Fundamentals of Electrical Engineering
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Lecture – 01
Basic Concepts, Examples

So, welcome to this course that Fundamentals of Electrical Engineering. So, before giving you introduction just I like I would like to tell one or two words, that is a this course is mainly for the first year engineering students where in fact, all the first year engineering student can take this course and this is a very basic course. Only at the beginning I am telling that in the introduction you know that a video that 5 minutes video, their one thing I said only independent sources, but I found at dependent sources also it is very simple thing.

So, dependent sources also will be covered so, those are the things and we will start from the basic concepts right basic concepts and from there will your what you call slowly and slowly will move into you know much deeper understanding. And your first the dc part will be covered and then your single phase, three phases is circuit everything will be covered may have your including resonance or maximum importance for theorem and your what you call that magnetically couple circuits.

And then whatever first year courses is there for your transformer single phase transformer your equivalent circuit and after voltage regulation. Then little bit of three phase induction machine up to your equivalent circuit as were as first year course is concern and then that dca machine right so, this way let us start first thing is that your basic concept right. So, generally all branches of electrical engineering actually are based on two thing that is your electric circuit theory and electromagnetic theory, where is the I mean this is the your what you call will be that main two things.

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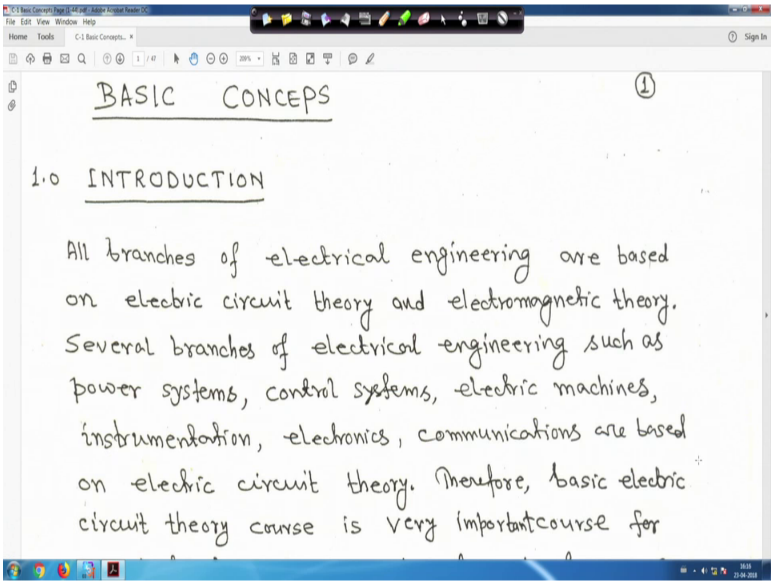

So, several branches in electrical engineering like power system, control system, electric machines, instrumentation, then electronics, then communication, all are based on your electric circuit theory right.

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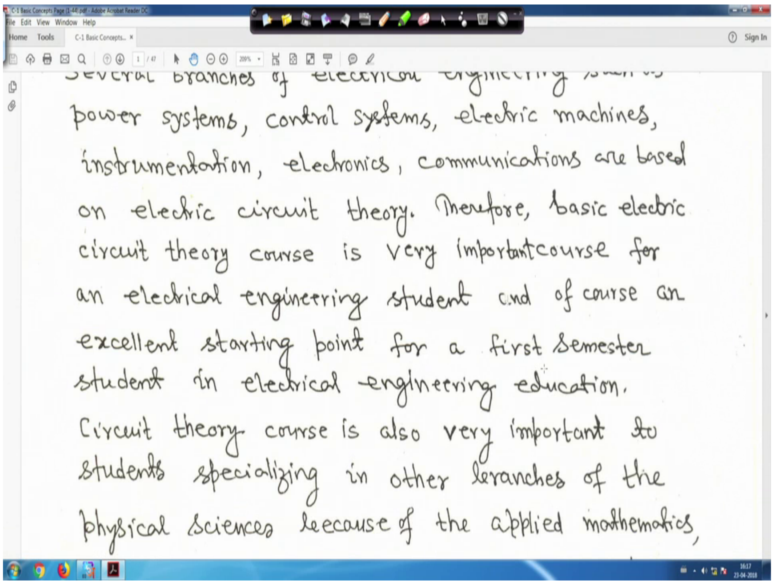

So, this codes is mainly your what you call that your suitable for your what you call the first semester or your first year rather electrical engineering student and so, we will start from your very basic thing.

So, therefore, the basic electric circuit theory course is your important course for an electrical engineering student and of course, and excellent starting point for a first semester student or first year student in electrical engineering education, electrical engineering means it covers all the things like electrical, then your electronics ecu call then your instrumentation. So, everybody I mean all the specializing in first year they can they can take this course right and.

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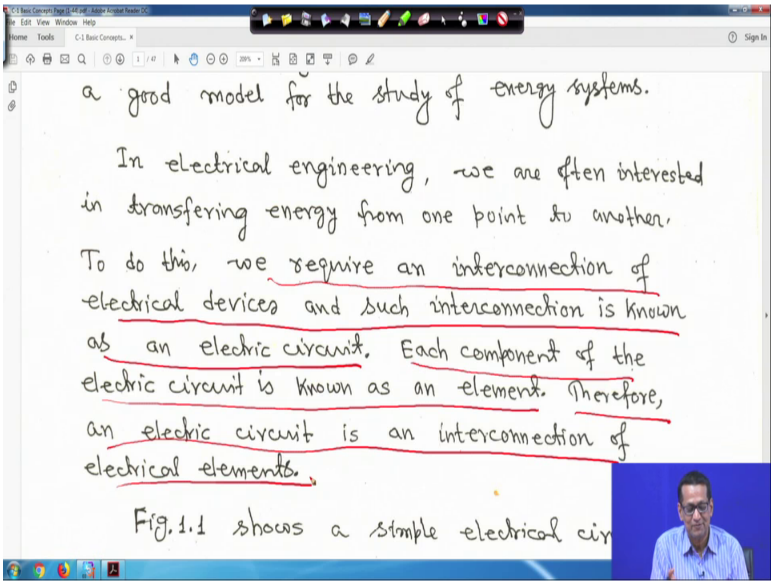

So, and basically if you think about electrical engineering we are often interested that actually electrical transfer in energy from one point to another. This is this is common idea you have when is look at that circuit at house hold and you might have seen somewhere in that power generic station right But ultimate thing is that you often interested in transferring energy from one point to another that is also your transferring energy. So, to do these we require in interconnections of electrical devices right.

So, and such interconnection is known as an as your as an electric circuit like if I mark it by this, if this thing this plain we require an interconnection of electrical devices and such interconnection is known as an electric circuit right and each component of the electric circuit is known as element. So, what we need actually we require an interconnection of electrical devices and interconnection it will be through wires only conducting wires only and such interconnection is known as the electric circuit and each element of the electric circuit is known as your element; that means, each component of the electric circuit is known as an element right.

Therefore, an electric circuit is an interconnection of electrical elements. So, this is the your what you call this is your the I mean require may the your electrical elements and electric circuit is an interview what you call therefore, electrical interconnection of electrical elements. So, just will come to the figure one is shows a simple electric circuit right so, it consist of 4 basic elements look.

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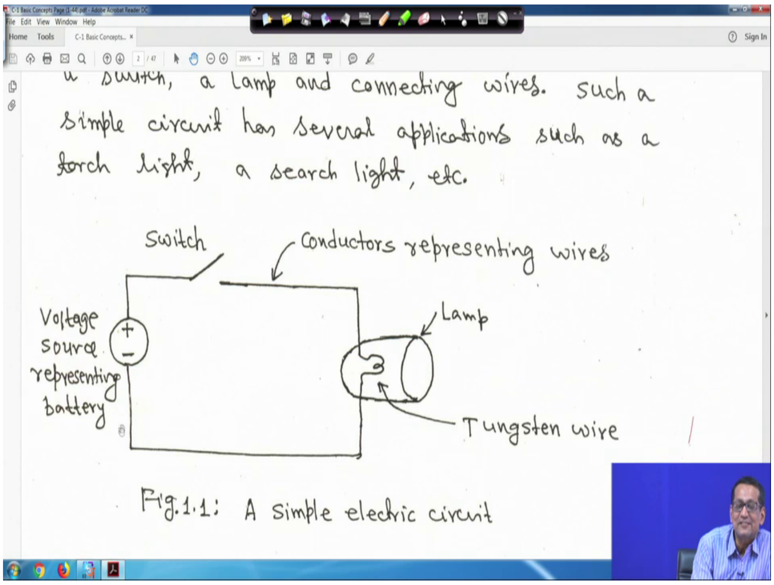

Just look at this circuit it consist of four basic element so, one is voltage source so, this is very you know very basic things we have started. So, this is a voltage source representing says battery this symbol will come later battery symbol will come later this is the switch and this is conducting material. If you close, this which will be close, if it is open it is open and this is actually conducting wire there is a conductor represent wire and this is the lamp and this is the filament say it is a made of tungsten right.

So, this is the simple circuit so, a lamp connecting such a simple circuit has several applications such as your torch light or search light etc. So, this is a simple electric circuit now let us come to the voltage source representing a battery.

