Basic Electrical Technology
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Lecture - 01 & 02
Introduction

Hello everybody, today we are beginning a course on Basic Electrical Technology. This will be roughly about 40 hours. Today I will give you the introduction to this series of lectures which we will follow. We will not have any technical lecture session today. Today we will just be introducing the course and the topics and it is divided into two major parts. The first part of today's session is the motivation; why do you need this course and the second part is the course content meaning what is to follow, what are the lectures to follow for the rest of this course. So I will be using the power point presentation to introduce you to the course that is the basic of electrical technology. First let us deal with the motivation; why do you need the course.

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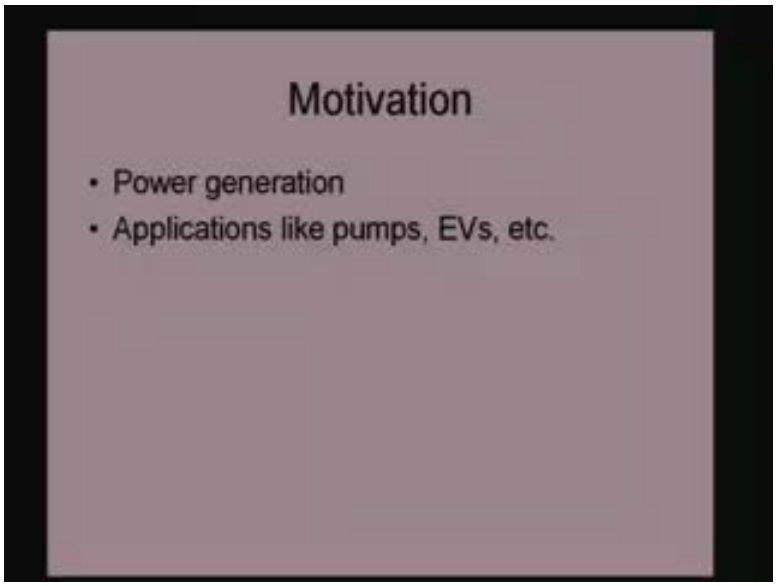

There are two points there in the motivation: one is power generation and the other one is the load, the applications like pumps, the electric vehicles etc. See, most of the applications require electrical power and traditionally the electrical power is generated from the fossil fuels. Coal is

used for generating major power major amount of power in the country something like 70 to 75 percent of the energy is by the fossil fuels, the coal thermal plants.

However, for the motivation let me deviate in this introductory session and not deal with the traditional examples of the coal thermal power plants for the power generation, let us take examples of the renewable energy system because today the clean energy, clean environment and renewable non-conventional energies is a simple theme towards good living. So let us take some examples on the renewable energy methods of power generation generating electricity and some applications.

And applications also let me try to sensitise you on the renewable systems; hybrid electric vehicles or the electric vehicles and similar such systems. Of course there are whole lot of applications that one can look at which are there in the literature. But just to give some sensitisation also to what is current which is the clean energy issues we will look at some renewable energy systems and how it will fit into our basic electrical technology course theme.

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One of the methods of generating electrical power course is the hydroelectric power. There are many methods. As I said, traditionally coal has been used fossil fuels used for generating the electrical power, thermal to the electrical and then hydro to the electrical you have the photovoltaics to the electrical, you have the wind turbines to the electrical, you have the bio-mass methods of generation, microhydel and so on and so forth.

Now if you see in the electrical method of generation from the hydroelectric power you will have a four bay tank, a reservoir which is going to store up some kind of water and there is a pen stock which will lead the water to a turbine and this turbine is connected to electric generator it will generate electricity and then pumps it to the grid the local grid.

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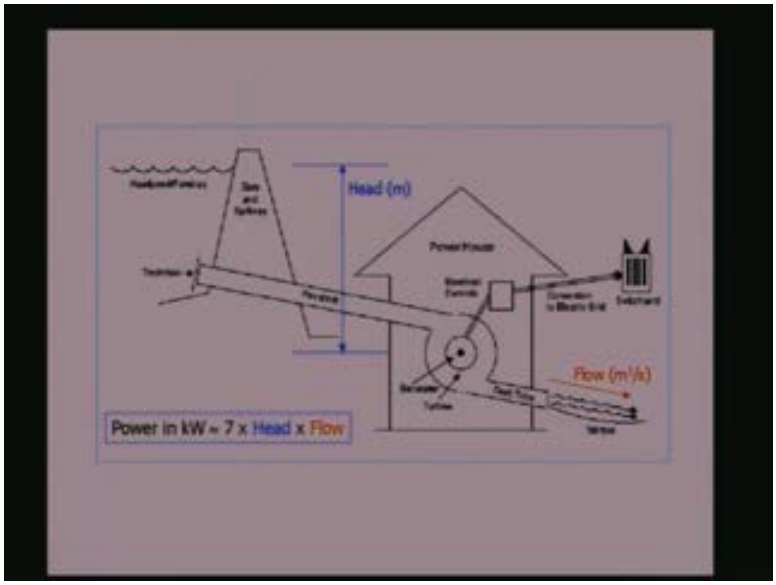

Roughly you will see the power in kilowatts is the order of 7 into the head into the flow of water in metre cube per second. This would be the general scheme of an hydroelectric power generating system where do we fit in. In the Basic Electrical Technology we will mostly be thinking about divisors and systems in this domain that is in the electrical domain. From the prime over which is giving power it goes into the electrical domain in the generators and then again putting it to the grid. So the domain which we are interested in this is the electrical domain.

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Wind mill, wind generations; you would have seen lot of wind mills also in our country in Southern part of India there is and also in the Northern parts of the country, Tamil Nadu and the areas of Rajasthan, Gujarat there is a whole lot of areas where wind mill have been active. Wind mills give electric power by virtue of the motion of air. The amount of kinetic energy which is stored in the wind is transferred to the blades which rotate the shaft of a generator which converts it into electrical energy then pumps it to the grid or the loads.

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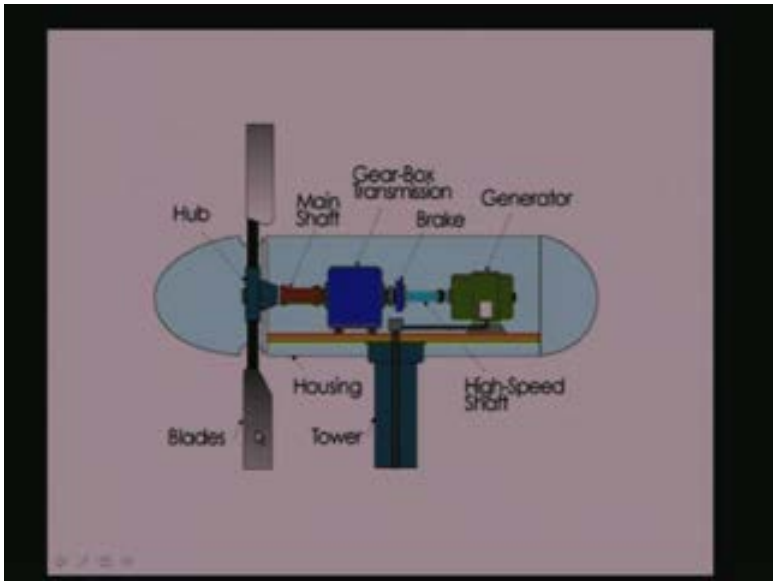

The wind generator looks as something like this. You see here the blades which are actually the ones which is in contact with the kinetic moving air of the kinetic energy that is stored in the air is given to the shaft of the blade that is the blades.

Now these blades are connected to a shaft here, it goes through a gearbox because this shaft will be rotating at different speeds and the generator will have a shaft rotating at different speeds to have the speeds compatible you have a gearbox and the generator which could be an induction motor or a DC generator, induction motor acting as an induction generator or it could be an alternator all these induction machines can be used for converting the mechanical power to the electrical power electrical output.

Again the focus, the issues of interest for us is in the electrical domain which is the scope of this course that is we will be focusing on devices which is the electro-mechanical devices, the DC motors, DC generators, induction motor, induction generators, synchronous motors, alternators and so on and so forth.

