Experimental Methods in Fluid Mechanics
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Lecture 03
Basic Concept of Dynamic Measurements

Good afternoon to you all. So, we will continue our discussion on Experimental Methods in Fluid Mechanics.

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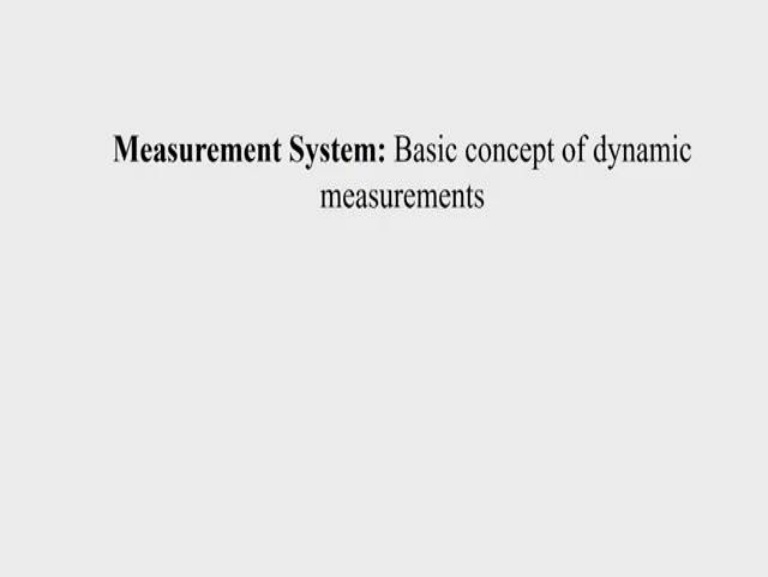

Today, we will discuss about measurement system and while discussing measurement system, we will be focusing on the static and dynamic measurements, and we will discuss; why this static and dynamic measurements are needed to be studied and in which aspects they are different. But before I go to discuss about that, I would like to briefly recapitulate the units, system of units and system of dimension and that is very much important at least to those who will be working in the area of experimental research.

And to do any experimental experiments we need to handle several instruments, several equipments and capture data from those instruments devices, we need to analyze. So, we should have an understanding to analyze those data and for that we need to know how we can have

conversion of energy from one unit to other and what are the basic units we need to know? And to have an understanding on that, I would like briefly recapitulate those aspect.

So, we know those things because we have studied units, dimension, all those things in our school days, but just I would like to recapitulate and I would like to write all the definition of all those terms once again. So, to start with I will write the definition of what do you mean by dimension, then unit, then system of units and system of dimension. I will discuss systematically.

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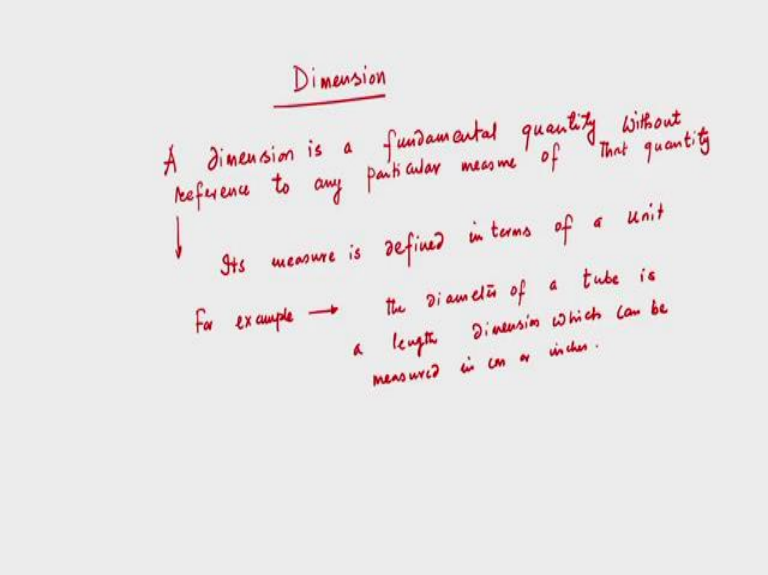

So, first I am writing; what is dimension. So, basically; what is dimension that is very important? I will write the definition. So, definition is, A dimension is a fundamental quantity, a dimension is a fundamental quantity, without reference to any particular measure of that quantity, so without reference to any particular measure of that quantity.

