Experimental Physics I
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Lecture – 07
Basic components

So, today in this lecture, I will discuss about the Basic Components in laboratory.

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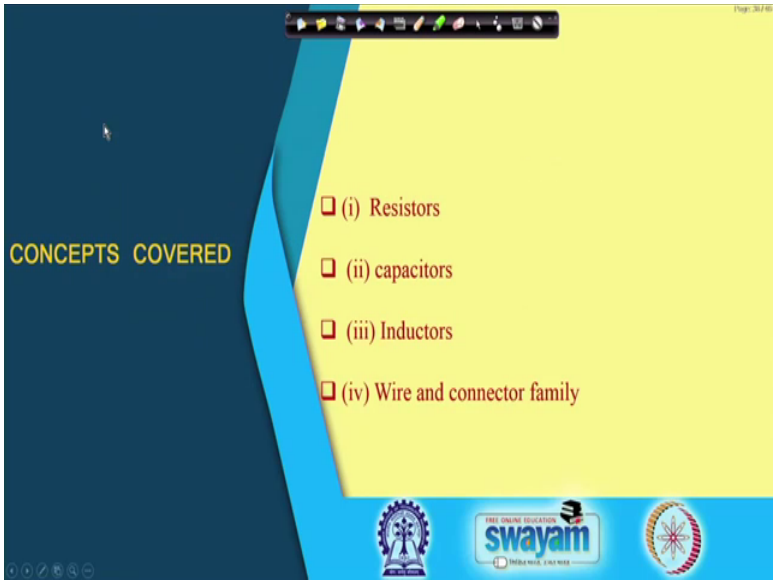

So, this basically I discuss about the resistor, capacitor, inductor. So, these 3 are very basic components electrical or electronics components in the lab and they are very important it is not that you will use this components in your lab. But in future you need these components to everywhere wherever you want to plan to fabricate some students or to set up some experiment. So, this components is very essential. And then just I will show you these some different types of wires and connectors we use in laboratory.

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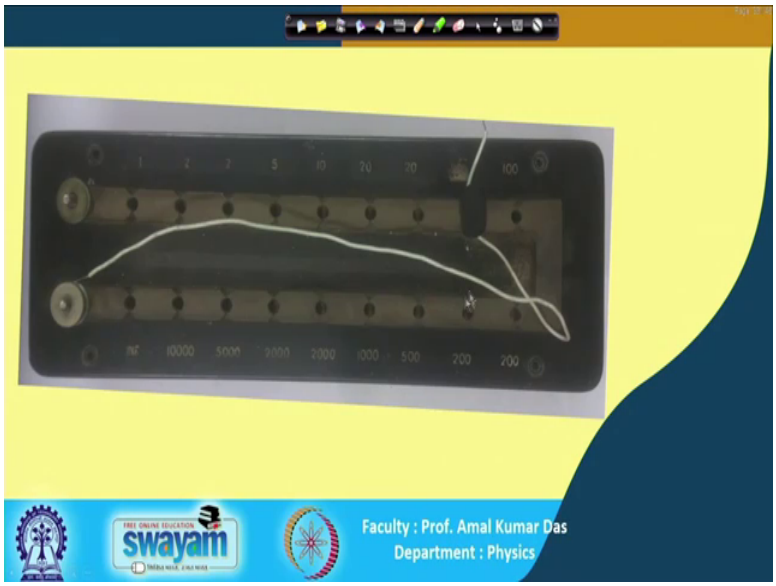

So, first is this very common components that is the resistance box right so, this box figure I have taken.

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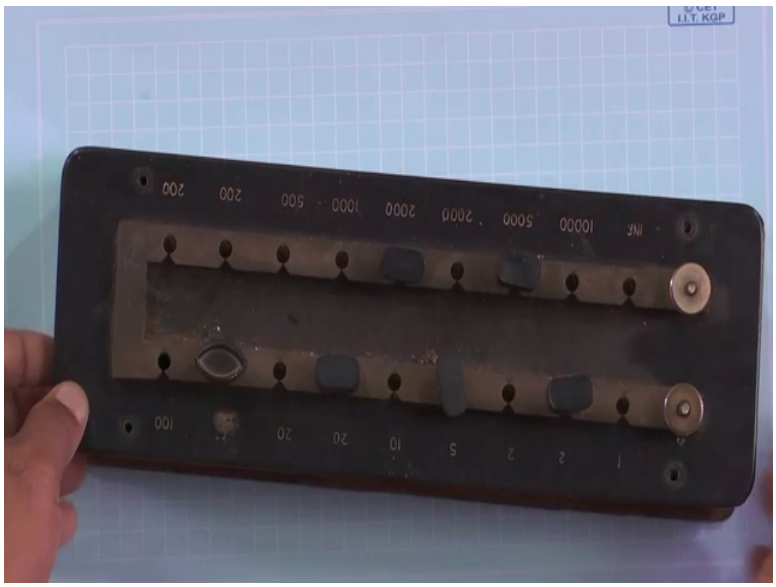

