Experimental Physics I
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Lecture – 06
Basic tools and apparatus (Contd.)

So we are discussing basically basic tools and apparatus in the laboratory. So, I was discussing in 5th lecture that is the galvanometer and 4th lecture I was discussing about the screw gauge and slide calipers. So, just one mistake I did probably. So, I will just rectify it.

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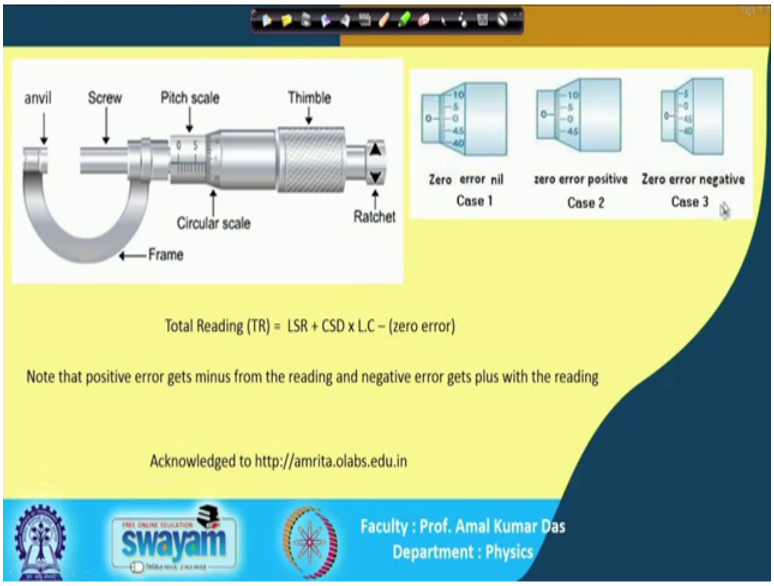

So, in screw gauge about zero error: so in this case it is a negative zero error, because it just cross this zero of the linear scale right.

So, I was taking this zero error the reading its coinciding. So, this 45 or 46, it is coinciding with this linear scale zero, but that is not correct. Actually this zero, zero of this circular scale, so where it is with the linear scale, so how many. So, from this zero its crosses this how many division of circular scale. So, that we have to take. Here basically it crosses I think the zero. So, this is a 1 2 3 4 from this 0 to this 0. So, this is a 4 division of the circular scale it crosses this 0 of linear scale.

So, this basically error is this 4 of this 5 division in to this least count. So, that will be the zero error, it is the negative zero error means minus this 4 into least count 0.001. So, it is basically 0.005 minus 0.005. So, that will be the zero error and in this case also. So, this how many division between this two 0 you know. So, it is around three division. So, this error is basically in this case positive error.

So, plus 3; three division in to least count 0.001; so plus 0.003; so that will be the least count it is just slightly different from the slide calipers. Slide calipers we are seeing this there is that when 0 of the vernier scale its. So, that it coincides with how many division of this main scale. So, that way we took and in this case just we are taking the number of division on circular scale between these two 0 between these two 0 what is the number of division on circular scale.

So, that division number of division into the least count ok. So, that will be the zero error. So, in this case is negative minus in this case is plus. So, this if you consider this plus or minus error here. So, this minus will be minus plus minus minus into minus will be plus. So, that is why negative error will be added with this main reading and this positive error will be subtracted from this main reading ok.

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So, I will go to the today's topic. So, this voltmeter and ammeter as well as multimeter we will discuss in this lecture.

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So, I was showing you these three main tools a apparatus, we use in our laboratory when you do electrical circuit. So, these are the common tools common apparatus we use, and I was discussing about the galvanometer ok. So, today I will discuss about the voltmeter and ammeter.

So, what we have what I told about the galvanometer?

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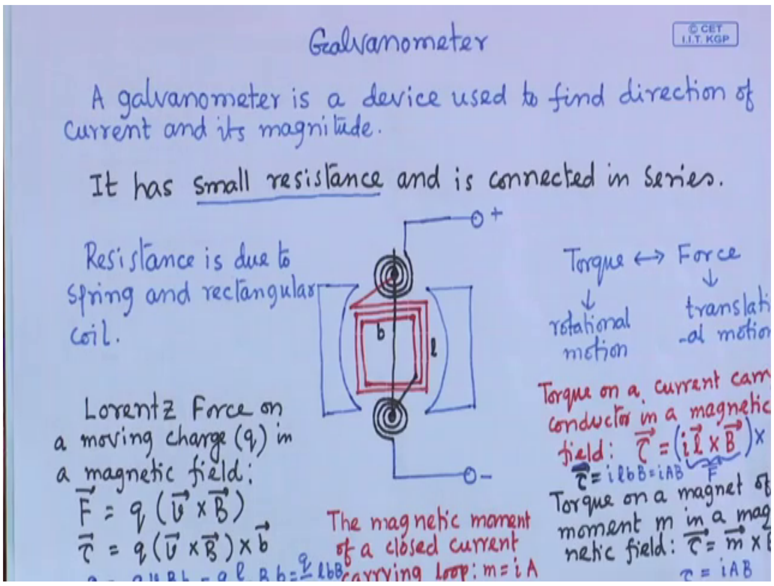

So, galvanometer is basically a galvanometer is a device used to find the direction of current and its magnitude. So, direction of the current and its the magnitude of the current, that is the we determine we find out from the galvanometer ok.

So, galvanometer is basically it has a very small resistance and its connected in series in the circuit. So, that I will show you; so this small resistance of the galvanometer from where this resistance is coming: so basically galvanometer have this. So, this is rectangular coil. Now on top and bottom of this coil this as I told this two spiral springs are there right.