So, this is the definition of the dimension. A dimension is a fundamental quantity without reference to any particular measure of that quantity and its measure is defined in terms of a unit. So, its measure is defined in terms of a unit. So, this is the basic definition of dimension. For example, for example, say the diameter of a tube is a length dimension which can be, which can be measured, which can be measured in centimeter or inches.

So, (diamens) diameter of a tube, so the, its dimension is a length, so a length is a dimension and which can be measured in term either in centimeter or inches. So, what, what do you understand

from this? That dimension is a fundamental quantity without reference to any particular measures of that quantity and its measure is defined in terms of a unit.

So, say diameter, it is a dimension, if you would like to measure this dimension, if I would like to define this dimension, we need to define an unit, in which unit we can measure this, this term, we can measure using length unit either centimeter or inches. Now, we have studied that there are many system of units, SI, you know, FES, CGS, we have studied in our school days.

But despite the widespread international effort to adopt the SI system, because effort is there to adopt SI system and to make the system universe, I mean universally, universal for any measurement. That means despite the effort is there, despite the widespread international effort to adopt the SI system, engineers, scientist, students, who are working in the arena of experimental research, experimental and who are doing experimental investigations; they need to deal with English or other older variants of the matrix system for the foreseeable future.

The reason is very simple. I will discuss, while I will be discussing the unit and other system of dimension in details. So, why it is important? That I have used the word that our effort is to make SI system to be used invariably even then engineers, student, scientist, who are working in the area of experimental research, they need to know English version or even older variants of the matrix system.

Because while they are dealing with experimental equipments, devices then situation may be there, they need to handle our system because that is integrated with the manufacturer. They may not be convert, they may not, those instrument may not be conversed with the SI system, so the data results recorded by those instrument we need to converse in the SI system. So, that means whatever I told, the reason is, inherent danger.

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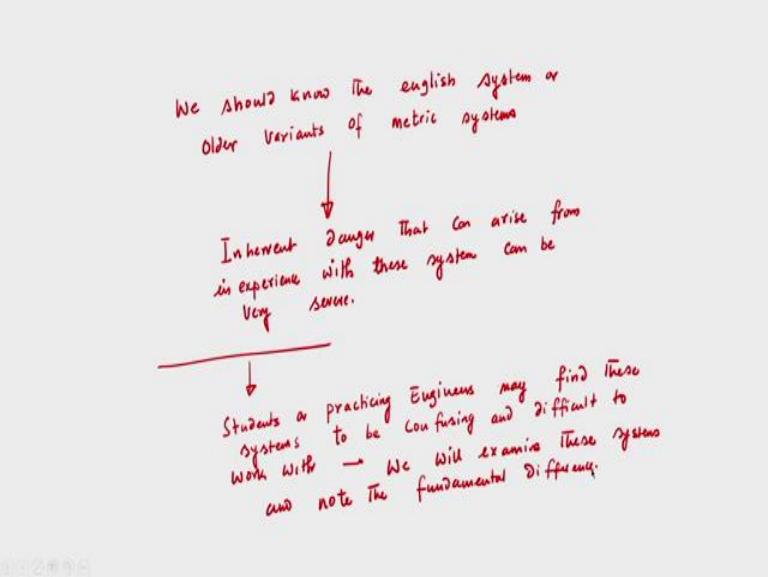

So, I can write basically we should know the English system or older variants of metric system, reason is that is what I would like to tell that inherent dangers; inherent danger that can arise from in experience with this system, with this system, can be very severe. How? So, very important is that, so I will discuss little more on this. May be the student who is doing experiments, he or she may not be familiar with the English system or other older variants of the metric system, but the equipment or the device he or she is using, and the data recorded by that particular instrument or device is providing data in those systems of units, maybe English system or other variants of that.

So, if the student is not having sufficient background of conversion of units and conversion of one unit to the other unit, the results he or she is going to plot may not be correct. So, basically, we need to know how we can converse unit from one to other because it is very much important. The equipment, device, instrument, will give that, will give the data in a unit, which is not, which may not be the SI unit or which may not be SI unit always.