So, basically from on left so this resistance box and all of you have seen in laboratory. So, this resistance box here it is a resistance is a 1, 2 then 5, 10 right the up to it is the one it is a 10000 ohm. So, these 2 are thus in connection; so we with we connect these 2 in our circuit. So, when we connect this 2 in our circuit. So, this is the resistance included in the circuit.

So, you know this these are the key. So, when I put key here; that means, this resistance 1 is shorted. So, this resistance 1 is shorted; so it will not include it will not be included in the circuit. So, this is just this key we use to shorten this resistance of, but to bypass this resistance.

Basically see if I put this a these 2 resistance. So, this wherever I have put; so, this resistance will not be included in the circuit. So, open part; so this will be included in the circuit ok. So, this is the principle of using this resistance box right. So, how it how it is happening see if we want to see. So when I I put it here; so I am telling this resistance is not include in the circuit.

So, what is the mechanism here we have used so that this putting key is basically excluding the this resistance and opening the key is basically including the resistance. So if you want to know; so, we have to open this box and see what is in inside. So, already there is the to screw over there to 4 screws are there.

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So, this if I already I have unscrewed it and if I open it; so you can see, so you can see this box you can see the box this is the wooden box nothing is inside.

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But opposite side of this resistance box this top part is if you just rotate it. So, what you are seeing? You are seeing just this; you see these are this wire threaded right here very thin wire. So, this it is we have rounded it on a some insulating wheelers.

So, if you see this one; this one this it is very few turn of wires here and here maximum turns of wires are here. So, if you see this on here it is written; this resistance is 1 right; resistance is 1 which is return resistance is 1. So, this is basically this one and this other one this one where the maximum transfer there same wire maximum transfer there. So, if you will just see what it is? So, it is the maximum resistance right 10000 ohm.

So, basically it is why here more number of transfer there than this one? Because this wire itself gives resistance. So, this resistance is basically is R equal to rho l by A R equal to rho l by A. So, rho is the resistivity of the material of this wire ok; the wire is made of some material right.

So, resistivity of this material is rho and into l divide by a right. So, l is length of the wire and a is the radius of the wire; so radius of the wire also here fixed. So, rho and a not a is radius is the area cross sectional area of the wire ok, cross sectional area of the wire; so that is also fixed. So; now if you take more and more length so, resistance will be more and more. So, here these resistance if varies with the length of the of the wire.

So, here this highest length of the wire; so this number of transistor more ok; so this is the just principal here. Now, you can see each one is; each one is connected. So, this resistance it is connected by these wire with the next one then it is connected with the next one; so that way; so all are connected all are connected. So, one end is here and another end is here.

So, this is the 2 end; now from here ok. So, it is not that the 2 end it is basically here this again is connected in this here ok; these 2 is connected here. So, it is basically starting from here to this then it is from top it is connected it is connected then come back and then it is this is the 2 place wires they are connected here; they are connected here.

So, basically now you understand this is basically one resistance you know it is a one resistance from in bottom it is the one wire not resistance it is one wire. Now ,this now they are divided into different parts they are divided into different parts and that it is divided from here; means here this is the it is a breaking point these are continuously it can be continuously may be continuously connected if this whole system they are.

See if I put this ok so, then it says it will it will be connected; it will be connected. So, current when it will go; so, there will be 2 paths one it can go through this wire or another it can go through this one. So, since this is less resistive path; so current will flow this way when it will come here. So, this path is open means it is a very high resistance; so, in 5 resistance. So, current will not go this way it will then it will go through this wire.

So, bypassing this 2 it will go this with their through the third one; so, that way of this resistance box is fabricated and mechanism is very simple, but interesting. So, now, after seeing this one now you when you will use it you will understand that when you are putting why it is shortened; when you are taking out then why this resistance is included.

So, this is the box we used in the laboratory as well as there are other resistance also use the stereo state is another kind. So, it is not with me now here, but reo state you know this they are also this resistance of the wire. So, this wire is owned it on a cylinder and these 2 ends are connected at this at the 2; 2 2 I think 2 pillar from higher with we take the connection in the circuit.

