Computer Graphics
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Lecture 32
Concluding Remarks

Hello and welcome to the last lecture in the course Computer Graphics. So we have reached the end of the course. Let us reflect on what we have learnt so far and how to use the knowledge.

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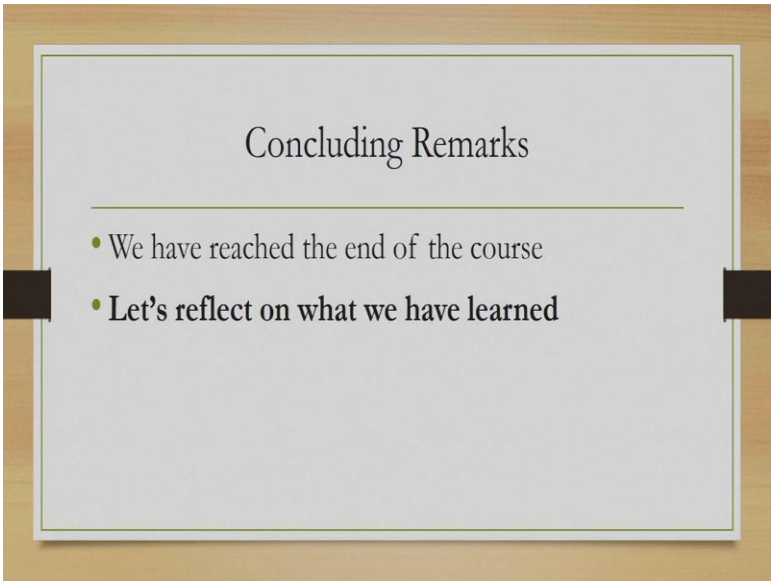

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So, we started with some objectives. What are the objectives?

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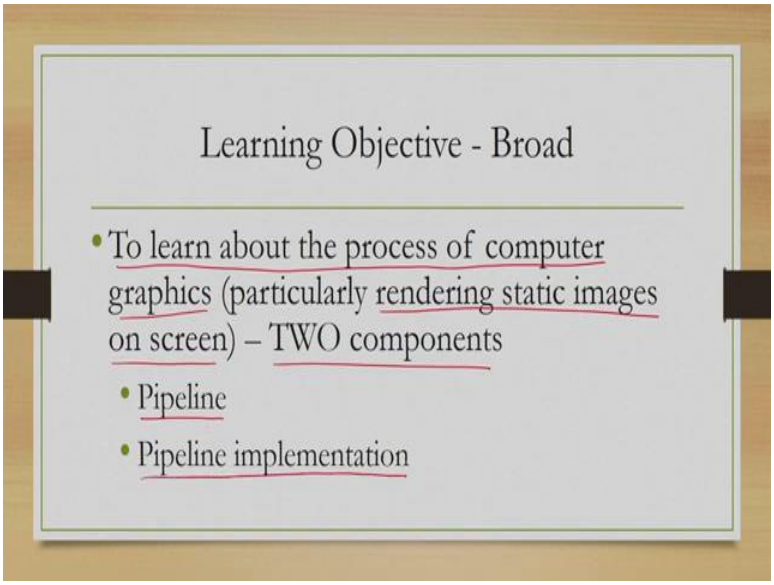

Our broad objective was to learn about the process of computer graphics. In particular, rendering of static images on a screen. Now it has broadly two components, one is the idea of the pipeline and the other one is the implementation of the pipeline. So essentially what we tried to learn is that how an image is displayed on the screen, starting from object definition to final image synthesis and display.

And it has two components. First one is, how to create the image or synthesize the image. As we have discussed that is done through the 3D pipeline and secondly how the image is actually physically rendered on the screen, that is done with the hardware and software support together which is part of the implementation of the pipeline.