So, that is why you need to know how we can have conversion of unit from one to other, and obviously to get a more realistic, more accurate, more correct prediction. So, that is what I was telling that student or I mean practicing engineer, who are find the system confusing and difficult

to work with. So, even I am writing, students or practicing engineer may find this system, may or may not, may find this system to be confusing and difficult to work with.

And not only that, because of this confusion, because of this problems, students or (practi) practicing engineer may not be familiar with the other version of unit and the ultimate consequence will be like this that largely error, grossly erroneous results while they are predicting. So, to succumb this, to get rid of this, we should know, we should know systems and note the fundamental difference.

So, basically, I have, I will take this class to discuss on this, so that those who are doing this class and will be working in the area of experimental research, he or she may be aware of these things, may be the equipment or instrument is giving or the equipment or the device is equipped with this kind of system, I mean older version or English system.

But the person who is handling those devices, those systems, those instruments, they should know, they should examine the system, they should check the system and they will eventually converse the data from the unit recorded by that, recorded from that instrument to the conventional, most usable and mostly used SI unit.

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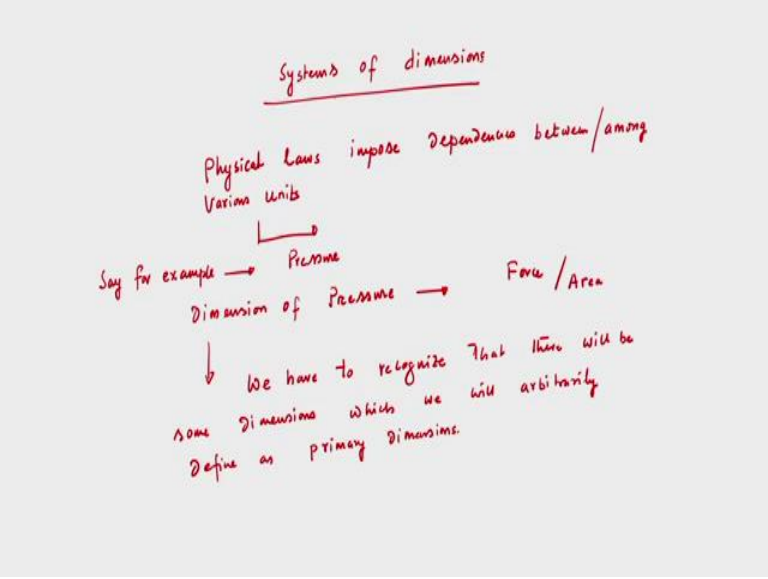

So, now I am coming to the system of dimension. So, system, systems of dimension. So, what are the system of dimensions? What are the systems? We can again recall that we have studied

that rather we have to recognize that the physical laws imposed dependencies between various dimensions, which is not, which is usually not a problem.

See, I can give you a another one example, so what we should know that physical laws impose dependencies between various dimensions, so let us write at that, so we should recognize that physical laws impose dependencies between or among various units, among various units. This is usually not a problem, but say if I, for example, if I taken, take the unit or take the dimension.

Say dimension of a pressure, so if I take a quantity pressure, the dimension of that quantity, so say, for example, if I consider pressure as the quantity and dimension of pressure is essentially force per area, right? That means pressure, if I need to know the unit of pressure, at least you should know the unit of force and also the area, otherwise we cannot do it, we cannot define the unit of pressure.

But there are a few quantities while defining the unit of those quantities physical law, physical laws impose dependencies between other different units and but this may not be the case always. So, this again I am telling, this may not be the case always. So, what we need to understand? So, we need to, we have to recognize, we have to recognize that, we have to recognize that there will be some dimensions which will arbitrarily define as the primary dimension.

Because if I go back to that example, say pressure, so pressure while we are defining the dimension, unit of that pressure is governed by the unit of other two quantities, other two dimensions that is force and area. So, we have to recognize that there will be some dimensions, which will use, which will arbitrarily define as the primary dimension.

So, that means I would like emphasis that why we do need to have, why do we need to have the requirement of the basic or primary dimensions. So, that means I hope we got the clue that we have to recognize that there will be some dimensions, which we will arbitrarily define as primary dimensions. So, the basic requirement of defining primary dimension is like that, because there are a few quantities, if you would like to define those dimensions, we need to know other dependent dimensions and that is governed by the physical laws.