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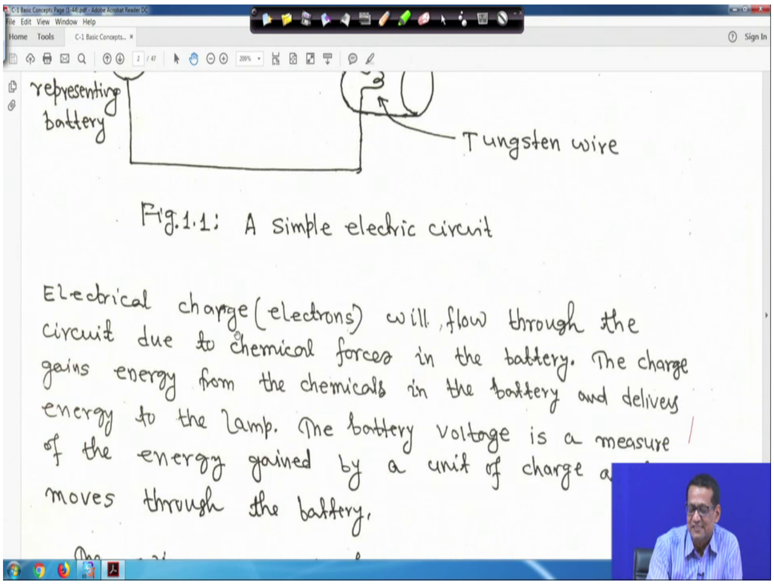

So, basically what happen electrical charge that is electron say in that it were writing electron. So, we will flow through the circuit due to chemical forces in the battery right due to the chemical forces in the battery of course, little bit of your battery you calling little bit of physics your in physics you have studied the battery is right.

So, here will not your what you call here will not cover to the chemical reaction another thing, but some whatever we have learn from there only we talk about that. So, will flow through the circuit due to the chemical forces in the battery the charge gains energy from chemicals in the battery and delivers energy to the lamp right; So, these negating charge I will come to little bit later. So, the charge actually gains energy from the chemicals and your in the battery and delivers energy to the lamp the actually the from here actually energy is coming to the lamp right and the battery voltage is a measure of the energy gained by unit of charge as if moves through the battery.

Later will see the your voltage another things , but the battery voltage is a measure of the energy gain by unit of charge as it moves through the battery, but of course, if the switch is switch is closed right. But one thing is that that suppose this conductor wire suppose it is a your it is a your what you call that, copper wires and the plastic insulation will be there right and this is the tungsten, tungsten wire actually is not a good your what you call a conductor as compared to the copper will come to that right.

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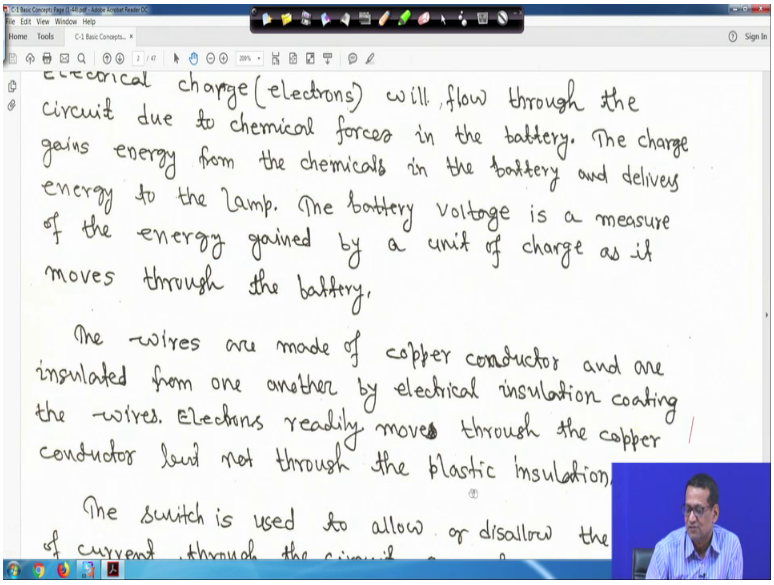

And, but question is the wires are of made of copper conductor I just told you and had insulator from one another by electrical insulation coating the your coating the wire that you have seen that you have seen. So, electrons actually readily move through the copper conductor, but not through the plastic insulation. So, this wire is there, but it is your plastic insulation right and that switch I told you it will allow this allow the current.

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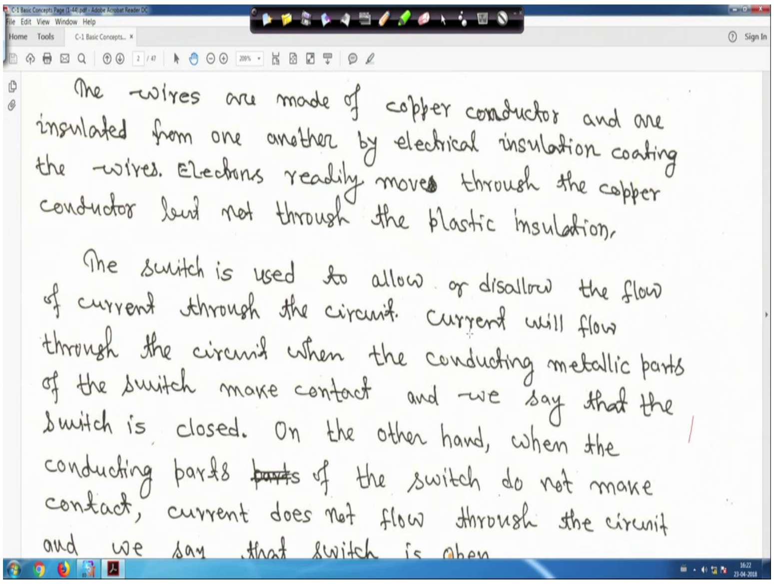

If you close the switch current will flow if you just open it and current will not flow.

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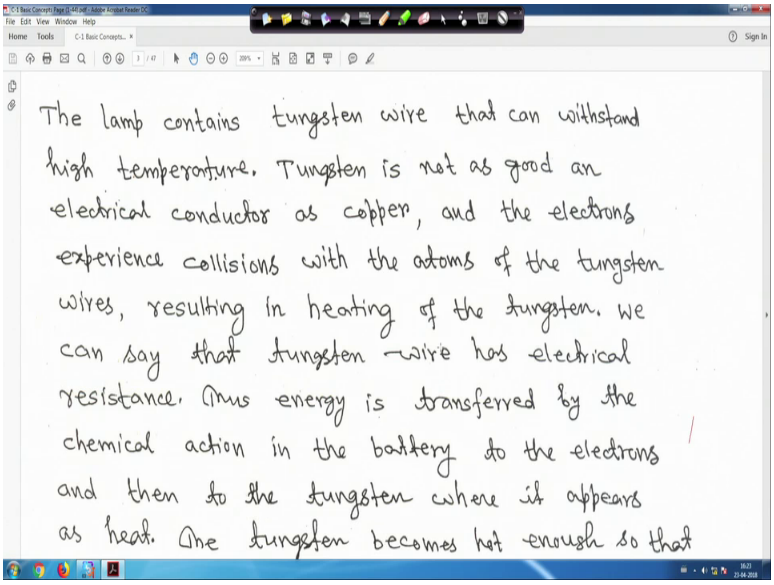

So, and the lamp actually I told you it contains tungsten wire it can withstand high temperature. So, tungsten is not as will be as your electrical conductor or as copper and electrons actually experience collisions with the atoms of the tungsten right and that is the tungsten wires, because that if that is to the copper conductor that your what you call charge or electron is flowing and it will make a your what you call collision with the atoms of the tungsten wire. So, therefore, resulting in heating of the tungsten and we can say that tungsten wire had electrical resistance.

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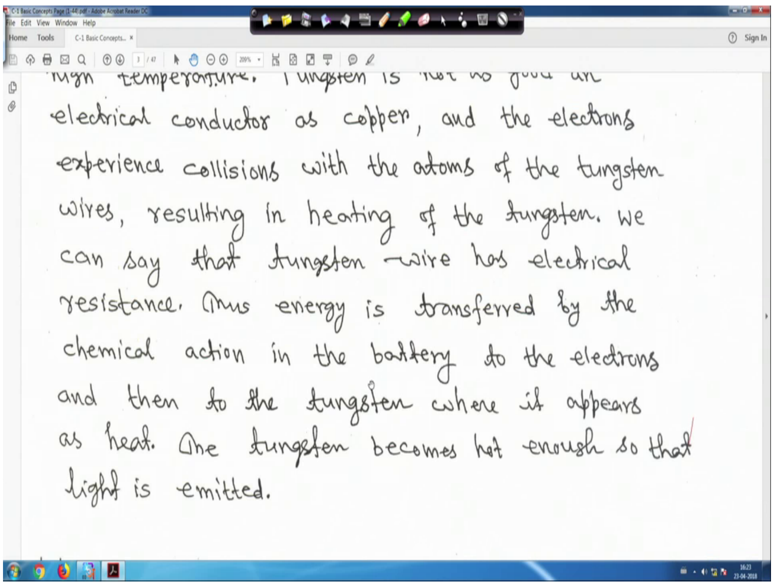

So, thus energy is transferred by the chemical action in the battery to the electrons right and then to the tungsten where it appears as heat. So, the tungsten becomes hot enough so, that light is emitted. So, I will put a question to you that your a that is your is many questions on this thing when I will move that. So, whatever that electrons flow just let me go to this circuit just hold on, is that actually electrons is flowing through this copper conductor, when it come to that is at collision actually we that of the tungsten and therefore, it is causing as you know heat.

