Experimental Physics I
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Lecture – 05
Basic tools and apparatus (Contd.)

So in last class we have discussed some of the Basic Tools in the Laboratory. So, mainly we have discussed the length measurement measuring tools with the screw gauge and slide calipers these are very useful and all the time we need in our experiment, because one experiment means is the combination of many different measurement. So, this length measurement is frequently used for some many experiments.

So, next I will discuss about the most again this most important apparatus basic apparatus, which are used in the laboratory very frequently.

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So, these are the basically galvanometer, voltmeter, ammeter and multimeter. So, this very very basic apparatus are used in the laboratory. So, we should know about it, and I will try to show tell you about the basic principle of this instrument, and I will open the instrument and try to show this inner side of this instrument ok.

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So, this just I have shown you here, this galvanometer, ammeter and voltmeter. So, it is from our lab; it is the basically from our labs. So, I think voltmeter yes it is the voltmeter, then this is the ammeter and this is the galvanometer ok.

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So, this is actually we have taken picture from this instrument. So, this apparatus just this is how. So, it is in our lab from our lab ok.

So, this is the galvanometer moving coil galvanometer, it is called moving coil galvanometer moving coil galvanometer ok. So, I will discuss about the principle of this moving coil galvanometer. So, what is the use of this galvanometer that is known to you. If you want to measure the deflection in the circuit, current is flowing in which direction; current is flowing in which direction or whether current is flowing in the circuit or not ok.

So, you use this galvanometer or what is the amount of current flowing through the. So, that is also one can find out from galvanometer so, but mainly we use galvanometer to know the direction of the current, yes and then to know the amount of current flowing in the circuit. So, there we use this ammeter. So, this galvanometer and ammeter is connected in the circuit in series and if you want to know the voltage drop in your circuit ok.

So, what is the voltage drop across a resistors of in your circuit; so between two points. So, then we connect this voltmeter we connect this voltmeter. And this voltmeter is connected between these two points in parallel. So, ammeter is connect is connected in series voltmeter is connected in parallel in the circuit galvanometer is connected in the in the series ok. So, these are the fined it is well known fact now this you know also that you know also that this ammeter and this voltmeter is nothing but the galvanometer this is the basically galvanometers. So, galvanometer is converted into ammeter or it is converted into voltmeter.

So, how it is done so? That also you know that when you connect a shunt when you connect a shunt means a very low resistance in series in parallel with the galvanometer in parallel with the galvanometer then it becomes a ammeter. When you connect a high resistance in series with galvanometer then it become a voltmeter. So, basically ammeter and voltmeter; so it is nothing but the main mainly it is galvanometer. So, in one case we are adding a shunt in parallel, the shunt that value is very small and we adding a high resistance in series with the galvanometer to get it function as a voltmeter ok.

Now we want to know this principle of this galvanometers moving coil galvanometer. So, that is the principle of this ammeter and voltmeter because in addition only we have to add resistance, small resistance and a high resistance one using parallel and another in a series to get this to other two instrument.

So, let me open let me open this galvanometer ok. So, I will not open this one, but exactly I have another one. So, that is not working. So, that I have opened and let it be I think this I do not need now. So, I think.

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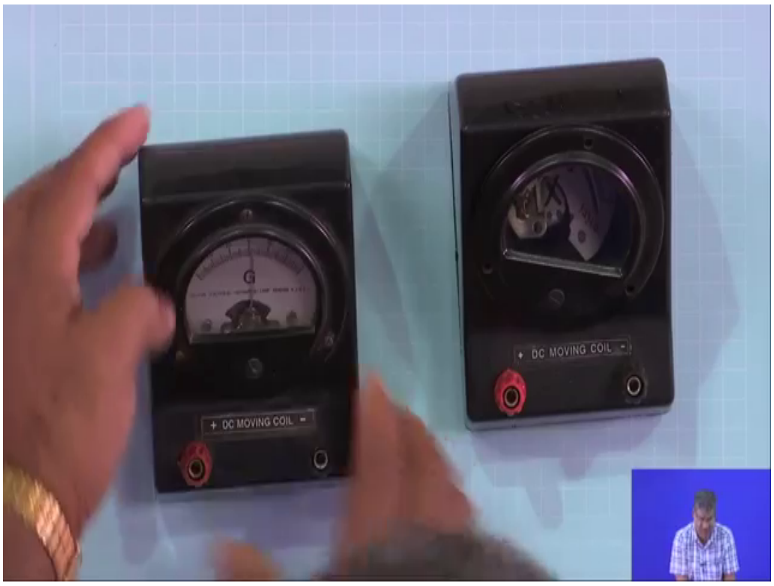

