrument. So, what we can understand? Primary standard is very accurate, precise, secondary standards are basically those are calibrated against the primary standard, so we cannot say that the accuracy, precision of the secondary standard would be as good as the primary standards are having.

Tertiary standard, again we will lack, we will suffer from precision, that I mean the precision or accuracy may not be even equal to the secondary standard and if we go

further higher, that means if we go down this chain of standards, then accuracy and precision will decrease.

So, that is why I am writing, so if we go down, this chain standard, chain of standards, accuracy precision will decrease, this is very important. So, now from this discussion at least we can understand that the instrument or equipment or device, whether those instrument, equipment devices, we will be using for our experimental measurements, experimental investigations.

If those equipment devices are calibrated against the secondary standards or the tertiary standards, or even higher level, because it is very true that those equipment devices are not calibrated against the primary standards. So, definitely, accuracy, precision, these two things, I mean will not be accurate even if we are using with any commercially available scientific instruments because those are calibrated against only the secondary standards or even higher level of that.

So, with this I conclude my discussion on the dimension and unit. Next, I will go to discuss – What do we mean by measurement systems? This is very important that measurement system are composed of a combination of different stages. So, when we talk about any measurement system, all measurement systems are composed of a combination of different stages.

And now here we will try to identify, what are those different stages and not only that, when you are having different stages in a measurement system, what is the requirement of those stages, rather what are the function of those different stages. So, I will try to describe this measurement system through block diagram. At least through that block diagram we will try to identify different stages and will, I will try to outline their functionality.

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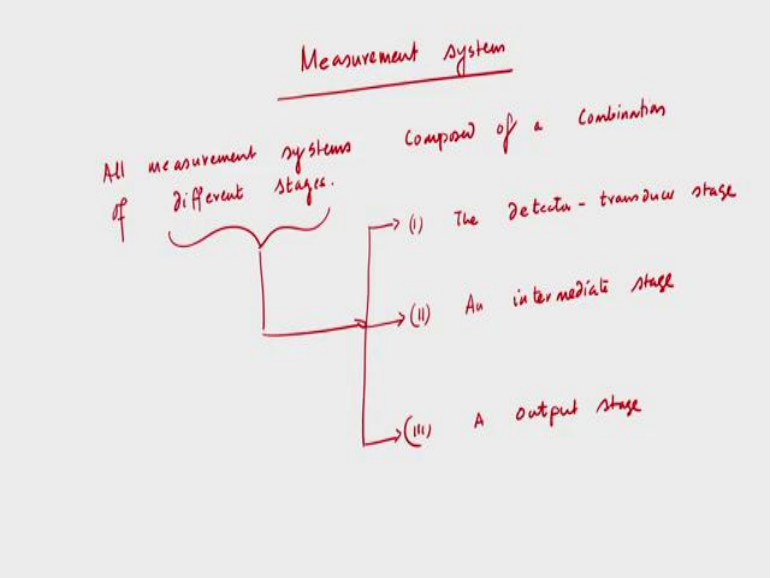

So, I am writing that a measurement system, just I am writing that all measurement system composed of a combination of different stages. What are the different stages? Different stages, we have, number one, the detector transducer stage. I will write through block diagram again, and intermediate stage number 2, and number 3, number 3, an output stage, a output stage.

So, at least for the time being, we should know that all the measurement system are having these three different stages, the detector, detector transducer stage, and intermediate stage, and finally, we should have a output stage. What are the function of this? I mean, what is the function of these three different stages, that is we need to know.

So, we will start with the first one that is detector transducer stage. The detector transducer stage is the basic measurement device. So, I am talking about, note that, we are discussing measurement system and the system is having three, these three different stages.