So; that means, we can say the tungsten has an electrical resistance right and I will put a question here that we have seen that your that bulb 40 watt, 60 watt, and 100 watt and so on. So, they have all the filaments tungsten filaments say so, a question to what is the diameter on this, your this tungsten filament because if you see then you will find it is look like a coin right and what is that your diameter of this tungsten filament this is a question to you.

So, this is actually your, what you call that, how that we get that, your bulb this thing right. So, 40 watt that later will see 40 watt, 60 watt or 100 watt right. Therefore, the energy is transfer by the chemical action in the battery because battery has a chemical action. So, that energy is transformed in the electrons and then to the tungsten where it appears as the heat. So, tungsten becomes hot enough so, that light is emitted. So, this is a basic philosophy you have your what you call that is simple circuit is simple dc volt a simple switch wires and your tungsten lamp. Whatever you see in that your what you call 40, 60, your 80 sorry 100 watt bulbs.

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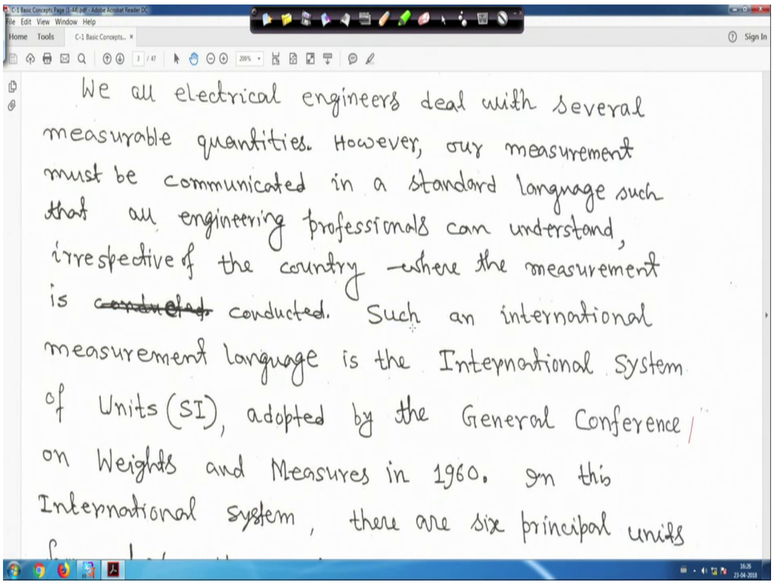

So, now system of unit actually in all electrical engineer is this thing we deal with several measurable quantity like quantities like voltage your then current ampere right power watt and so on. So; however, I have measurement must be communicated in a standard language, such that all engineering professionals can understand irrespective of the country where the measurement is conducted such an international measurement language is the international system units.

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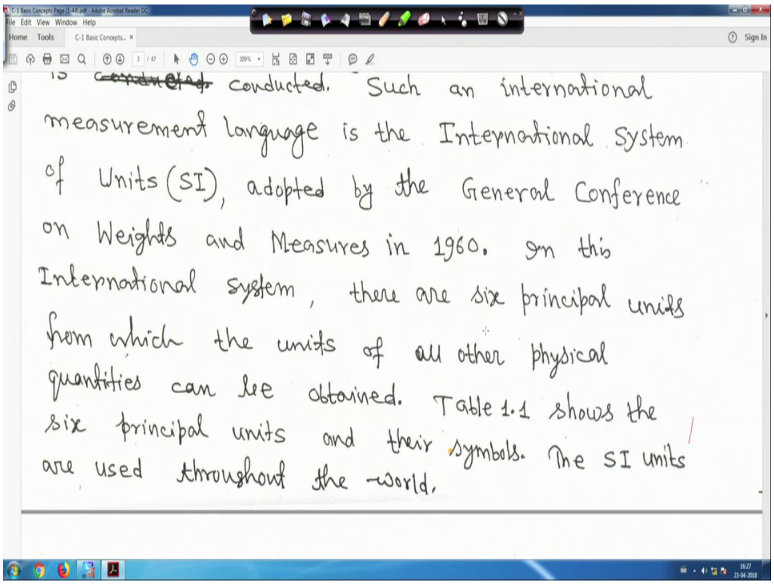

That is we call in short SI unit right, it is a international system units we call SI units right. So, adopted by the general conference on weights are measured that was in 1960. So, we follow that your what you call that SI is SI units, we call international system u of units in sort we call other way we call is SI right. So, basically in this international system there are 6 principal units basically 6 only 6 principal unit, we need from which the units of all other physical quantities can be obtain right.

So, just I am giving with this 6 units so, table 1.1 it shows the 6 principal units you needs and there symbols the SI units are use through the throughout the world right.

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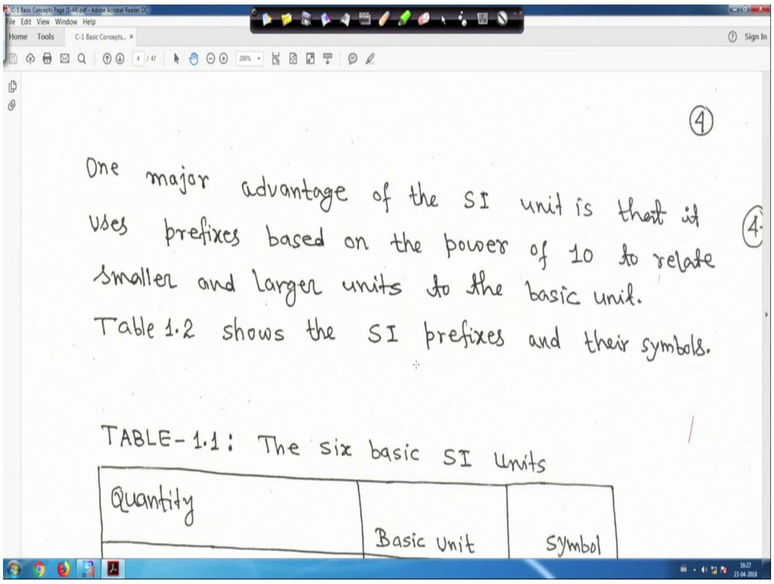

So, one major advantage of the SI unit is that, it uses prefix says based on the power obtain and to relates smaller and larger units to the basic units. So, table 1.2 shows SI prefixes and that symbols will come to that first this 6 basic SI units right.

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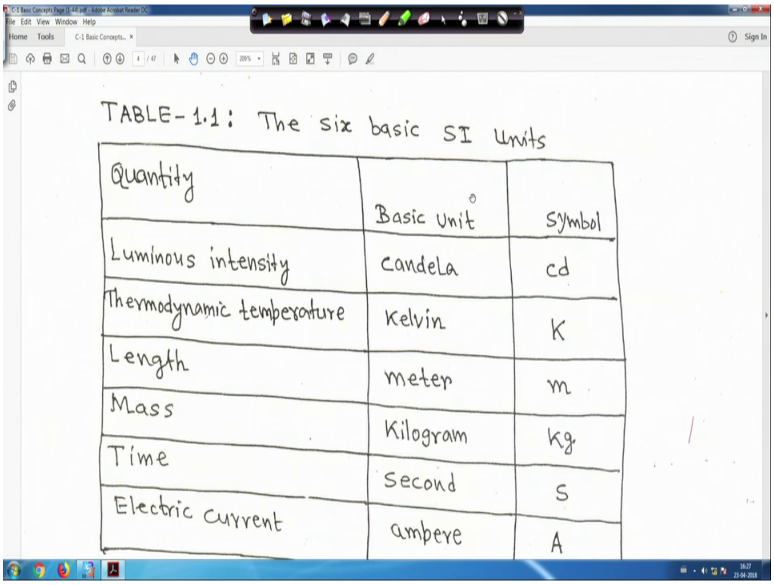

So, this is the your six basic, one is luminous intensity candela that is it call cd, another is the thermodynamic temperature Kelvin in sort in your symbol is K and is the length meter symbol is m, another is mass kilogram it is kg, another is time it is second, an electric current in ampere A this is the 6 standard international or your what you call SI units form which other can be other can be obtain. So, this is the stat 6 say your basic SI units. So, it should be in your mind and then your table 1.2 it is actually will see that the SI prefixes.

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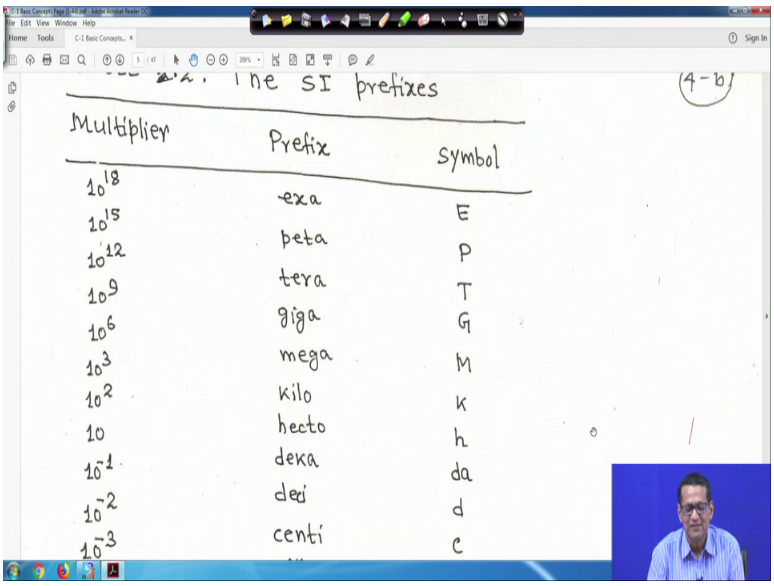

So, there are many 1 or 2, I am making that like if it is 10 to the power 18 it call exa it is symbol is capital E, you know this is 10 to the power 15 you call peta it is capital is your what capital P, we call 10 to the power 12 you call tera it is T, then 10 to the power 9 right. So, it is giga it is G, then when come 10 to the power 6 it is mega right it is M and so on, 10 to the power 3 is actually it is a not coming to alien to this, but 10 to the power 3 means kilo. So, accordingly number accordingly numbering you can make it right it is k so, these way your deka, desi, centi, milli, micro all.