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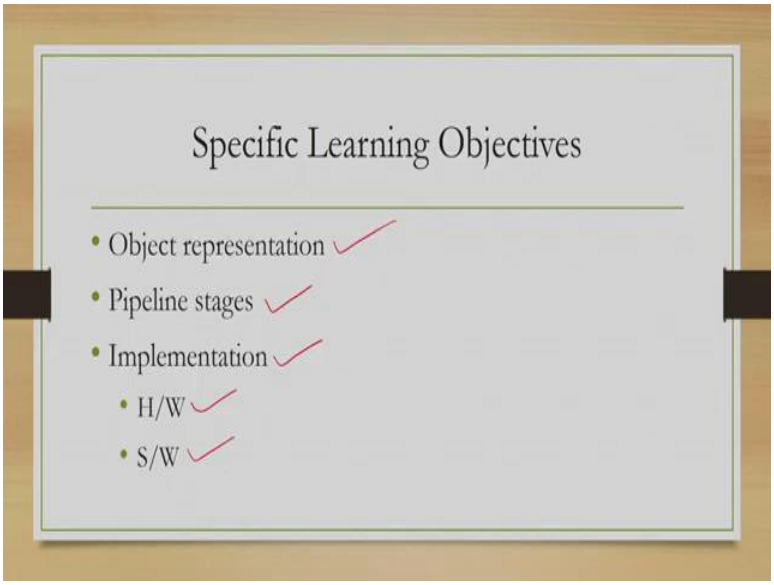

Now that was the broad objective.

In order to achieve that broader objective we divided our learning objectives into smaller specific objectives. There are broadly these 3 specific objectives, learning about object representation which is the very first stage of image synthesis, then the pipeline stages which converts object definitions into a representation on the pixel grid and finally implementation of that representation on the physical screen. There we have the objective of learning about the basic hardware as well as the software.

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Now let us see, how we have learned the Broad Idea and what are the things that we have learned.

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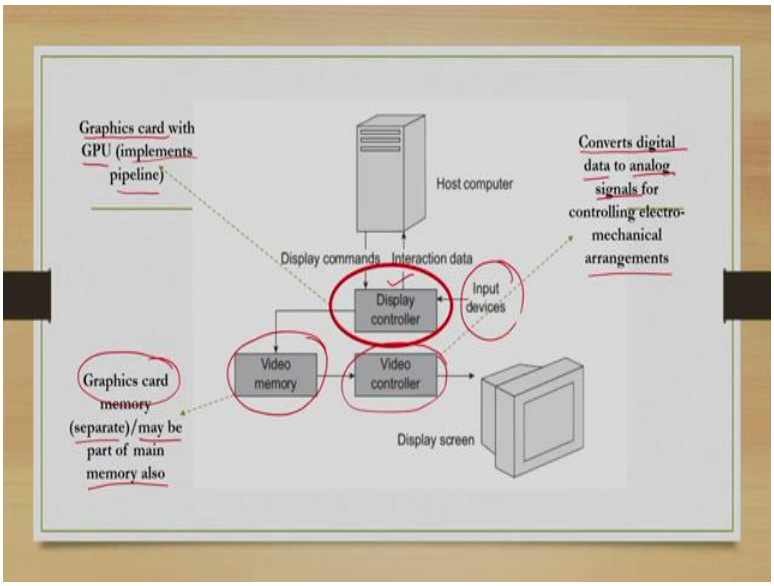

To start with, we learnt about a very generic graphics architecture to understand the image synthesis process. This graphic system architecture consists of 3 major components, one is the

display controller as shown here, then we have video memory and finally we have video controller. And these 3 components are used to synthesize an image. Now display controller is essentially the graphics card with the GPU or the graphics processing unit.

Now this is the component responsible for implementation of the pipeline stages in hardware. Recollect that the idea is to exploit the inherent parallelism in the graphics processing operations and that is achieved with the use of GPU. Video memory is again there in the graphics card, it is the memory component of the card which is separate but it may be part of main memory also, which is typically not the case.

And finally the video controller is used to convert whatever is there in the memory, digital data to analog signals for controlling electrochemical arrangements that are ultimately responsible for exciting the pixels on the screen. Along with that there may be input devices attached to the graphics system which allows the user to change the synthesized image that is the broad idea of the graphic system and the components involved to process the graphics operations.