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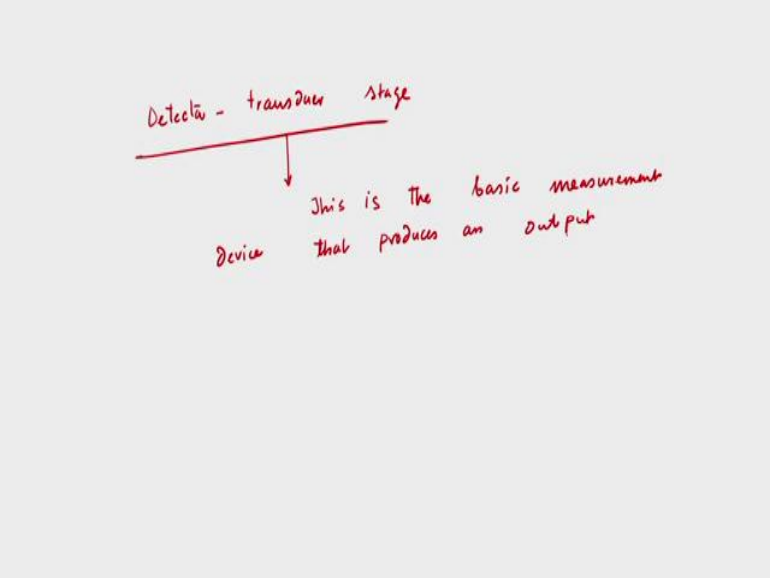

So, the first stage is detector transducer stage. This is the first stage. The detector transducer stage is the basic measurement device that produces an output related to the physical variable we used to measure. I am writing, so this is the basic measurement device, basic measurement device that produces an output.

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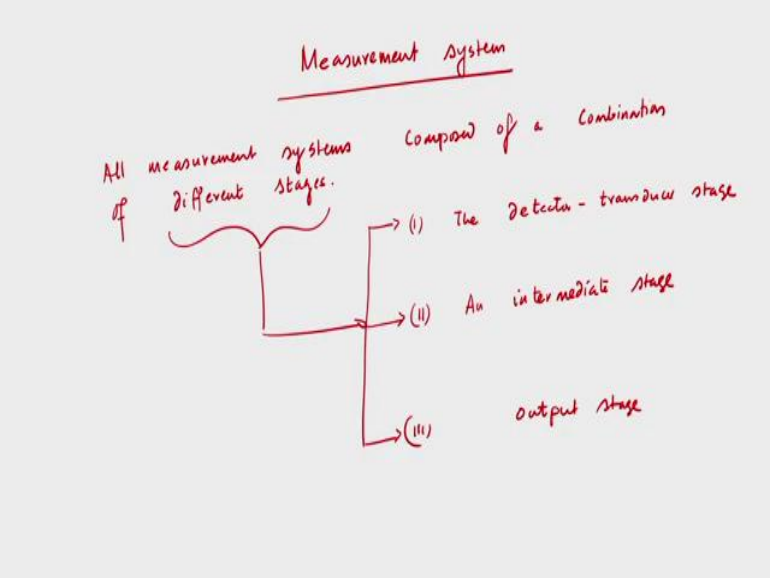

Here we can write the output stage or simply we can write the output stage.

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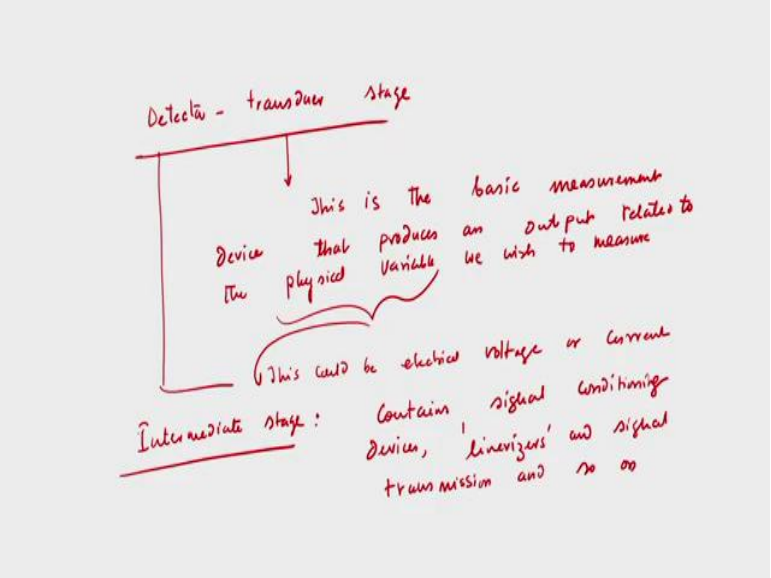

This is the basic measurement device that produces an output related to the physical variable we used to measure. So, in a measurement system this is the basic measurement device and this device will produce an output, and that output should be the physical variable, that means whether we would like to measure velocity, whether we would like to measure pressure, temperature, that is the primary requirement.