So, but there is a another jockey it is key kind of thin. So, it can you can move it moveable jockey. So, if you do not use the jockey; so, when you will use this 2 end then whole resistance of this stereo state will be use. So, it will be; it will no longer be variable resistance so, but if you use one end and other NDP use in the circuit this jockey one.

So, then basically you are using the resistance between the jockey and this one end. So, in between whatever the number of trans are there the what length of the wires are there; so, that resistance will be include other part will not be included. So, that way basically we have varying the resistance means we are changing the basically effective length of the wire and yes we are getting variable resistance.

So, this is very important component for the lab and for many purposes it is used and resistance of a material is very very useful for different purpose. It is whatever the simple resistance I told you; there are different kind of resistance. Resistance of the material changes with temperature like thermistor it is thermistor it is a another resistance. So, length of the wire is fixed now if you change the temperature of the; of this wire then it is resistant changes; so, this is called this is basically thermistor.

So, in other way also it can be fabricated, but principally is that if you change the temperature of the material it maybe; it maybe wire or it may be in other form; so the it is resistance will change.

So, that way if you change the resistance; so, it is called thermo resistance or thermistor. And then also another type of resistance is there this is called magneto resistance; means if you apply magnetic field in a material may be in form of wire or in other form.

Then the resistance of this wire of this material changes with magnetic field. So, this then this type of resistance is called magneto resistance right. So, different kind of resistance are there and it has various application in device. So, whatever here just I am telling about the resistance it is not the simple resistance you are using in the you know lab.

So, basic; what about the basic formula for the resistance R equal to rho l by a; so, that is very important formula. And using this formula basically taking the wire of different material means rho will be different length or different cross section.

So, we can vary the resistance you can you can; so you can use this formula for your application which what you want to do. And which one you want to vary either rho want to vary or l you want to vary or a you want to vary.

So, this rho is basically varies with temperature rho it varies with the magnetic field; so, that way it is you will get resistance due to the change are change of temperature; resistance due to the change of the magnetic field etcetera. So, it will be so here just I showed you that how the just using wire and just rounding this wire and using the suitable mechanism; how the resistance whatever we used in the circuit or made of.

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So, next one next component is basically here just I have picture and showed you the same thing.

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So, next is basically other 2 components; this capacitor and the inductor. So, here is my intention is to show you that in electronic circuit or electrical circuit you just use the commercial resistance; commercial resistance commercial capacitor; commercial capacitor right.

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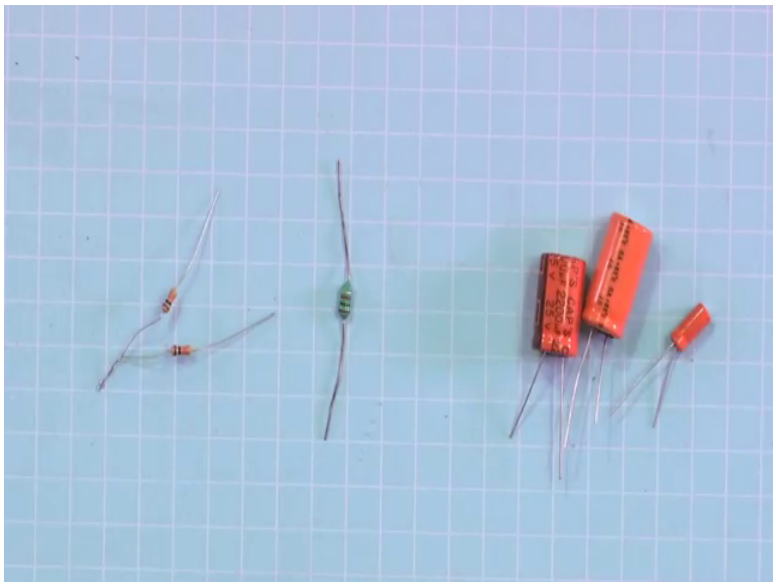

Commercial capacitor and commercial inductor commercial inductor; so, this is the commercial resistor right. So, if we use this one then it is difficult to tell how it is made right you may not be it is oil inside this one. So, as I told this it can be in different form because as I told this not only wire it can be some coil kind of things some like this very thin coil this we tell also fin. So, this fin kind of things.

So, whatever that inside that without bothering that one just we use this and whatever the color code from color code you can find out what is the resistance. So, this we use if we use this one; so without knowing anything you know that this is the this much resistance. So, for your circuit you need this resistance; so you can connect. So, these 2 ends are there you can connect; so this is the commercial resistance.