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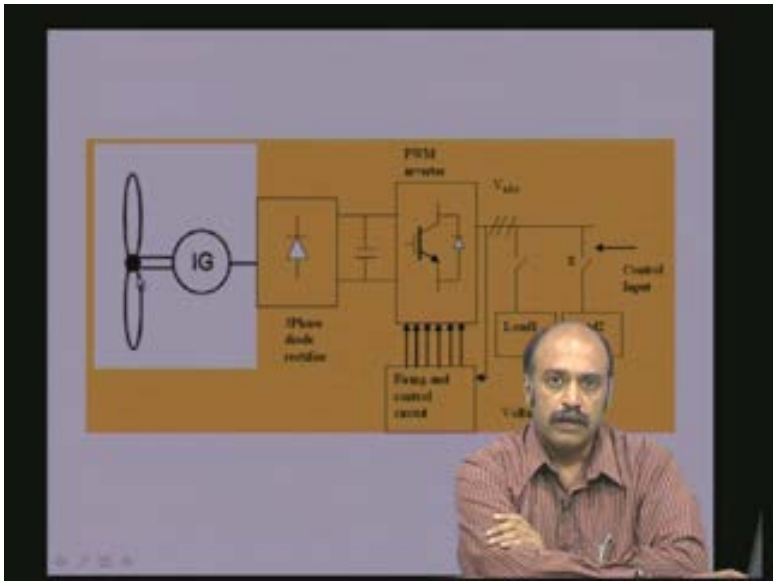

The wind generator gives the mechanical energy to the induction generator or any electrical generator the output of which can be converted, rectified into DC and the DC what you get here can be inverted by means of modulation. These are the modulation signals firing angle (Refer Slide Time: 10:41), these are (I…….10:42) or bridges. So, by pulse width modulation you can get out here three phase or single phase sinusoidal output voltage which can interphase with the load or which can also interface with the mains the grid.

So here again you see there is lot of electronics and electrical items which is the electrical equipment here and the electronic and circuit elements which are coming into focus in the picture in these kinds of applications. These types of things will be the focus of this course which will form a part focus in the course.

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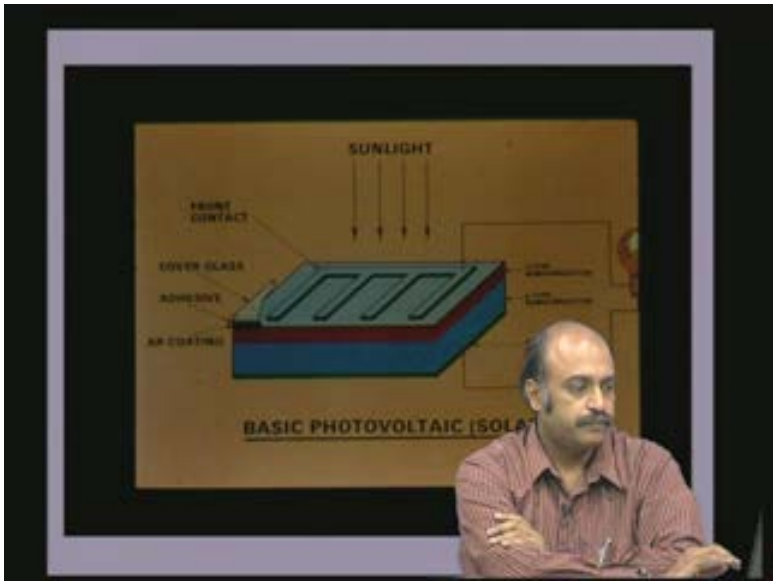

Another means of generation, is the photovoltaic cell, photoelectric effect. You see here in the picture is the photovoltaic cell; it is nothing but a pn junction. You have a P-type material the blue, the N-type material the red, you have the you have the metallisation here, the contact here on the base and what you see here is the glass covering (Refer Slide Time: 12:09) which will actually cover the whole part of the top layout, top cell, top portion of the cell. So when sunlight falls on the cell there will be lot of electrons that gets agitated and go into the conduction band from the valence band and these free electrons will start moving in the external wire and supply the load.

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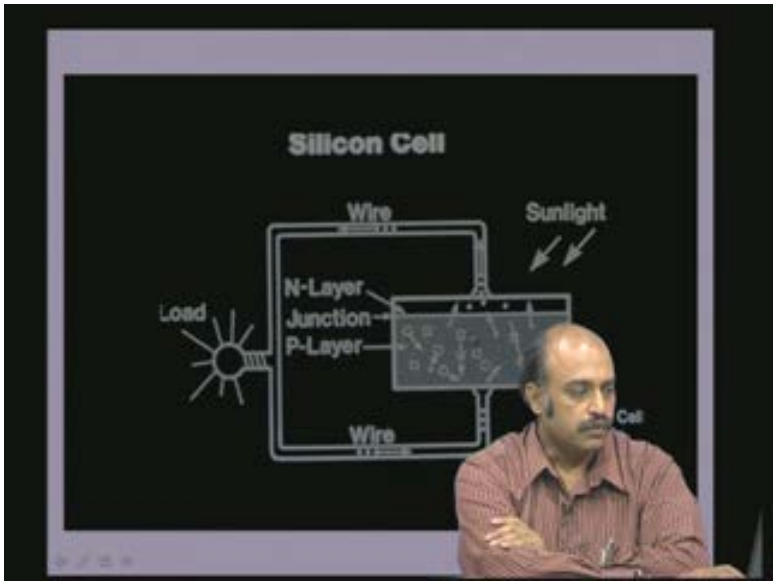

Schematically you will see the lot of free electrons get generated which go into the conduction band because it absorbs the energy from the sunlight and they flow in the external wire to supply the various loads.

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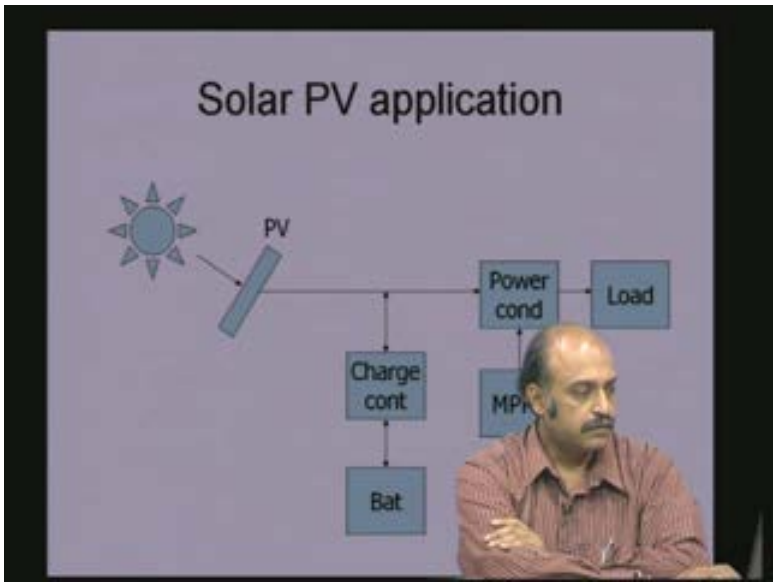

Typically the solar photovoltaic applications are of this blocked schematic nature; you get the input from the sun which is the source and then there is a convertor here, the photovoltaic cell which converts the sun light energy to electrical energy. So once it is in the electrical domain all these aspects all these blocks are of interest to the analytical engineer. You have a charge controller, it will charge up the battery and it goes through the power goes through a power conditioner which will make it compatible to the load, here is a maximum power point tracker which is used for tracking and obtaining the maximum energy from a given photovoltaic cell; all these are part of electronic equipment which are basically formed from integrating the various portions of the circuits. These are of course of importance towards circuits, its analysis, synthesis are of importance towards which will also form a part of the course.

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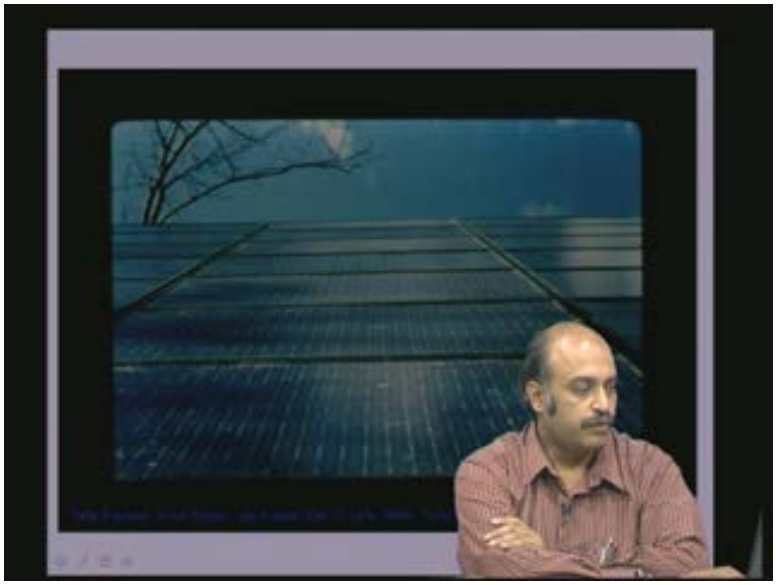

Few examples of the photovoltaic cells; these are how the photovoltaic cells look in the real world; each is a module as you see here mounted on the roof top of the home.