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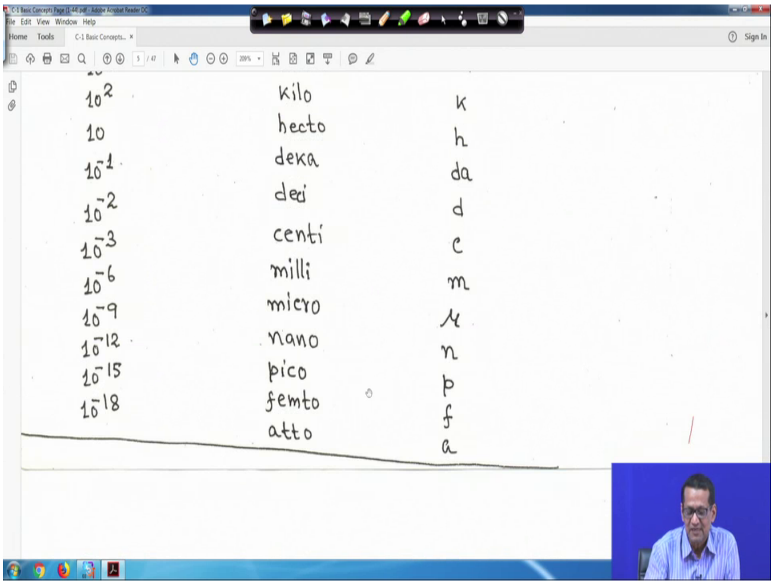

But last one is 10 to the power minus 18 it is call atto in small a we call a, 10 to the power minus 15 it is called femto f and 10 to the power minus 12 it is pico p and so on. So, from 10 to the power 18 the 10 to the power plus 18 to 10 to the power minus 18 these are actually your, what you call the SI prefixes this is multiply this is prefix and these are the symbols. So, first basic 6 SI units and these are your what you call the SI prefixes so, this we should know right. Next is the charge and current.

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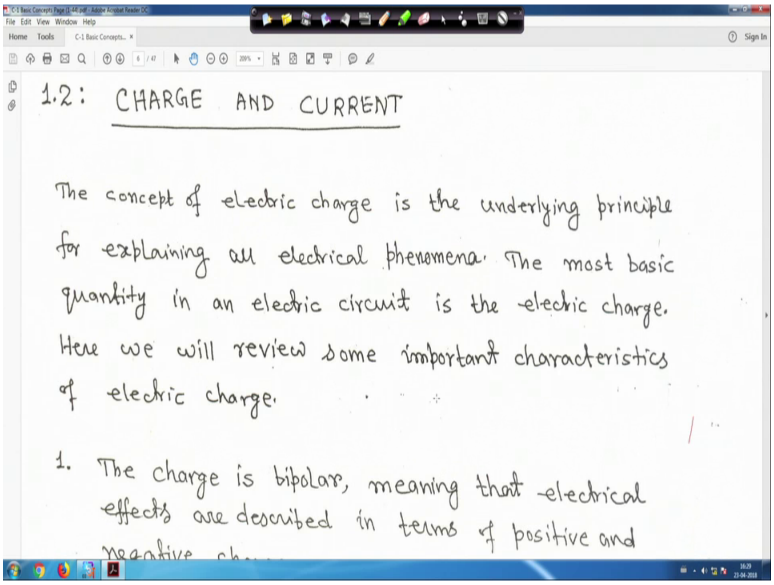

Now, the concept of electric charge is the underlying principle of explaining all electrical phenomena, the most basic quantity in an electric circuit is the electric charge, here we will review some important characteristic of electric charge.

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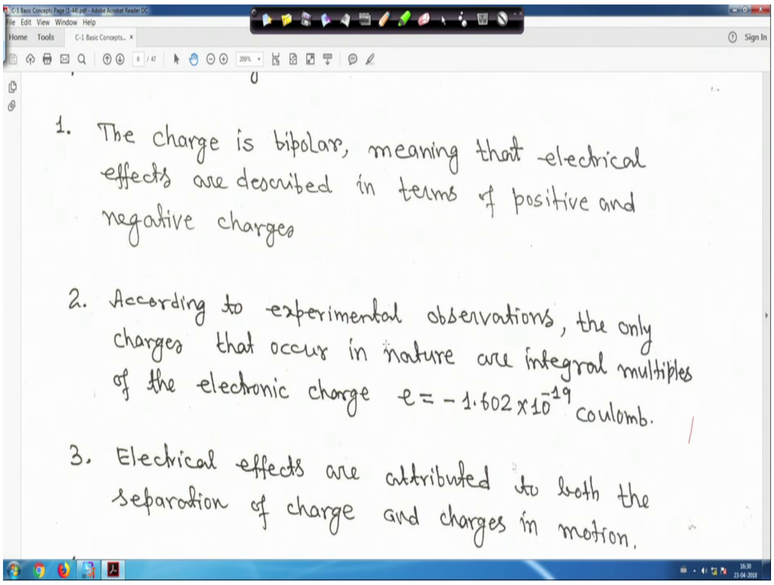

Then will come to the current actually current is the rate of change of your what you call the charge flow. So, will come to that the first one is the charge is bipolar, meaning that electrical effects are observed in your are describe in terms of positive than negative charges right. So, charge is bipolar so, it means electrical effects are describe in terms of positive and your negative charges the first thing.

Second thing is according to experimental observation, the only charges that occur in nature are integral multiplies of the electronic charge that e is equal to this will know from your class 12 physics also, e is equal to minus 1.602 into 10 to the power minus 19 coulomb right. So, this is your the only charges that occur in nature or integral multiples or the electronic charge that is this value.

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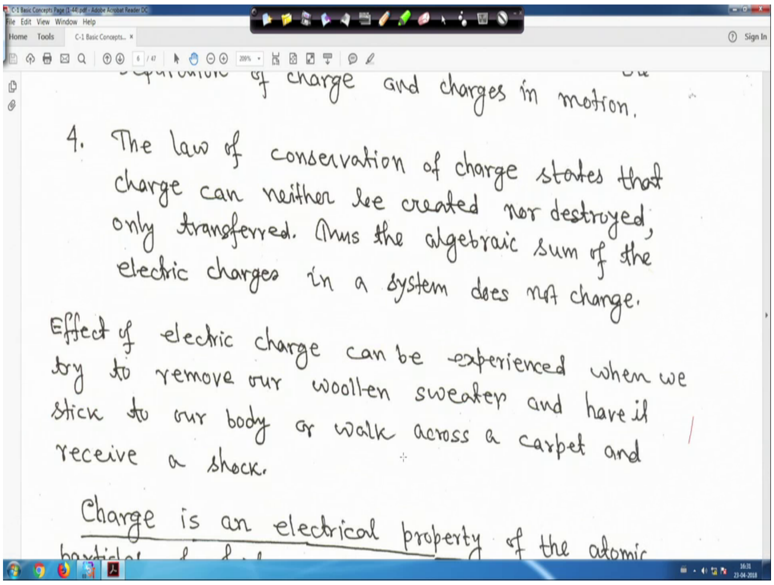

And third point is the electrical effects are attributed to both the separation of charge and your charges in motion and the fourth point is the law of conservation of charge state that charge can neither be created nor destroyed only transferred right. So, it neither you can create nor you can destroy only it can be transferred right. Thus, the algebraic sum of the electric charge is a system does not change.

So, the fourth one is very important right so, this should be in your mind. So, effects of electric charge can be experience when we carry to a remove our woolen sweater I mean you might have seen also remove our woollen sweater and have it stick to our body or walk across a carpet and receive a shock. Other electrical charge I mean if you I mean when remove our your woolen sweater, you know you can see that it is your sticking and our body this is due to the electric charge or sometimes so, we get some kind of shock when you are working you know you receive a shock when you are working only carpet.

Other thing is that you take a very small pieces of paper and keep it and if you raw away take a plastic and raw we can your hair and just after that you hold it on the piece of paper you will find that all piece of papers are attracted towards their what you call towards that your that plastic right you can experience of your own so, anyway.