Now, the one end of this circular rectangular coil this connected with this one end of the spring and other end of the rectangular coil is connected with the one end of the bottom spring ok. Other end of the spring this basically is connected there is the we are taking these two wire as a connector of the galvanometer

So; that means, when. So, this when it is connected in circuit so, these two end is connected in circuit. So, when current will flows through this; it is going through this spiral of the spring and then this rectangular coil, and then this spring. So, basically this resistance is due to this spring and the rectangular coil. So, that is the resistance of the galvanometer.

Now, here just yesterday I mentioned that because of torque there will be rotation of this of this rectangular coil, and pointer is connected with the rectangular coil that pointer will move on the scale. So, this angle of rotation that is the basically its proportional to this to the current in this coil, and whether it will go towards positive or towards negative it will depend on the direction of the current. Thus one can find out the magnitude and direction of the current in the circuit using this galvanometer right.

So, torque and force what is the difference between torque and force?

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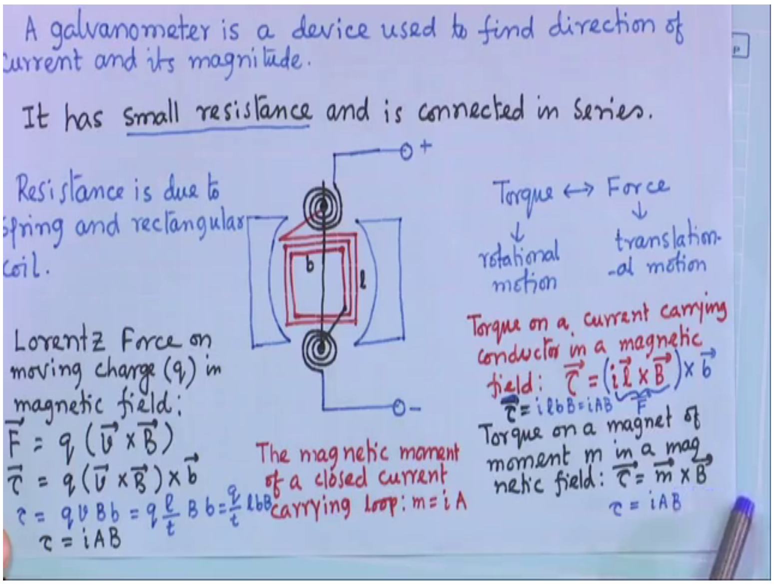

So, due to torque there will be rotational motion and due to force there is a there will be translation motion ok. So, when we consider translation motion. So, force is responsible for this translation motion, when we consider the rotation of a body. So, torque is responsible for this rotation

So, in this case our coil is in a magnetic field, in a radial magnetic field why we need radial magnetic field that I have explained. So, in this case this torque for this type of situation for this type of situation. So, this because here current is flowing through a we can consider through a through a coil means to the to the conductor to the conductor, it has length breadth.

So, torque on a current carrying conductor in a magnetic field that you know, the torque equal to basically force is ideal current passing through this. So, this is the current carrying conductor that element ideal current carrying element ideal cross B magnetic field. So, that is the force into this force into this as I mentioned that there will be two force in opposite direction on this arm and this other arm that force magnitude or this force is this ok. And these two force they are perpendicular distance is b perpendicular distance is b. So, force into that that distance between these two force b. So, this force cross product of b will give you torque.

So, this is this way one can find out the torque. Another way to find out the torque is if a magnet of moment is in a magnetic field then torque is m cross b m is the magnetic moment of the of the magnet which is placed in a magnetic field B. So, m cross B that will be torque. So, that torque will work on this magnet ok.

So, here what is the from where this magnetic moment is coming? So, we you know that the magnetic moment of a closed current carrying loop; if any closed current carrying loop it is whether it is rectangular or circular ok. So, it is a it is equivalent to a magnetic and its magnetic moment is m equal to iA. i is the current flowing through the closed circuit and A is the area of this closed circuit.

So, here it is closed circuit. So, area is l into b right a is l into b and. So, m is i l b m is ilb, m is i l B. So, lb is basically area. So, I have written area a or i A directly from here. So, m if I replaced by i A; so, i A B.

So, that since they are in perpendicular direction etcetera; so one can consider the direction and that tau will be i AB and here also from here also I can get that this two are equivalent equal. So, because I torque equal to il cross b cross b small b. So, this is force into this that b distance this couple basically between these two force. So, this I can write ilbB ilbB. So, cross product from they are since they are perpendicular to each other. So, sine 90 degree; so from cross product sine 90 degree will come and so, that that basically 90 degree one sine 90 degree one. So, that is why you will get i lbB lb is a; so iAB. So, from here also from this definition of torque in this case you are getting torque the iAB. If you take this definition of torque then also you are getting tau equal to iAB.

So, basic of these both formula is basically Lorentz force you know. You know the Lorentz force what is Lorentz force; when a charge particle is moving in a magnetic field. So, this force act on this force act on this on this moving charge and that force is q v cross B, v is velocity and B is the magnetic field and q is the charge.

So, here is here current is flowing means charge is flowing with time; so basically q by t that is the current ok. So, b is basically distance by time and current is charge by time. So, here this is the force and I need to find out torque. So, torque is this force into again b. So, again these two force in this to one there will be two force in opposite direction because current in this direction if it is up then it is down. So, velocity is if up charge then in this case, it will be down or just vice versa.

So, two force and their perpendicular distance is v. So, force cross b the distance. So, that will be torque. So, now I can write tau equal to q vB q vB and then this b again in this case v B this b all are perpendicular to each other. So, that is why it just directly it will come and what will be the ultimate direction of the tau there is axis of rotation that one can find out right from cross product.

So, this I can write tau equal to qvBb. So, now, qv I can write velocity there is the; so velocity of charges particle along this length l. So, l by t I can write velocity l by t if it charges particle takes time t two cross this length l. So, I can write l by t Bb ok. So, now here just slightly you adjust it q by t I can write q by t into lbB. So, q by t is i i lb is A and this B magnetic field B; so here also from here also tau equal to iAB ok.

