Experimental Physics I
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Lecture – 50
Experiment for Sensitivity of Blastic Galvanometer

So, in last class I have discussed about the Sensitivity current sensitivity and as well as charge sensitivity of a suspension or type of moving coil galvanometer. So, now, we will perform the experiment using this galvanometer.

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So, this is the setup experimental setup for this experiment.

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So, this is a galvanometer; this suspension type galvanometer. So, as I told this coil rectangular coil is hanged is suspended by fiber rope. So, here inside you can see this is basically this magnet this basically permanent magnet and pull piece you can see these pull piece is also this concave type pull piece. And inside pull piece this rectangular coil you can see rectangular coil and there this coil is suspended using this rope and on top of rope this is a one mirror you can see this round one mirror is there is attached as I mentioned this there will be mirror on the suspension coil.

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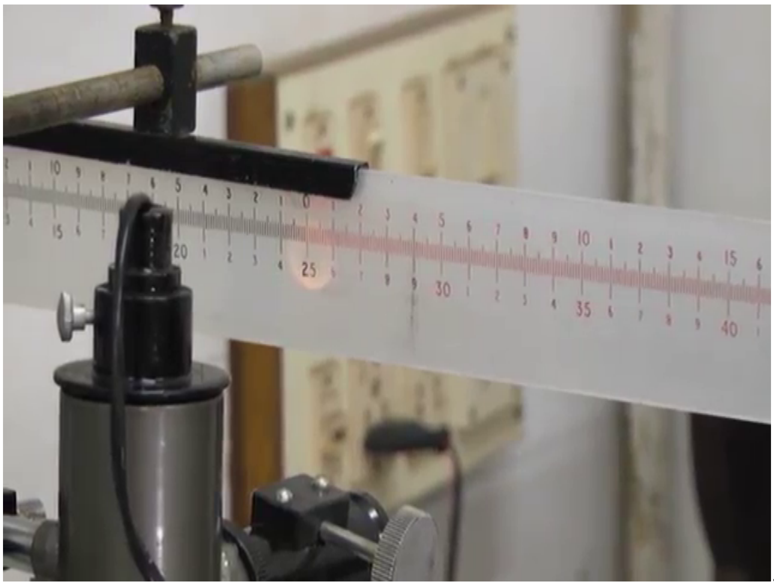
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And, now this light is falling this is the light scale arrangement this is the light scale arrangement this light from here it is coming and falling on this on this mirror and this reflected one is coming and falling on the scale. So, now, at the moment this you can see this round you can see here this round spot light spot. So, that is the that we have kept at 0 position, we have kept it at 0 0 position, right.

So, so if any rotation of this coil then mirror will rotate and then this what light spot will move on the scale. So, that is basically that displacement of this light spot that if we measure that one and if we know the distance from this scale to this mirror then basically we can find out the angle of rotation. So, this is the galvanometer and if any rotation of these of this suspension coil with some angle theta, so that we can we can measure using the light scale arrangement.

Now, what you want to find out? We want to find out the current sensitivity and then charge sensitivity of this galvanometer. So, current sensitivity what is the current sensitivity? So, di by d theta; so, that is basically we can write i by theta.

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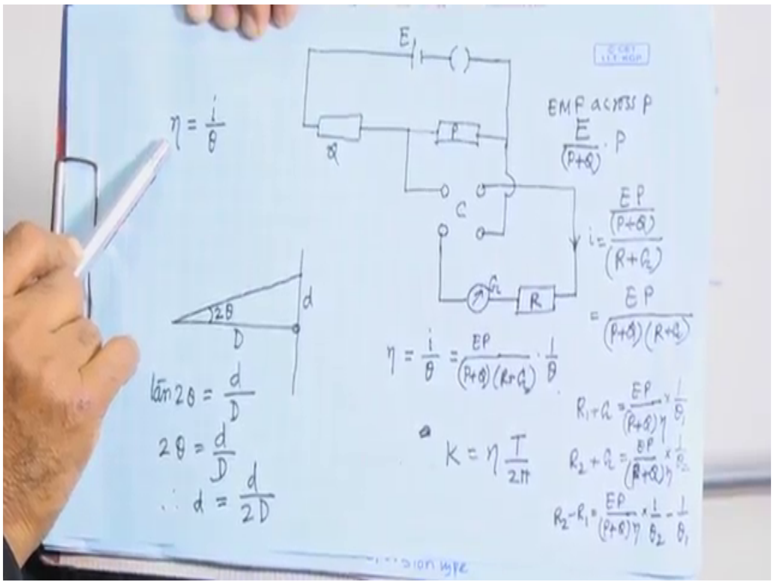

So, eta; so, I will just tell you I will tell you that eta current sensitivity is basically i by theta equal to some constant c by n ab. So, now, what will happen this i is proportional to theta; this propensity constant is this eta. So, there is the current sensitivity. So, now, I have to pass current through the through the coil of the galvanometer, then what is the deflection of this coil that I have to measure. So, I need arrangement for passing current through the galvanometer and then using the light scale arrangement we will measure the theta, right. So, so basically when mirror will be rotated by theta this reflected light. So, this is the initially initial light at 0 0 position.