So, exactly I have another one. So, basically I have another one this similar dc galvanometer. So, these are same this is the same as this one ok.

But this I just opened it, to show you inside what is there. So, this is the cover if I take out this cover let me take out this cover.

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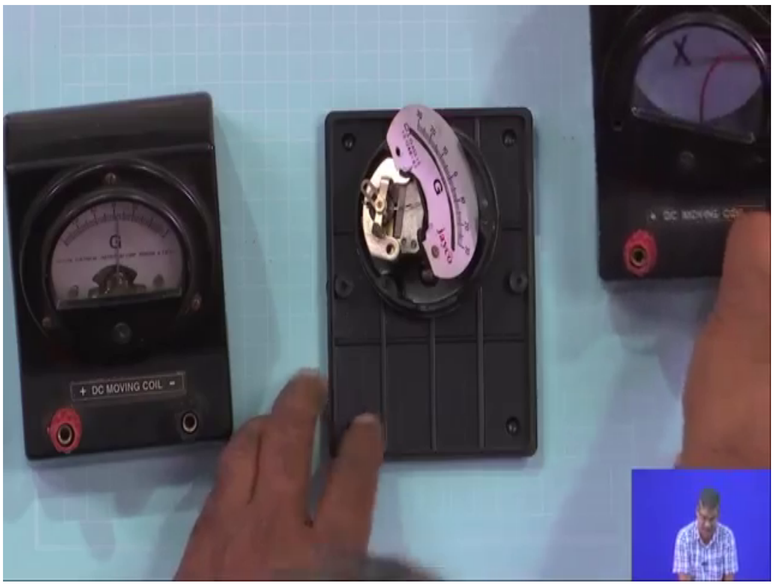

So, let it be clear I think I will just keep it, I will show you this is the cover; and this is I think whatever these scale ok.

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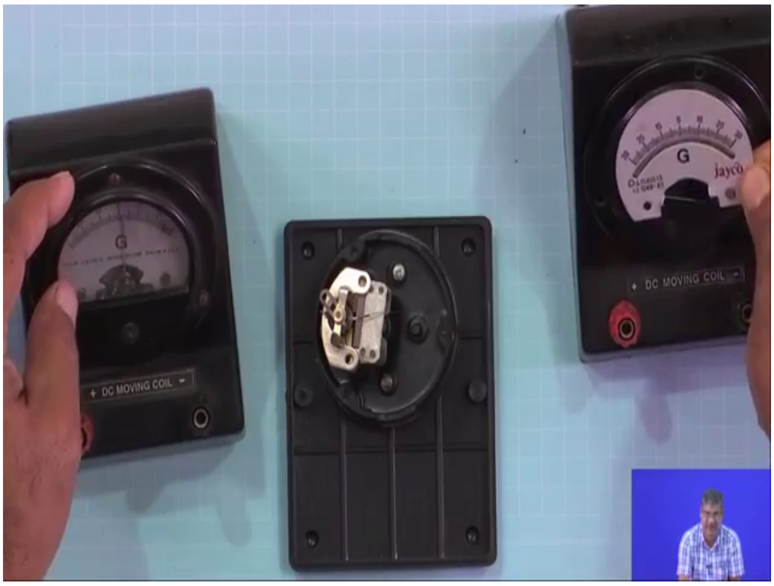

This scale was basically here inside ok. So, earlier I just opened it because to open it takes time. So, it will wastage of time to open it here. So, just I have opened it earlier to show.