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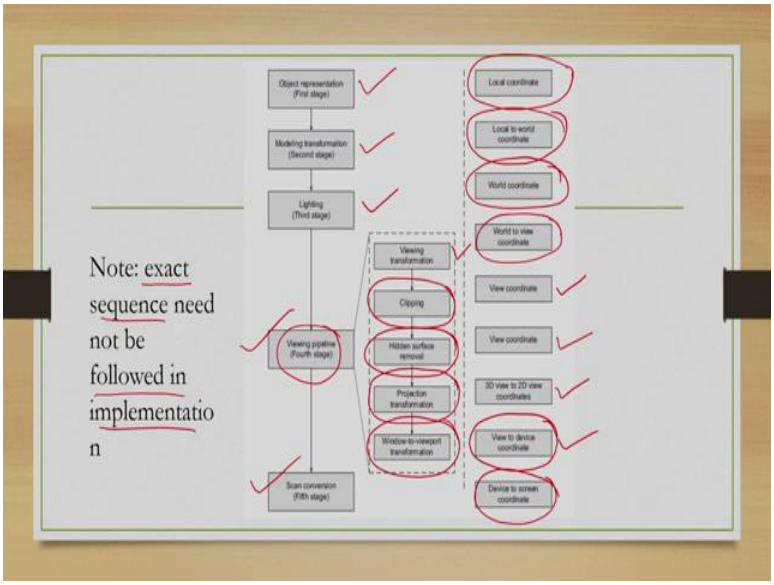

And then we learned about the pipeline that is the conceptual stages involved in converting an image described in the form of component objects to the final synthesized image. We learnt the stages in a particular sequence starting with object representation that is the first stage. Here the

objects are defined in their local coordinate system. Then we have second stage that is modeling transformation. Here a transformation takes place which is responsible for constructing a scene in the world coordinate system by combining together the objects that are there in the local coordinate system.

So essentially here there is a transformation from local to world coordinate. In the third stage we assign color to the objects where we assume that the objects are defined in the world coordinate. In the fourth stage, a series of transformations take place, this fourth stage is called viewing pipeline, again it is a pipeline of sub-stages. There are 5 sub-stages, first sub-stage is viewing transformation. Here we assume that the world coordinate scene is transformed to a view coordinate system, so essentially world to view coordinate transformation takes place here.

Then in this view coordinate system we perform clipping so we define a view volume and whatever objects are outside that volume are clipped out. So this takes place in the view coordinate system. Then whatever is there inside the view volume are further processed to remove hidden surfaces with respect to a particular viewer position, this also takes place in the view coordinate system conceptually.

After that we project the view coordinate scene to a 2D view coordinate system, so from 3D view coordinate system to 2D view coordinate system and this transformation is the projection transformation. Finally from the 2D view coordinate system we transform the image description to a device coordinate system that is the final sub-stage of the fourth stage. After this viewing pipeline stage is over we can convert the resulting image description in the device coordinate system that means from a continuous device coordinate we map it to the discrete pixel grid or the screen coordinate system.

So these are the 5 stages that we have learnt in the pipeline. I would like to emphasize here again that these stages need not be in this exact sequence in which we have learnt. In implementation, this sequence may be different, so exact sequence need not be followed in implementation of the pipeline. The sequence I have used just to explain the concepts rather than explain how they are actually implemented.

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So to achieve this broader learning objective we have covered several topics, let us go through an overview of those topics.

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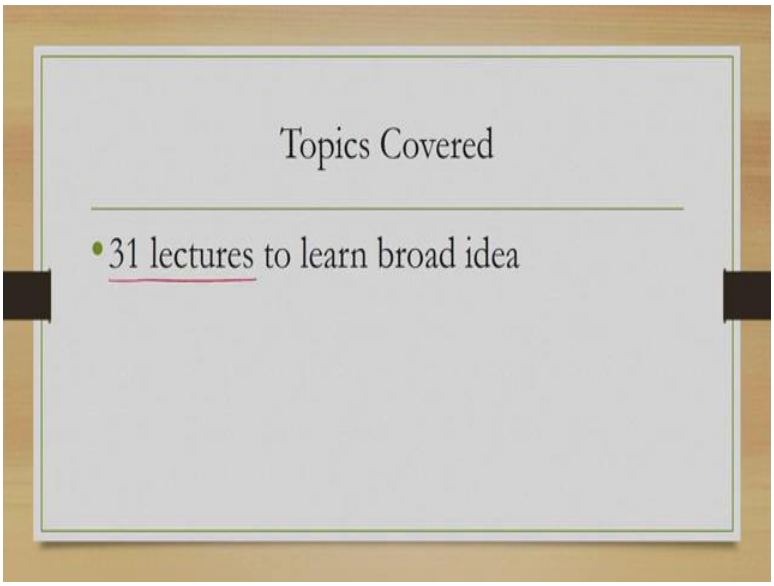

So there are total 31 lectures to learn this broader idea.