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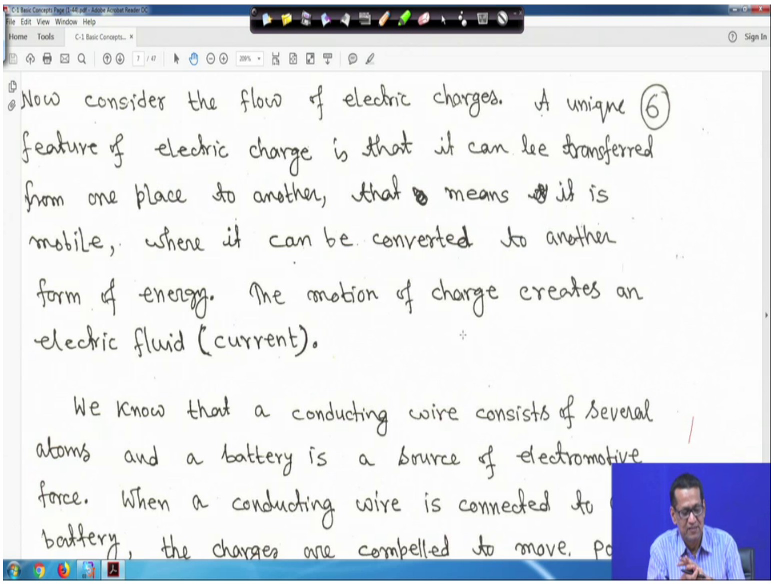

So, therefore, charge is an electrical property of the atomic particles of which matter consists measured in coulomb. So, charge unit of charge is a coulomb and it is an electrical property of the atomic particles of which matter actually consist so, measure in coulomb.

Now, consider the flow of electric charges a so, actually this is actually you do not look it this as the page number right. So, now, consider the flow of electric, a unique feature of electric charge is that it can be transfer from one place to another place; that means, it is mobile; that means, charge can be transfer for one place to another. So, in cities mobile when it can be converted to another form of energy right and the motion of charge creates and electric your fluid we call it is current.

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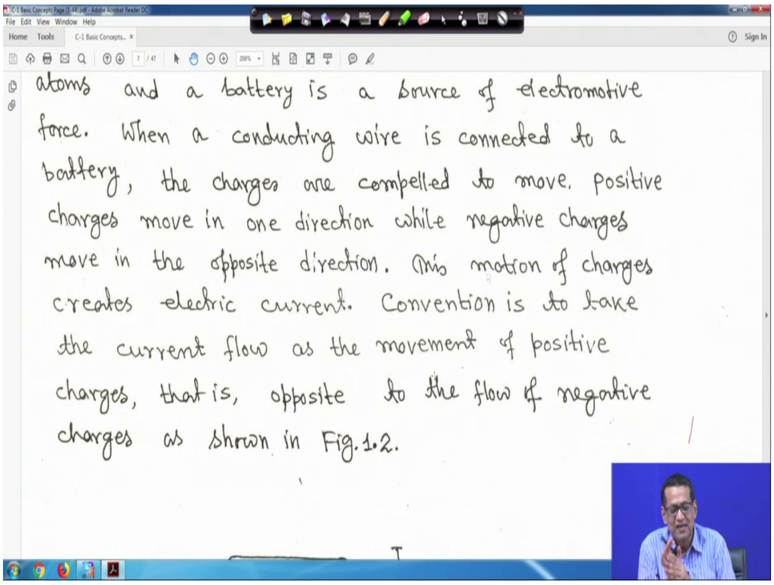

So, the little bit way of to see that when you, we know that a conducting wire consists of several atoms right and a battery is a source of electromagnetic force. So, conductor conducting wire consist of several atoms and a battery is a source of electrometric force, when a conducting wire is connected to a battery the very fast example what we saw that voltage source is switch, conducting wires and a transient lamp right.

The charges are compelled to move so, as soon as a, you know battery is there a conducting wire is there so, as soon as the connected the wire that was the battery. So, what will happen, charges are compute to move positive charge is move in one direction and the negative charges move in the opposite direction a very simple logic this motion of charge is create electric current.

Now, which direction of the charge we will consider the direction of the current, convention is to take the current flow as the movement of the positive charges that is opposite to the flow of negative charge is as shown in next figure 1.2.

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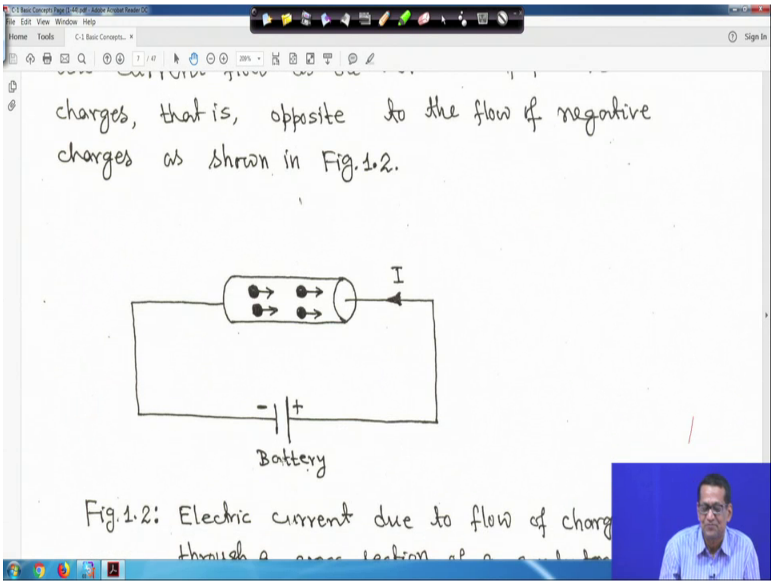

So, if you look at this, suppose this is battery this is shown little bit you know bigger way to show that your charge flowing. So, this is actually negative charge flowing, this is the negative terminal, this is the positive terminal. So, the charge will flowing in the direction of the your what you call positive flow of charge so, this way.

So, that is the from plus so, this is the convention so, this the direction of the current or in other way it is opposite to the flow of the negative charge, this is the flow of negative charge it is move this is minus so, it is moving in a other way. So, this is actually convention therefore, if you look into that the convention is, this is the convention is to take the current flow or the movement of positive charge is that is opposite to the flow of the negative charges as shown in figure this is figure 1.2.

So, the way the direction of the positive flow charge is these are the direction of the current or the opposite to the directive flow of the charge. So, the electrical effects caused by charges in motion depend on the rate of charge flow, the rate of charge flow is known as the electric current suppose if q is the charge, t is the time and i is the currents. So, i actually is equal to dq by dt.

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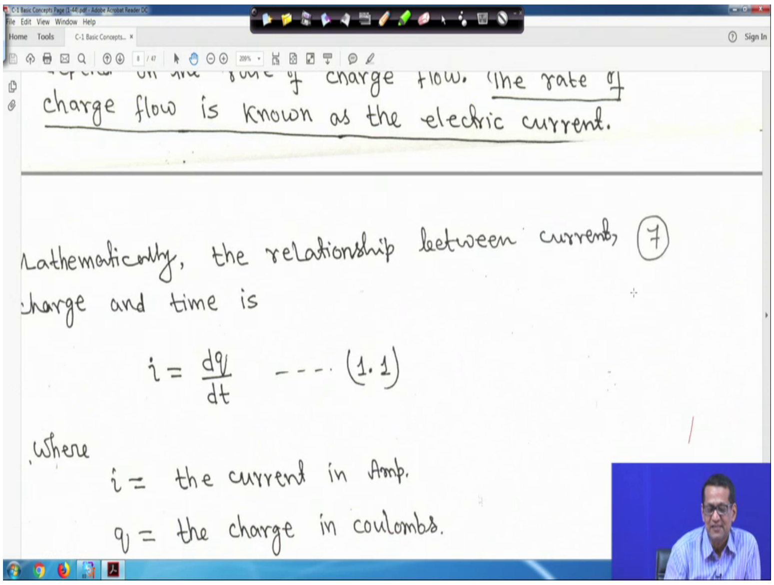

So, mathematically the relationship between current and charge and time is different in that i is equal to dq by dt this is a equation 1.1, that i is that current in ampere, q is the charge in coulombs and t the time in second. So, basically current is the your what you call by is equal to dq by dt.

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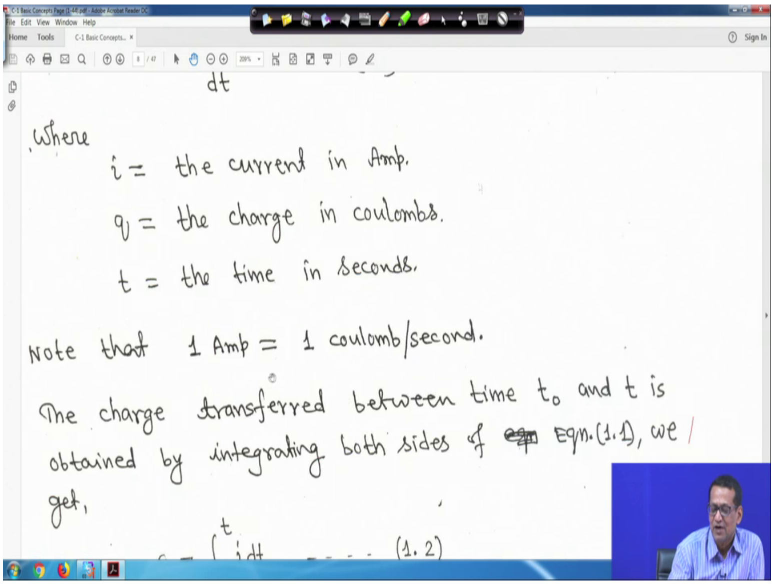

If note that 1 ampere is equal to 1 coulomb per second; that means, if this side is 1 ampere this side it has to be 1. So, this is coulomb, this is second so, it will be 1 coulomb per second right.

Suppose if q for example, a suppose you take the data in such a fashion such that the dq is 5 dt is also 5 so, that way. So, it will be your what you call that per 1 coulomb per second right. So, the charge transfer between the time t 0 and t is obtain by integrating both side of equation 1 we get; that means, suppose at initial time t is equal to t 0 and your final time is t, then if you integrate this equation if you get this equation therefore, that q can be made that is equal to t 0 to t idt ; that means, this one of you come that your dq is equal to i into dt, therefore q is equal to integral of t 0 to t then idt.