Now, if mirror rotate by theta, so, this reflected one will rotate by 2 theta. So, this displacement if it is small d and this distance mirror and this scale distance is capital D. So, then tan 2 theta will be equal to d by capital D. So, theta so, this will be basically not d so, it will be basically theta. So, theta will be equal to d by 2 capital D, ok. So, capital D we have to measure. So, generally it is given the student or we can measure using the meter scale and of course, this small d we have to measure; that means, I will show you.

Now, theta will be able to measure using this light scale arrangement. So, now, I have to pass current to the galvanometer and for that current what will be the deflection that I have to measure. So, for that this is the circuit. This is the circuit for passing current to the galvanometer, right; so, these are simple circuit.

Now, we see you have galvanometer, right. So, I want to pass current through the galvanometer I want to pass current through the galvanometer. So, in series we have added one resistance box that is R, ok. Now, if power supply is connected here power supply is connected here so, then current will flow through this. Now, this current, current passing through the current passing through the galvanometer that I can control that I can control just changing the changing the resistance R from this box if I change the resistance R. I can vary the current passing through the galvanometer, right.

So, but here I have not added this power supply directly. So, here what we have done? So, I have used one commutator; reason is that this I want to just change the direction of the current. So, I want to change the direction of the current. So, that is why we have used commutator. So, in commutator you know this there are four option for connection. So, this of diagonally opposite these two are collected here, for this main circuit and this battery is connected to the other diagonally other to end.

So, now, when you will just close this two when you will close this two then what ever the direction of the current. So, you can reverse the direction of the current if you just reverse if we close open this two and close this two. So, this way just we can just reverse the current. So, this is the standard procedure to reverse the current in the circuit; so that we have added here.

Now, here basically I have to add the power supply. So, again means I have to I need power supply between this two point and or EMF between this two point. Now, here I have I have a battery. So, it has fixed it has fixed voltage EMF. So, that EMF is E. So, now, this I am not connecting with this one directly, but rather I am I have used this voltage divider you know. I can choose the voltage I can choose and vary the voltage between these two point. So, that is why I have use the voltage divider circuit.

So, these are standard circuit you see this is the this is the battery or this is the just one circuit breaking key, ok; if we close then the circuit is closed, if you just open it circuit is open. So, these battery is now I have collected this registers box Q in series and another resistance box or just resistance simply resistance P, ok. So, this you can take as a circuit this you can take as a circuit. So, current will flow through this circuit will be will be E divided by total resistance Q plus P, E divided by Q plus P or P plus Q, ok. So, these will be the current flowing through this circuit.

Now, then voltage drop across this resistance will be into P, i into P resistance P, ok. So, these will be the voltage drop across this one. So, now, this we act as a voltage source for this circuit if I collect this way if I collect this way. So, this voltage drop that is now EMF across this P. So, this is now power source for the circuit. So, this is the EMF, this is the EMF or voltage for these two points, ok.

Now, now current will flow through these circuit through the galvanometer. So, this I can write i g I can write i g current passing through this galvanometer. So, this voltage divided by total resistance in this circuit. So, total resistance in this circuit is R plus G plus basically P; P is the one can take as the internal resistance of this one, but we neglect P because this P will keep is keep it very small compared to this registers R. So, condition you can only neglect condition is you have to keep P very small compared to R. So, this assumption you have made. So, during experiment that assumption we have to follow, right. So, that is why we have neglected this resistance P.

So, we have taken total resistance in this circuit is R plus G. So, this potential this voltage EMF divided by this resistance. So, that will be current in the circuit that will be the current in this circuit that is i g. So, basically then EP divide by P plus Q into R plus G. So, that is the current passing through this galvanometer, right. So, , now, then eta is basically I by theta I by theta. So, i is this one; i is this one into 1 by theta. So, that is what I have written expression.

So, here you see. So, here I can write basically R plus G R plus G equal to eta I can take here R plus G equal to EP by P plus Q I have to write yeah P plus Q into eta into 1 by theta, ok. So, I can because the G is not known to me. This G is the basically the resistance of the galvanometer that is not known to me is I want to avoid it. So, that is why for a particular value of for a particular value of R, so, that is R 1. So, deflection I will get theta 1 for another value of R, R that is R 2 plus G I will get deflection theta 2. So, this is 1 by theta 2, right.