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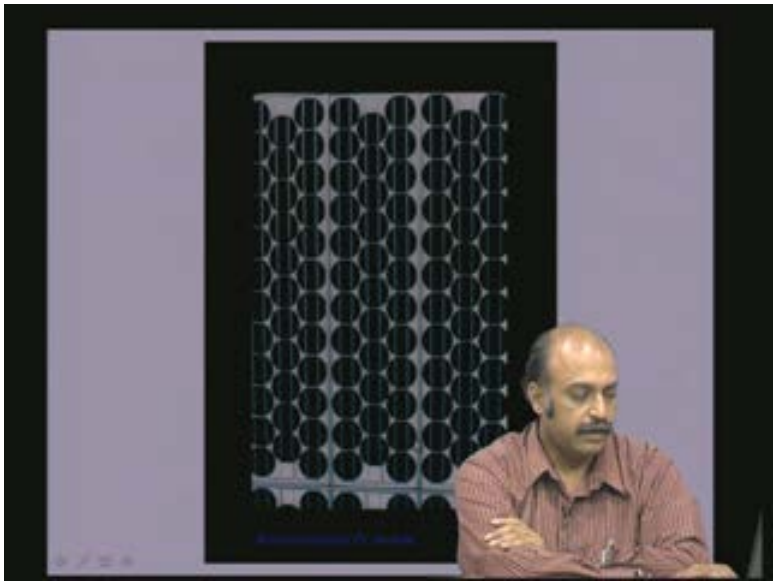

This is also a photovoltaic panel; these are monocrystalline photovoltaic modules available in the market. These modules are available in the wattages of around 36 watt modules or 44 watt modules that are pretty costly today. Of course the costs are coming down. It averages somewhere around 180 rupees per watt.

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These are also some other photovoltaic modules. These are polycrystalline modules. These are 44 watt modules and of course (Refer Slide Time: 15:25) these are mounted on top of our laboratory here to do experimentation.

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Again this is another array to power or to give the electricity requirements for a small community of about fifteen homes.

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The photovoltaic array charges up this battery band and from this battery band it goes through a converter to supply the various loads as I showed or as I have told earlier in the block diagram.

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Another application here you will see this is the solar challenger which is run purely by solar photovoltaic cells. We will see the photovoltaic cells are on top here on the wings. It contains something like 160000 cells at 2.7 kilowatt rating.

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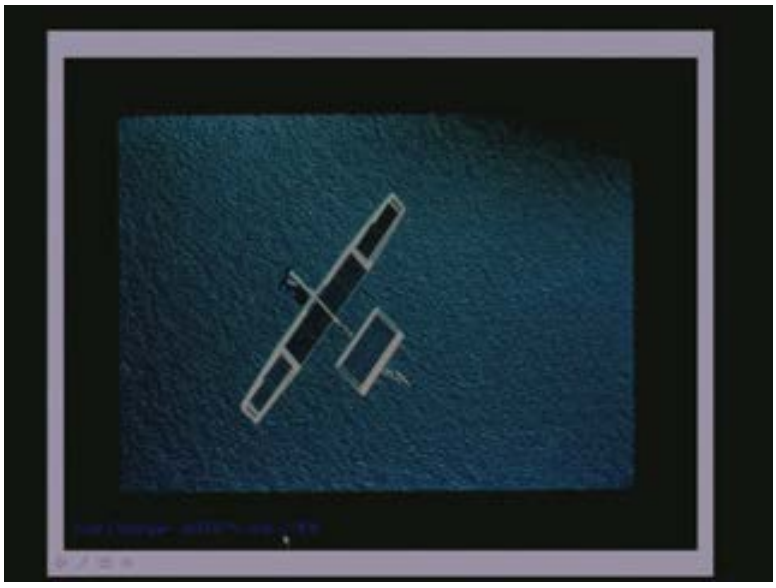

But this is where the photovoltaic cells are on top of the channel.

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Here is another application where solar photovoltaic cells are found used. This is in the middle-east. This building is a desalination plant which takes in the sea water, sea water contains lot of salt and it is desalinated by reverse osmosis process.

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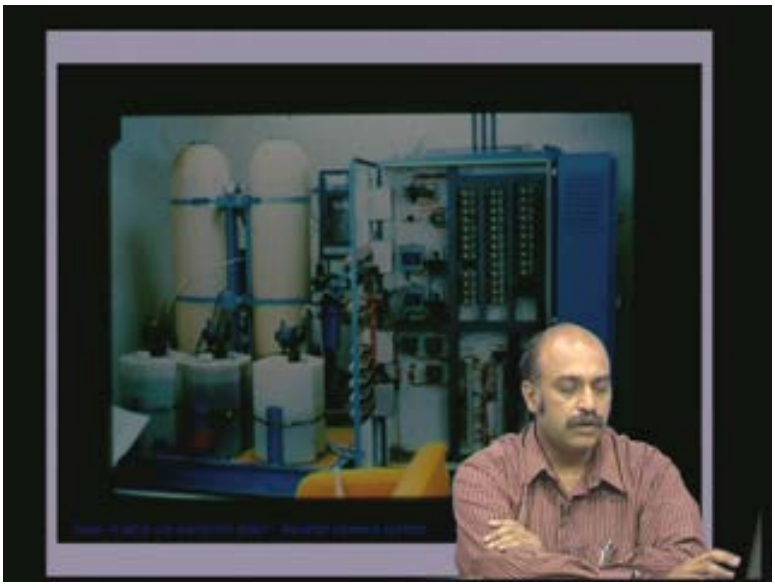

And out of this reverse osmosis process you get two byproducts which is brine and fresh water which can be used for drinking. So the input is the sea water and the output is fresh water in brine.

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Now the output's electric power can be used for applications like powering various home loads or various office loads which are 230 volts. This is an inverter system where the input is photovoltaic just like your UPS system or input of the battery this is something similar with the input as solar photovoltaic cell and the output is 230 volts AC mains.

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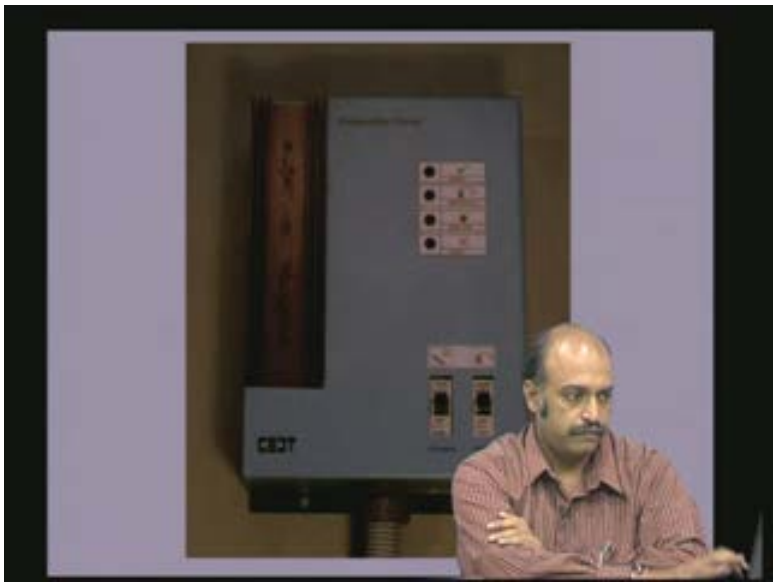

This is another application module you see here the photovoltaic pump which is used for pumping up water from the sump to the overhead tank. The photovoltaic pump finds lot of useful applications and quite competitive also with respect to the regular pumps.

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This is another useful application a standalone solar power pack where input is the solar PV and output is 230 volts which can be used to drive any home loads.

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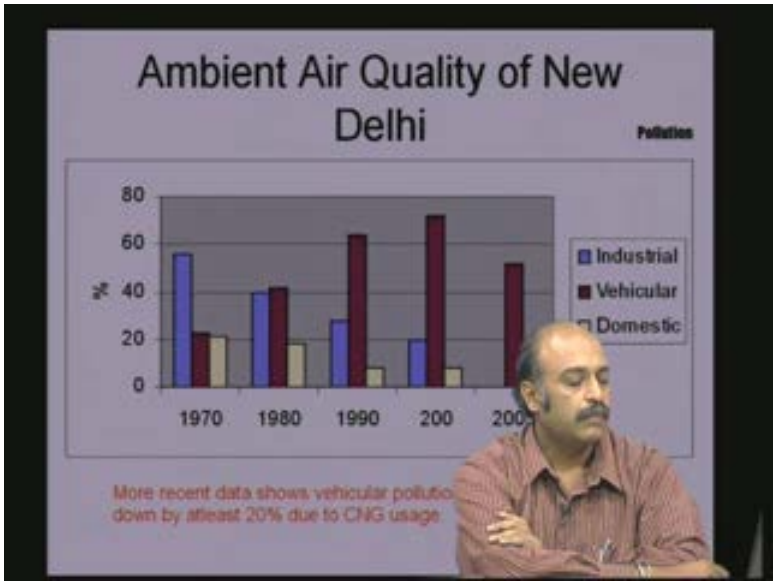

We are discussing the motivation of course; why this course, you see that lot of these products involve circuits which need to be analysed which need to be synthesized, which needs to be designed, implemented were all the focus or part of this course which need to be addressed.

