Illumination Engineering and Electric Utility Services
Prof. N. K. Kishore
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 01
Introduction

Welcome to this course on illumination engineering and electric utility services.

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This course is a piece of process, a basic understanding of basic electrical engineering and electrical circuits.

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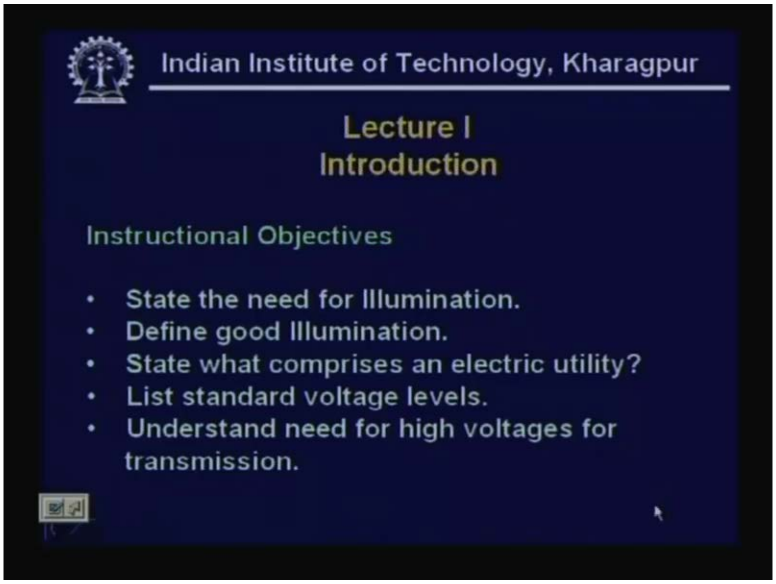

This is the lecture 1 of the course dealing with introduction. And to begin with let us look at the instructional objectives for this particular lesson. What do we expect at the end of this lesson? Number 1, state the need for illumination, number 2 define good illumination, 3 state what comprises an electric utility, 4 list standard voltage levels, 5 understand need for high voltages for transmission. So these are the major instructional objectives and at the end of the course one must be able to understand these instructional objectives.

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The course overview is as follows. The course overview begins with the radiation and colour, the eye and vision obviously because most of our illumination is sensed through our eyes. There is a chapter on eye and vision; it is followed by different entities of an illuminating system. There are various components that form an illumination system, therefore one looks at the entities that comprises an illumination system. The light sources have to be absorbed considering the day light which is a normal natural light, the artificial lights formed by incandescent electric discharge, fluorescent arc lamps and lasers. The luminaries, wiring, switching and control circuits obviously here there is a implied understanding that it is the artificial lighting implies electrical energy and hence the various control aspects that involve using electrical circuit systems is been addressed. Laws of illumination, illumination from point line and surface sources continuing with overview of the course then comes the need for measurement. Let us recall what lord Kelvin said, unless we measure whatever we try to understand or analyze a study it is incomplete, therefore there is the need to measure and hence the topic of photometry, spectrophotometry photocells etc is the next.

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Continuing with the course overview, you can see the effect of the environment and all of us have encountered glare at some point or the other, how the glare arises, how it is specified, how it is avoided these are some of the issues. Having talked about all the principles, one looks at the general illuminating design. Then the illumination for interior purposes, it could be a residential office, department stores, industrial environment, an indoor stadium, theater or hospitals then comes the exterior lighting which commonly encounter as flood lighting, street lighting, aviation lighting, transport lighting, lighting for displays and signaling, neon signs, LED, LCD displays, beacons and lighting for surveillance as one could see lighting is for functionality, lighting is for surveillance or security aspects. And all these as already told, involves electrical systems, so electrical utility services for various large buildings, office complexes and layout of different metering instruments and protection units are necessary.

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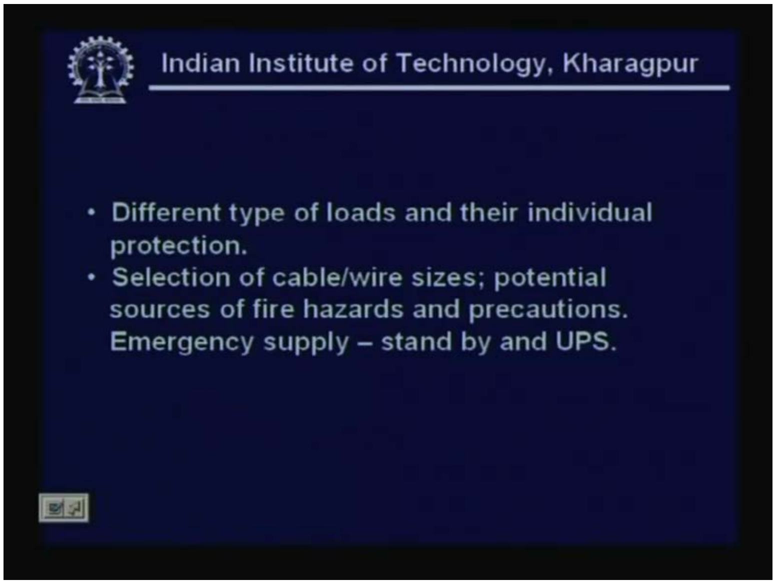

Next, so and once we have this we need to look at the various type of loads and how they are individually protected or in a group and one must emphasize but all these needs some kind of a conductors to carry the electrical energy which are in the form of a cables or wires. And the moment we use cables there are insulating materials involved and there are certain potential sources for fire and necessary precautions. And these days of an advanced technologies, one needs a continuous power supply therefore there are necessities for having an emergency supply and a standby mode and one of the common techniques that is used these days is to use uninterrupted power supply. In fact the computer control of this lecture is also being helped in the form a, by use of a UPS. A specific design problem would be addressed towards the end. All this assumes that one has all basic understanding of a basic electrical engineering principles and ability to analyze an electrical system in the form of a basic electrical circuit.

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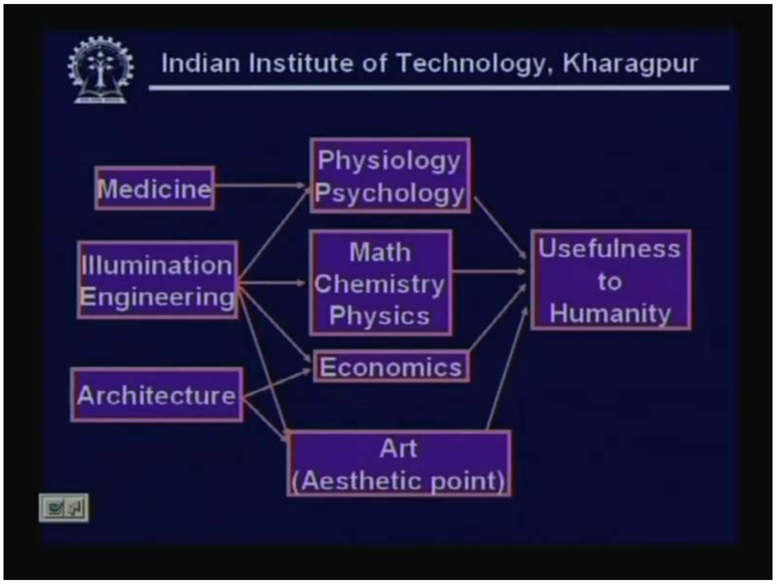

Let's see this picture here shows the various streams of sciences and various professions and how there are made useful to humanity as of the society or humanity. Let's take the first profession, the medicine which is helping us to live a healthy life is basically involved in the application of a science of physiology and psychology to address the usefulness to humanity which is somewhat empathic in nature. Coming to architecture, it needs economics together with art to be able to provide proper ability of architectural facilities for a human, this support.