So, it was basically here ok. So, I think here this yes. So, from inside one can put this inside one can put this ok. So, that is a. So, this I have opened it fine. So, this let me keep it here. So, then inside what was there? So, it is basically where you know this it was this way, it was this way and also it was this way this scale was there. So, on top you are fit there is a; yes I think I have to put this like this ok.

So, this it was in side of this box ok. So, I do not need this.

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So, this is the scale, this is the indicator ok. So, this is fine what is the very small parts inside you know. So, this called moving coil galvanometer, because this principle is based on this on the moving of a coil. So, where is that coil where is that coil? I have to show you where is that coil. So, I think it is here I have to show here two parts is there you know, one is moving coil another is permanent magnets.

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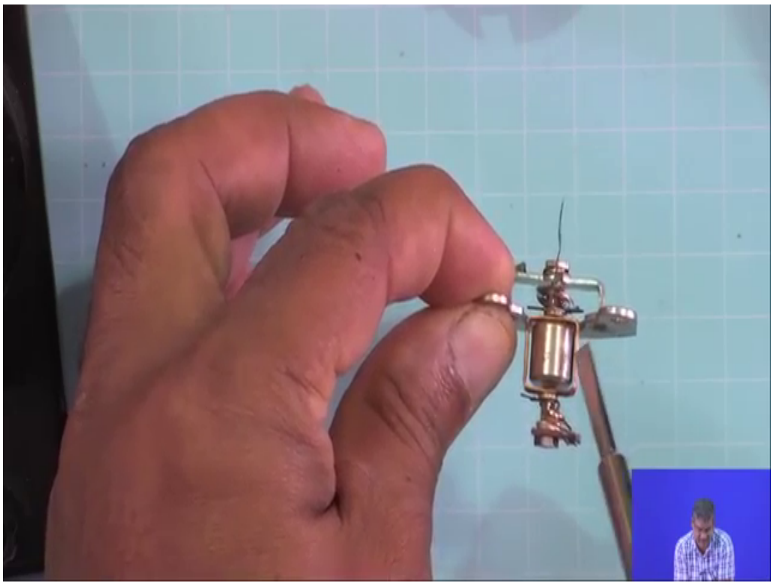

So, I am taking out this one from here, because earlier just I opened it.

So, this is the permanent magnet I will discuss about it. So, keep it here and this is another parts of moving coil ok. So, here now clearly you can see here now clearly you can see this, this is some coil is there. So, this is the coil ok. So, I think you can see it is the coil right. So, I think I can use this magnifying glass and, but it is not you know, but if you focus then you can see this clearly this moving coil ok. So, this is the coil rectangular coil you can see right and this one is seen because of the some soft this magnetic material basically this is not magnet. So, it is a permeability is high. So, it will helps to increase the lines of force magnetic lines of force.

But these currently forget. So, this is the coil ok. So, this coil can move this coil can move, and this indicator is connected with this coil and now this coil you see on top and bottom you can see you can see this is the this is the spring kind of things you know. This is the spring kind of things this is the spring at bottom and top also you can see this you can see this spring ok.

So, two springs are there one is at the top of this coil, seen this rectangular coil and another is bottom of this rectangular coil ok. So, what does it mean? Its means that when this coil rotate when this coil rotate; so spring also they sets you see this it is called the spring also it is twisted ok. So, there will be restoring force on this there will be restoring force on this on the on the rotation due to the rotation of this coil not coil its the rectangular coil due to the rotation of the rectangular coil. So, there will be restoring force of torque to bring back in bring back in the original position.