Another issue that needs to be addressed application-wise you see; as I said there are two parts in the motivation: one is power generation; the other portion is the load itself that is application.

The environment is a serious issue today. See, lot of pollution, you will see that way back in 1970s there were equal pollution was somewhere here (Refer Slide Time: 19:24) and today in the 2000s the vehicular pollution is actually increased and is the main contributor to the air quality. As a typical graph of New Delhi which I have taken from some of the internet webliography there is a drop here; you see, after Delhi introduced the CNG Delhi introduced that CNG should be made compulsory mandatory for public vehicles there has been significant drop in pollution. Then if you look at these applications you see there is a lot of electrical and electronics which get involved just to give you it ties you to the issues of these things and you will see that even here there is lot of scope for analytical engineer to get involved and solve issues.

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You see here the picture of few electrical electric vehicles and hybrid electric vehicles. The Reva, this is the Vikram, you see here the Toyota Prius, the Honda Insight these are hybrid electric vehicles, this is an electric vehicle (Refer Slide Time: 20:50), this is also an electric vehicle, these are also….. this is Vikram and this is Bijli there are all electric vehicles DC motors, these are hybrid electric vehicle etc.

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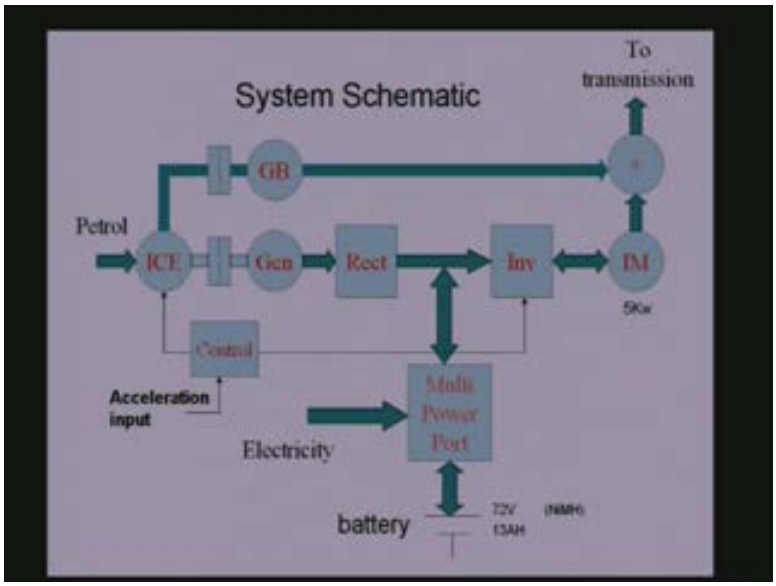

See, if you look at the block diagram you see where all we can contribute and probably learn as engineers learn as electrical engineers. In electric hybrid electric vehicle there are multiple energy inputs. You see petrol is one of the energy inputs, electricity one of the energy inputs, battery another energy input. Now all these energy inputs are ultimately are going through the transmission to the wheels so the petrol is driving let us say an IC engine an internal combustion engine and let us say the output of that is connected to a generator alternator which is rectified, now it is in the electrical domain it is now charging up the battery here (Refer Slide Time: 21:53) or it can go through the inverter, drive an induction motor to the wheels or conventionally traditionally it will drive an IC engine and through a gearbox it goes directly to the wheels. Yeah, that could be the way the general normal automobiles work. This schematic is a more general schematic if you look at.

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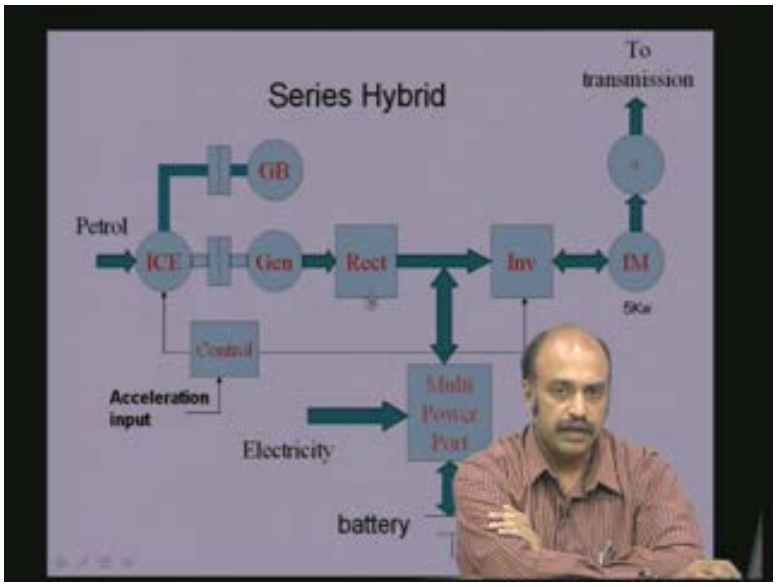

This schematic is called as series hybrid where the internal combustion engine is not directly coupled to the wheels; the internal combustion engine is coupled only to a generator which generates electrical energy and all the electrical energy is used for either charging up the battery or driving the induction motor which is the only thing which is connected to the wheels so it is called as series hybrid.

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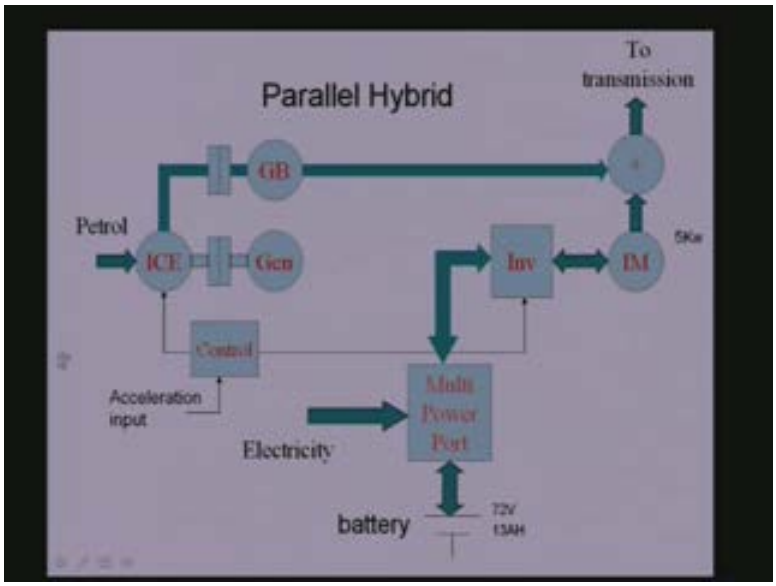

In the case of a parallel hybrid the IC engine that is the internal combustion engine is connected to the wheels like in conventional traditional vehicles. There is the battery where the electrical portion of the source which will drive an inverter an induction motor or it to drive the convertor and the DC motor and then get connected to the wheels. So you see the wheel is driven by two power sources two park sources; two fellows are pushing the vehicle for it is a parallel hybrid vehicle.

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Some of the home applications that you can also think of you see water pumping from sump to the overhead tank, the grinders single phase motors, you have the mixers and mixies at home where you use the universal motors they are also electrical equipment, compressors and the refrigerators they are all electrical equipment; so all these are containing the electrical equipment, electrical components, electromagnetic components which are which you see in everyday life and you need to understand it, you need to be able to analyse it, you need to be able to design that therefore we need to study the basic electrical technology at least the first level and then later on depending on our interest learn the advanced level courses.

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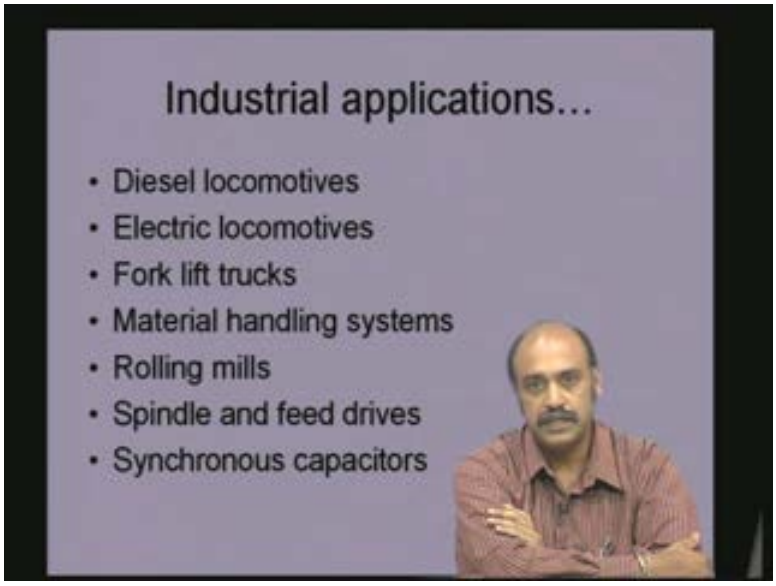

You also have several industrial applications where electrical technology is very useful and probably becomes a must in many of the cases.