So, if you just take difference between these two so, R 2 minus R 1, G will go. So, I will get EP by P plus Q into eta into I think I have to put bracket I have to put bracket, into this. So, , basically this expression is now not having the G. In this expression all are known to you because R is known, P is known, then Q is known E is known then theta you have to measure. So, for difference so, so our task is basically we have to vary R and measure the theta, then we will plot graph; we will plot graph 1 by theta versus R 1 by theta versus R.

So, this we can write R 2 minus 1 by theta 1 minus 1 by theta 2 divide by R 2 minus R 1, and then eta I will take this side. So, eta will be equal to EP by P plus Q into 1 by theta 1 minus 1 by theta 2 divided by R 2 minus R 1. So, that is basically if you plot 1 by theta along the y-axis and along the x-axis R and if you do the experiment for few R, so, for different R what is 1 by theta that I will plot and I will plot and this from this slope of this of this curve slope of this curve basically will give you this 1 by theta 1 minus 1 by theta 2 divided by R 2 minus R 1.

So, then, other value are known to you. For that this we are not varying this, we are keeping fixed. Only we are varying R and then if you vary R then i g will be different for different i g theta will be different. So, we will measure theta for different R, that is what our task then we will find out tau eta. So, that will be the current sensitivity if I know the current sensitivity. So, then I can find out the charge sensitivity because eta is already known from this experiment and then only I have to measure the oscillation, time period for the oscillation of the curve of the of the of the of the coil, ok. So, that T I have to find out then I can get this charge sensitivity.

So, our experiment is basically for different R 2, different R I have to measure theta, ok. Then I will plot it and get this slope and then I will get eta and then I will measure the T time period, then I will get the K charge sensitivity.

So, now this circuit I need. So, I will show you the circuit as I showed here in my sketch in my drawing. So, here just compare with this one compare with this one. So, so, let me show you this part first this part first this circuit for that for the galvanometer part, ok.

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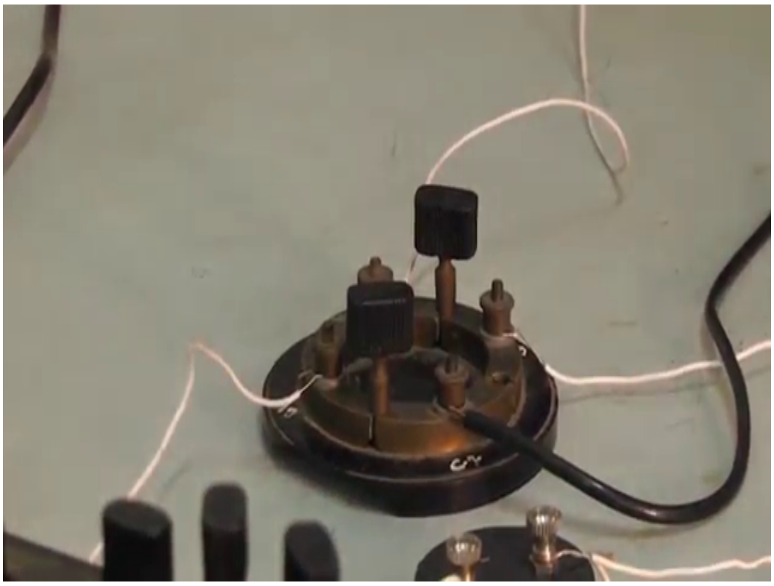

So, this is the commutator, this is the commutator, this is the commutator, right ok. It has four as I told this it will have four connection option 1 2 3 4, ok. So, this is kept closed or just should keep because this circuit is big is kept big. So, that is why if you put here also there is no problem. So, so this commutator; so, now, you see this as I told diagonally opposite diagonally opposite so, diagonally opposite take this one and the other one. So, these two is connected with the galvanometer through a resistor R.