Now illumination engineering is one such profession which involves physiological aspects as well as psychological aspects because the functionality of illumination system depends on the environment and most of the use of light is in perceiving objects through our eyes therefore psychology and physiology play a lot of role. But at the same time like any engineering science, it needs all the inputs of exact science of mathematics, physics, chemistry and economics because optimized usage of resources has to be maintained to be able to get the illumination. All these not compromising aesthetics, so illumination engineering brings in a set of new professionals who are needed to have much more broader areas of sciences and art rather than any other profession like medicine or architecture. So it's very clear that the humans depend very much on light and it is said that light is that natural phenomena which is very vital for our existence is taken for granted, it's never I mean we assume that it is available.

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We never even know what would have been in the life if light were not there. In fact if you recall our life involves in the cyclic variations of day and night with sunrise and sunset, prehistoric man had all activities restricted only to the sunrise to sunset. And today in fact we have more or less extended activity period and we talk of systems which are operational round the clock round the year in terms of 365 24 by 7 services. All this is possible because of extended activity period due to the artificial light and artificial light has to be planned, optimized at the same time minimizing the utilization of the available resources. This is a very important aspects minimizing.

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Now this artificial illumination could be, is to be bore in mind that vision is affected by this artificial illumination and is the most important sense among the various senses which human beings have and is this one sense through which we acquire more than 80% of our information that is to be kept in mind. The exertion of information could be through sun or moon, moon light is basically direct or reflected. Artificial light whenever created has to be closest to the natural light that is closest to the sun light which is the most important sources of day light or natural light. Here it must be necessary for us to see what is the good lighting, in fact this has been one of the first instructional objectives. We say the lighting is good when our eyes can clearly and pleasantly perceive the things around us. This is what Teichmuller says and that is to be kept in mind.

So artificial light has therefore has to be functional, it should be pleasing to physiologically as well as should psychologically to the mode. For instance the type of lighting that is required when I am making praying or mediating is different from the type of light I need when I am doing a persistent soldering on a pcb that has to be kept in mind. So it could be using a large number of sources. That is why I have mentioned here multiple sources and sources should be economic. Already we said illumination engineer has to have an idea of exact science of Maths, Physics, Chemistry together with understanding of physiology and psychology of humans at the same time keeping in mind economics and produce an aesthetic artificial lighting system.

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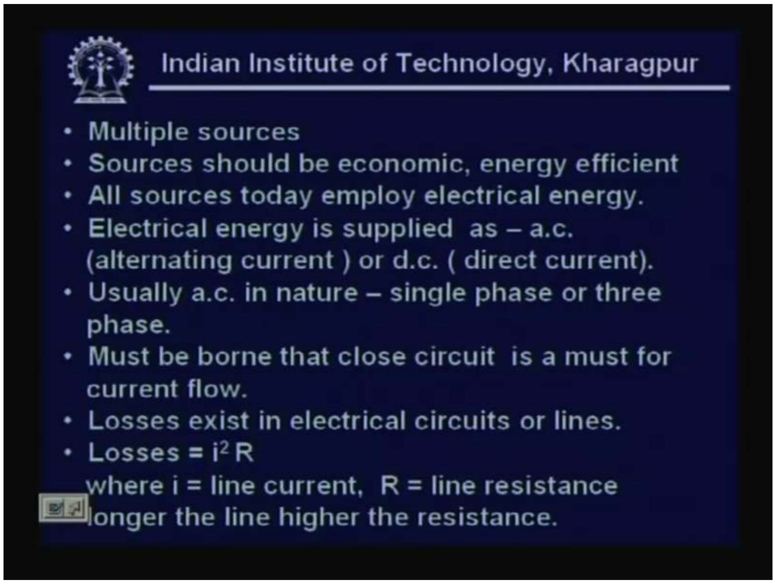

So the sources have to be economic, energy efficient. All sources today employ electrical energy in some form or the other, therefore one needs to look at how electrical energy is supplied as already learnt in a basic courses, it could be in the form of a alternating current that is which cycles at a particular frequency which is commonly at 50 hertz in our country and most parts of the Europe and few parts of in North America is at 60 hertz or direct current.

Usually as I said it is AC and it is either single phase or three phase, we look into the details but one has to remember that recall that any close, any current flow calls for a closed circuit.

Without a closed circuit current cannot flow, this has to be kept in mind. And the other issue which one has to remember it is that there are certain losses in all electrical circuits or lines. Remember that every conductor has a certain resistance to the flow of current which is expressed as a resistance and any current carrying conductor has an associate magnetic field, therefore it has certain inductance associated with it and any conductor raised at a certain potential separated from another conductor, separated by a dielectric medium possess a capacitance.

So in that sense every element of electrical circuit has all the three components and it is the resistive part of the network that gives rise to losses and our aim in having an electrical system must be to reduce these losses. And the losses as may be recalled from the courses on the electrical engineering is that R given by i squared R where i is a line current flowing through the line connecting your energy supply and the illumination system. We are looking at the illumination system in this particular program and at this point of time, we are looking at the fact that artificial light sources use electrical energy, we are trying to see how these electrical systems work and R stands for the line resistance, longer the line, higher the resistance. So what we do?

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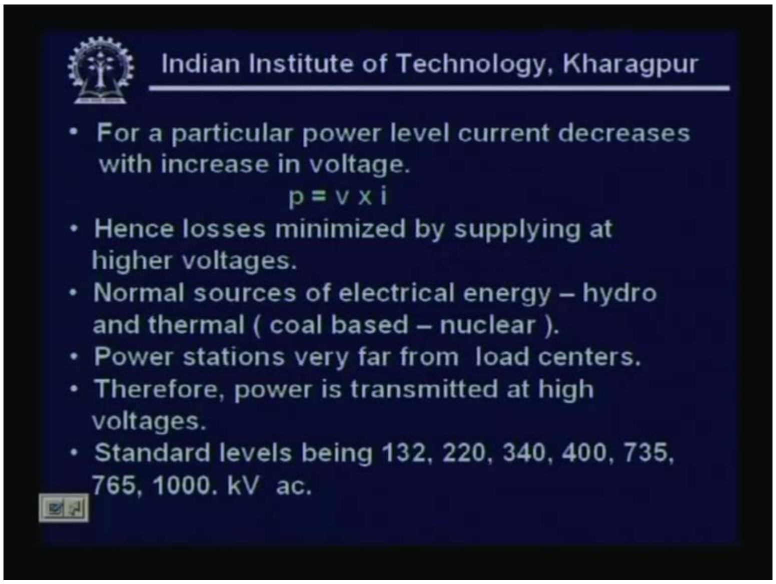

In order to reduce, we find keeping in the mind for particular power level current increases with increase in voltage bearing in mind look at the equation p equal to v into I, one could reduce the current if we increase the voltage, hence losses are minimized by supplying at higher voltages. So invariably power transmission is at higher voltages, however energy is obtained either in the form of hydro or thermal, thermal loss include coal based nuclear energy also. And being hydro or thermal, being a coal based or nuclear you understand coal based stations are located at the pit head of coal mine, hydro stations are located at the hydro reservoirs and nuclear stations for purpose of safety are located away. As a result power stations are very far from load centers; therefore power has to be transmitted at high voltages to reduce the losses. And this may be mentioned at this point of time standard levels for transmission are 132, 220, 340, 400, 735, 765, 1000 kV ac.

Now all these are kilo volts and it must be mentioned at this point of time, the higher system voltage as of today in the country is 400 kv and 800 kilo volts class that is 735 kV and 765 kV is perhaps the next higher level which the country is thinking of, that must be borne in mind.