So, if the two force will work two torque will work here one is this from the rectangular one, this rectangular this coil. And when it is in magnetic field permanent magnetic field so, that I will show you. So, there will be torque on this coil and because of that it will rotate indicator also just move; and when you rotate this spring, it will be twisted and then there will be restoring force it will be twisted there will be restoring force and that force we will try to take it back.

So, it will be at a final position where these two force; one is from this torque on this torque from this rectangular coil another is restoring force from this or restoring torque from this spring. So, at equilibrium position they will be equal ok. So, that is the balance equation and from there basically one can understand the rotation of this indicator in terms of which tell theta fine; so that I will discuss. So, this coil is basically you have to put in you have to put in this is the magnet you see this is the magnet you see. This is the magnet it is quite strong permanent magnet.

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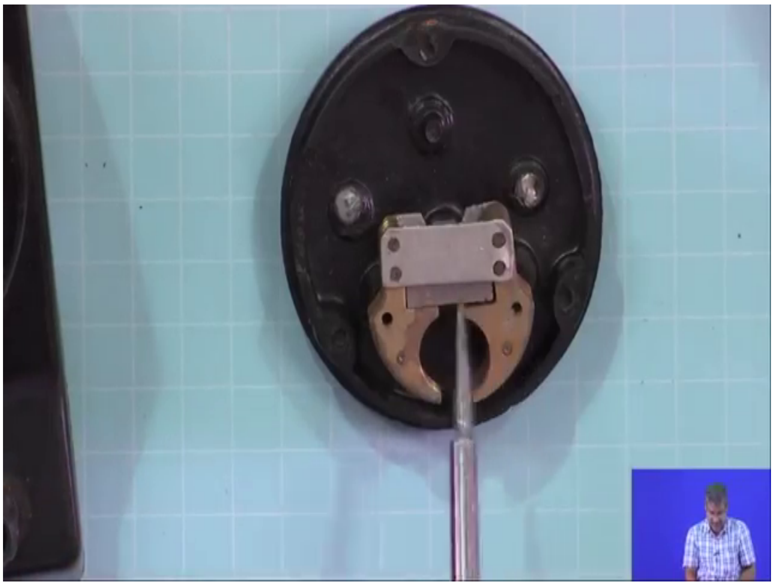

So, here it is a horseshoe of magnet you know, this is basically magnet is here this one now this two are pole this circular pole these are pole. So, it is called a horseshoe magnet ok. So, here magnetic field is basically radial magnetic field yet; lines of force is along the diameter along the diameter ok. So, if you take just two pole pieces two piece just rectangular these two piece if you take ok. So, then in between the two pole piece, if it is rectangular its the two pole piece they are parallel to each other. So, you will get lines of force magnetic field like this magnetic field like this ok.

Now, in this case you are getting magnetic field basically along the diameter, along the diameter ok. So, magnetic field is not in a particular direction, it is basically along the diameter along the diameter ok. So, in all directions magnetic field is there in all direction of the magnetic field in from the center you can tell in all directions. So, this is the radial magnetic field. This is the radial magnetic field not just like parallel pole pieces whatever it gives its gives the magnetic field in a particular direction.

So, there is a reason why here it is that is circular pole horseshoe pole is used. So, that also I will explain; now this you have magnet permanent magnet which is giving you radial magnetic field.