So, for this case what is the torque? So, there are many ways to find out so, but this is the basic one Lorentz force from Lorentz force, you can you can get this result which is same as you can get from other formulae.

So, that was the galvanometer now what is ammeters or voltmeters let me tell you this. So, what is ammeter what is ammeter.

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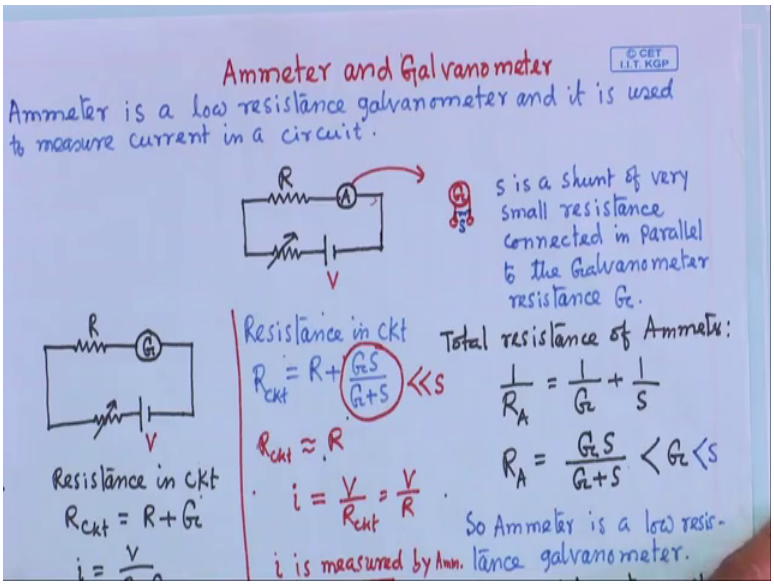

So, ammeter is nothing, but galvanometer, it is a low resistance galvanometer ammeter is a low resistance galvanometer and it is used to measure current in a circuit ok. And this is a circuit typical circuit electrical circuit and this ammeter, we connect in series in the circuit.

So, we are telling this ammeter is nothing, but a galvanometer, but low resistance galvanometer means resistance of ammeter is lower than the resistance of the galvanometer. So, what it is giving us advantage? Instead of using the galvanometer we are using ammeter and how we are making the resistance of the galvanometer lower to use it as a ammeter that is the question.

So, here basically I dont know you can see this I think I need to zoom it; so this part to show you. So, just this is symbol ammeter. So, I have taken here this is nothing, but this galvanometer and this one resistance I have added here this is parallel to the galvanometer ok. So, this is called shunt S ok. And this is the two end of this external end of this of this galvanometer, now it is basically ammeter after adding these shunt resistance in parallel ok.

So, this combination galvanometer and the shunt resistance is parallel. So, this is a ammeter ok. So, that is why we are telling ammeter is nothing, but a galvanometer, but this arrangement gives the resistance of this ammeter is lower than the resistance of the galvanometer same galvanometer.

So, you know shunt resistance is very very small resistance its very very small than resistance of the galvanometer, resistance of the of the of this R used in a circuit. So, these shunt resistance is connected with galvanometer in parallel. So, total resistance of the ammeters, then what will be the total resistance of the ammeter? If it is RA. So, they are in parallel. So, you know this how to find out 1 by RA equal to 1 by G plus 1 by S. So, from here RA is basically GS by G plus S ok.

So, this is basically is less than G and even less than S ok. So, total resistance of ammeter is even less than the shunt resistance and shunt resistance is lower than this galvanometer resistance. So, resistance of the ammeter is very very low than the resistance of the galvanometer. So, using this shunt using this shunt technique, we are reducing the resistance of the galvanometer to a very small resistance.

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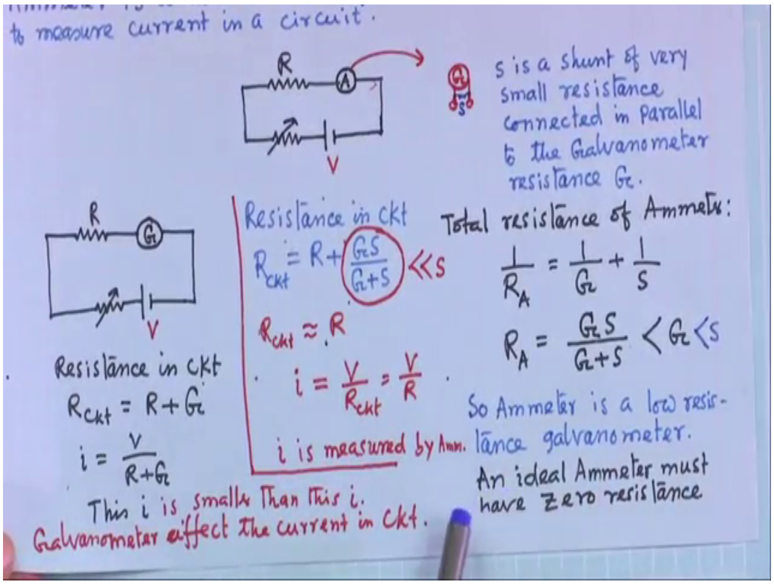

Actually this resistance in ideal case and in ideal ammeter this resistance generally its taken as a zero resistance or tends to zero resistance. So, why we need why we need to make it smaller resistance zero resistance or very very small resistance; because in my circuit current is flowing and that current I want to measure for that I am using an instrument that is called ammeter. So, that ammeter I am connecting in a series in the in series of the circuit.

So, that means, I am adding resistance in the circuit ok; so then if we add the resistance in the circuit for a particular, that constant voltage. So, current will change in the circuit, but that I do not want. I want to measure the current flowing in the circuit for measurement I am using an instrument ammeter. When I am using adding in the circuit current in the circuit should not change if it change then I will not get the actual current flowing in the circuit which I want to measure ok.