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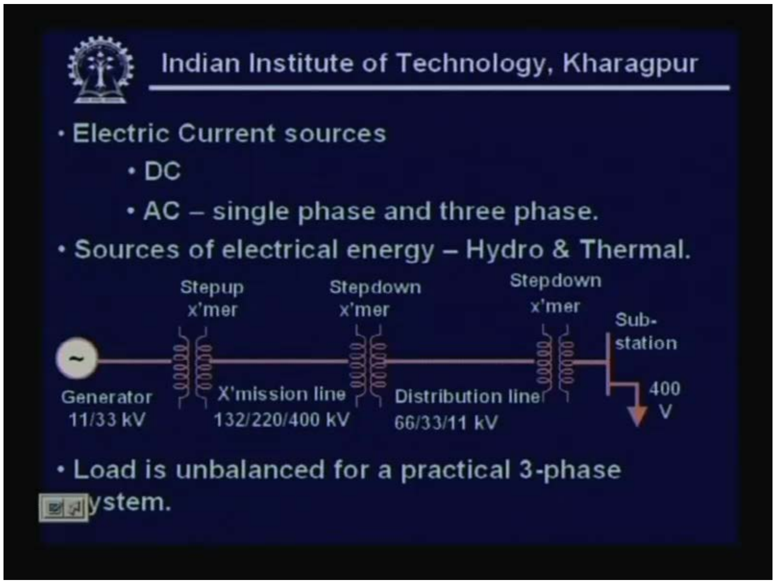

Electric current sources dc or ac, it is in fact we are trying to recall what has been done about the electrical current sources, they are either from hydro or thermal and the picture here depicts the complete power system. One could see a generator which could be generating at a 11 kv or 33 kv which is the stepped up and a transmission line may be at 132, 220 or 400 kv transmits which is step down for distribution line which could be distributing at 66, 33 or 11 kv and which is further stepped down and through a substation supplies the loads at 400 volts. We look in to what this connotes. So what do we see? We see that there is a generator, there is a transmission system, there is a distribution system and there are transformers which enable stepping up, stepping down and in it voltages.

Here I have not put anything beyond 400 kv because today the system voltage is higher system voltage available in the country is 400 kv. Load in a practical system is unbalanced, we look at how it is balanced and unbalanced what it means, we already done in basic courses but let us see what it is. Now before we go further on any of these things, what 400 volts 3 phase 50 hertz means to us? 400 volts 3 phase 50 hertz tell us that the supply is 3 phase ac at a frequency of 50 hertz with a line to line voltage of 400 volts rms. As can be seen from this figure, it is a periodic signal of 20 mille seconds that is 50 hertz, 1 over 20 mille seconds gives us 50 hertz and it has a peak magnitude of 564 volts.

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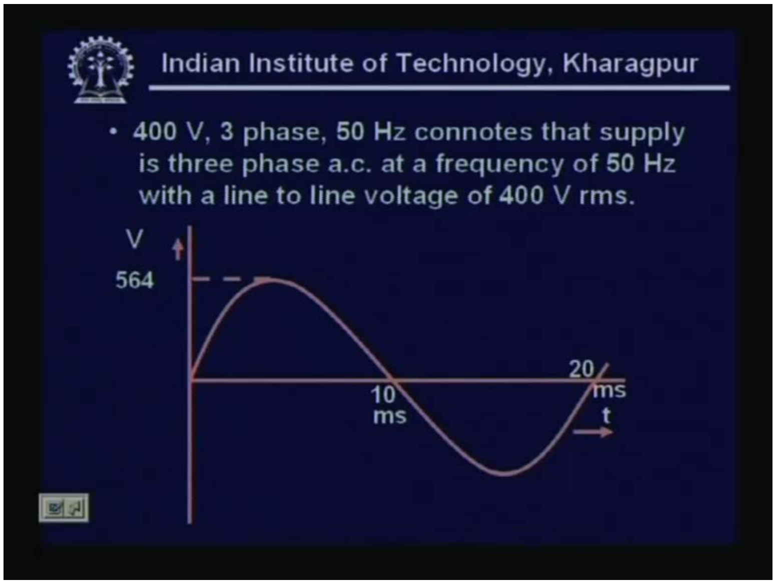

Now as may be observed it is a sinusoidal voltage, this is a line to line voltage it become clear what a line to line voltage is when we look at three phase connections. Little later we will be looking in to the generation aspects of a single phase ac generation which shows to us the generation by nature is sinusoidal and the easy way of expressing the complete sinusoidal voltage is in terms of a what we call as phases or rms values. And it is known that for a sinusoidal wave form, the peak to rms ratio is root 2, therefore we have 400 root 2 as 564. The another important thing why we talked of rms is we are trying to have equivalence between dc and ac in terms of heating and rms value uses an equivalent ac value that can produces same heat.

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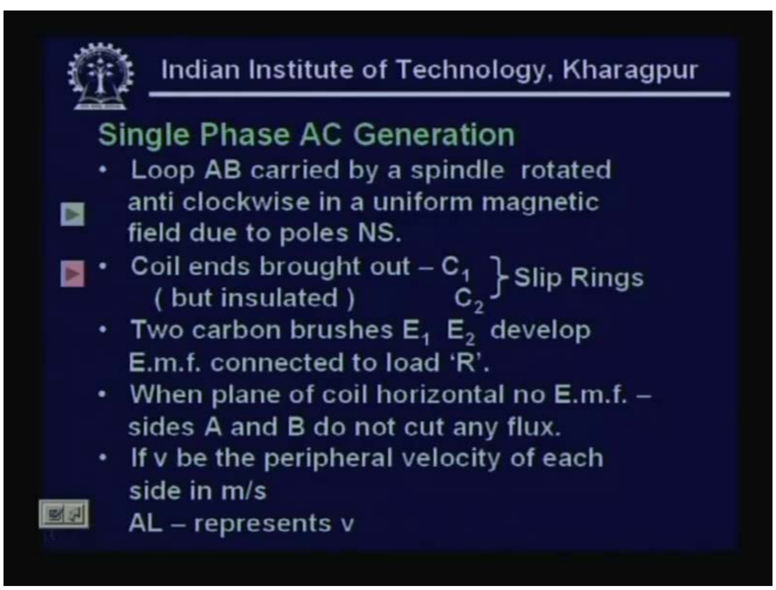

Now let us consider the single phase ac generation. In order to consider a single phase ac generation, recall that when a magnetic current carrying conductor is moved in a magnetic field it produces induced emf and this is explained through a figure. We will consider here a loop AB carried by a spindle and rotated anti clockwise.

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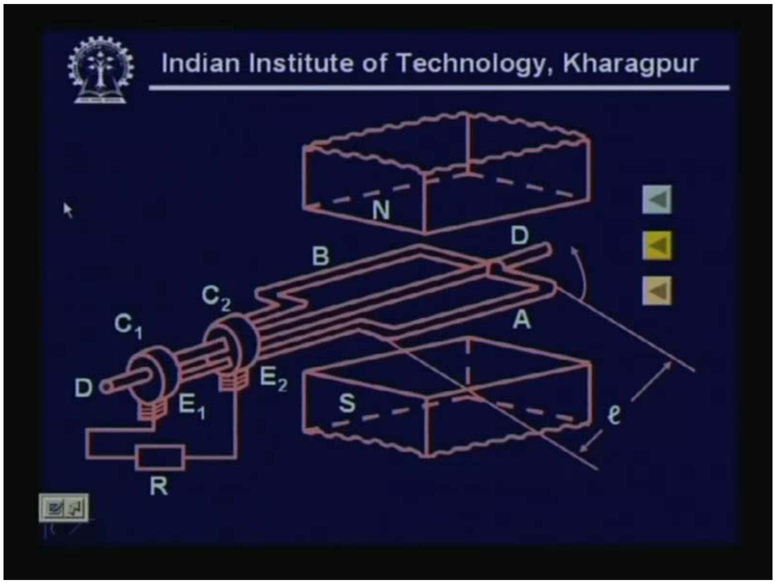

You can see here there is a clock, there is a loop A B which is being moved by a spindle and the in the field of permanent magnet north south at a constant velocity in an anti-clockwise fashion. And you can see that there are coil ends which are brought out these through the slip rings, they are insulated okay and two carbon brushes E_1 E_2 where the emf is connected, collected and is connected to the load. So this is how now when the plane of the coil is horizontal, there is no emf and sides a and b do not cut any flux and this becomes, so if you have the v, the velocity of each side given in meters per seconds, the AL represents velocity let us see this.