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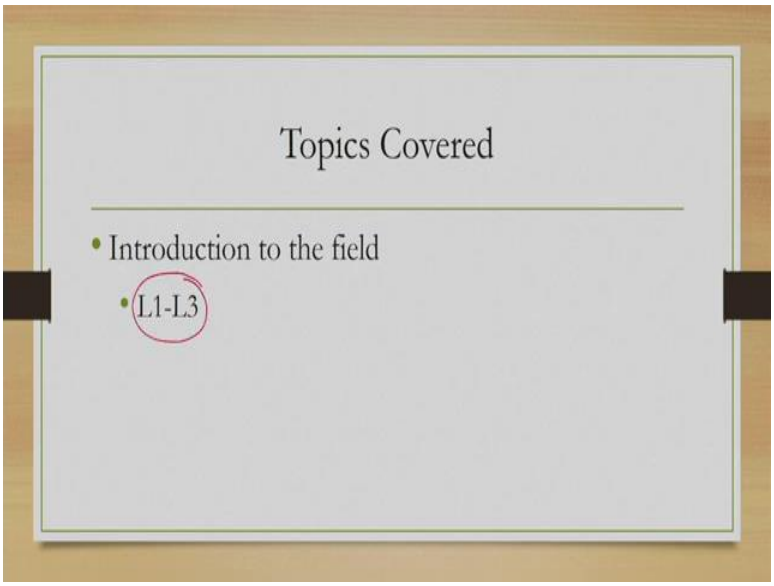

And these lectures were divided into groups. So, first 3 lectures were devoted to introduction to the field.

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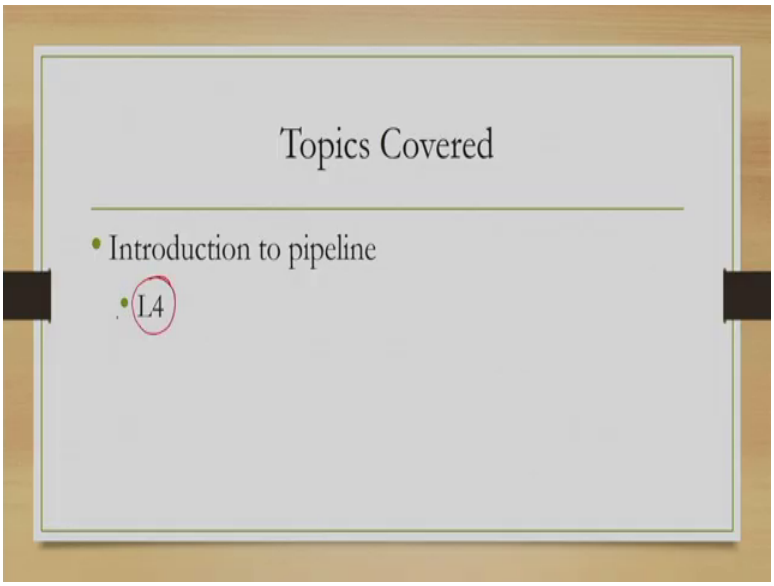

Then introduction to the 3D graphics pipeline was covered in lecture 4.