Diesel locomotives where the diesel engine is connected to a shaft which will drive an electrical generator like an alternator and the output of which is converted into DC and then again an inverter motor to drive all those things, the electric locomotives, the forklift trucks; you would have seen the forklift trucks which are battery driven DC motors seize motors which generate high torque to lift heavy loads. The material handling systems, rolling mills, spindle and feed drives and lathes and CNC machines, the synchronous capacitors which are nothing but synchronous motors used for power factor improvement and strategies; these are all electrical equipment, devices which you will be seeing in the industrial environment that needs to be understood and studied.

That is about the part on motivation meaning there are lot of applications various application that you will see in everyday life and that too I have given only a concise list; in fact, the list is endless. And also I have been focusing more on the renewable applications as I told you so that we just have something different, you will see that in the textbooks and literature that there are

whole lot of applications which will be reported where the electrical equipment becomes a major part. In fact, in most of the cases it will be the heart of the system which needs to be understood, analysed, designed, synthesised and so on and so forth.

Now, coming to the second part of this lecture session I would like to tell you what you will what the course will hold forth in future; meaning what are the topics that will be covered hour by hour.

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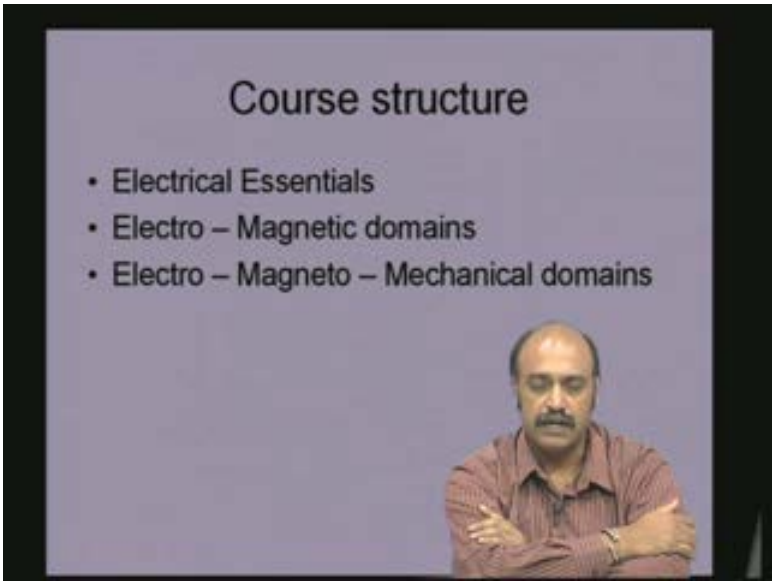

The course is structured into three components. The first part of the course will focus on electrical essentials which are really essential for any electrical engineer to operate on the electrical technology. The second part we will focus on electrical equipment which are the electromagnetic domains mainly transformers. Transformers are electromagnetic devices and therefore they are called the magnetic transformers which transform the electrical energy from one electrical energy domain to another electrical energy domain without contact. They are in fact part and parcel of almost every electrical system and they form the core and they are central to most of the electrical systems. An electrical technology course without a proper understanding

of the transformer is always incomplete. So the second part will focus entirely on the transformers which is the electromagnetic domain.

The third part focuses on the electro-magneto-mechanical domain. What it basically means is the energy flows through the electrical domain, the magnetic domain and the mechanical domain which are the machines. The DC machines the DC generators; and the induction machines induction generators; synchronous machines synchronous generators alternators and so on and so forth. So the machines will have actually all these three domains: the mechanical domain, the electrical domain and the magnetic domain involved and in fact the remaining of the electrical systems will involve these equipment also.

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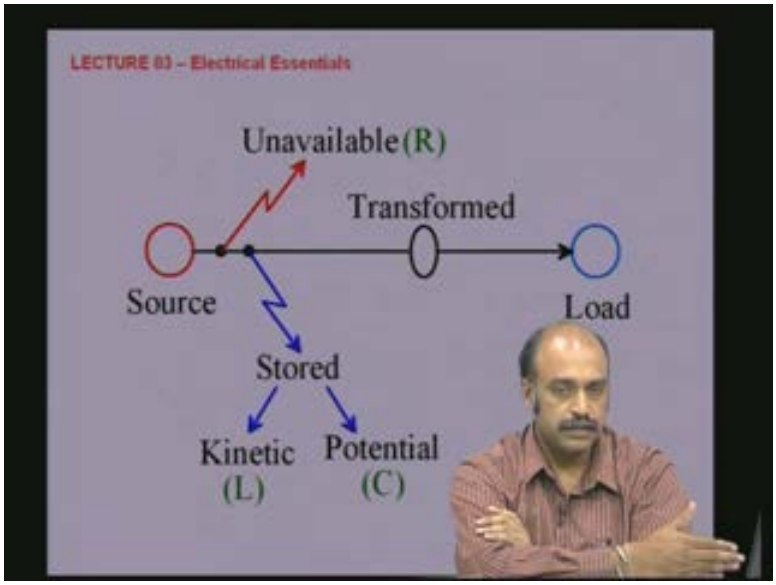

So the lecture 3; I consider this as lecture 2 meaning the first part the motivation as 1, the second part the course contents as 2 and the lecture 3 which will be of course the next hour; all the lectures are 1 hour except for these parts 1 and 2 which does not have that 1 hour constrain. The lecture 3 that is lecture 3 will deal on the topic the core topic of the electrical essential; it of course gives you an insight of what is the source and the load and how does the energy flow from the source to the load.

When energy flows from the source to the load there are few things that happen to it; some portion of it will get stored it will stored as kinetic energy, it will also get stored as potential energy whichever be the domain electrical or mechanical or any other domain and some of the portions will get dissipated in the dissipative components like the resistor and the electrical domain they will go unavailable, there will be some portion of the energy that may get transformed and then go to the load. So these are the things which will…… these are the aspects of the energy flow that will come in to being and in the circuit how does this get analysed will also be focused on.

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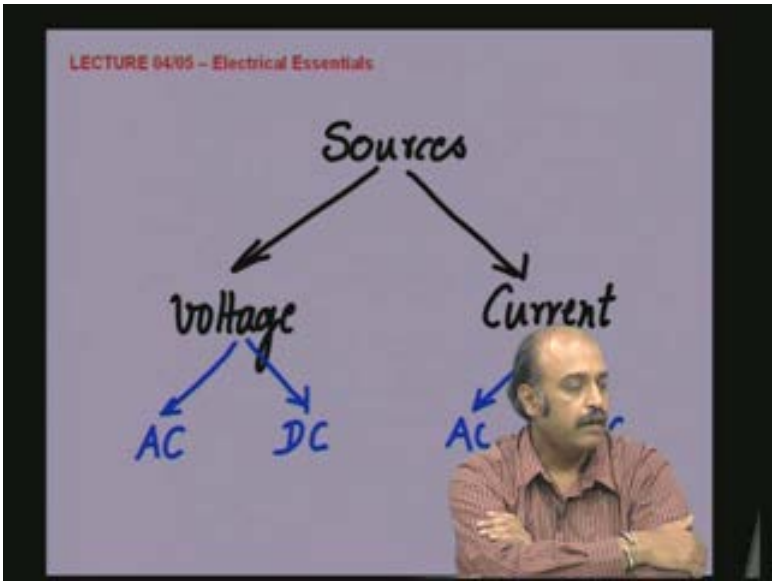

So lecture 4 and 5 again electrical essentials. We are going to discuss on sources. what are the what are voltage sources what are current sources and in voltage and current sources what is the AC source, what is the DC source, what is the characteristic feature of the sources, how do you characterise them these are the topics that need to be covered and that will be covered in lecture 4 and 5.

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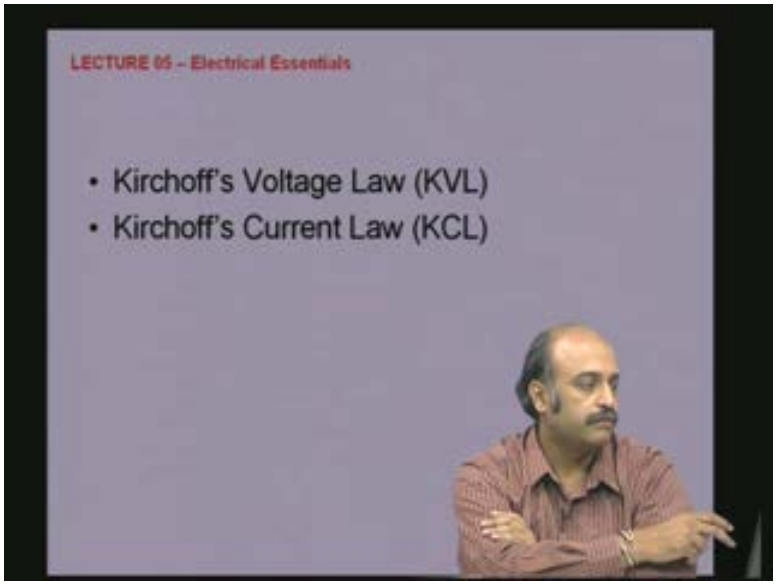

Lecture 5 towards the end of it let us let us discuss two important laws which of course has come to be known as the Kirchhoff's voltage law and the Kirchhoff's current law. These two laws are central to the analysis of electric circuits any electric circuit. So a proper understanding of these two laws is very important and that will be focused in lecture 5.