So, this is a commercial inductors; this is a commercial inductor. Now, commercial inductor means somebody if told you this is the I think few henry not henry microhenry or nano henry this of inductances few micro henry or nano henry or milli henry whatever.

So, for your circuit whatever you that how much henry you need or milli henry you need. So, depending on that you can choose this commercial inductor. So, this generally does that give any feelings of the inductors of the inductance whatever the definition we have read.

This also does that give feelings with the definition of resistance we are familiar with. Similarly, these are the commercial capacitor; I think it is a value is written 100; it is the 1000 microfarad, 1000 microfarad; here it is written. I think it is difficult to see, but I think here you can see 1000; here I can see is the 1000 microfarad; yes 1000 microfarad. And this one is 2200 microfarad and this one is 20 22 microfarad probably.

Anyway; so, these are the again commercial capacitor; commercial capacitor; these 3 are commercial capacitor. Now again this; this does not give any again feelings about the about the definition what about; we know what is capacitor.

So, what is capacitor? Whatever definition we know. So, when you are using commercial one; so that is, so it is difficult to connect with the fabrication of this capacitor with with our definition; so fine. So, commercial one is we have to use also let us say about this capacitor.

So, what we have learned? What is the definition of the capacitor? This 2 parallel plate 2 parallel plate is separated by the dialectic ok. Then it is a capacitor we tell parallel plate capacitor or it can be cylindrical also; these 2 cylindrical co axial cylinders.

So, between these 2 co axial cylinder if some dielectric is there then that also it for is the capacitor cylindrical capacitor. So, simple one is the 2 parallel plate is separated; 2 parallel 2 parallel 2 metal plates; if you place them in parallel and they are separated by dialectic; it can be air also dialectic or some dialectic material then that is the capacitor we know; that is the definition of the capacitor right.

So, but unfortunately we never fabricated such type of capacitor or most of the student have not seen this type of metal capacitors or we know the definition; now I have doubt whether we believe whether we believe that this if I take a 2 piece of metal plate and if I place then will parallel; so, this will act as a capacitor ok.

Because this type of demonstration generally we do not give the student. And so what about the definition I told you; that we read for capacitor and now in lab we are using this type of capacitor.

So, my point is there is no connection between this or definition and these some as if these 2 are separate. So, but here I want to show you I want to show if the real means

equal fabricate capacitor there are plate capacitor and that has enormous use for device fabrication. So, I think if we take 2 metal plate here I have 2 metal plate 2 metal plate.

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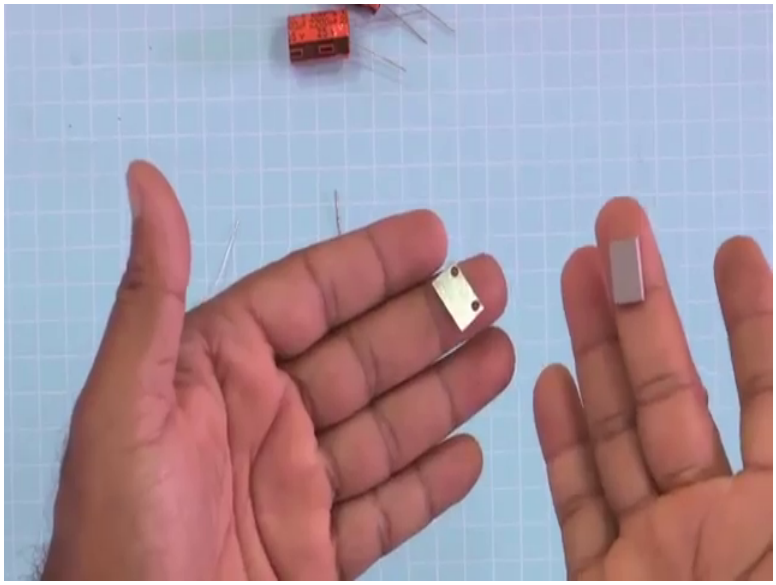

Now, these 2 metal plate if you can put them parallel way this way ok. So, now you have to make them separated ok. So, you have to whole them; so, you need some arrangement. So, if you can make this arrangement then this will this is a capacitor parallel plate capacitor and you can use as a capacitor. So, I have a in my lab I use this parallel plate capacitor for some for some small for a very interesting research equipment; probably if I will discussing sometimes. So, this type of capacitors I will show you as probably earlier I have shown you.