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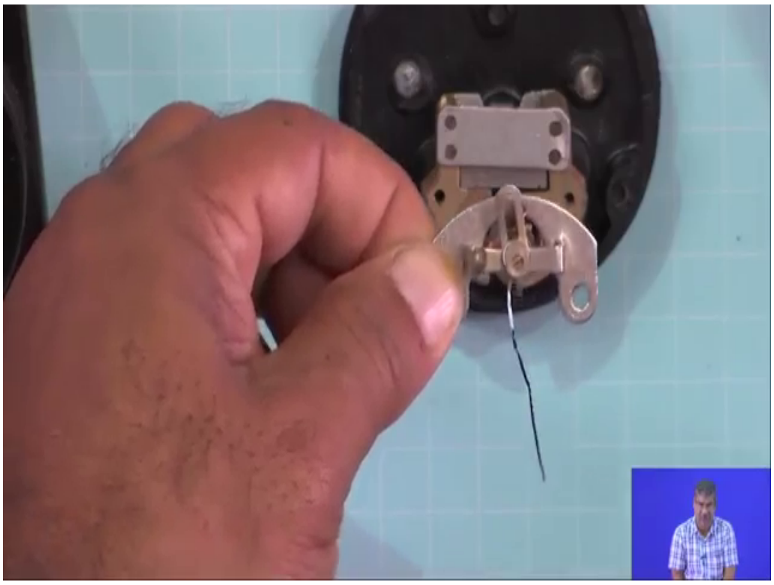

Now, this is at center of this one and center axis of this rotation of the coil, axis of this rotation of the coil this basically this is the axis; now this here when I will put. So, this two center this axis here and axis here. So, this is basically its the same line say coincide.

So, when I put here so; that means, my circular coil it is free to rotate it is free to rotate about this axis about this axis ok. Now here what I am just do? I am putting this coil it is the moving coil it can move about this axis it is in a permanent magnetic field permanent magnetic field radial field ok. And this moving coil it has a top and at bottom there are two spring two spring is connected. And this pointer it is attached with the rectangular coil if rectangular coil move so that movement is showed by this pointer ok.

Now, when it rotate pointer moves ok, but there is a restoring force given by the by the spring attached with a rectangular coil at the top and bottom ok. Now current now current; so externally there are see two I think this I will show you ok.

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So, this externally when it is connected. So, basically these two black and red positive and negative ok; when you are putting in the circuit in a series. So, current will enters ok. So, we do not say it will enter. So, it will enter from it. So, this one is connected with the one of them is connected is connected with the basically top spring and another is connected with the bottom spring means current will enter from here, then through the top spring it will go and it will go.

And this top spring is connected with the rectangular coil one end of the coil this coil is nothing but the. So, it is basically just take wire copper wire, insulated copper wire and get then make it rectangular this many turns of that will give you this coil. So, that current will enter into this coil from the top through the top spring and then at the end of this coil. So, it will go out the current from the coil to the bottom spring and bottom spring that end is connected with this other one ok. So, that way it will complete the circuit so; that means, current will pass through this coil ok.

So, this coil it is a moving coil it is able to move, and this coil is in a magnetic field is in a magnetic field and now this magnetic field is. Now this when current passes through the coil when current passes through the coil. Then this I think I have to put totally because this is the.

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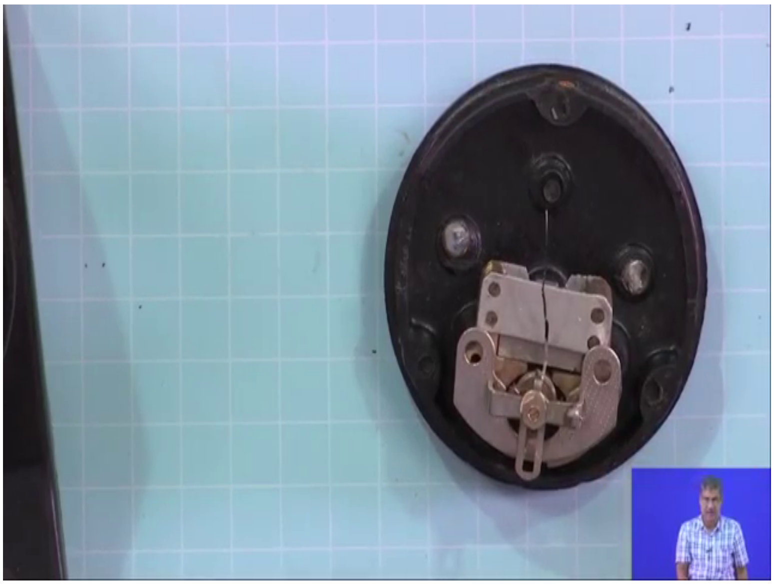

So, when current passes through the coil, then depending on the direction of the current in the coil and magnitude of the current in the coil; so this coil it is just rotate. So, this amount of rotation it will depend on the amount of the current. So, that is why this helps to know the direction of the current and amount of the current passing is passing in the circuit ok.