So, now see the difference. Galvanometer also used to measure the current ammeter also used to measure the current; so why? So, what is the difference in measurement of current? So, if you use galvanometer here. So, it has resistance G ok. So, then actually it will it will change the actual current of the circuit which I want to measure. So, that is why galvanometer is used to basically measure the direction of the current, and just approximately magnitude of the current ok. So, it cannot give the accurate current ok. So, if you want to get the accurate current in the circuit. So, you have to use ammeter.

So, that is the difference. So, ammeter is a galvanometer, but it has negligible resistance. So, using shunt that we have we have make it and it is used in series it is used in series.

So, how to calculate shunt etcetera what is the value of the shunt that, that one can find out. So, I think this is a standard I will not discuss it, but here I important is that how this galvanometer is converted to the ammeter and why it is done for measuring the current ok. So, that I try to explain.

So, in reality I have one I think. So, where I was that?

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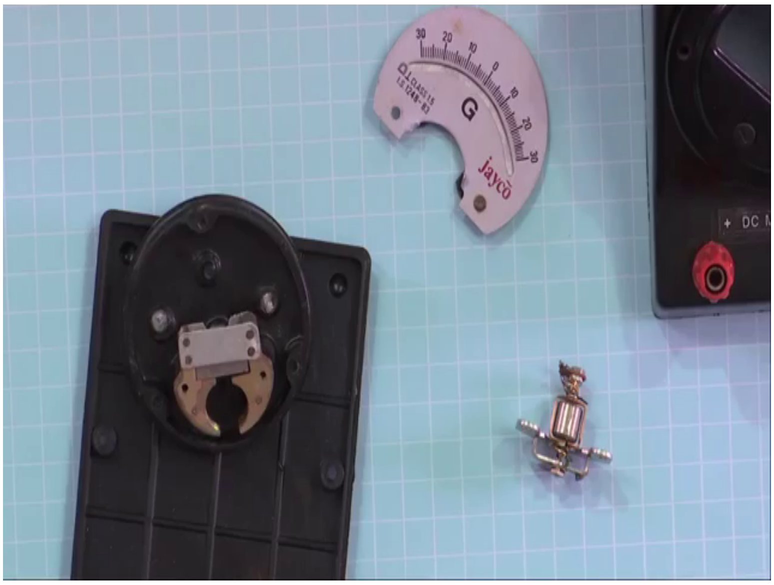

So, yesterday I have shown you, I open the galvanometers I open the galvanometer and I showed you all parts. So, here also you can see nicely I have opened.

So, this is galvanometer. So, I opened it, and showed you all parts it is I think external this connector for this galvanometer ok. So, here I opened and showed you this is magnet and this is rectangular coil rectangular coil is placed I need this I think here.

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So, I think here I showed you this rectangular coil right rectangular coil. So, this is the rectangular coil right.

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And this two spring also I have shown you; two spring one is at bottom and one is at the top. So, in figure I think ok.

So, this is the pointer also this is the pointer you know it will move on the scale it will move on the scale.

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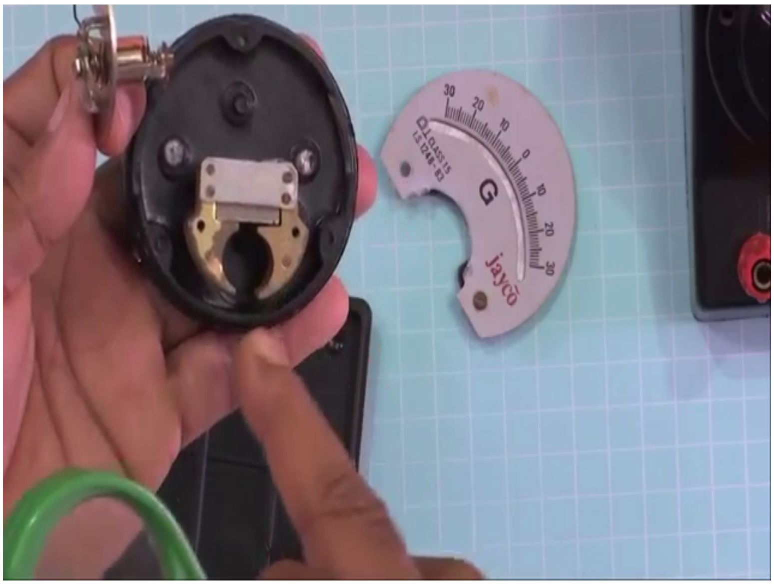

So, now this permanent magnet as I told this it gives radial. So, it is a horse shoe kind of a pole pieces. So, it gives you this is the radial magnetic field ok.

So, electrical connection we take form this bottom and one from the top ok. One from the top one from the top and another from the bottom I think yes ok. And total resistance as I told this coil and spring that will be the resistance of the galvanometer.

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So, I think in figure here its more clear here just check it. So, I have taken picture. So, this is the rectangular coil; this is one spring, this is one spring, and this is another spring and this connection is taken from here and it is taken from here ok. So, this two connection is taken and current will flow through this and go out I go I think this is the voltmeter let me ok.