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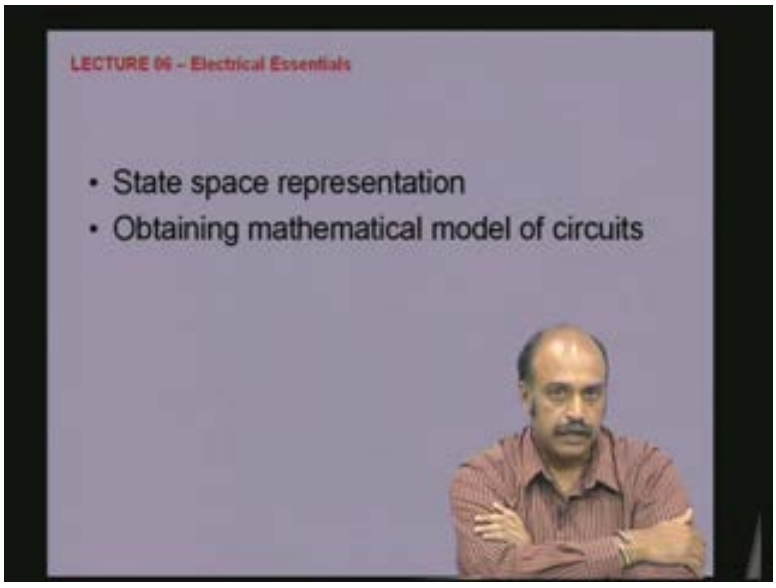

In lecture 6 in the electrical essentials, once you know how to deal with the analysis of the circuit in terms of the Kirchhoff's voltage law and the current law you should be you should know how to represent the electrical equipment electrical circuit in a mathematical form.

What is the mathematical representation of the circuits; how do we how do we go about obtaining the mathematical models?
Here the state space representation gives you the dynamic model of the circuits and equipment. We will spend time in trying to understand the state space representation and how do we go about obtaining the mathematical model for the various circuits; at least the methodology the courses of obtaining the mathematical model.

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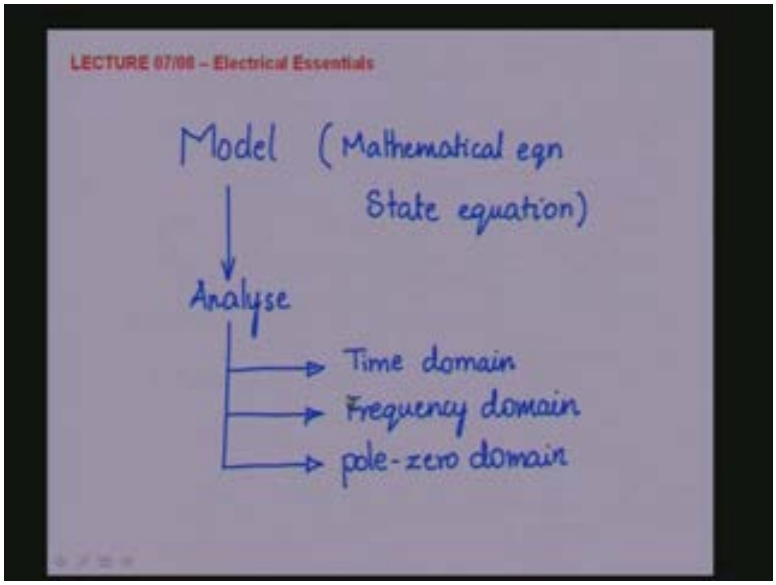

After we are able to obtain the mathematical model we should know what we want to do with it. We should know under what analysis that we want to do it, how do we analyse it. So lectures 7 and 8 of the electrical essentials will focus on analysis of the mathematical model that has been developed in these three domains: in the time domain, in the frequency domain and in the pole-zero domain.

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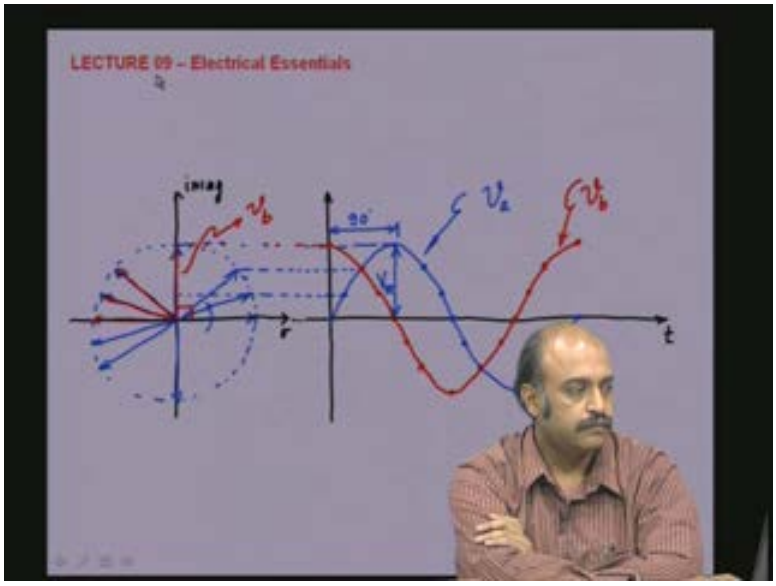

Lecture 9 brings you the concepts of the phasor, the vector, the space-vector, space-phasor because in the analysis of the electrical circuits and especially when sinusoids are used the phasor diagram are used extensively to analyse or represent the circuits pictorially and therefore it is important to understand the concept of the phasor notation and what it means by a space phasor.

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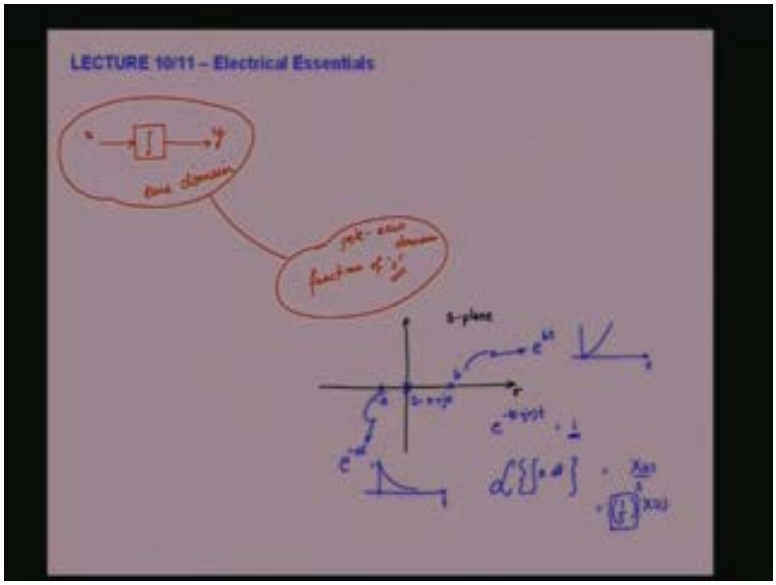

Lecture 10 and 11 of the electrical essentials we are talking of the same system which can be represented in the time domain, which can also be represent in the pole-zero domain and how we move about these domains, what is its significant in the other domains; these are issues that we will deal with.

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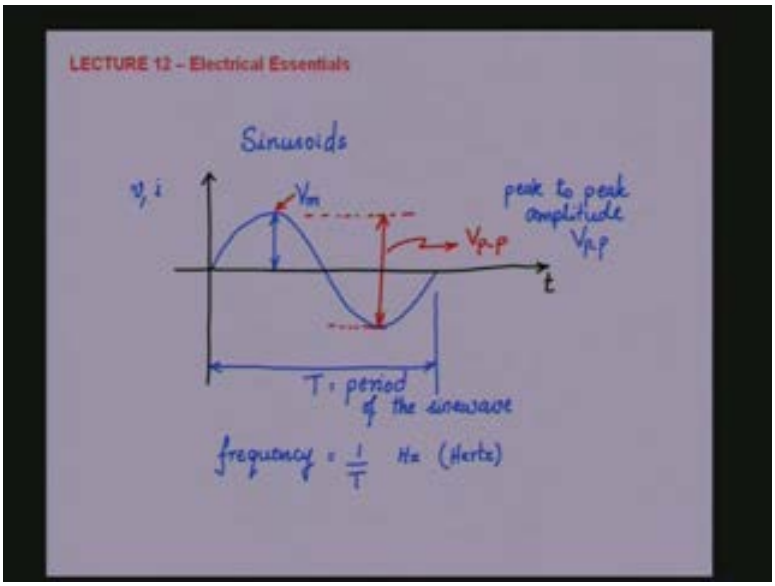

And lecture 12 of the electrical essential describes the sinusoids. The sinusoidal wave shade, the sinusoidal waveform is a kind of a reference waveform for electrical engineers it is used it is kind of ubiquitous in almost all the electrical systems and it will appear as an input as an output, an intermediate waveform almost everywhere and a good understanding of the sinusoidal wave shape the various parameters its definitions, what is peak to peak, what is the RMS, what is an average and all those things should be properly understood and the sinusoid will be defined.