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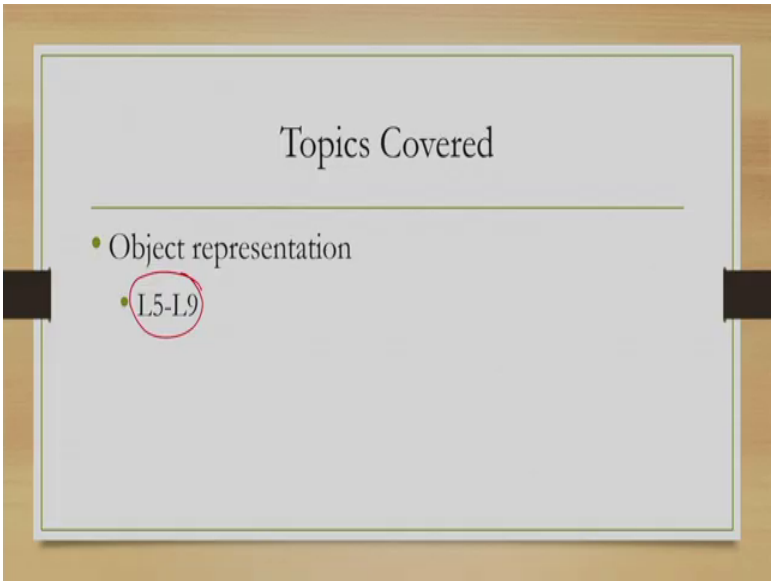

Lecture 5 to 9, were devoted to discussions on object representation techniques, various techniques we covered.

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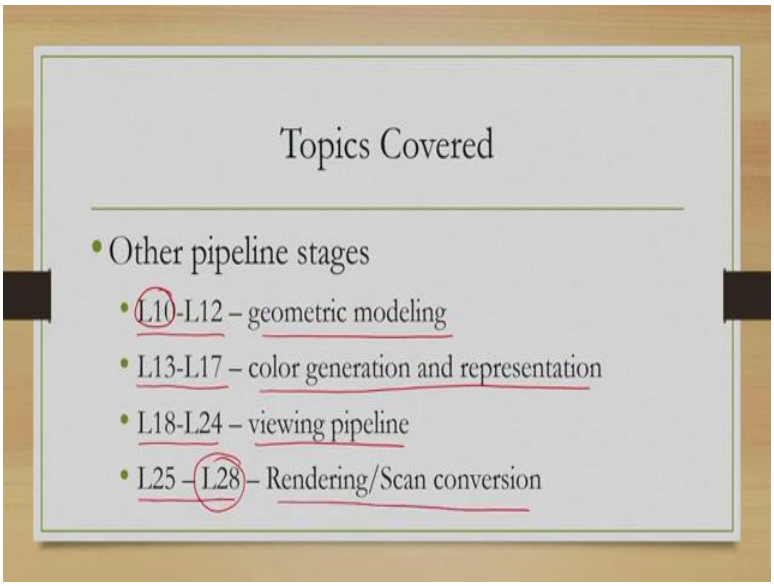

Then the other pipeline stages were covered in lectures 10 to 28. Now lectures 10 to 12 covered geometric modeling, the second stage. Lecture 13 to lecture 17 covered lighting. Lecture 18 to 24 covered viewing pipeline and lecture 25 to 28 covered the final stage that is rendering or scan conversion.

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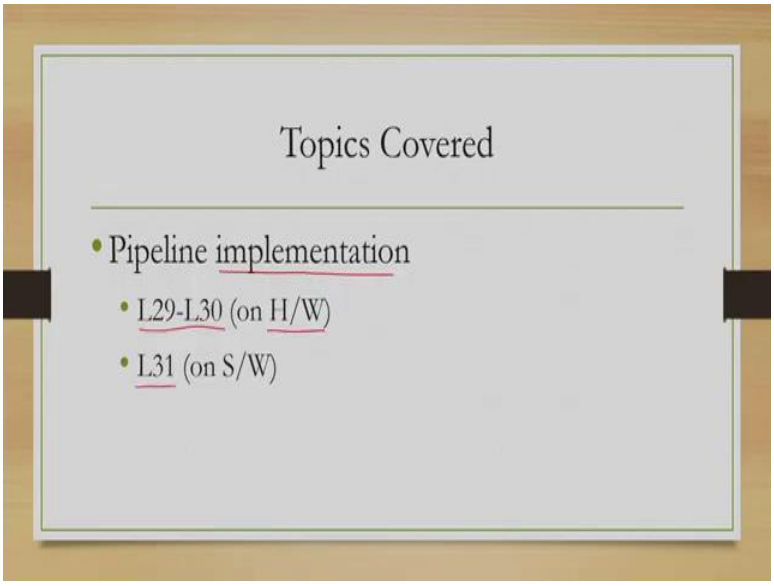

The pipeline implementation, how the pipeline is implemented in hardware as well as using software were covered in the remaining lectures. The two lectures 29 and 30 were devoted on the explanation of graphics hardware and the final lecture, lecture 31 was used to discuss software, graphics software.