So, basically because of these physical laws, because of their, because of the quantities which are governed by the physical laws, which are dependent on other two, other quantities we need to

define a few primary dimensions and that is what we have recognized. Again I will recapitulate, although we know, although we have learnt from our school days, but still this primary dimensions will be used to define all other dimension that we know.

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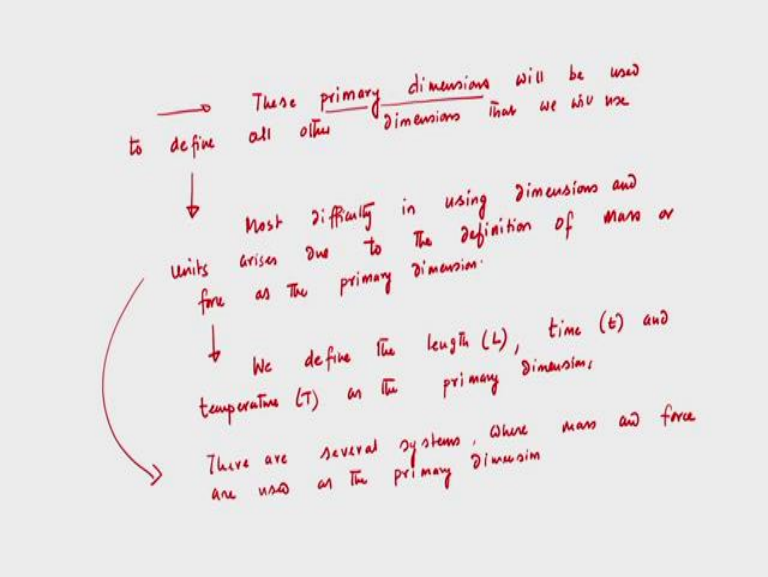

So, that means in the last slide we have understood the requirement, the basic requirement of having primary dimensions. Now, I am telling these primary dimensions will be used to define all other dimensions we will use. So, I am writing these primary dimensions, these primary dimensions will be used to define all other dimensions that we will use.

So, this is very important. Now, question is, there is a issue that most difficulty in using dimensions, units, and units arises due to the definition of either mass or force as the primary dimensions. So, if in this sentence, if I underline the two words, so if I underlined these two words ‘primary dimensions’.

So, that means, now I am telling there will be, there is a issue, rather most difficulties, most difficulty in using dimensions and unit, in unit, dimensions and unit arises due to the definition of mass or force as the primary dimension, so that means as the primary dimension, so that means we need to have primary dimensions, but while we are defining primary dimensions, we should know that if I use other dimensions using mass and force as the primary dimensions there is a issue and will find difficulty.

So, to knowing that we will face difficulties in using mass and force to define other dimensions considering them as the primary dimension, we can define, rather we always define primary dimension like length, time, and temperature. So, next point I am coming that knowing that, what we can do, we define, we define the length L, then time t and temperature T, then time small t and temperature as the primary dimensions.

So, these we use only because of the fact that, if I use and if mass and force comes as the primary dimension to define other dimension, we will face difficulties and we will discuss that in detail, why we face difficulty and because of that we define this length (sma) time small t and temperature capital T as the primary dimensions. So, but this is not the case.

There are many systems, there are different systems rather where mass and force is also used as the primary dimensions. So, while I am writing this, I cannot write that this length, time, and temperature, is always used as the primary dimensions, rather there are, there are several systems where mass and force is used, mass and force are used as the primary dimensions.

So, knowing that difficulty arise, difficulties arise or difficulty arises or difficulty may arise, but there are a few situations, there are a few systems rather several system where mass and forces are used as the primary dimensions. Now, question is, we know that there are different systems.