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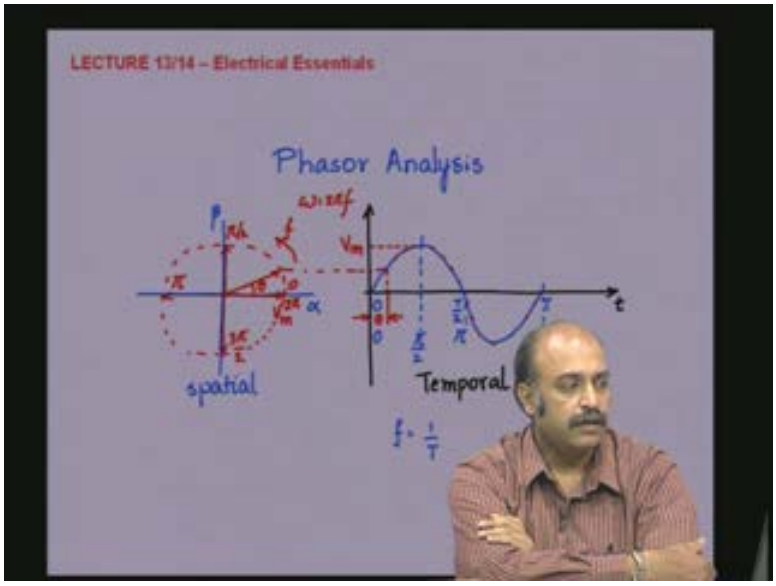

Then lecture 13 and 4 as I said, the electrical circuits and equipment have a graphical representation, also you have a mathematical representation find in the form of equations, you will also have a graphical representation in the form of phasor diagrams. So we will spend some time to understand what is this phasor analysis, how do we go about doing, given a circuit diagram how do we draw the phasor diagram and try to get meaning out of it. So you will have the spatial vectors, the temporal vectors and how do they relate to each other and things like that.

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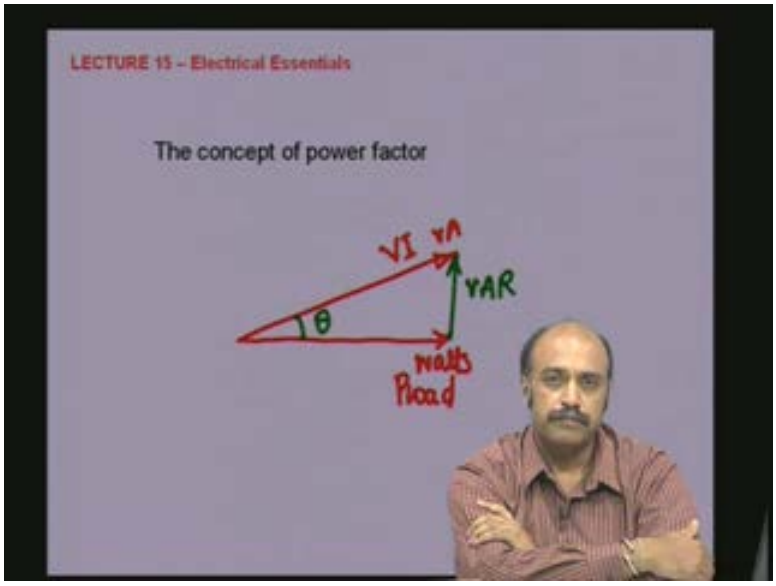

Lecture 15 brings you the important concept of power factor. Power when we draw from the source has two components: the reactive power and the active power. The active power is the one which actually goes to the load, the reactive power goes to setup the storage mechanisms as I said the energy flows from the source to the destination, you will see that energy gets store in a kinetic or in electrical in the potential form in between before it reaches the load so to setup the kinetic and the potential energy those that are not dissipated you will see that the power that is drawn from the source will have a reactive part which will basically be given back but it has to be drawn and the active part which is consumed and goes off to the load. So what is the concept to the power factor this will be discussed. What is VA, what is VAR and what is the watts.

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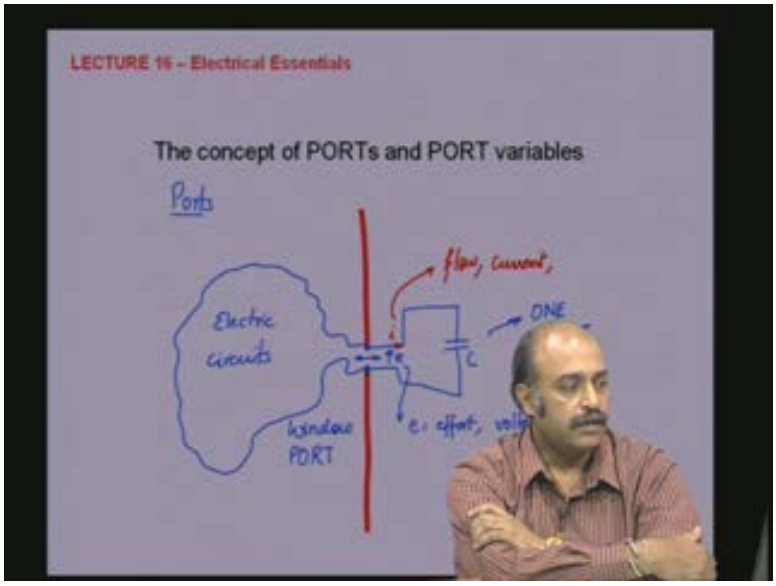

And lecture 16 of the electrical essentials introduces to you the concept of ports the energy ports because you will be transiting from one domain one energy domain to another energy domain like electrical domain to the magnetic domain electrical domain to the magnetic domain to the mechanical domain. So when one transits from one domain to another it is by means of ports and we define what is a port in any domain. It is basically the flow of energy, flow of power at that particular port of a window. So this will be defined and explained so that this concept will be used for explaining various other devices.

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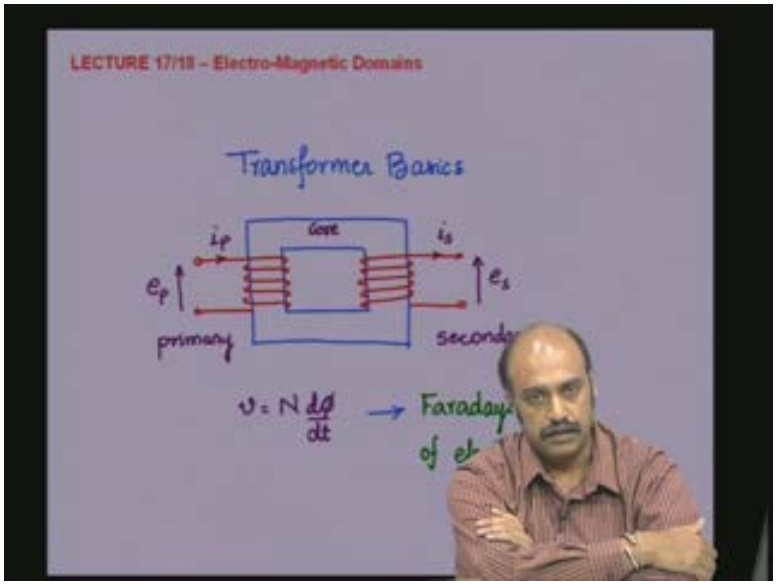

Lecture 17, 18 now enters the part II of our course pattern course lecture pattern which is electro-magnetic domain. First was electrical essentials that is over by chapter that is over by lecture 16. Lecture 17 starts with the electro-magnetic domain, transformer, transformer basics, what are the essentials that is Faraday's laws of electro-magnetism what is it, how is the operation of the transformer so all those things will be discussed.