So, let me now I showed you now let me describe it theoretically. So now, I have to find out basically when the coil will rotate in a magnetic field. When current will pass through the coil then there will be torque on the coil ok. If there is a torque on the coil about an axis, then coil will rotate when coil will rotate it is with the spring. So, there will be restoring force in the equilibriums. So, these two force or these two torque we have to equate we have to equate and then you will get the balanced equation ok.

So, now let me tell you this how this torque is coming torque is acting on the on the coil ok. So, I think I will just calculate here. So, I have yes.

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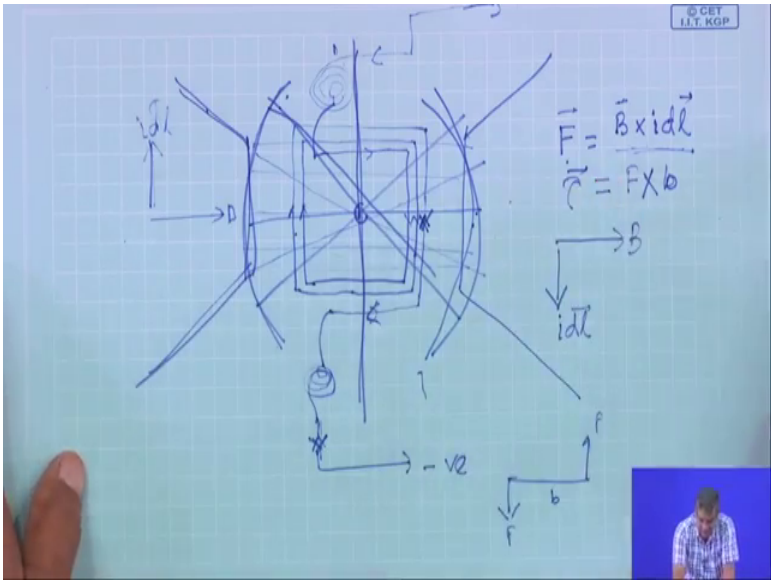

So, first two things I will discuss one is you have a coil right you have a coil rectangular coil you have a rectangular coil. So, there are many turns in this coil just let me show few turns ok.

So, now this is one end of the now this is another end of the wire of this which is used for this making to this coil. So, this is connected with the spring with the spring with the spring, this is also connected with the spring with the spring just a rough drawing I am making. So, now this is connected with the positive end say, this power we are giving battery. So, it is a negative electric.

So, current will pass through it current will pass through it say this other way current will pass through it. So, current will pass through this coil and then come out. Now you know this current carrying conductor when it is in magnetic field, when it is in magnetic field. So, it field force. So, there is a force that is why this current can be collected field force and that force that force F equal to I think this is the B cross i dl idl B idl B il B idl. I think this force is like this. So, the now this B this is basically is coming from the permanent magnet permanent magnet.

So, if you take permanent magnet this two pole flat pole pieces, flat pole pieces this magnetic field will be in this direction. So, while we draw like this while we draw like this, two flat pole pieces ok. So, then magnetic field is like this uniform it is in say uniform magnetic field its like this ok. So, this is the direction of the magnetic field, this is the direction of the magnetic field B and when current is flowing through this arm you can see this is the direction of the current is sorry in this direction.

So, it is coming this way this way then it is in this arm is a downwards, current is in downwards and in this arm it is upwards. So, in this case current direction is this right. So, now, here force direction will be. So, this is the cross product this is the cross product ok B cross i dot idl or idl cross B. So, I think that I did not remember first idl cross B maybe yes, but whatever the case. So, now here this is the direction of B this is the direction of the current; so this i idl. So, what is this idl and this is equal current element ok.