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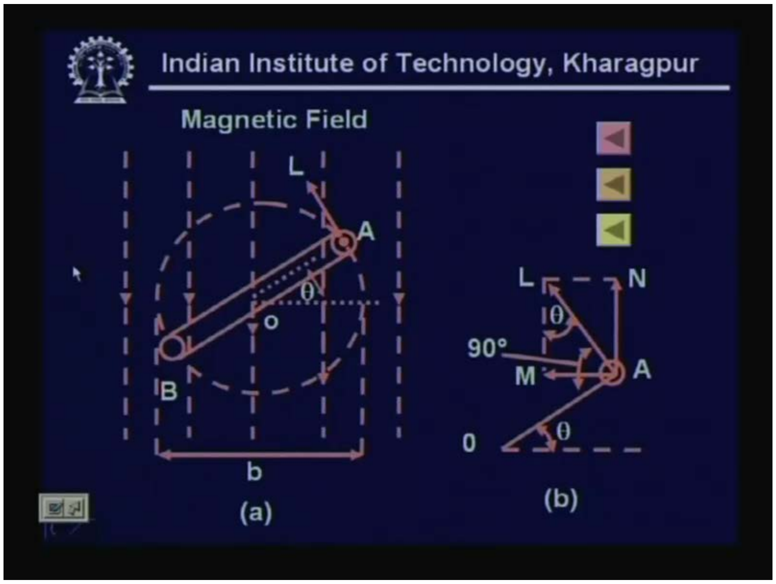

You see this is the vertical hash lines are the flow of magnetic field and this is the loop A B which is being moved anti clock wise. The AL shows the peripheral velocity of this coil as can be seen, since this velocity is radially outward along the anti-clock wise direction, it has a component in the horizontal as well as vertical and it is the perpendicular component which is responsible for the generation of emf and therefore we will see that how one gets the voltage generated.

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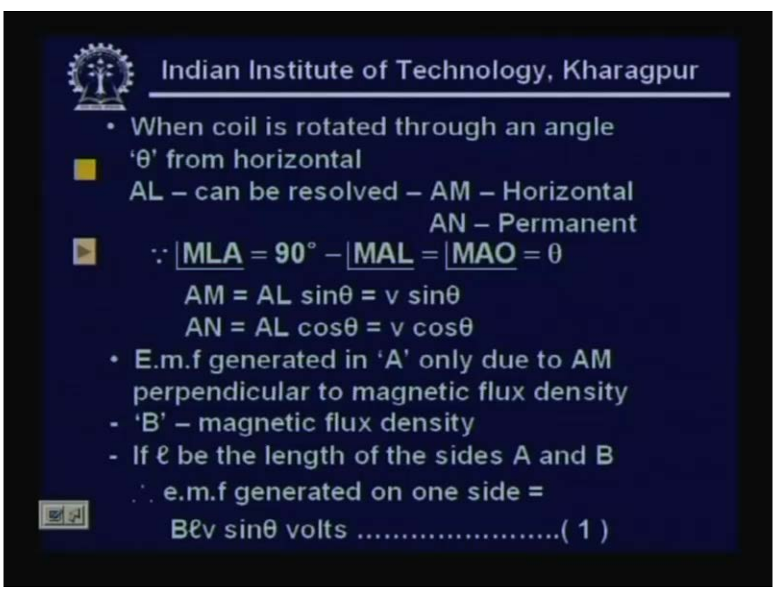

Now this is a situation when we consider that the coil has been rotated through an angle theta from the horizontal and as already said AL is resolved into AM AN and we can write AM is the perpendicular component which is V sin theta and V cos theta. And we have already said, this is from the sinusoidal law of electromagnetic induction that emf is generated in A only due to AM because only that component produces a perpendicular this thing between the flux density and the direction.

Now here one could say if be B the magnetic flux density, L be length of the sides A and B then we know that emf generated on one side would be BLV sin theta. V sin theta is the velocity component, L is the length of the coil conductor involved, B is the magnetic flux density. This is the voltage generator due to the flux cut by one side of the coil. Remember that the coil has two sides, therefore you have totally emf generator is equal to 2 blv sin theta.

Let's look at the figure once again, what do we have? We have a permanent magnet which is shown by two poles north and south in which there is a conducting load A B which is being rotated with the help of a spindle about the axis D D in anti-clockwise direction at a constant velocity. There are two slip rings as C_1 and C_2 and carbon brushes E_1 and E_2 through carbon brushes E_1 and E_2 generated emf is picked and connected to the load R.

So the total emf generated is 2 BLV sin theta and if theta is 90 degrees, the coil is vertical and the emf generated is a maximum and therefore EM or the e maximum is 2 blv, hence one arrives at the equation as e equal to E_m sin theta. Let's take look at the velocity component once again. The hash lines show the flux lines due to north south magnetic field and A B is the coil loop which is being rotated and at a particular point theta away from the horizontal, we find the velocity is directed towards AL which can be resolved into perpendicular and horizontal components in terms of AM and AN. AM is perpendicular to the flux density, remember that when we are talking about the perpendicular nature of the velocity component, it is perpendicular to the magnetic field that's what we are looking at not perpendicular to the, not perpendicular to the x axis as understood, as normally understood.

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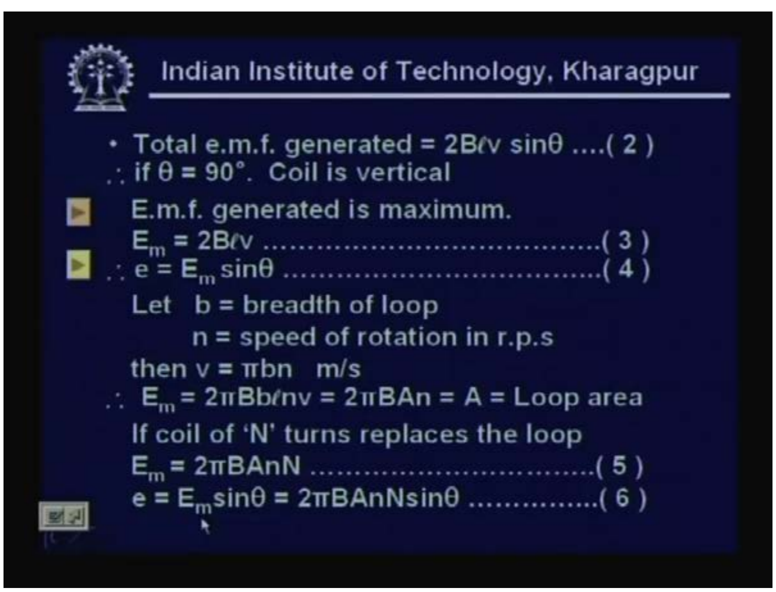

So total emf we have already seen that E is going to be 2 blv sin theta, a maxima is 2 blv hence we have ES E_M sin theta. So this shows that a single phase generated emf is sinusoidal in nature with the certain peak and if the b is the breadth of the loop, n is the speed of rotation then one could say v is the velocity equal to the pi b n meter per second. Hence e max becomes 2 pi bb Anv or 2 pi B A n where A is the loop area in square units. And if there be n turns or remember if the loop is replaced by the coil of n turns which is normally the case in a generator, you have E_m as 2 pi B A n N that being the case one arrives at the equation as E_m sin theta. So this tells us that the voltage generated is a sinusoidal in nature with the magnitude of the E_m. This is the essence of a single phase generation. Now what is the three phase generation, let us see.