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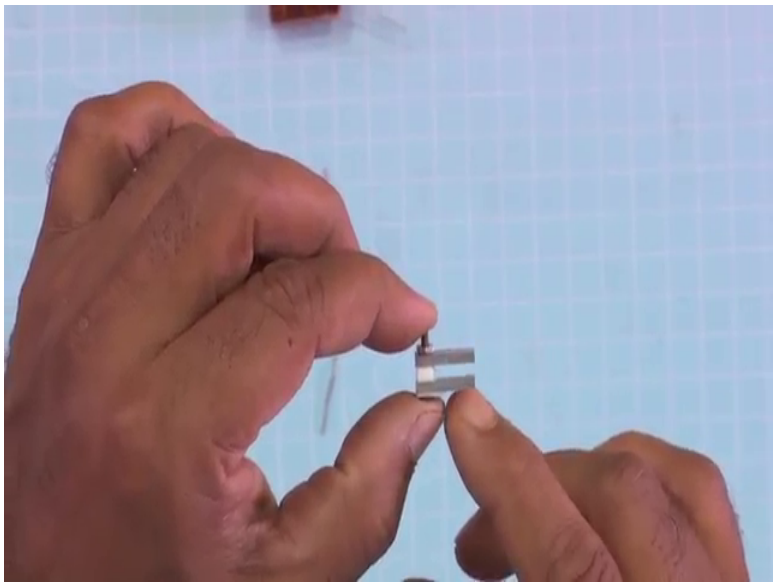

Now, also you can see this is the capacitor in my lab this we are using you see these 2 parallel plate capacitor. Now, this I have to; I have to placed they these 2 has to be isolated you know; so, I have to use some insulator. So, here in between I have used the tape loan insulator tape loan piece. So, they are separated and I have to hold them. So, I have use screw and on top of screw you can see this again tape loan I have used because through screw, there should not be any contact with this metal plate. So, this 2 plate should be electrically isolated; for that we are using the tape loan that is insulator to isolate them.

Now, this is a parallel plate capacitor; now if we apply voltage between this these 2 plate ok. So, then you will get what you will get? So, this capacitor plate this capacitor basically is used to produce electric field; this parallel plate capacitor is used to is used to produce electric field. Because, you see when you will measure when you want to study some sample as a function of electric field like dialectic material.

So, this is very sensitive to the electric field like magnetic material it is very sensitive to the magnetic field ok. So, dielectric material it is very sensitive to the electric field. So, how to produce magnetic feel? Either you can take permanent magnet as I have shown you in case of voltmeter galvanometer.

So, also people can use the electromagnet. So, that also I will show you in sometimes for producing magnetic field. So, in lab and that magnetic field we used for starting some

property of the material right; like this magneto register. If we want to measure the change of resistance of a material as a function of magnetic field.

So, you have to apply magnetic field and you have to vary magnetic field. So, you have to know how to produce magnetic field in the laboratory that also I will sometimes I will discuss I will show you ok. Similarly, you need to produce my electric field in laboratory; so how to produce electric field in the laboratory.

So, this is the capacitor; parallel plate capacitor is used to produce electric field in the laboratory. Means, you say the wire you will get the electric field basically this electric field will be between these 2 plates, If we apply voltage between these 2 plate; so, then there will be electric field in this in between these 2 plates. So, because you know this what is the relation between the electric field and voltage? Relation between electric field and voltage is here I will write relation is electric field E equal to V by d.

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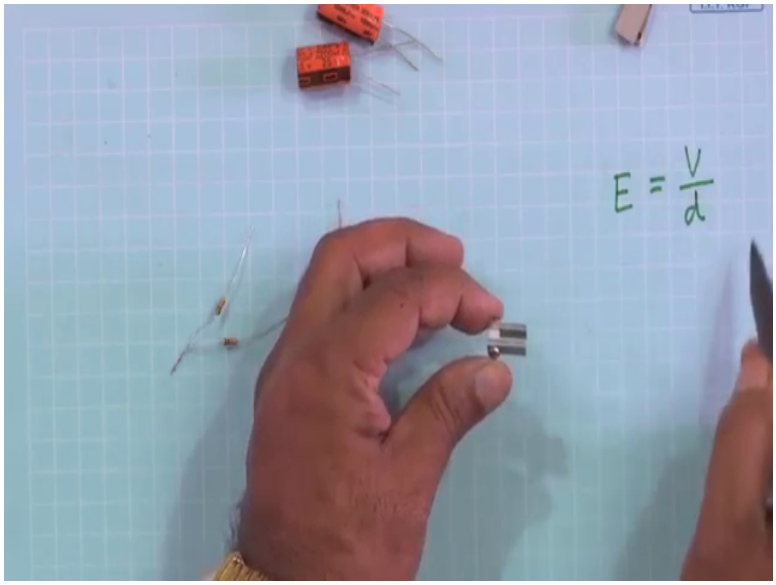

Means voltage we have applied to this capacitor plate and if separation between them is d ok; so, electric field will be V by d. So, this capacitor parallel plate capacitor is use in the laboratory to produce the electric field. So, this is just one application I told this a parallel plate capacitor used for other purpose in this as equipment. So, that I will not discuss the, but I will tell you. So, this is consistent with the without definition right whatever we need from plus 9, 8 ok.