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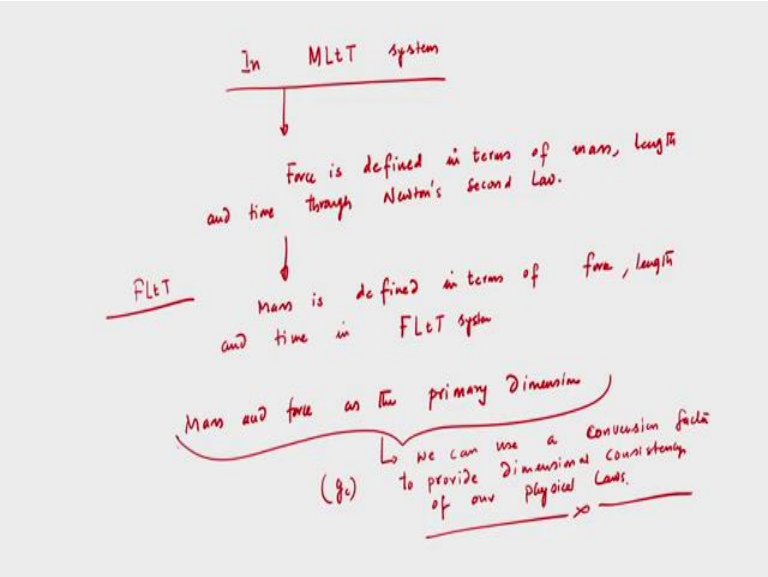

So, if I now focus on the first one that system of dimensions, so in ML small t capital to, capital T system, so in MLt system, small t and capital T, here according to the system, force is defined in terms of mass, length and time through Newton's second law. So, in this system force is defined in terms of mass, length and time, through Newton's second law.

Similarly, because as I said you that mass and force, if we use them as the primary dimension, we may face difficulties, to avoid that we may use force length, that is what I have discussed, force, sorry, length, small t and capital T that is time and temperature as the primary dimensions, but there are several system where mass and force are used as the primary dimension.

And one exam, typical example is that MLtT system that is, in this system force is defined in terms of mass, length, and time, through Newton's second law and force is defined, force is defined in terms and similarly mass, similarly mass, mass is defined, mass is defined in terms of force, length, and time in FLt, force, mass is defined in in terms of force, length, and time in FLtT system.

So, now we have FLtT system. In MLtT system force is defined in terms of mass, length, and time through Newton's second law and we need to know mass, then again mass is defined according to the FLtT system and defined in terms of force, length, and time. So, difficulty in using, basically and sometimes we use mass and force as the primary dimensions and that, and in that case we use a conversion factor and that is we know very well.

So, even if you use mass and force, mass and force as the primary dimension, as the primary dimensions and use a conversion factor to provide dimensional consistency for our physical laws, and so we have seen that if we use mass and force as the primary dimension, we make face difficulties rather there is a issue, because all the dimensions are, there are a few dimensions which are governed by the physical laws.

So, if you use mass and force to define again as the, define as the primary dimensions, then perhaps we need to use a conversion factor, so that the difficulty that may arise in using these systems, because of this, I mean difficulties arise can be removed by introducing a conversion factor, which will provide dimensional consistency.

So, that means if I use mass and force are the primary dimensions, then we can, then we can use a conversion factor gc to provide dimensional consistency, dimensional consistency of our physical laws. So, this is very important, we may use mass and force as the primary dimension, but for that case if you would like to have conversion from one unit to other unit, then we have to use a conversion factor, which will essentially provide a dimensional consistency of our physical laws.

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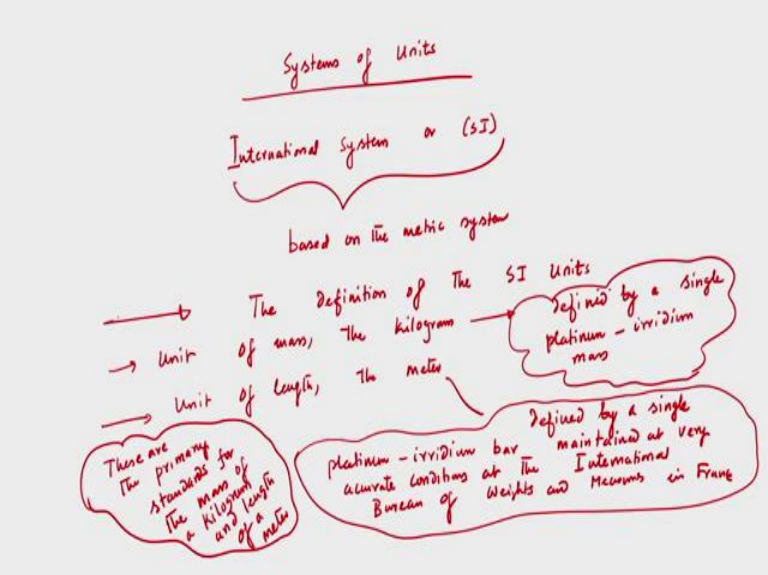

Now, we can go to the system of units. So, now we will go to systems of unit, system of units. So, again I am telling, this is just a recapitulations, recapitulation of what we have understood from our school days, and this is the basic requirement and we should know at least those who are working in the area of experimental research, we should know these basic things and keeping that in mind I am just trying to recapitulate all those things.