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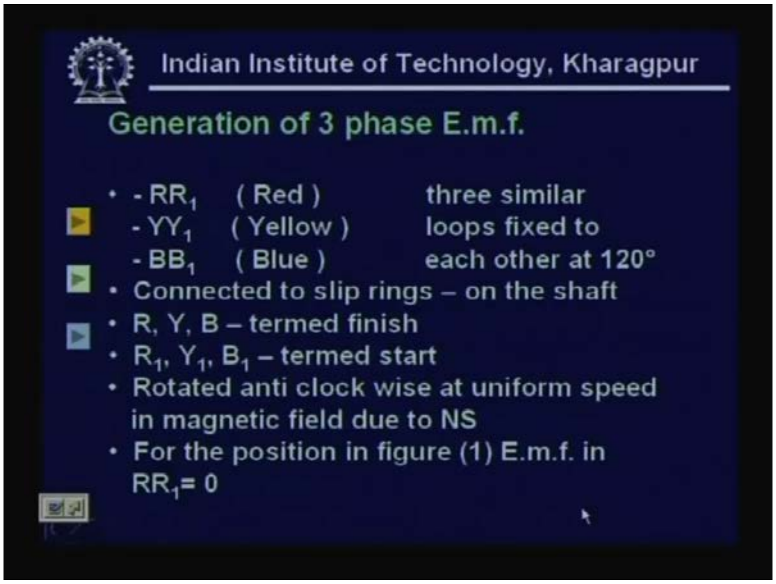

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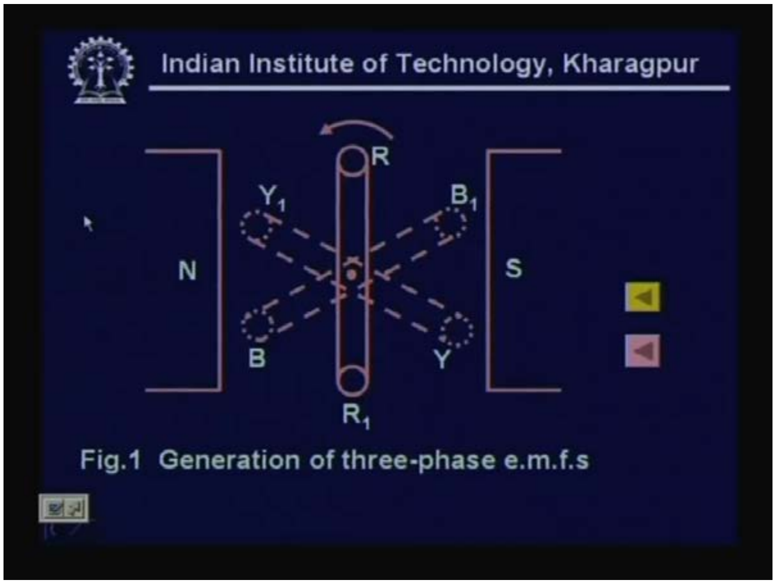

Consider that there are 3 coils just as we had a single loop rotated anti clockwise in the previous situation, let us say we have 3 coils which are placed on a single axis at 120 degrees from each other as shown in this figure. You have R R_1 forming one loop, B B_1 forming a second loop, Y Y_1 forming a third loop with all these axis at 120 degree is to each other. That is how you have 3 coils and let us say just as we did in case of a single loop in the previous single phase generation, we rotate anti clockwise at a constant speed in a magnetic field due to north south magnetic poles, we will see what is the nature of the emf generated.

Mind you, these are three similar loops and they are fixed at 120 degrees to one another. Now here one may say the notation R R_1, Y Y_1 and B B_1 has been used because it is often helps the people on the field to have a color code in the form of red, yellow, blue that is what has been done. Now just as we did in the previous case, they are connected to the slip rings on the shaft and you have there are finish and start terminals, here the notation used is R Y B are finish terminals, R_1 Y_1 B_1 are start terminals and they are rotated anti clock wise at uniform speed in the magnetic field. Now we already know that we already know that supposing there is a particular loop rotated in a magnetic field anti clock wise, we find that the generated emf is sinusoidal.

Now what we are going to show in this particular case is when there are three loops, it will be as though they are 3 voltages generated at each displaced in time which is equivalent to displacement of 120 degrees phase shift or electrical shift. Now recall this figure where it shows this is all the figure one, the way it is placed the R R_1 is not cutting any flux therefore the voltage generated in R R_1 is 0. As you recall the velocity component has to be perpendicular to the magnetic flux only then there is an induced emf, so that being the case the emf in R R_1 is 0. Let us see how one could…

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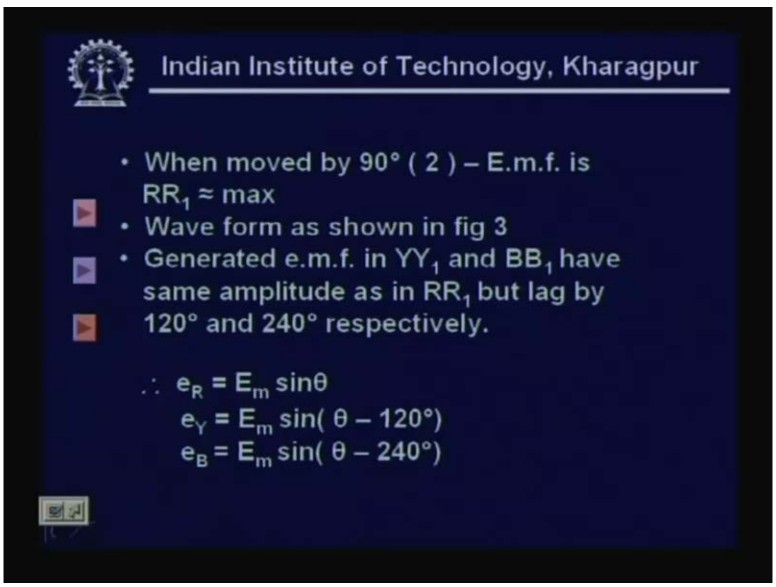

Now let us move the R R_1 by 90 degrees then you have our emf is in R R_1 a maximum and one could see this in figure 2.

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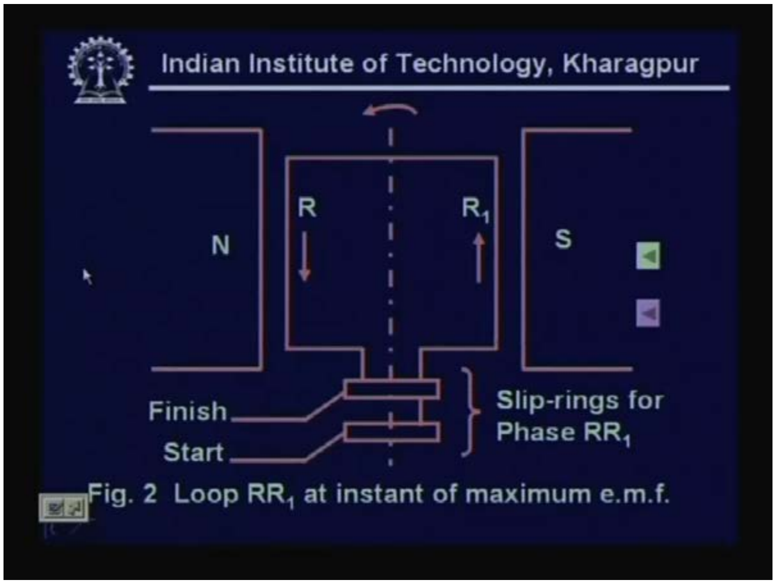

Fig. 2 Loop RR_1 at instant of maximum e.m.f.

This is the situation where R R_1 has moved and you find that it is cutting the maximum flux, the velocity vectors is going to cut the maximum, you have the maximum emf generated. Now as there are the 3 coils or 3 loops fixed at 120 degrees to one another, you will find that there is a time or a time lag equivalent to 120 degrees about this rotation in retaining a maximum like theta equal to 90, you got a maximum for R R_1, you will have maximum for Y Y_1 at 210 degrees 90 plus 120 and at 330 for the B B_1. That is you have, just as you had a 120 degrees physical phase shift, shift between the two 3 coils you will have an electrical shift or shift in generated emf maxima.