That means the variable, physical variable, which is our main target to measure that will be given, that will be measured by this basic measurement device and that is the detector transducer stage. This detectors transducer stage, this could be an electrical voltage or current. So, this could be physical variable we talked about.

So basically we can, this could be electrical voltage or current. This physical variable which we would like to measure. So, next is the intermediate stage. So, an intermediate stage, an intermediate stage contains the signal conditioning devices, like linearizers, signal transmissions and so on. So, I am writing again this intermediate stage contains signal conditioning devices, linearizers, and signal transmission and so on.

In many measurement system this stage may not be recovered, so detector transducer stage is very important, the basic measurement device, but intermediate stage that may not be required in many measurement system, it may so happen that the output we are getting from the first stage that is the detector transducer stage.

That stage is giving us information about the variable that we like to measure, but that is not giving any kind of signal, if the output of that particular stage is signal that again that we need to pass the signal through this intermediate stage and intermediate stage upon receiving signal from the first stage, it will, it will as I said this is, it is a signal conditioning devices, device, so it will try to linearize and then ultimately it will try to transmit the signal as an output and we will collect the data from other stages.

So, it depends, depending upon the situation, depending upon the (())(27:33) we would like to measure, depending upon the system requirement, depending upon the situation we may or may not have this intermediate stage.

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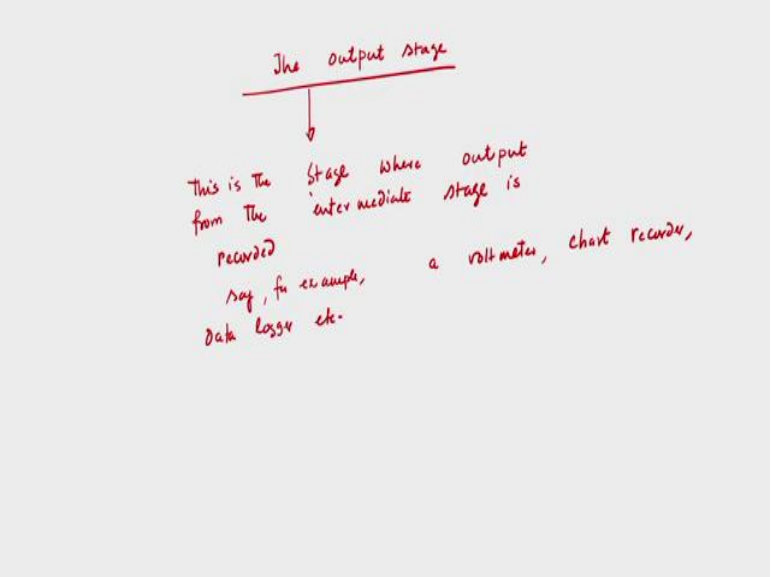

Next, we go to the output stage. So, last is the output stage. This is very important stage. Output stage is a stage from where, output from the intermediate stage is recorded. So I have just now told that signal transmitted by the intermediate stage will be taken by the output stage, and if the intermediate stage is not required at all depending upon the requirement, then directly we will get output from the detector transducer stage.

So, output stage is the stage, this is the stage where output from the intermediate stage is recorded, where output from the intermediate stage is recorded. Example, say a voltmeter. Say, for example, a voltmeter, chart recorder, data logger, et cetera. So, this is the three different stages in a measurement system.

Now, so far we have discussed we can put them through block diagram, rather the relationship between the stages or among the stages can be shown through a block diagram that is what we should now try to see. What important is the detector transducer stage can be exposed to the physical variable that is what I said for a measurement of, for a measurement or even a calibration source for calibration.