So, what is system of units, and what do we know? See, system of units that until quite recently, the system of units that used for the measurement, of course, experimental measurements are very confusing, and of course, non-standard. Say, a gram, for example, would be different depending upon where you are, it is a nightmare for commerce and science.

Through International Cooperation, we have standardized this quantities to a few system that are used throughout the world and we have quickly adapted ourselves to a single system which will

give, which are used in the world. So, basically to remove any confusion, to remove controversy of having different units, different dimensions, all those things, through the (copera) International Cooperation, we have standardized these quantities to a few systems and that are used widely.

So, basically that is SI based or SI based on metric system. So, International, International system or SI, this is based on the metric system. Now, following that system, that is international system to have a common platform of measuring all the dimensions following the same unit. So, the definition of SI unit of mass.

So, the definition, I am writing again, the definition of the SI units, the mass, sorry, maybe the definition of the, of the SI units of mass that is the kilogram, definition of SI system of length, the meter, definition of the SI units of any other quantities can be expressed in these two, following these two.

So, now, as I said that this is the International unit, so and this is used widely, so whenever we are telling the definition of the SI unit of mass the kilogram, definition of the SI units of the length, unit, so units, say units of mass, unit of kilogram, then we have a standard process, standardization by which we can define the definition the SI definition of the unit of mass.

What is that? So, basically this mass is defined by a, just I am writing here for the sake of completeness and for your information, definition of or defined, say this is define, I can write defined by a single platinum iridium mass, by a single platinum iridium mass, so that is basically the SI unit of the mass.

And similarly, the unit of length, SI unit of the length, the meter and it is also defined by a single platinum iridium bar maintained at a very accurate condition of the International Bureau. This is very important, defined by a single platinum iridium bar maintained at very accurate conditions at the International Bureau of Weights and Measures in France.

So, this is again important to know, this is just, I am discussing in this context like, what do you mean by Calvin, just like in the context of thermodynamics we have studied that the existence of temperature scale following the second law of thermodynamics that their existed temperature scale, which is not dependent of any working substance, which is.

So, we need to define a temperature scale, which should not depend on the working substance, which should not depend upon the modes of operation, so that was again defined by the International Conference of Weights and Measures. Similar to that, to standardize this, to have a universal unit.

I mean, basically to avoid the complexity, to avoid the confusion, to avoid the controversy, this international system is defined through the International Cooperation and unlike the (inter), that if I define mass following this system, if I define force following this system, there we need to have conversion, but this unit of length following this SI unit is defined by a single platinum iridium bar, which is maintained at a very accurate condition at the International Bureau of Weights and Measures in France.

So, these are the primary standards for the mass of a, so these are the primary standards for the mass of a kilogram and the length of a meter. So, basically I am writing, these are the primary standard, primary standards for the mass of a kilogram, mass of a kilogram and length of a meter that is what we should keep in mind. So, these are the primary standards for the mass of a kilogram and length of a meter.

And see similar definition for standard unit have been defined for all primary unit, so all other primary units are defined following the similar definitions. So, the common feature of a primary standard are that, they are exceedingly accurate and precise. So, the common feature of this primary units are that, they are exceedingly accurate and precise, and they are not typical useable for most measurements.

Where I would like to discuss little more on it, but today time is up, so I will continue this discussion in the next class for some time, then I will discuss, I will go to the next topic. So, what we understood today? We have just tried to recapitulate our understanding on units and dimensions.

We have understood what is dimension and then we have discuss about systems of dimension, then have moved to the unit and we have slowly came to the case, why international system is required and following this international system, if we use, how can we define primary

dimensions. So, with this I stop my discussion today, and we will continue our discussion in the next class. Thank you very much.