So, its direction is taken this in downwards; so then force ok. So, this cross product this force direction will be either up upwards or downwards depending on this idl and cross B fine. So, this on this upper arm what is happening. So, this magnetic field direction is this same direction as this one ok, but current element that is the direction is this. So, direction is this ok. So, it is just opposite of this other arm it is just opposite than the other one whatever we have.

So, here you can easily tell if this force for this case if it is upward. So, in other arm it will be downward. So, exactly you have to find out from this see some rules is there ok. So, from there this upward or downward that one have to one has to find out, but it is clear here if one is this upward direction, then other one will be in downward direction. So, basically you are getting force like this. So, here one is in this direction and other one is this direction.

So, two force like this here basically two forces are working one is say if it is this way at this other distance it is in this way ok. So, two forces are working. So, two forces are working at a perpendicular distance of say B ok. So, then torque then torque is torque will be this F cross B right torque will be f cross B ok. So, this is the force direction, this is the force direction and this is the B direction. So, this torque direction will be in third direction. So, one is these another is this. So third direction third direction is this third direction is this.

So, torque direction will be this. So, in case of torque this direction is basically axis of rotation; so about the axis of rotation. So, as I showed you this is the axis of this is the axis of this coil ok. So, about this axis of the coil, because of these two opposite force, this is from the couple and due to this couple. So, it will rotate about this axis it will rotate it will rotate ok.

Now, what about the other two end? Here in this case you see this magnetic field is in this direction, magnetic field B is in this direction and idl this current element also in this direction ok. So, they are in same direction. So, cross product is 0 right sine theta theta is 0. So, is 0. So, here also its the same its the same direction, but in opposite that is the minus sign it become, but it is zeroes or plus sign minus sign does not matter.

So, there is no couple from this on this other two arms ok. So, thus it is. So, only magnetic field on the parallel to this area parallel to this area of the coil it will give you the torque basically and any other this if it is a perpendicular component of this field. You will not give any torque it can it will. So, perpendicular current is in this direction say current is in this direction it is a perpendicular.

So, I think a third direction is this one perpendicular field perpendicular field if it is perpendicular to this. So, I think this. So, it is the torque is in this direction are not torque force is in this direction, other force in this direction ok. So, in that case this force is basically of the same line along the same line. So, they will cancel each other. So, there will not be any couple ok. So, there will not be any torque right.

So, only PNR field will give you now I will explain now you see now imagine now it is about this axis it is rotating ok. So, magnetic field is in this plane (Refer Time: 32:34) rotating. So now, magnetic field now it is not parallel to the plane. So, it has some angle. So, you will get. So, you can resolve it will get two component of this magnetic field, one is on the plane another is perpendicular to the plane ok. So, effective magnetic field will be only this parallel component parallel to this plane right.

So, now this torque now effective B is now its smaller because you have getting only component ok. So, then basically your torque will be torque will be torque will change when it is rotating. So, for each rotation it is (Refer Time: 33:25) of magnetic field is changing effective magnetic field parallel to the plane it is changing. So, you will get the torque will it is changing means torque is reducing ok. So, that is what with that we do not want; we want that torque should be constant when even if it is a rotating torque should be constant.

So that means, B should be constant, B all the time you should get B same B on a parallel to the plane. So, that is why we are taking here we have taken the circular we have taken instead of this flat pole, we have taken circular form we have taken circular form we have taken circular form ok. In case of circular pole from this magnetic field it is basically radial field you will get sorry radial field you will get radial field you will get radial field you will get radial field ok.

When it is radial field wherever that this coil is moving you know, this coil is moving; so in radial field. So, magnetic field all the time it will you will get along the along the radius along the diameter. So, effectively you see for a particular position. So, magnetic field is now along the radial ok. So, I have coil I think say I have coiled. So now, coil is rotating coil is rotating. So, how to show you, coil is rotating like this you have radial field.