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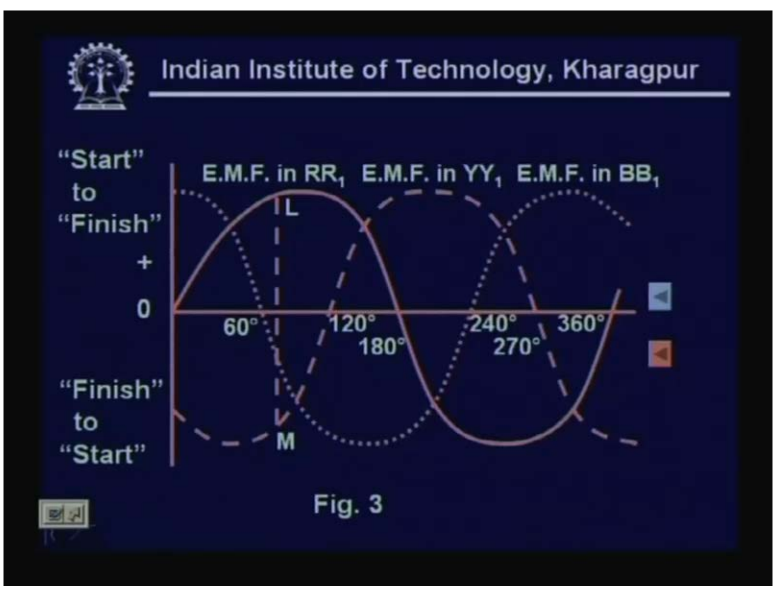

Fig. 3

So the wave form therefore generated could be like this. As you can see you have emf in R R_1 shown by a bold line followed by a dot, dotted line for emf in B B_1 and hash line for emf in Y Y_1. As you can see there is a time difference between each of these in reaching their peak and the 0. As you can see R R_1 is reaching the, begins at a 0 and reaches the first 0 at the end of the half cycle at 180 degrees electrical which is proportionate to a 10 mille seconds in a 50 hertz. And what do we find? The first zero beginning from negative going positive for Y Y_1 is at 120 degrees away from the beginning which is corresponding to 120 by 180 into 10 that is 6 by 9 two thirds of 10 that is 6.67 mille seconds or later that is 120 degrees later Y Y_1 comes, there is a phase shift and B B_1 likewise comes 240 degrees away from the R, R R_1.

So that's how we see that a three phase wave form is generated they, since the three coils are identical in size and shape and they generate same amplitude but lag 120 degrees and 240 degrees respectively which in the form of expressions is expressed as E_R equals to E_m sin theta, e_Y equal to e_m sin theta minus 120, e_B is equal to e_m sin theta minus 240. So what have we seen? We have seen that ac generation is sinusoidal and it is possible to generate three phase source in a single generator by having identical coils placed 120 degrees apart from each other and that is been done and we find that generates.

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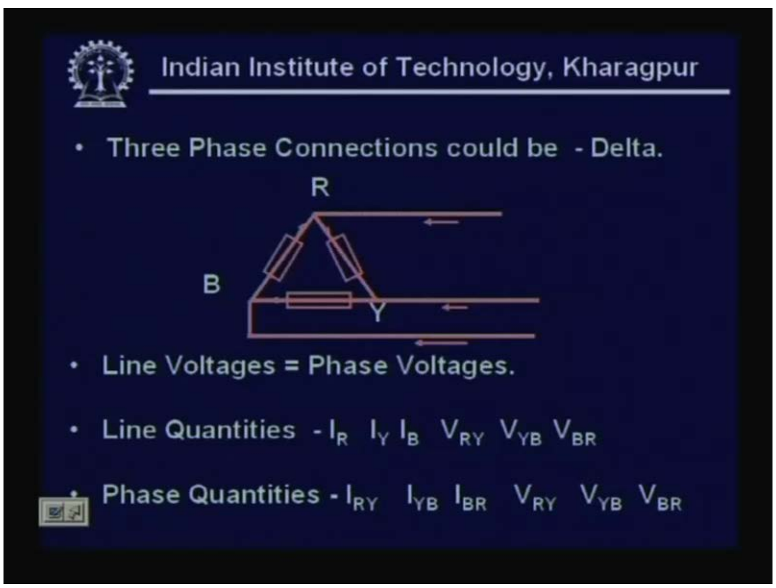

Now once you have a three phase generation, now the question arises how do we use this? This is used by various connections, these connections are two major methods which are adapted are delta and star. So three phase connection could be a delta as you can see three sources are connected because if you take the instantaneous sum of the voltages generated and connected, it is a zero. And therefore the moment you do this, we have two things coming up, there are lines and phases. So we have line quantities and phase quantities coming into picture. Within the delta the currents and the currents through and voltage across are called phase quantities and the three lines employed the currents through them are called line currents and the voltage across them are called line voltages.

As may be seen the line voltages are equal to phase voltages in case of a delta and as I told you there are line quantities which are I_R I_Y I_B V_{RY} V_{YB} V_{BR} and phase quantities are I_{RY} I_{YB} I_{BR} V_{RY} V_{YB} V_{BR}. So what do we have? In case of a delta, we have line voltages equal to phase voltages. Now here it may be coming to somebody's minds, why we are talking about line and phase, why delta? Had we connected these three sources to three different loads in a separate manner, we would have used 6 set of lines, two lines for each voltage source that way we use 6 conductors. As against that when we make a connection in the form of delta or a star, we reduce the number of lines employed and there by optimize the amount of copper that is used in transmitting this power and this is a usefulness.

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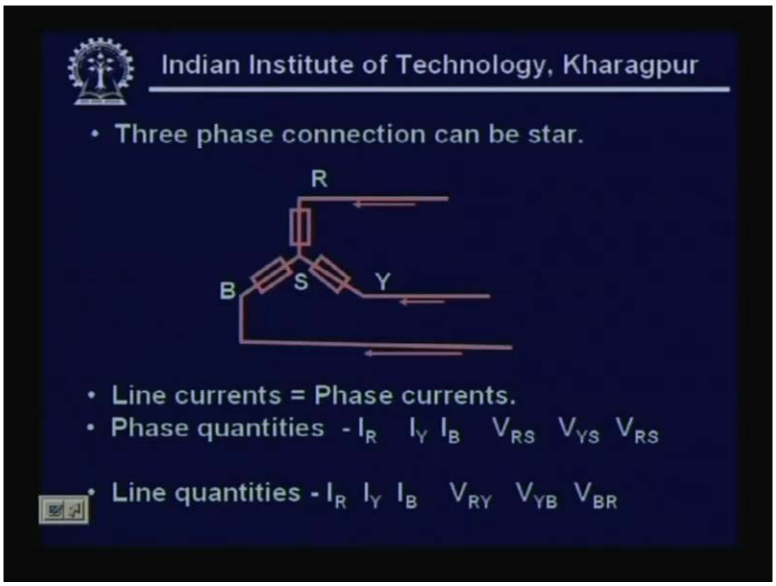

Now, the other connection as I told you apart from delta connection, it could be a star. The star connection is shown here and junction point is what we call as a star point. Now remember the three sources we had in a three phase generation, say I connect all the three starts or all the three finishes together then I would find that there is no harm and I can use just 3 lines and if I have identical loads and they draw identical currents then I can see that instead of 6 conductors, I could have perhaps done with 4 but since the fourth conductor which forms a neutral conductor carries zero instantaneous current, some of the zero it need not to be there. Once again instead of having 6, we able to do with 3 lines and therefore and one could easily observe the phase currents are equal to line currents where as the phase voltages are not equal to line voltages. Phase voltages are obviously less than the line voltages, needless for me to mention at this points that these are analyzed using the complex algebra because each of these quantities in ac has both magnitude and phase. So, we have phase quantities as I_R I_Y I_B, the phase voltages as V_{RS} V_{YS} V_{BS} and line quantities as I_R I_Y I_B V_{RY} V_{YB} V_{BR} become the line, line quantities.