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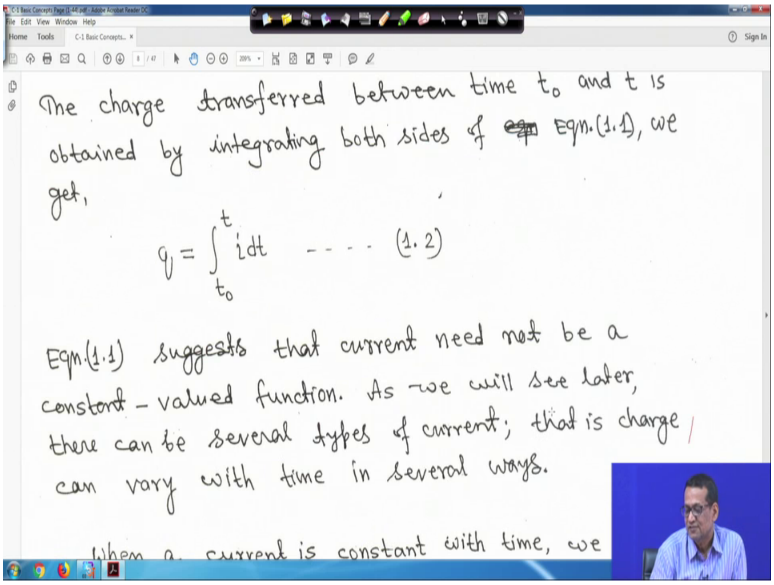

So, that equation we are writing q is equal to t 0 to idt; that means, charge transferred right if between time t 0 and t. So, this is the equation q is equal to t 0 to t idt, this is equation 1.2 right so; that means, equation 1 suggest that current need to be a constant valued function that means, here from this equation 1 it suggest that current actually need to the constant valued function right.

So, constant valued function as we will see later that can be several types of current that is your charge can be vary with time in several ways. We will see both bc and ac, ac at the time you will see current is time warring right and for dc actually current is constant so, it will not time warring right.

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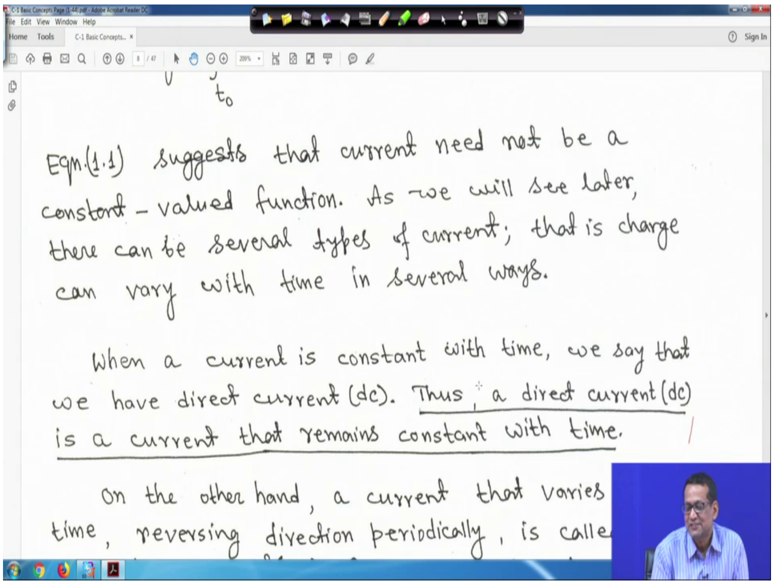

So, when a current is constant with time right, we say that we have direct current that is dc current, I will show you the diagram thus a direct current is a current that remain constant with time. So, I mean it is your what you call it is your whatever may be the time the current is constant.

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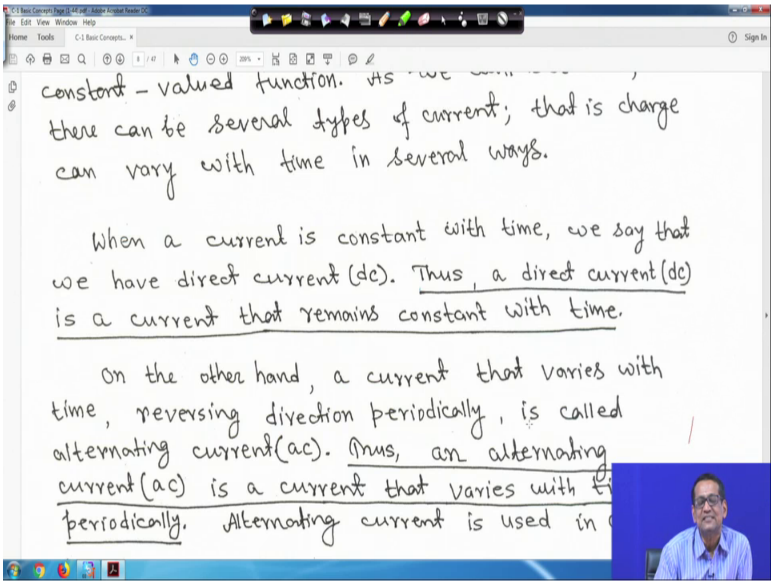

On the other hand, a current that varies with time and reversing direction periodically that is plus minus plus minus say right is call the alternating current, this alternating current we will see for ac circuit not now, but little bit of diagram and other things I will show you for the sake of your what you call understanding. So, thus an alternating current is a current that varies with time periodically right so, that means, it will be plus minus plus minus.

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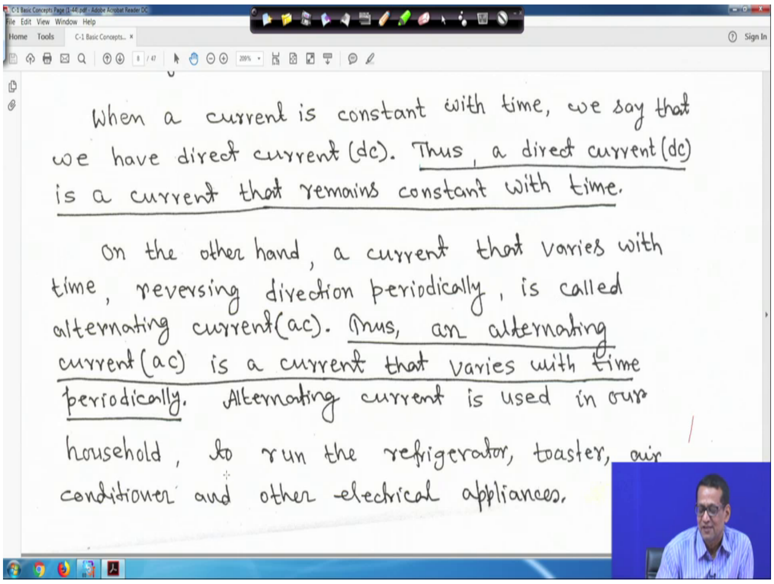

So, alternating current is use in our house hold the because all our household everything is ac source, ac power right. So, ac circuit will see later first dc then ac to run the refrigerator, toaster, air conditioner and other electrical appliances, whatever ac dense will get these are all your ac power ac voltage ac current right.

So, but dc it has current is constant so, figure 1.3 actually shows the values of a dc current and then sine sudden ac current.

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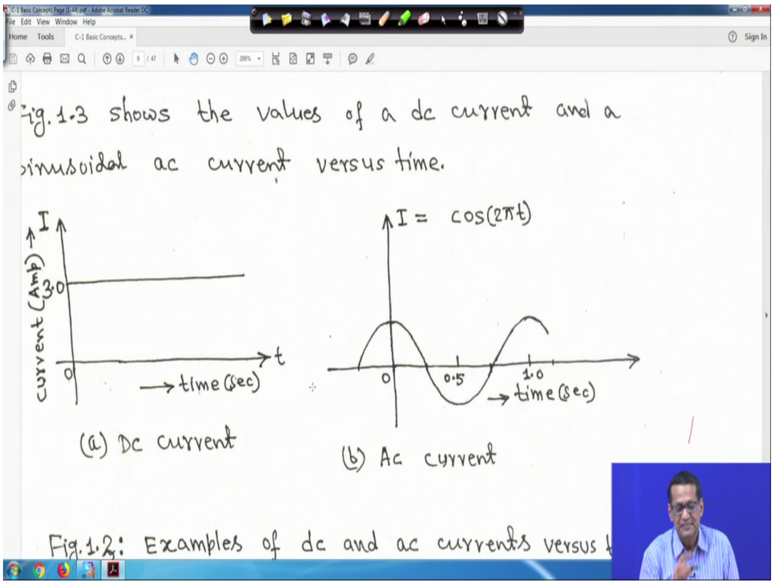

So, in this case you are this is understand the wave, this is sinusoidal and little bit as portion as cutter or this is sinusoidal or this is figure 1.3. So, this is a dc current, this is current, this is time second, it is the constant suppose current dc, current is that 3 ampere it is constant right.

Final this is actually a periodic this is periodically changing from plus to minus. So, this is ac current this is a cosine function and this is your ac current it is given i is equal to say cosine 2 pi your 2 pi, t just hold on that this is the function, i is equal to cos 2 pi t right. So, this is ac current ac current will see later.