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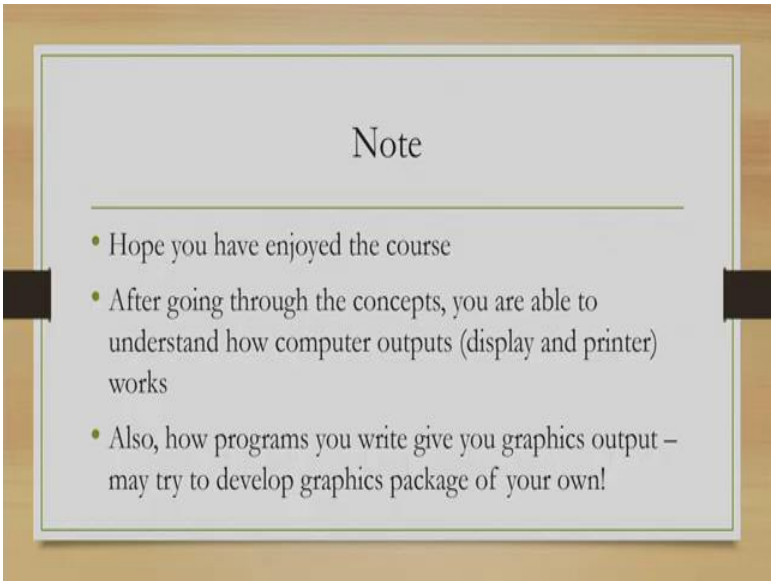

So I hope that you have enjoyed the course the lectures and you have learned the concepts. So with this learning I hope that you will be able to understand how graphic systems work. How your program can create an image on the screen of your computer and may be with this knowledge you can even think of developing a library of your own, a general purpose graphics library which others can use to create their own programs. Also you can think of developing special graphics applications using these library functions like the one we discussed earlier painting packages or CAD packages and so on.

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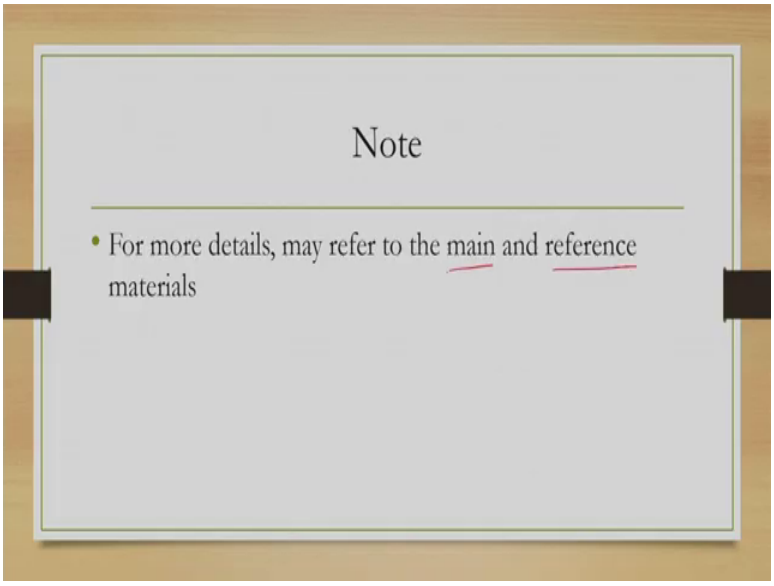

So I hope that you have learned all these concepts, the lectures were interesting and understandable. Ofcourse in the lectures I could not cover everything so for more details you may always refer to the main learning material as well as the reference learning materials that I have mentioned throughout the lecture. That is all. Wish you all the best, thank you.

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