Now you remember we said it is 440 volts line to line, so that is the thing between this line R and Y the voltages going to be 400 volts or 440 volts. When you say it is line voltage, it is that so they could be in delta or star.

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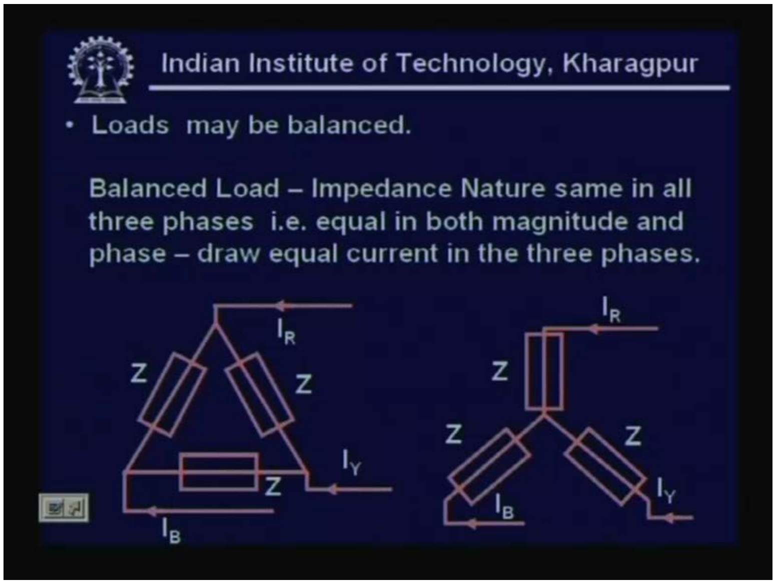

Now comes the question of loads. Now we talk of term loads may be balanced, you recall when we showed the diagram of the power system, we said generally loads are three phase unbalanced. What do we mean by balanced? We had already said load has nature in the form of a resistance, inductance and capacitance or electrical circuits. So the combinations is talked in terms of resistance and reactance, reactance could be due to the inductance and capacitance. Now in a three phase connection where we said it could be delta or star, if the load impedance is same both in magnitude and phase in all the three phases then I say it is a balanced load. When I mean magnitude and phase it means both the reactive component and inductive, I mean the reactive component and the resistive component are same.

If I define that the R is the resistance in a phase, it is same in all the three phases. If I say X is the reactance of a phase, it is same in all the three phases. That is when we say that is it is the balanced load. So loads could be a balanced. A balanced load means impedance nature same in all three phases that is equal in both magnitude and phase and thereby it draws equal currents in the three phases. See here one phase opposition has been there that system voltages are balanced that means when you have a generator, you have an identical calls and generate equal emf displaced in 120 degrees without any problem. So that is been assumed, as you can see in this diagram for both delta and star, you will find that the magnitude of currents will be same in all the three phases. Hence in all the three lines, as you recall in the cases of delta line currents are more than the phase currents and incase of star, line voltages are more than the phase voltages whereas line voltages are equal to phase voltages in a delta and line currents are equal to phase currents in case of a star. So these are some of the issue, fundamentals which we are trying to recall which we have learnt in basic electric engineering courses.

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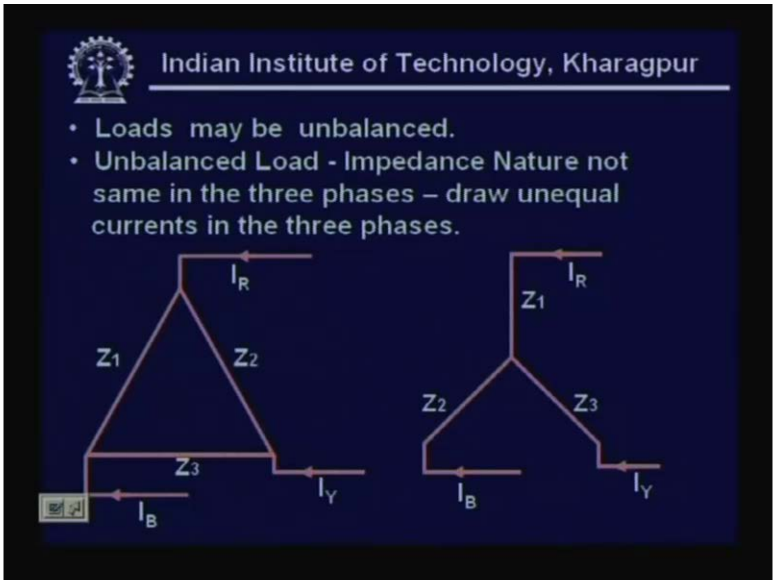

Now as I said loads could be balanced, loads may be unbalanced. In fact I have already made a statement that loads are generally unbalanced. Having already said what is a balanced load, we know what it is to be an unbalanced load. Impedance nature is not same in the three phases, though while designing an electrical system designer takes care to see that all the three phases are loaded equally. Supposing a room is getting a three phase supply and it has got three rows of seats, what designer would do is lamps pertaining to one row of seats are loaded in R and other row on Y, third row on B. That is how one does, but while using it is not necessary there may be a situation when one row of seats are occupied and thereby that phase is not loaded at all and that’s the situation. And another interesting thing is although by design, one can have a balanced system but when the power is going to be used or power is going to be drawn, it depends on the user and I as a designer or generator have no control over the user.

So coming back to the discussion on unbalanced thing, as you can see for both for delta and star you find that the magnitudes of these currents are distinctly different. See in case of a balance system, the call of the nature being same, the currents are going to be same. Now this diagram, you can see one thing I have not put same impedance z_1 z in all the three phases of delta or star. They are marked as z_1 z_2 z_3 that means each phase has a different impedance, may be resistance is different, may be reactance is different may be both are different in either case it becomes unbalanced. This is how one could see that the loads could be balanced or unbalanced.

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Now the question arises, what do we understand by distribution? Distribution is the ultimate way of delivering the electrical energy to the users and at what voltage do you do. Now if you recall, I have already said we use the voltage at 400 volts three phase all around. All our appliances are operating at 400 volts but is the distribution done at 400 volts, that depends on some factors which we will address. As seen is sparsely populated, short distance distribution is at 400 volts. Why? Again the reason is same. If the length is longer, the resistance is going to be higher, the losses are going to be higher that is what has to be kept in our mind. And the other, on the other hand, I did mention the distribution levels could be anywhere from 11, 33 and 66. As said, densely populated are a vast areas, distribution is at 11 or 33 kv.

Now when you are distributing, there are two alternatives that are available to us and one of this is through underground cables or the other is overhead lines. Again the options depends on the requirements like where the population is dense, the number of building is large, it is may not be possible to get space to erect overhead lines and there one goes in for underground cables. And on the other hand where the space is available you go for overhead lines. Going by this, you will find that urban localities are invariably serviced by UG cables where as rural settings where lot of space is available, they are serviced by overhead lines. This is supposed to be borne in mind.