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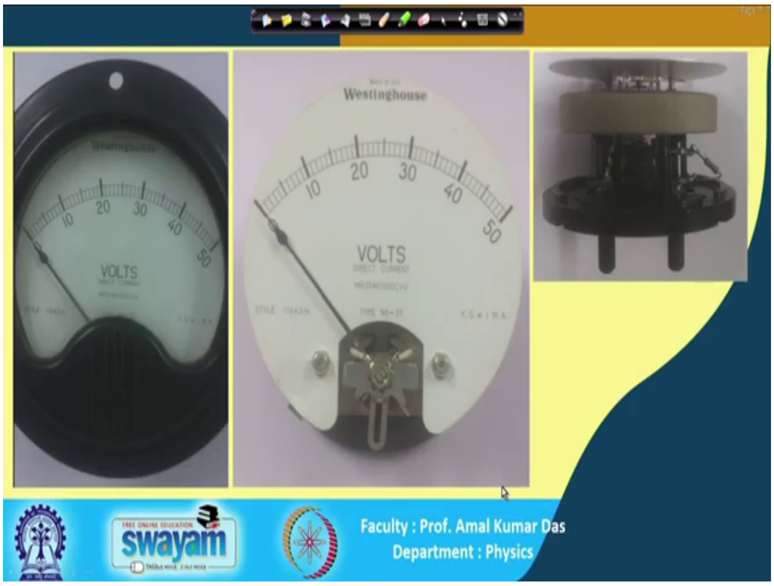

Let me show the voltmeter first and then I will discuss. So, this is the galvanometer.

So, here if I with this now this galvanometer is converted to the galvanometer is converted to the voltmeter. So, I have opened one voltmeter.

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So, what is this? This is the voltmeter right.

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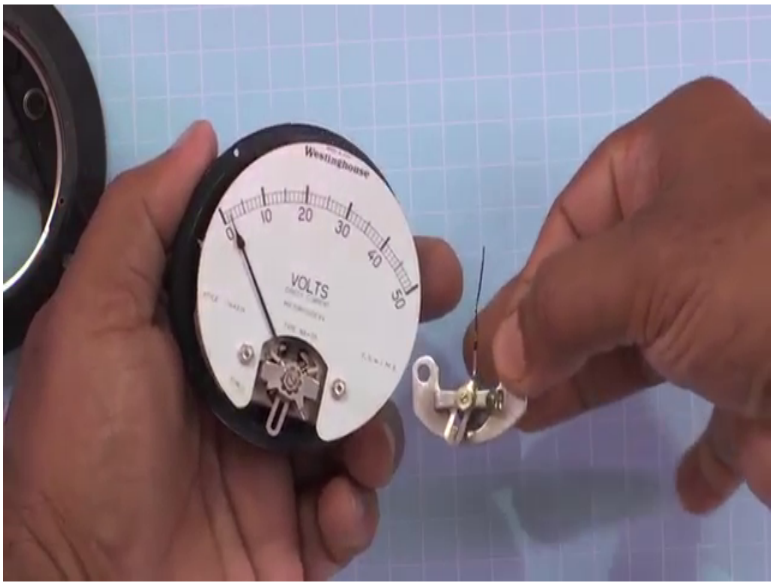

If I open it; so here I have not opened completely, so this here this part you are seeing as the same as this one you know already I have opened, this part is same as this one you can see. That means, this galvanometer this is the galvanometer main part of the galvanometer rectangular coil etcetera. So, that is there.

Now, here are just I will show you that resistance in case of ammeter resistance is connected, the shunt resistance connected in parallel to this to this galvanometer and in case of voltmeter, high resistance is connected in series with this galvanometer this is the difference right; so that I will show you in calculation.

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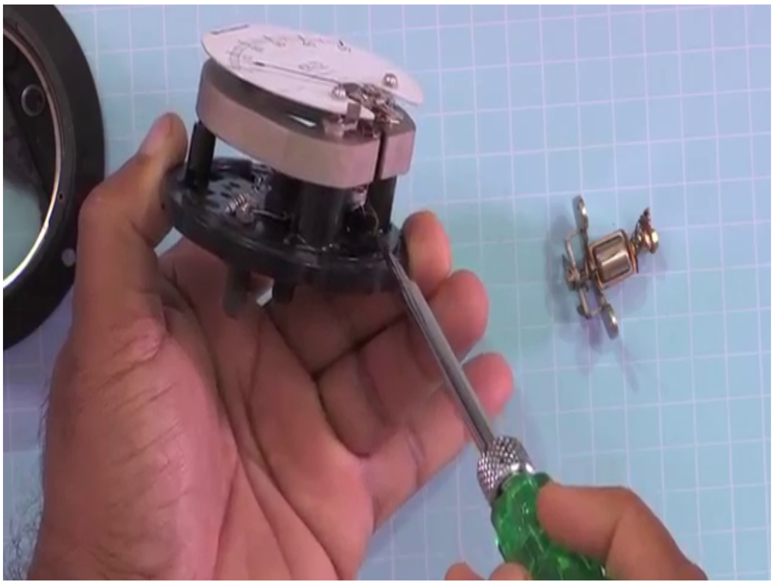

So, here just I will show you the just I will show you that these two are these two are the external connection ok.

So, now if you now if you just see it this one, this one here this right here this one right I think I need smaller one; so this one right. So, this you see now from this you see one that way high resistance two resistance is connected, and this part is going to here at the bottom of this circuit at the bottom of the circuit.

So, actually this from the bottom of this galvanometer whatever the connection, now, it is in this case is directly connected it directly connected now in this case its connected its connected a that resistance here basically two resistor is connected and this is coming. And other one is just directly connected other one is just directly connected to the stop to the top.

So, when current will flow through this current is going is not going to the galvanometer the resistance directly. So, current will go through this series resistance high resistance and then galvanometer resistance and then come out. So, here basically in this case this high resistance is connected in series. So, here I have shown you that same from the same I have taken picture. So, this is the high resistance is connected in series of this galvanometer right.

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So, I think here its a looks better, here its looks better. So, here also you can see this is the galvanometer structure and with this galvanometer structure that spring here also we can see in better with one spring up and one spring down, and then I think this is the this is the coil this is the coil rectangular coil.

Now, additional this here this, but I have zoomed and you see this series resistance is connected right series resistance is connected this way and other connection is just from the top of this galvanometer resistance. So, this is an galvanometer of high resistance.