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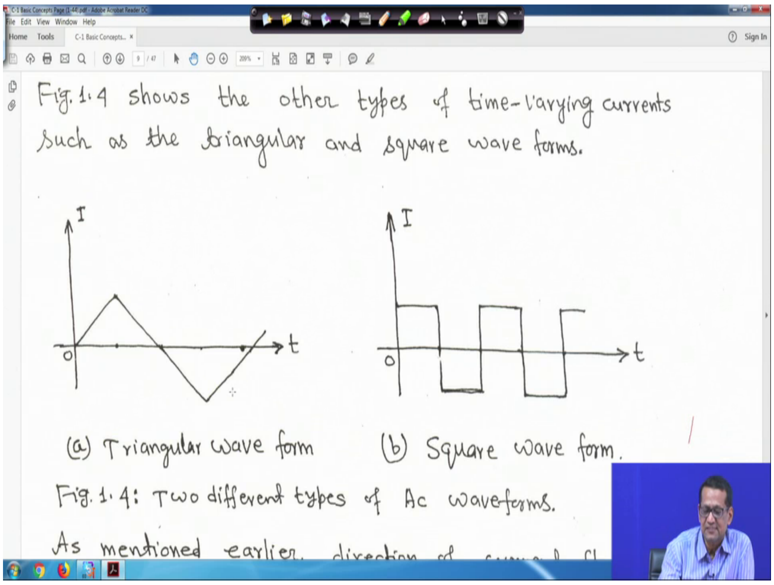

So, and this is a example of dc current, now figure 1.4; that means, this one such the other types of time warring current such as the triangular and square wave, this is also time warring current this is triangular function this is current and this is also it is rectangular one, this is also changing periodically. So, plus minus, this is also, this is triangular wave from this is square wave from this is also alternating, alternating current right.

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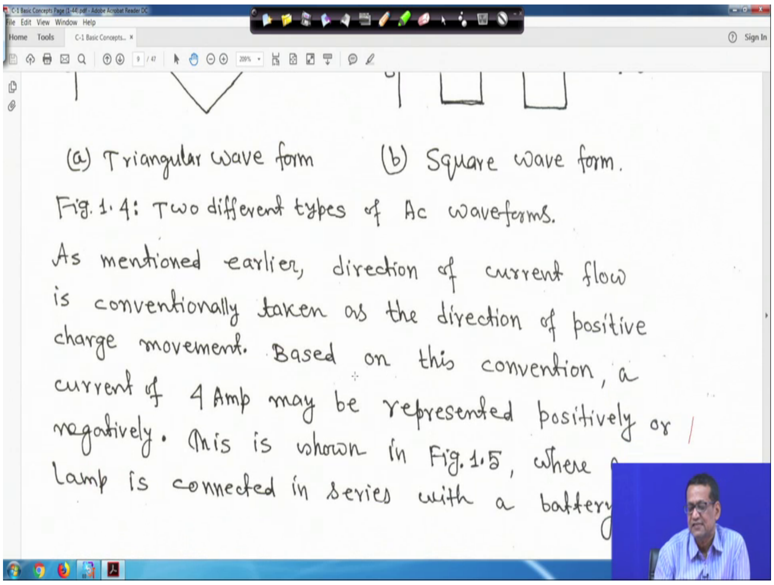

So, now as we have seen earlier the direction of current flow is conventionally taken as the direction of positive charge movement I told you, that current when you take the battery symbol plus minus form the plus the positive charge is flowing. So, that is why is taken has direction of the positive charge movement.

So, based on this convention a current of 4 amperes say may be represented your positively or negatively, this is shown in figure 5 where a lamp is connected in series with a battery look how it is.

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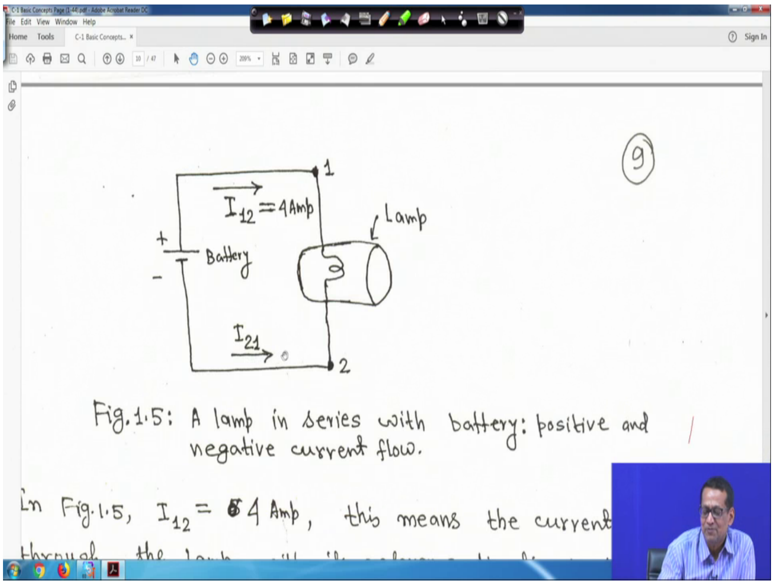

Starting from this let us will try to understand the if we start to understand everything the later stage we will find things say are things are become very simple to us. So, what will do, the just tried to understand the basic flow basic understanding if this is clear then you will find circuit theory this your what you call this circuit pattern another thing is a very simple for example, this is a battery, that is a battery symbol another thing so, will come later.

There is a battery, this is plus symbol, minus symbol and this is your 2 terminals are mark 1 and 2 right and this is your say tungsten lamp, this is a lamp and when you take the 4 ampere current says flowing say 4 ampere current is flowing. So, it is 1 to 2 it is given 1 to 4 ampere, then what will be I to 21 it will just opposite know it will be minus 4 because this current actually moving like this, when you take this current is coming like this I 12 and, but when you take reverse a direction that I 21 it will be minus 4 ampere.

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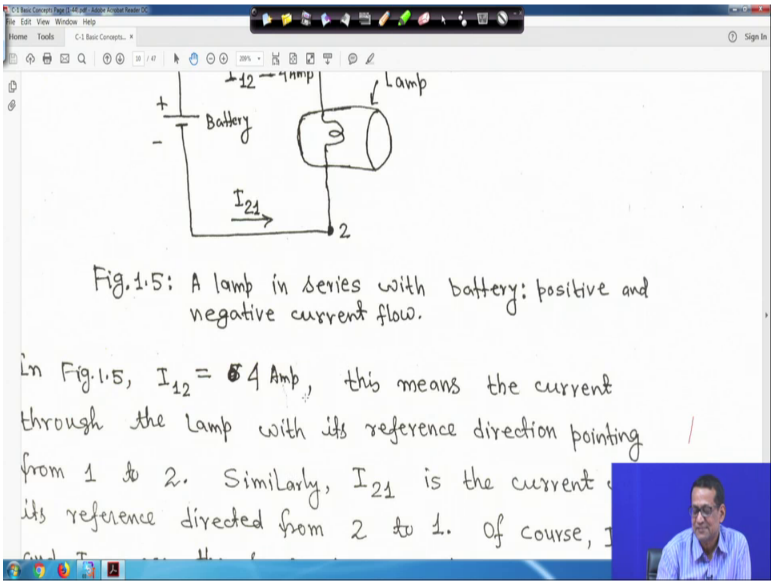

So, in this figure I 12 is 4 ampere this means that current through the lamp with it a reference direction pointing from 1 to 2, that this is a reference direction 1 to 2 that if you take 12 to 4; that means, current is flowing 4 ampere 1 to 2 positive right. But if you take other way or suppose if you take 2 to 1 that it will just negative sine, it will be minus 4 ampere, if you take 2 to 1, just reversal of the your what you call the direction because here we have taken I 12 here we have taken I 21.

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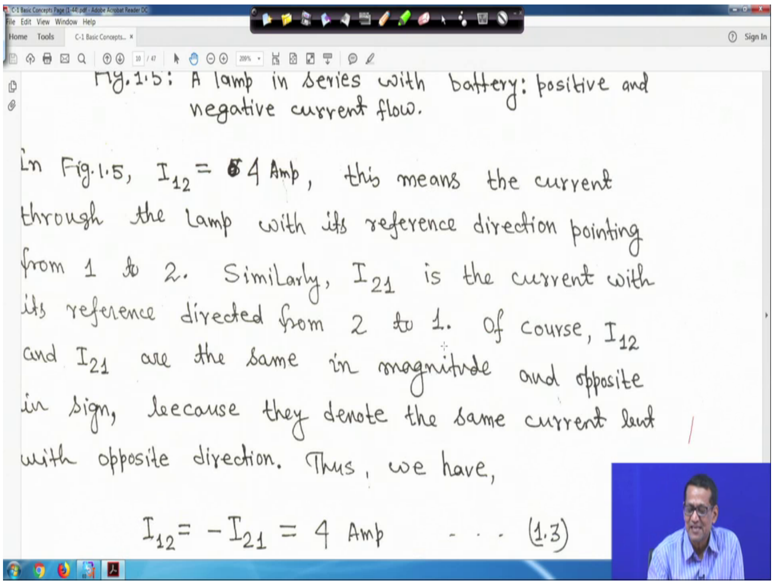

Therefore, your I 21 is the current to the with it is reference directed from 2 to 1 of course, I 12 and I 21 are the same in magnitude and opposite in sign so, because they denote the same current, but with opposite direction. Thus we have I 12 is equal to minus I 21 is equal to 4 ampere that magnitude is same , but I 12 is 4 ampere therefore, I 21 is equal to minus 4 ampere so, this is equation 1.3.