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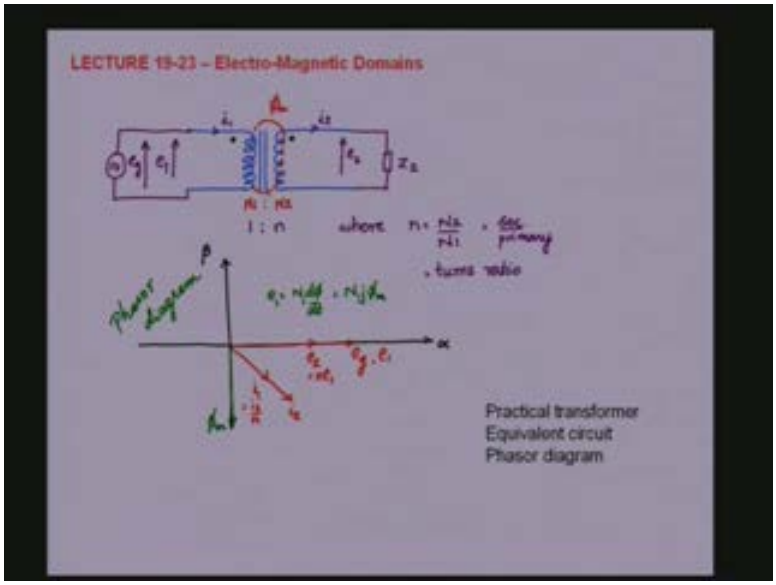

And then the equivalent and then the representation of the transformer in the electrical domain as circuit form, what is the phasor diagram all those things will be discussed in lectures 19 to 23. What is a practical transformer, what is an ideal transformer, what is the equivalent circuit of an ideal transformer and the practical transformer what are the differences and the various phasor diagrams will be the topic of focus in these lectures of 19 to 23 which is the electro-magnetic domain.

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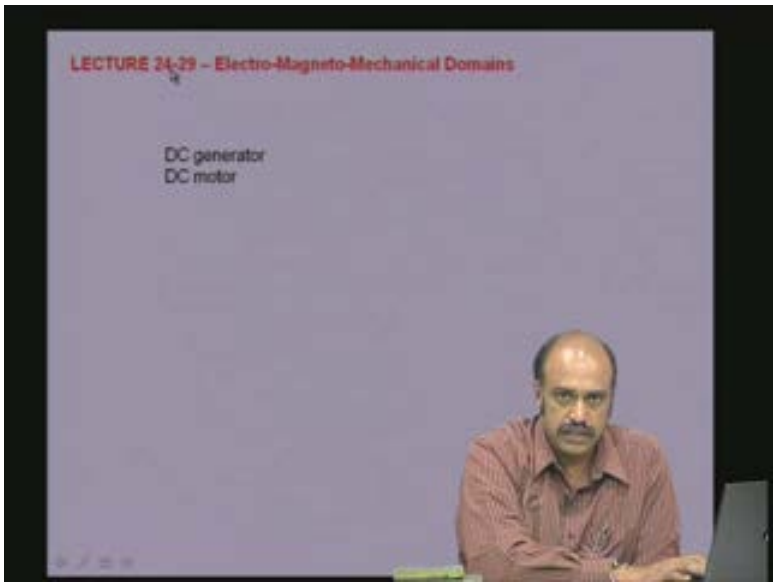

Lectures 24 to 29 that is 24 25 26 27 28 29 you have the electro-magneto-mechanical domain. You see we are now entering the third part of the course pattern which is the machines. So here that is 24 to 29 we shall discuss the machine DC generator and the DC motor where the basics is to the understanding of all the machines.

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Then we follow it up with lecture 30 to 35 lectures; again we are going to revisit transformers, again we are going to revisit the electro-magnetic domain that is the three phase circuits and three phase transformers. Till now we have been talking on single phase but you will see the majority of the electrical systems operate on…… lot of electrical systems operate on three phase and therefore you have three phase circuits and three phase transformer which will be dealt with detail in these lectures from 30 to 35.

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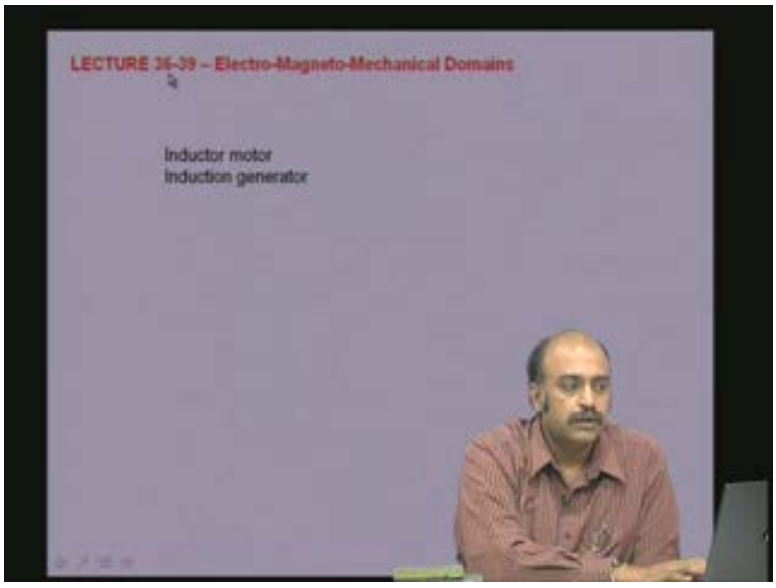

And 36 to 39 we are again discussing the electro-magneto-mechanical domain which is the induction motor and the induction generator. Induction motor and induction generator are very important motors; they form something like 75 to 80 percent of the prime movers of the applications world over so they are quite important and a good understanding of these is useful both in application and design. So induction motors and induction generators. You see the induction generators will be used in the wind turbine generators, induction motors will be used in lot of applications including the hybrid electric vehicles.

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Lecture 40 we will try to give you an insight into the synchronous machine and the alternator, alternator or the synchronous generator based on the concept that we have studied in the other two categories of machine the DC machine and the induction machine we will try to extrapolate and discuss the synchronous machine and try to get some insight to that and the lectures will conclude in lecture 40 with some typical examples of probably what are the topics for practical and research that can be done.

Now, coming to the references throughout the course I am banking mainly on these three books for the course. Of course there are full lots of books and then there whole lot of books of course the literature that I have studied and drawn upon from time to time.

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The first part that is the electrical essential part is drawn mainly from the concepts that are from this book which is the dynamics you see here System Dynamics A Unified Approach. The authors are Dean Karnopp, Ronald Rosenberg. This is a John Wiley publication. This actually…… the notations and symbols here are slightly different in the sense that it is using what is known as a bond graph symbols and methodologies.

However, I have mainly drawn the concepts from this book, I have reconverted the symbols and notations to what we electrical engineers normally understand and use in our undergraduate courses but this is a good book to study.

There is another book for the electrical essentials “Introduction to Bond Graphs and their Applications” by Jean Thoma it is a ((feragument……..44:33)) press.

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Again the notations will be quite far from the electrical engineer notation but the concepts are similar which I have converted it to the language of electrical engineer.

Then in the case of the electro-magnetic and the electro-magneto-mechanical equipment I have drawn upon this reference “Electrical Machines. Drives and Power Systems” third edition, the author is Theodore Wildi. It is a Prentice Hall publication.

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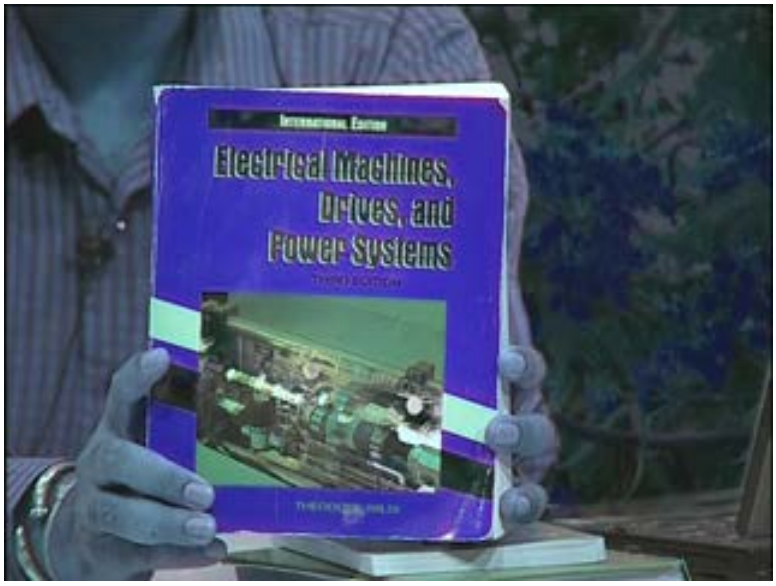

I have drawn lot of examples from this book while explaining to you when we were dealing in the latter two portions of the lecture pattern which is the electro-magnetic domain and the electro-magnetic-mechanical domain.

Apart from this there are host of other books and even the books that are referred in your undergraduate course sold by respective Universities is also good for you to refer and study and I hope that the coming lectures will be useful for you for your undergraduate syllabus, thank you.