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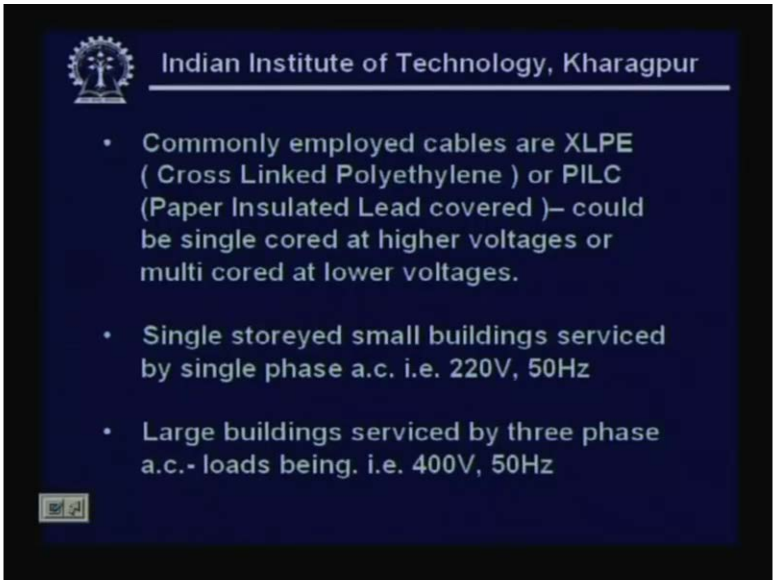

So, commonly the cables means cable has a conductor and an insulation and commonly employed cables are XLPE or cross linked polyethylene cables, PILC or paper insulated lead covered cables. These could be single cored at higher voltages or multi cored at lower voltages. So now having said so much, if it is a single small building, you might find this is servicing at a single phase ac 220 volts, 50 hertz where as a very large building serviced by 3 phase ac loads at 400 volts, 50 hertz. If there is a very very large building, it is quite possible that the supply could be at 11 kv to the building and it is redistributed at 400 volts, this is to be kept in mind.

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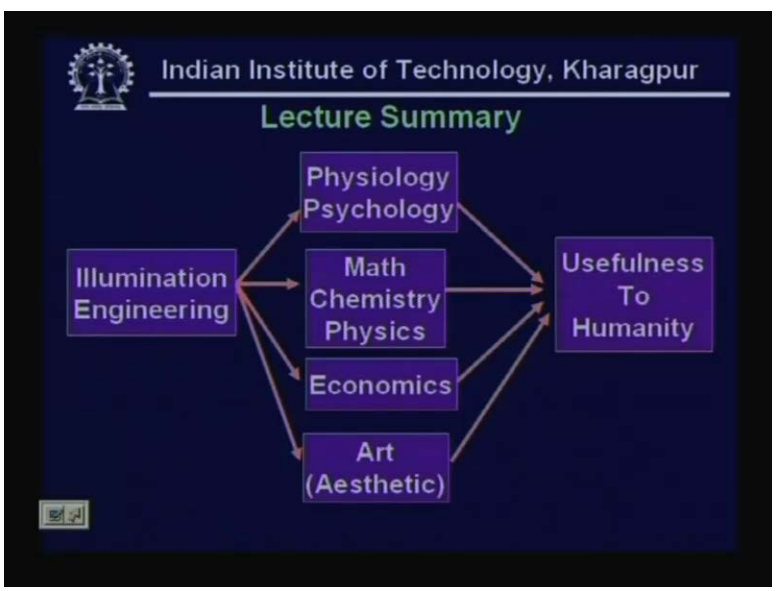

Now to summarize the lecture, we see that professionally illumination engineering profession is distinctly different from other professions in the sense it needs inputs from physiology, psychology and exact science of mathematics, chemistry, physics, keeping in mind the economic aspects because optimal utilization of resources and the aesthetic essence of architect is necessary to achieve the end goal of making a good illuminating system which is a must for acquiring the information. As already told 80% of the information acquired is through eyes and they depend on the light and we are trying to make the light as close to natural light as possible.

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As can be seen good lighting is very much necessary, our eyes can see clearly and pleasantly perceive the things if there is good lighting. Artificial lighting can use some form of physical phenomena. After all we said there are artificial lights which try to bring it close to the natural light, at the same time economize the resources and use the electrical energy. But there is some form of a physical phenomena which we will consider in a subsequent lecture on radiation. It could be a by way of incandescence, electro luminance, fluorescence or phosphorescence. All of us are aware of incandescence lamps we have been using for a very long time and even fluorescence lamp which are become abundantly available and other discharge vapor lamps which are used in the streets. And so that is the one way and as already told, all lighting sources invariably employ electrical energy.

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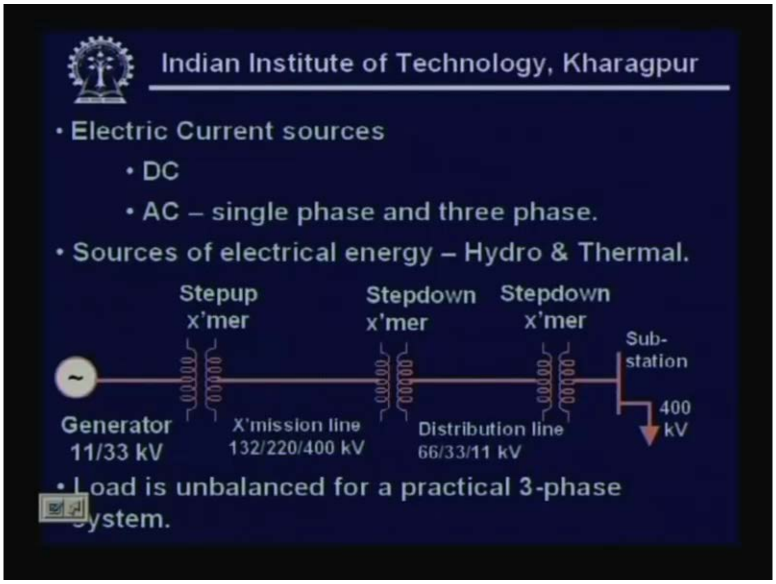

And as told already the electrical current sources, they are the dc or ac. In fact historically the first transmission system was direct current but the easy of stepping up, stepping down with the help of a transformer has bought in ac into predominance, it could be single phase or three phase. However this energy is generated predominantly using hydro or thermal. This picture shows a complete power system which comprises of a generator. A transmission system which could be at the 132, 220 and 400 kv, 400 kv being the highest in the country at the point, at this point of time and a distribution line which may be at 66, 33 or 11 kv and further stepped down and supplied at 400 volts three phase and as already told load is invariably unbalanced for a practical three phase system.

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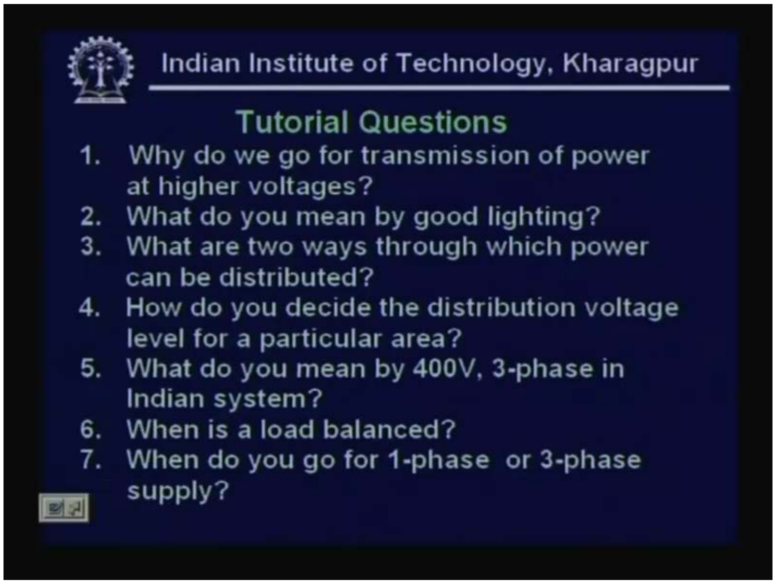

So we end of this lecture with a certain questions to be addressed and these questions will be answered in a subsequent lesson. Number 1, why do we go for transmission of power at higher voltages? 2, what do you mean by good lighting. 3, what are two ways through which power can be distributed, 4 how do you decide the distribution voltage level for a particular area, 5 what do you mean by 400 volts three phase in the Indian system? When is a load balanced? When do you go for single phase or three phase supply? Thank you, thank you.