So, this part is very simple, but understandable if you; that means, direct reference direction 1 to 2 means from 1 to 2 4 ampere if you take this is reference written 2 to 1 the sine is change, then I 21 should be minus 4 ampere therefore, I 12 is equal to minus I 21 is equal to 4 ampere, current magnitude will remain same only the sine part right other way. So, this is actually little bit understanding of the current, next is the voltage.

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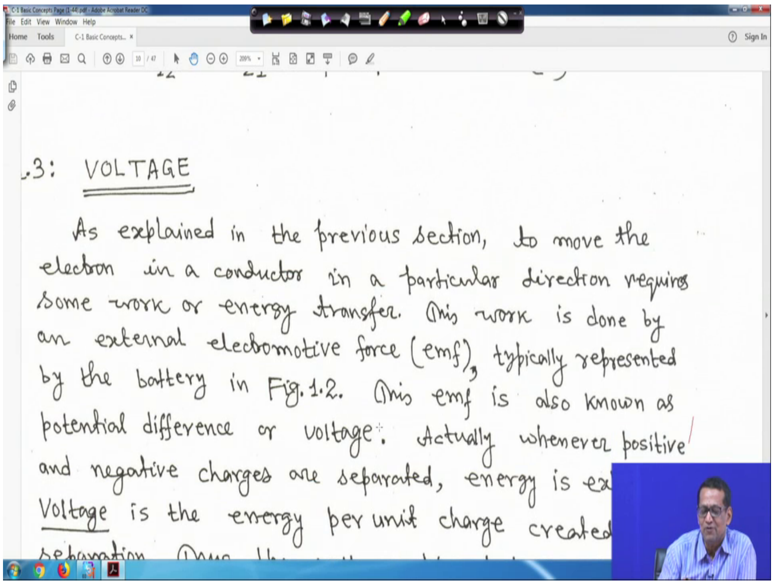

So, now current part is (Refer Time: 27:43) voltage, as explain in the previous section just now to move the electron in a conductor in a particular direction if require some work or energy is transfer right. So, this work actually is done by external electric electro motive force emf, typically represented by the battery as shown in figure 1.2 right so, this is your figure 1. 2.

So, this is actually external electromotive force emf, typically represent by the battery figure 1.2 will come, this emf now this figure 1.2 you have seen that your one voltage source, then your what you call the transient filament law right. This emf is also known as potential difference or we call sometimes voltage right, actually whenever positive and negative charges are separated energy is expanded.

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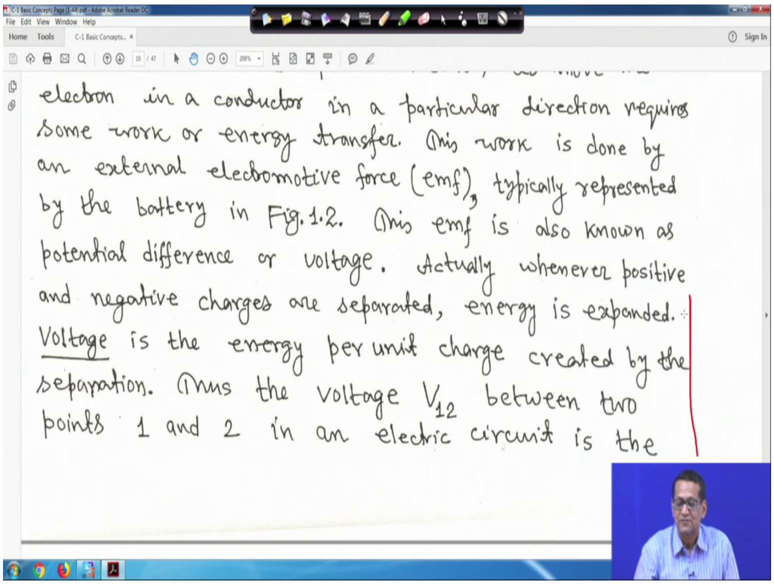

So, this emf is also known as the potential difference and voltage. So, actually whenever positive and negative charges are separated energy actually is expanded. So, voltage is the energy per unit charge created by the separation. Thus the voltage say V 12 between 2 points, 1 and 2 in an electric circuit it is something like this suppose electric.

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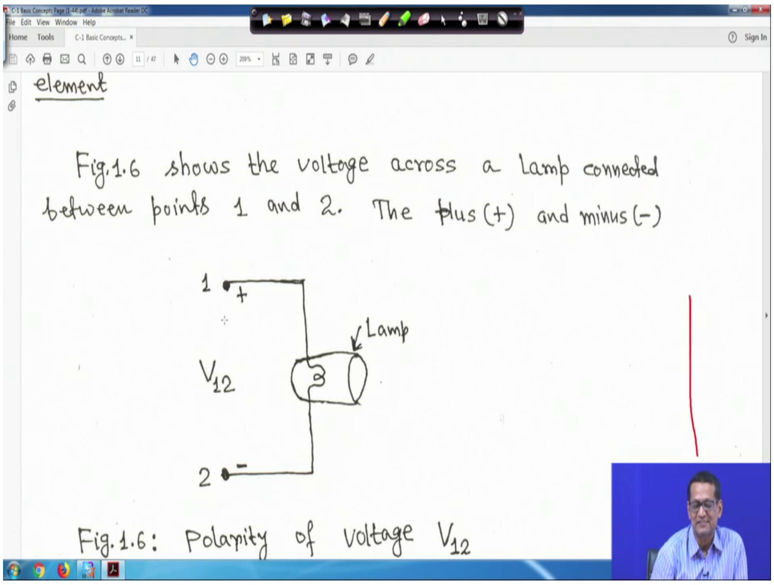

This is your actually 2 points say will come to that other thing, this is the 2 point this is 1 and 2 and this is the voltage say V 12 and this is the lamp right.

Therefore when you come here thus the voltage V 12 between 2 points say 1 and 2 in an electric circuit is that energy or work needed to move, a unit charge from 1 to 2. We express this ratio in differential form that is b is equal to small v is equal to capital V 12 suffix is equal to d w upon dq, for w is the energy in joules, q is the charge in coulombs and V 12 the voltage in volts. So, voltage actually that is your V 12 actually dw of dw by dq the w is the energy in joules and q the charge in coulomb.

So, in equation so, this is actually your equation 1.4 therefore, equation 1.4 it is evident that 1 volt is equal to if it is this side is 1 volt it will be 1 joule per coulomb. So, that is why it is 1 joule per coulomb or 1 joule is equal to your 1 Newton meter. So, one Newton meter per coulomb, but 1 joule per coulomb there will be used.

So, thus voltage or potential difference is the energy required to move a unit charge through an element right you will just I just I say thus why underline the voltage or potential difference is the energy require to move a unit charge through an element like figure look at the figure, figure 1.6 source the voltage that was a lamp connected between points 1 and 2, the plus and minus symbol sines are also given. So, this is the polarity this is 1 and this is 2, 1 is positive, 2 is negative. So, sines are used to represent reference direction of voltage polarity.

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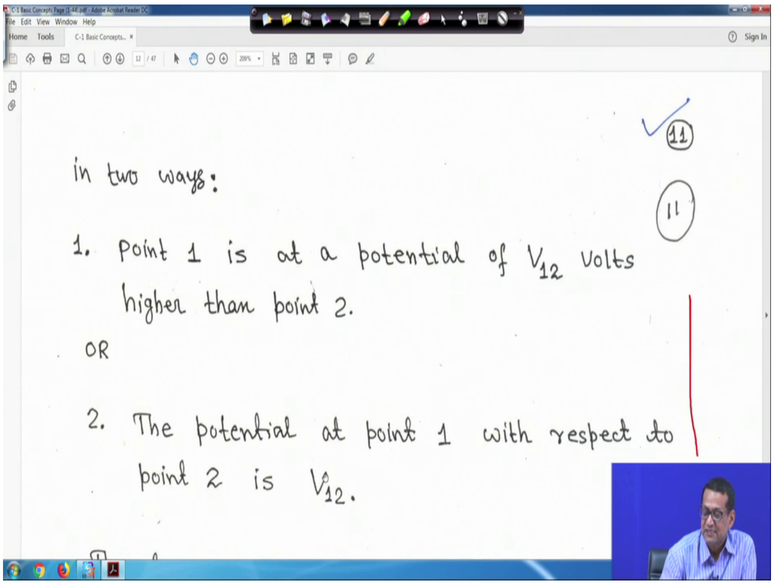

So, the voltage V 12 to can be interpreted as your in 2 ways first thing is this point you try to understand first one is the point 1 is at a potential of V 12 volts higher than point 2, look at this diagram right, it this point is your at a potential of V 12 higher than this your what you call that other point 2. So; that means, point 1 is at a potential of V 12 volts higher than point 2 or the potential at point 1 with respect to point 2 is V 12 or the potential at point 1 with respect to point 2 is V 12 second one easy at to remember right.

So, this is the concept the plus minus right. So, in this case either point 1 is at potential or V 12 volts higher than point 2 or the potential at point 1 with respect to point 2 is V 12 right. So, therefore, the logically it follows that V 12 is equal to minus V 21 ; that means, if you take say we suffer example say just for example, say V 12 is equal to just one minute say.

Student: Sir, transient (Refer Time: 32:18).

Student: May maybe is could.

White board.

Student: White board (Refer Time: 32:39).

Ok

Thank you we will be back again.

Thank you.