So, but unfortunately we never demonstrate; we never see this type of capacitor; so these the capacitor. So, commercial one whatever; so it is made like these or some cylindrical some other way see inside what is there, but for producing like for producing electric field you cannot use this capacitor right.

So, this you can use just for why do you need the some capacitor capacitance ah? So, there you can use in that circuit, but this type of capacitor whatever if you from definition you can fabricate and you can you can fabricate. And you can use for different application; I told you just two application; one is producing electric field in the laboratory, another is I used in my research for some purpose that I will discussed later on it is fine.

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So, that is the about; so here basically whatever commercial is there fine, but apart from that from your definition whatever you have learned in your plus 8, 9, 10, 11, 12 ok. So, practically you should demonstrate it and it has many practical application; so one of them is capacitor; so, that I showed you. And about resistance this again this resistor commercial these resistors is one type. Another type this from original resistance of it is from R equal to R rho l by A R rho l by A.

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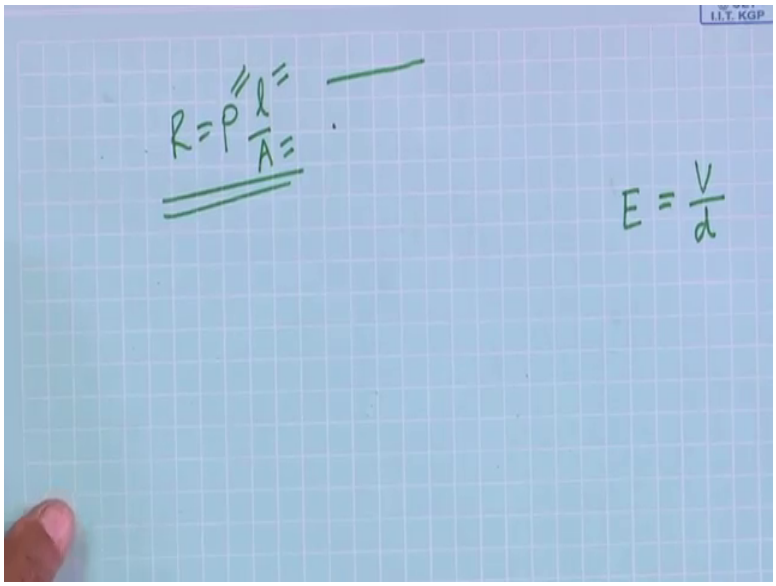

So, from this definition taking different material having different rho; taking different length or taking different you know you can fabricate you can fabricate your own resistance. So, and that resistance box I showed you so that based on this just definition. And so the way I am; so the way we have learn the definition, the same way I am I am trying to show you this components so that wherever you need you can think; you can think to fabricate yourself.

So, next one is inductor inductors as I told this showed you; this is the commercial inductor, these are commercial inductor it is a few micro henry value. So, this you can use, but by definition from definition or how to fabricate the inductor?

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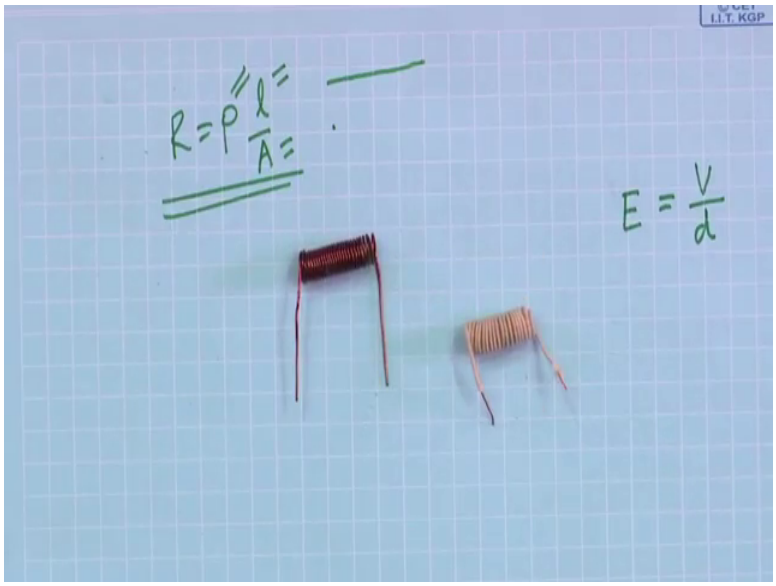

So, basically this these are the; these are the basically inductor you know. So, this just I have I have; so promised state wire. So, I have rolled out by respond on a I think on a pencil or here is silicon.