So, parallel to the plane there is a magnetic field, parallel to the plane there is a magnetic field now others magnetic field are not parallel to this plane, but this both side they will give some component ok. So, but main field is parallel to this plane that is there if it is rotate if it is say rotate in different direction if it is rotate in different direction. All the time main field are on parallel to the plane it is there, because it is radial and from other components ok. So, this some component from other radial field you may get parallel to the plane. So, that will be more or less it is for same for all position that component part also will be same ok.

So, this radial field is basically during the moving of the coil, all the time it is moving the constant magnetic field, which parallel to this plane of the coil. And thus this torque will be torque will be constant during the moving of the coil ok.

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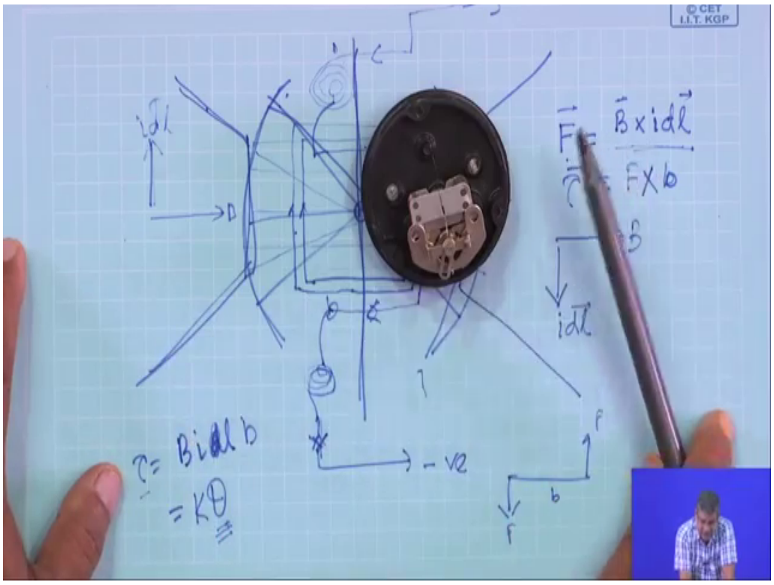

So, this torque because of this torque it is it will rotate and then you are taking basically this basically B i dl or l into B. This is basically this is the width and this is the length, with l I can write basically this dl instead of dl I can write length this is the length and this is width.

So, I B i lb that will be torque and then this torque will be balanced by the basically a restoring force restoring torque ok. So, that restoring torque is basically it can be two types its come from spring here. So, it can come from the this these are from torsional its called when if this coil is held from the from a from a fiber kind of things ok. So, this is a twist ok. So, this is called torsional torque torsional constant ok. So, spring constant ok.

So, this in this case per unit length and this other case per unit angle ok. So, there is the constant K. So, here one can convert from length to angle you know this l theta, I think yes theta into radius r theta will be l r theta will be l ok. So, one can convert from length to the angle also. So, anyway for torsional torque constant or spring constant; so one can write it is the this torque is basically a theta ok.

So, this is basically this rotation of this coil means rotation of this pointer whatever I showed you; rotation of the pointer rotation of this pointer rotation of the pointer that is basically proportional to the B magnetic field it is constant for permanent magnet, it is a i it is the amount of current. So, this only this is variable lb on B this breadth. So, these are constant only.

So, this theta and K also is constant spring depend on spring. So, I is proportional to this theta ok. So, and of course, direction of this angle it will depend of the direction of the current ok. So, that is the measurement this rotation of the point it depends on the amount on the current and direction of the current. So, this is the principle of the basic principle of the now moving coil galvanometer right. So, that is what galvanometer which will be used in our laboratory and I have open the things and shown you and match with the theory practical part.

So I think I will stop here, I will discuss in next class yes.

Thank you.