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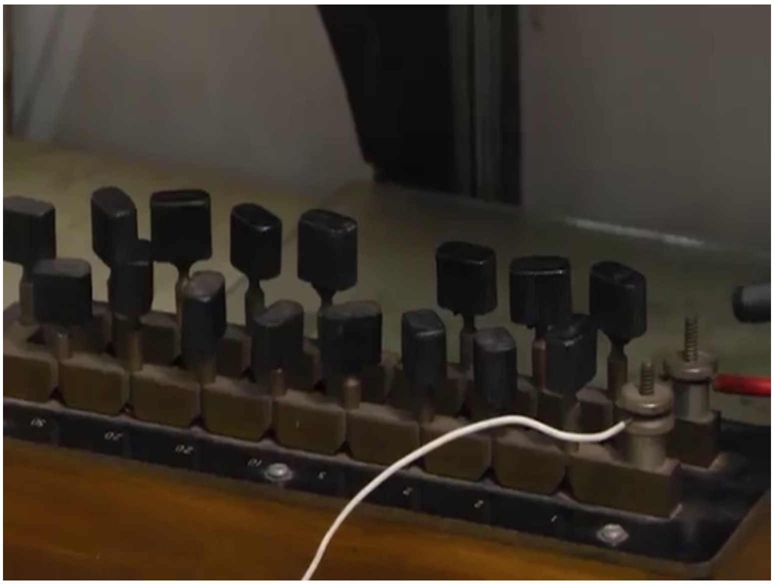

So, start from here come this is the R box resistance box R resistance box. So, this resistances in series with this galvanometer with this galvanometer. So, I think this, yeah this in series with this one this is coming here, ok. So, this the resistance box is in series is in series with the yes here it has come. So, opposite diagonally opposite connection. So, this circuit contain the resistance box R 2 R and this galvanometer in series, right.

Now, again here, this diagonally opposite this two I have to I have to connect the battery, right. So, this arrangement as I told this just for this is just for the for reversing the current in opposite direction. So, now, battery so, here this here as I mentioned here as I mentioned this we will connect just across this across this P because this whatever the voltage drop across the P, so that will be taken the power for this EMF for this part.

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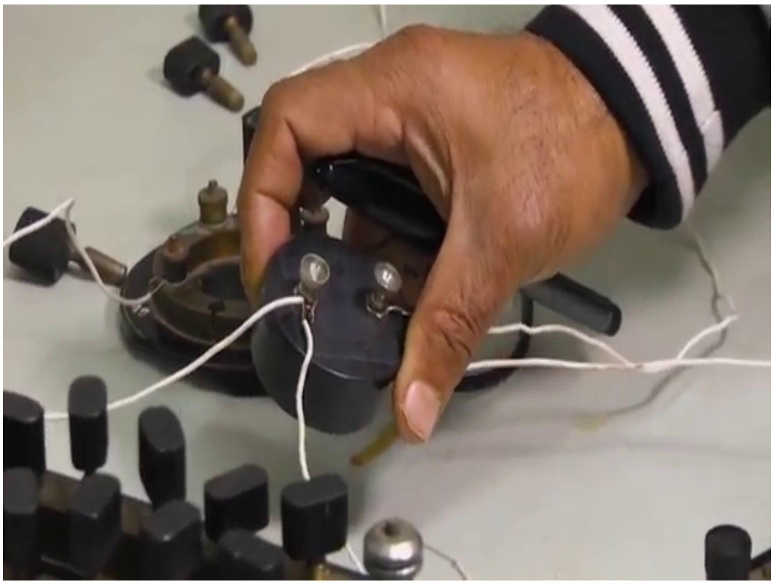

So, this two is connected across the P. So, this is P. So, this is constant resistance very small resistance how much it is written? It is it is ohm yeah, very small this is 2 ohm this is the 2 is written 2 ohm, ok. So, this 2 ohm resistance ok, that is P that is fixed.

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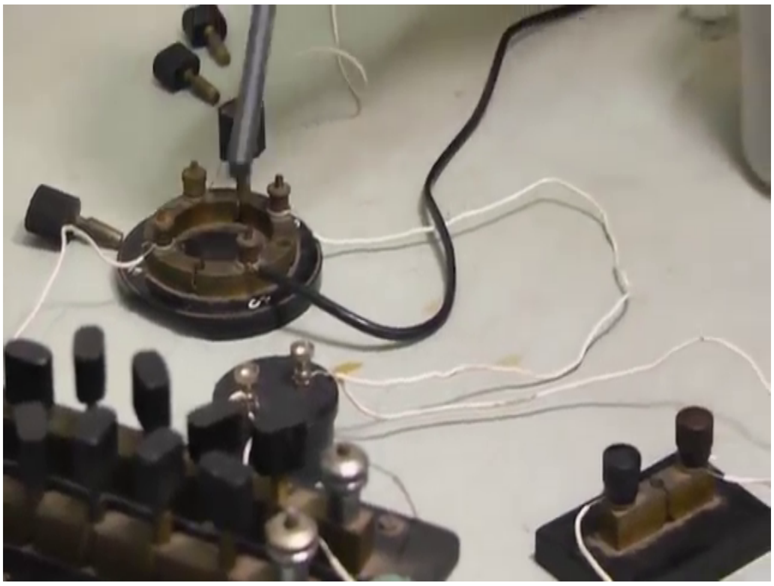

So, that that is connected this P is this one is connected across this P, ok.