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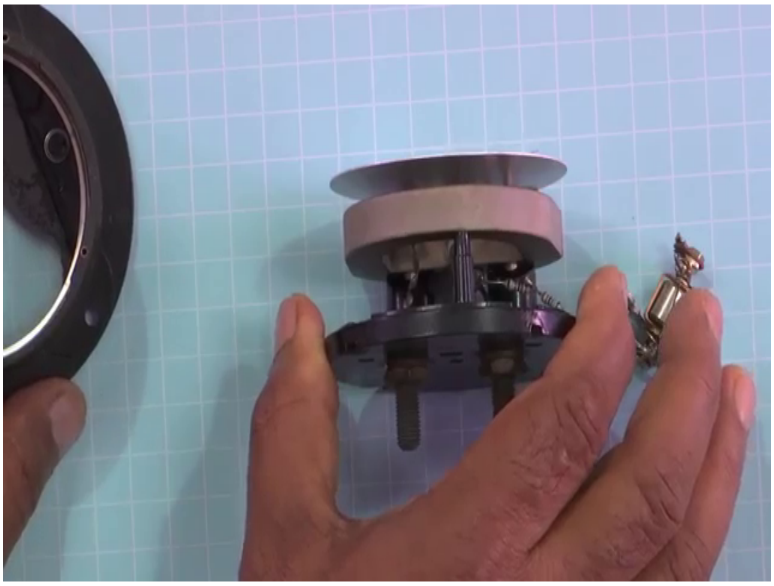

So, voltmeter is basically a galvanometer of high resistance. So, what is the galvanometer volt voltmeter? So, voltmeter is basically a galvanometer; voltmeter is basically a here I just I have shown you.

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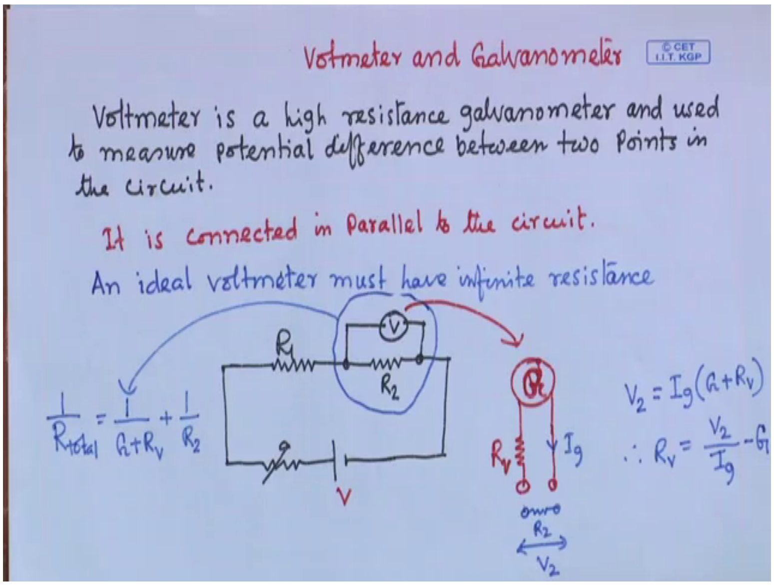

So, voltmeter is a high resistance galvanometer and used to measure resistance difference between two points in the circuit right. So, it is connected in parallel to the circuit.

So, ammeter is connected in series to the circuit, but in this case it is connected in parallel to the circuit and ideal voltmeter have must have infinite resistance. In case of ammeter its the zero resistance and in this case infinite resistance.

So, why I need infinite resistance? Because again in circuit I will connect this voltmeter to measure the voltage between two points and this whatever the voltage drop across this these two points against is a across this resistance I have shown in the circuit additional resistance. So, what is the voltage drop or potential difference across this resistance that I want to find out? So, for that I am using voltmeter and voltmeter is nothing but an infinite resistance. So, I have connected in parallel. So, this mechanism is such that, when I am using this measuring apparatus in the circuit it should not change current in the circuit.

So, if I connect in parallel, now you can see this is what will be the resistance of this part what will be the resistance of this part? Resistance of this part will be 1 by R total equal to 1 by resistance of the voltmeter means that is resistance of the galvanometer plus additional resistance in volt in galvanometer we have added as I showed you as I showed you here. So, this galvanometer resistance and this resistance in the; so I need to they are not showing. So, where I have kept it yes.

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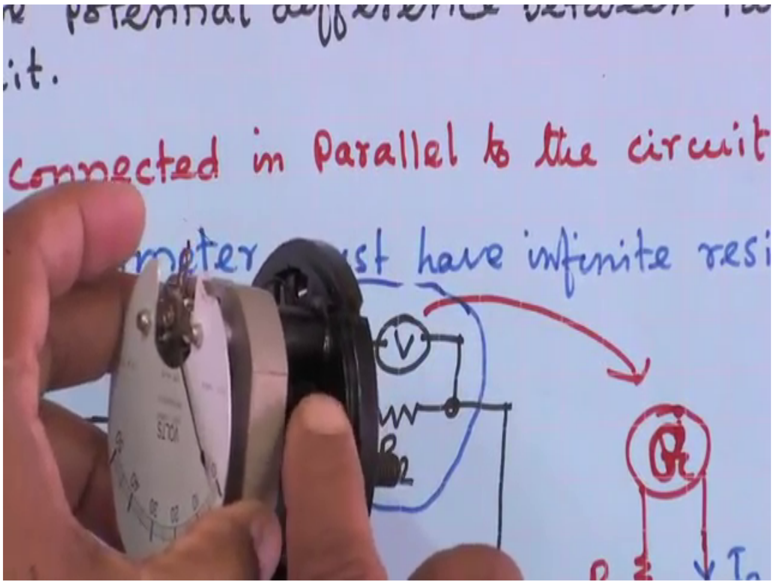

So, additional resistance this Rv I have written. So, that is the basically additional resistance of this is R v and g is the resistance of the galvanometer. So, here you can see here you can see this 1 by g plus Rv that is the resistance of the voltmeter and 1 by R 2 ok.