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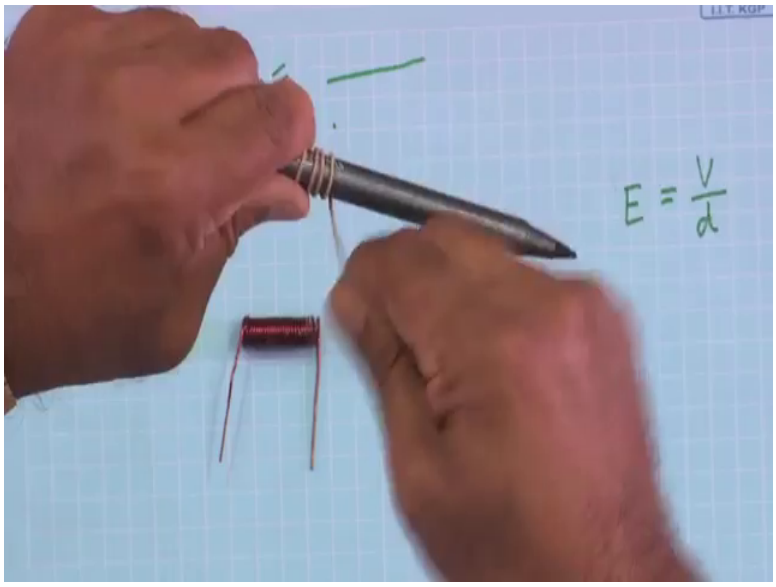

So, here I will show you so, you see this is the wire; this is the simple wire this is the simple wire; this is the simple wire. Now from there I can if I want to make inductor so, just it is simple by definition ok; you just roll it.

So, this is the inductor you know; now this is the inductor ok; this is the inductor. So, this is the inductor the same way you have made it. And this is so important component; so it has so many application you see if we just see this inductor and if definition is different ok.

So, with definition you cannot connect this one, but from the definition if you according to definition; if you just you are able to fabricate this inductors, then you can think of many application of this inductor. So, what is inductor? When this; when this wire in a coil form it is a what is called it is a spring kind of things you know.

So, it is a spring kind of things the spring kind of things. So, if you turned it rotate it on a in this form. So, and you connect with in a electrical circuit; so this will act as inductor. So, what is the source of inductance? From where this inductance is coming is basically; this is the coil which is used to produce the magnetic field ok.

You know current carrying conductor gives the magnetic field ok. So, this also this if wire is state; it will give magnetic field. If this wire is in this form it is the solenoid I was forgetting the name it is the form of solenoid you know. So, if current; so if current possess through this it was taped; it was taped; now it is in solenoid form.

So, if current passes through this; so it will produce magnetic field. So, maximum magnetic field you will get at the center. So, if it is infinitely long; this solenoid is infinitely long then the magnetic field if produce; that is B equal to magnetic field it produce that is B equal to i n A.

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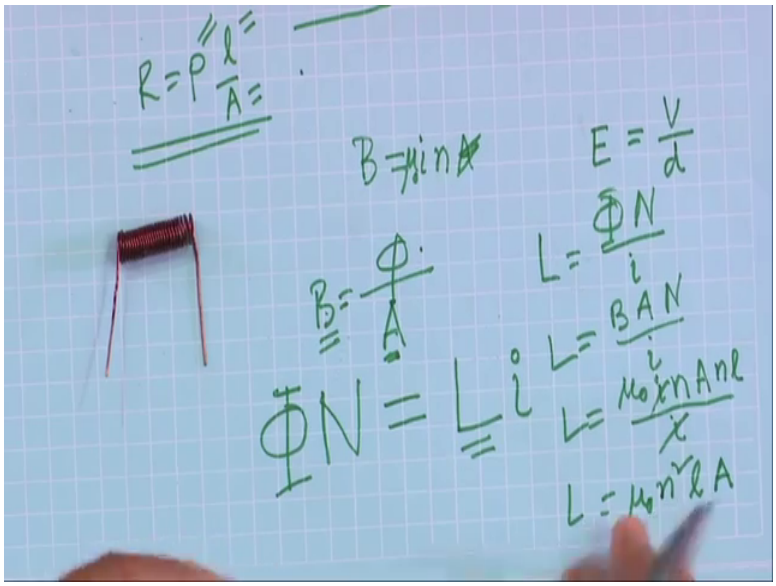

What is i? Is current passing through this coil what is n? N is number of transfer unit length; number of transfer because it is infinitely long is very long solenoid. So, n is number of transfer unit length of the solenoid and A is the; A is the area A is the area of this of this of this coil; so, this will be give you magnetic field.