So, the detector transducer stage can be exposed to a physical variable that is what we would like to measure for a measurement or sometimes it can be exposed to a calibration source for the record calibration. So, now what we should do is the block diagram of the three different stages and we will try to see, how they are interrelated through their functions.

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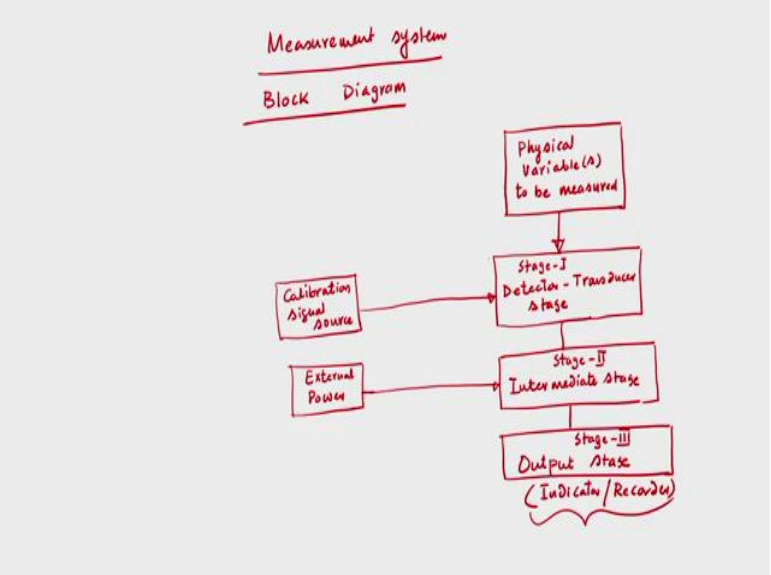

So, I will try to write now, so I am trying to, again I am writing measurement system block diagram. So, this is block diagram. So, we have one block where I am writing physical variable to be measured, physical variable or variables to be measured, then we will go to first stage, we will go to first stage that is the detector transducer stage. So, this is stage one that is detector transducer stage.

Now, in this detector transducer stage, we may require calibration signal source. So, fine, before I go to discuss that let us complete this second stage and that is the intermediate stage. So, this is stage 2 that is the intermediate stage and this intermediate stage or stage two, we need to, we need to connect through external power source.

Because this is signal conditioning device so we have to connect through external power, otherwise external power, and then finally, we are having the output stage or stage 3, output stage that is essentially indicator, we may have a pointer like this indicator, I know that is movement of a pointer or shown indicator or recorder, it may record.

So, these two are with this stage three. Now, in the detector transducer stage, as I said that can be exposed to a physical variable that is what we like to measure or sometimes calibration source for the calibration. So, that means I am completing this block diagram, then I will explain that is calibration signal source. This is calibration signal source.

So, this is the complete block diagram of the basic measurement system where we have identified three different stages; stage one, stage 2, stage 3. We have explained their functionalities and we have also explained that the intermediate stage may not be required for all the cases, depending upon the situation, depending upon the requirement, we may record this and to drive this stage or to drive this unit we need to connect this with external power.

And finally, we will get stage 3 that is output stage where we may get, I mean we may have moving pointer or so on or it may have recorded so that the data measurements results can be recorded directly. Another important thing that is what I should mention here that the detector transducer stage can be composed of a physical variable that is fine, and the output of the, output of that particular physical variable is not in the form of signal, then we may not record intermediate stage, we may directly get that.

Now, it may so happen that the detector transducer stage can be exposed to a calibration single source that means the physical variable what we are trying to measure in that case, it may not be equal to measure but we would like to calibrate, so whether that particular function, that particular device or particular instrument is to check their performance to calibrate them.

So, this part or this sub module also be, also needs to be connected with this detector transducer stage so that we can calibrate. So, this is the knowing this basic measurement system, knowing the module or units or modules of this basic measurement system and also identifying their functionalities, now we can move slowly to the basic concept of dynamic measurements.