Now, this if it is very very high its towards infinite so; that means, this part is 0, this part is 0, 1 by this infinite resistance very high resistance. So, you can take always. So, its close to 0. So, you can neglect this part. So, then one by R total equal to 1 by R 2; that means, R total equal to R 2; that means, this part having the resistance what this original resistance in the circuit. So, addition of this voltmeter is not changing the resistance in the circuit. So, there will not be any change in the current in the circuit.

So, the mechanism is such that this galvanometer we are using. And then resistance we are adding to the galvanometer in such a way then it is becoming ammeter or voltmeter. Now this ammeter or voltmeter again we are using in the circuit in such way that it should not change the original current in the circuit which I want to measure. So, if original current does not change, then I can measure the current get the current for ammeter. I can get the accurate voltage drop across this because R is fixed R 2 is fixed. So, if current is fixed it does not change. So, this i into R 2 that will give you give us the voltage.

So, if there is no change in the circuit there is no change of the current in the circuit, then I can get the actual current and actual voltage drop across the two points which I want to measure for that. So, this way we use voltmeter and ammeter. So, I think.

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So, then I just show you the ammeter.

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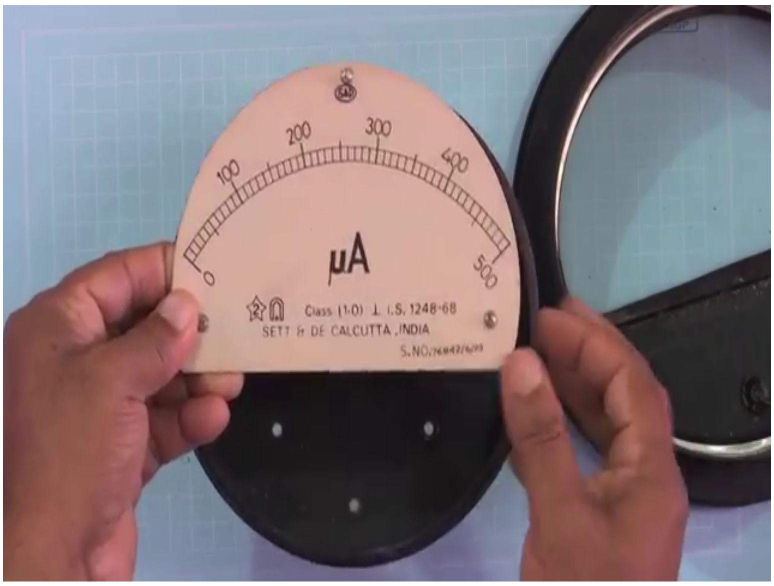

So, in ammeter here I have ammeter again I have opened it, I have opened it, I think I have opened it I have opened it ammeter I have opened it.

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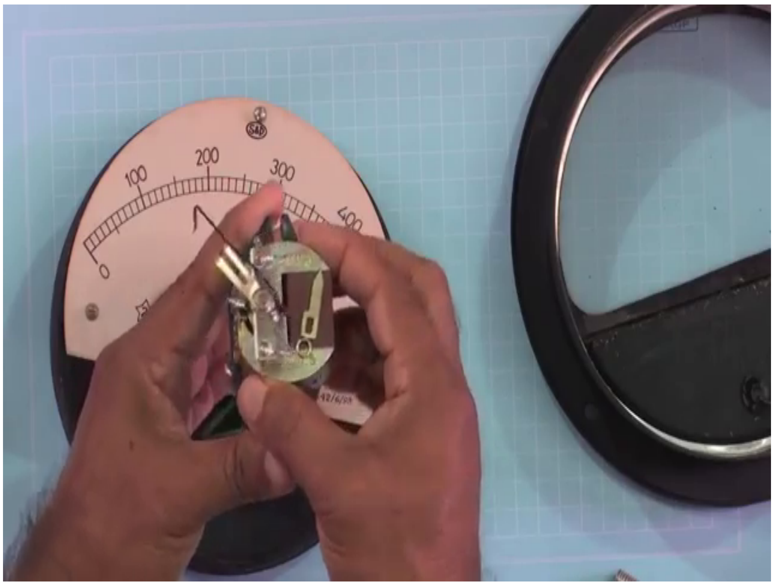

Now, just inside or this I have kept in a box just separated it ok. So, this was inside this was inside of this one.

So, here you see its I can show you here. So, this again this has magnet and that this galvanometer right galvanometer it has. So, inside you have this coil you can see I have. So, I think this is the coil means this spring, spiral spring and then this rectangular coil also there and so, in picture here I have taken. Here you can see better, here you can see better it is same ammeter micrometer as I have showed you, here you can see this is the spring top spring there is a bottom spring and connection is taken from the top one and connection is taking from the down one.

So, here the shunt resistance is connected, but I am not able to see here, but I think it is broken. So, this you see again this ammeter it is a nothing, but galvanometer, but a series a resistance, shunt resistance is connected in parallel. So, one has to connect in parallel, but here either it is inside which I cannot see.

So, again what information is that? This is the galvanometer, but additional shunt resistance one has to add in cd in parallel. So, that is not visible, so here from outside.

So, I think this is the information about the galvanometers, then how it is converted to ammeter and then how it is converted to.