Now, current is flowing through this coil; now it is giving magnetic field. Now, when magnetic field produced to you know this it has; so south pole and north pole ok; there is no monopole. So, magnetic field is nothing, but the magnetic lines of force passing through a per passing through per unit area.

So, B equal to i n A yes I think so flux that is we tell the flux lines of force magnetic lines of force we tell the flux. So, flux will come out from this solenoid flux per unit. So, flux we generally write phi; phi; so this phi per unit area per unit area passing through per unit area, whatever here. If you place some area; so total flux passing through this area, so now if we divided by this area then that is the magnetic field at that point.

So, magnetic field passing through this space. So, now that is a lines of for this lines of; so where it will go? It has to come back to the other end ok; it has to come back to the other end. So, it has to make poles magnetic lines; that means, this coil is producing the magnetic field due to the current in this coil in this solenoid.

Now, this field is outside you can get anywhere; now this that field is due to the lines of course. Now this same lines of force is link with this coil because it is coming back; it has to come back. So, it linked with this same coil again. So, flux now flux linked with this coil if it is capital phi; if it is capital phi flux link with this coil, if it is capital phi and this capital phi is basically flux linked with each turn of the coil ok.

So, this if it is phi then total number of turns in the solenoid because from these last end to the another last end of other end. So, it has to come back; so it will so linkage of this flux with all turns. So, for each turn if it is capital phi and if total number of turns is N in this solenoid, so, total flux linked with this coil is phi N.

So, this is basically is by definition it is a equal to Li ok; i is the current passing through this through this solenoid. And then this L is called the; L is called the inductance of this coil inductance of the. Now, L equal to L equal to capital phi by N by i.

Now this phi this phi is basically B A B A magnetic field B A ok. So, I think this I did mistake it is not A phi is i n A phi is i n A. So, this B is i n here it will be mu 0 or mu permeability. So, B is mu 0 i n A will be when I will write not magnetic field flux. So, it is mu 0 i n A for your core ok; if we use some other magnetic course of this that will be mu permeability. So, now B A N by i; so now, again B is mu 0; mu 0 mu 0 i n and A is there and this I think it it has to this capital N.

And now this capital N is now small n as I told this number of transfer unit length. So, if length is L of this solenoid; so this N I can write nl n l. Now, divided by i; so, this i i will go and then you will get.

So, basically you are getting this L; so this is basically L L L; it is L. So, L I am getting mu 0 n square l A. So, it is a basically constant you know number of transfer per unit length this is the length of the solenoid, this is the area cross sectional area of this of this solenoid area of this solenoid.

So, measure is the permeability of the air; so this is the inductance. So, now here from here basically you can calculate the inductance and I will later on discuss in different times. So, how useful this is EC this is used to produce the magnetic field in the laboratory electromagnet to get the electromagnet you with this one. This is one application great application for that you have to use this type of solenoid.

So, basically we used in solenoid for electromagnet or it is called hill moose coil to produce magnetic this is nothing, but this. Then another application where it is used as a search coil you know to sense the magnetic field; is a magnetic field sensor. This is used as a magnetic field sensor to sense the magnetic field or magnetization or magnetic moment.

So, this is used as is as a search coil is a detector kind of things. So, there this Faraday's law induction law is used; so it from magnetization or from magnetic field whatever flux comes and link if it is linked with this and if this flux changes with time. So, there will be it will there will be induced EMF in this coil.

Now, from induced EMF; you will get the current; so, if you may can measure this current. So, you can who relate with the flux; that means, you can co relate with the magnetic field or magnetization or magnetic moment. So, basically measuring this current electrical signal one can find out this magnetic field or magnetization or magnetic movement; so, for that purpose this coil is used.

So, when you are able to fabricate yourself this inductor, capacitors, resistor as our definition; then you will be think to use then for different application. So, for commercial from commercial inductor resist sensors it is very difficult to think this type of application.

So, that is why I showed you this 3 important component resistor, capacitor and inductor. So, from definition how can you can fabricate and there are anonymous application of this. So, I will stop here I will continue discuss in next class.

Thank you.