So, now, today I will briefly discuss about that why you need to have this dynamic, understanding of basic concept of dynamic measurements. So, I am writing and I will continue may be the next class, but today I will briefly discuss about what is dynamic measurement and what is static measurement.

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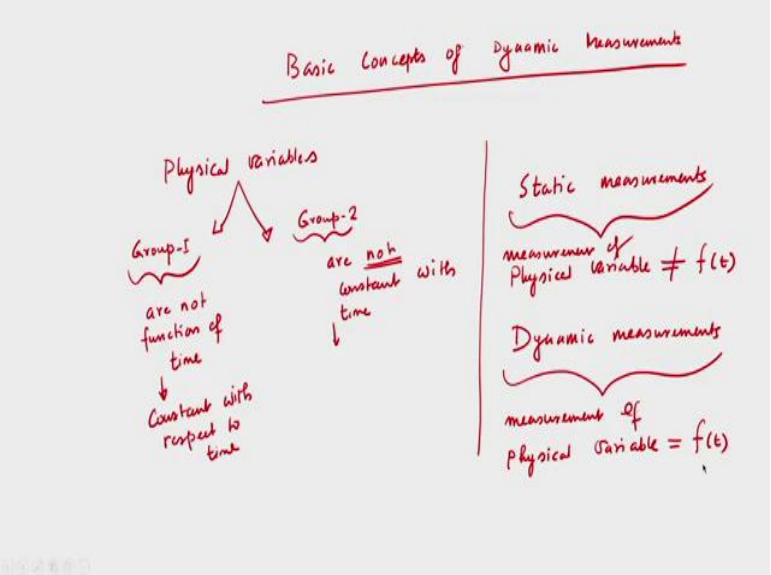

So, now basic concepts of dynamic measurement. So, basic concept of the dynamic measurement. See, many a times we measure data variable, physical variable, but at this juncture we should know that there is a significant difference between measurement of a physical variable, which is not a function of time, rather we may have, rather we may require to measure data, to measure any physical variable, which is constant with time or we may have to measure physical variables which is not constant with time.

And there is a significant difference between these two, between data which is a function of, which is function of time and which is not a function of time. So, these measurements based on the fact that whether they are function of time or not, these measurements can be classified into two categories, one is known as static measurement, other is known as dynamic measurements.

So, basically I may, I can write that just physical variables, physical variables, these physical variables, say group 1 and group 2, in group two or this is group 1, in group 1, that means all the physical variables belonging to group 1 are not function of time, rather constant with respect to time. On the other hand, group 2 variables, physical variables,

which are categorized in group 2, which are not constant with time, are not constant with time, rather they are function of time.

So, because of this whether they are function of time or not, there is significant difference and the variables which are not function of time, we can have their static measurement and the variables, the physical variables which are function of time, we need to go for the dynamic measurements. So, from there at least we can say that we have static measurements that is nothing but the measurement of physical variables, which are not function of time.

So, I can write physical variables which are not function of time rather measurement. On the other hand, dynamic measurement that means measurement of physical variable, which are function of time, different function of time. So, at least we have understood that the physical variable we are going to measure from any device, any equipment, whether they are function of time or not that we should know first.

Knowing a priori whether the function is, the major variable is a function of time or not, we should go for either static or dynamic measurements. The static measurements are relatively simple and straightforward, but the dynamic measurements are very complicated and not only that to have dynamic measurements we need to invoke many factors.

I mean we need to consider many other additional factors otherwise we cannot do. So, from today's discussion we can conclude that basic, we have identified the modules which are there in basic measurement system, their functionalities, and then we have tried to know the concept of dynamic measurement. We will discuss in detail that how we can measure any variable through dynamic measurements.

But before that at least we have classified these two, I mean static and dynamic measurements, whether they are, that they are either, they are function, they are not function of time for static and function of time for dynamic measurements. And also, we have noted that at least for this, today's, for today's discussion that static measurements are straightforward and simple and dynamic measurements are very complicated and we need to know many other factors; otherwise we cannot measure.

So, with this discussion I stop here today, and we will continue our discussion in the next class. Thank you!