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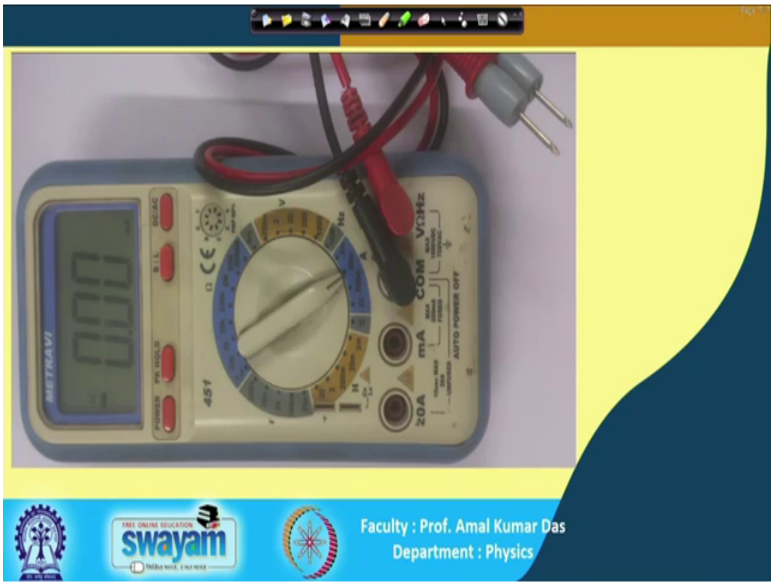

So nowadays, so we have very good multimeter. So, multimeter is basically it is voltmeter and ammeter and some more things you can measure direct resistance and you can measure directly the current flowing through the through the through the circuit ok. And also many more things you can measure you can check this here you can see this you can check this.

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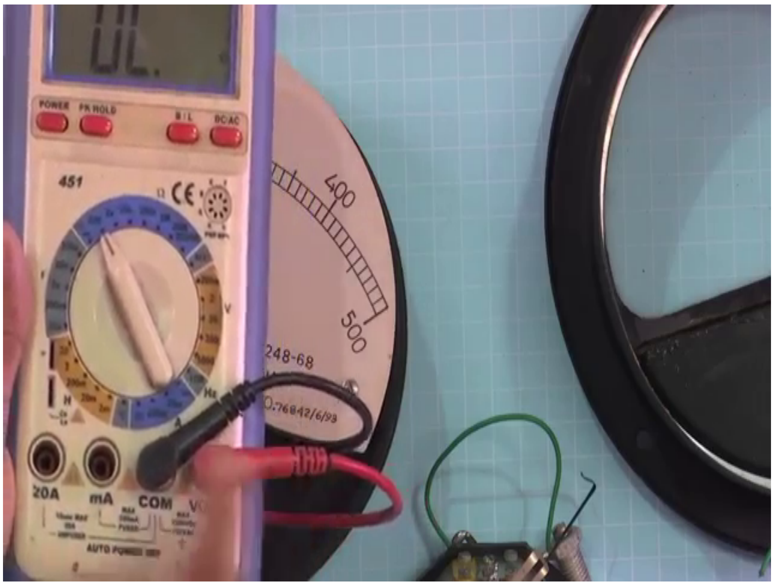

I think this I have, take it picture of this one I have to you can switch on this power on.

So, here you can see this common and then if you want to measure voltage. So, this is the voltage if you want to measure current their current, see in millimeter or current this if you want to measure ammeter ampere order of current. So, we have to take this red one here.

And this two end. So, I think you are familiars to use this.

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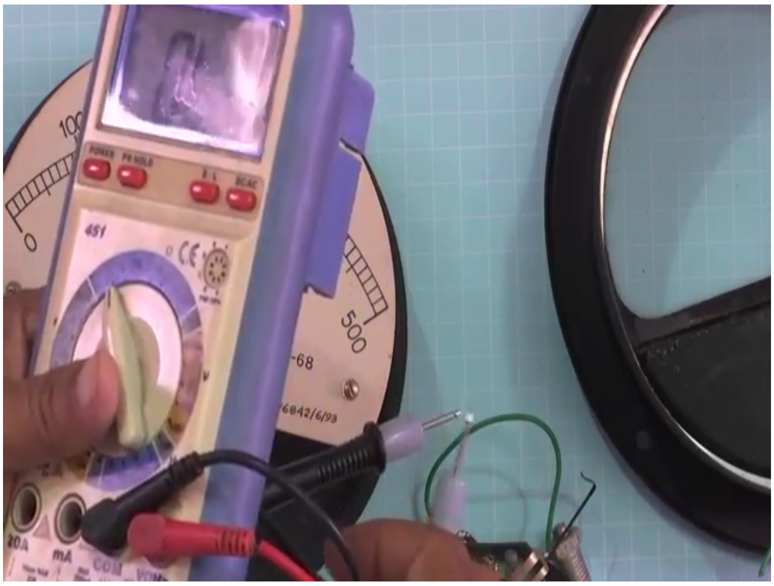

So, what I want to tell you, these are the very basic tools in the laboratory and you should be familiar, and you should be happy to use them whenever you need and this is very useful tools to check your circuit. So, whether it is conducting or not, where we want refer to a good conduction. So, after connection you can check between two points that whether its resistance is high or low. So, what you want to measure here.

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So, if you want to measure voltage, if you want to measure even frequency one can measure ac voltage also one can measure and you can measure the capacitance in this f is written capacitance f is written it can measure capacitance it can measure h means henry inductor inductance you can measure inductance capacitance resistance you can measure using this one even you can measure this check this np np np transistor also.

So, that is why it is called multimeter. It has multifunction so, but it cannot replace the voltmeter ammeter you know because in circuit. So, that is for dedicated one and this for (Refer Time: 41:16) one you know; so in circuit for dedicated circuit. So, we need to use voltmeter ammeter, but this is this (Refer Time: 41:23) one just a temperately if you want to check them we use this multimeter. So, here just I showed everything you know, but I just repeat it just to encourage you to use them ok; without hesitation you should use the instrument in the laboratory. So, I think I will stop you.

Thank you for your attention.