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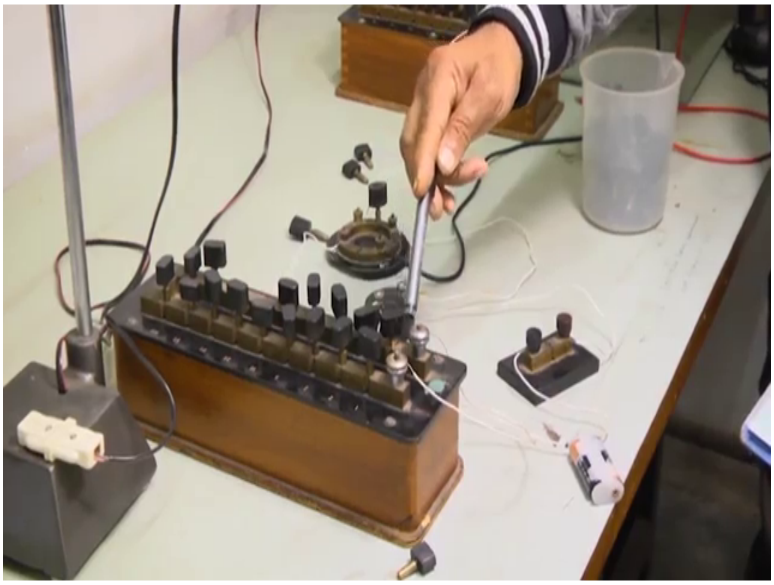

Now, this P and Q this box is Q; P and Q is in series with the battery with the battery.

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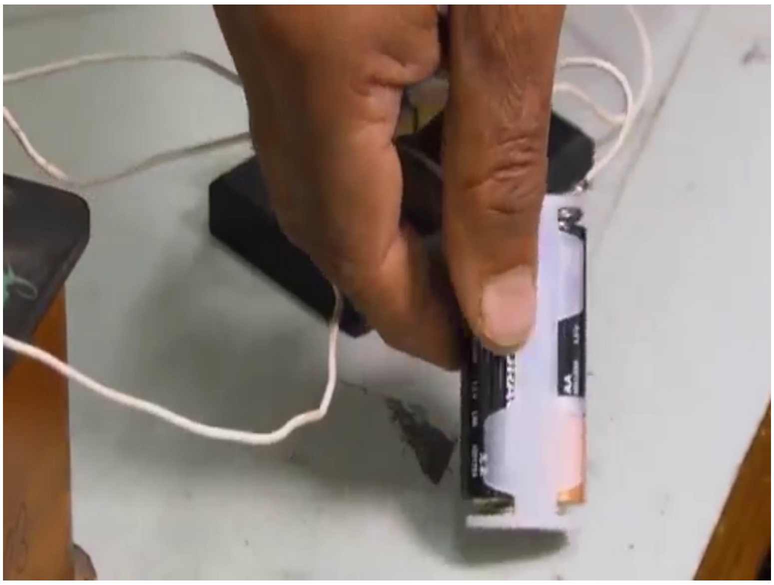

So, here we have use this battery. So, just yeah since basically how much what is the voltage is written here is 1.5 volt, 1.5 volts; so, basically 3 volts; so these two batteries are 3 volt.

So, now you see this start from the once end of this battery one electrode off the battery. So, if I start from here, so, this is going to this resistance box Q and then coming following this one, then passing through this P passing through this P here just break key we have used and it is coming to the other end, ok. So, this is a one circuit battery circuit. So, current in this battery circuit we can vary just varying the Q varying the Q because here P fixed and this one also fixed. So, varying the Q we can vary the current, ok.

So, now, voltage drop across this is this current in battery circuit into this resistance P, this is constant. So, varying the P basically I can choose voltage drop across this P which will be the source voltage source for this galvanometer circuit, right. So, now, what is the experiment I have to do as I told just I will vary the R and measure the theta.

So, that is the experiment I have to do. So, now, at the moment at the moment here we have said we have said this the resistance here this Q is here I can see this is 1000 plus 500, 1500 ohm this Q that I have to note down and here this P is 2 ohm that I have note down; battery voltage E is the basically 3 volt that I have to note down. Now, here R I kept is a value is 1000 here also a value I kept this a 1000, that I have to note down, ok. So, now, light scale arrangement, when no current is passing through this circuit so, it is at 0 position the spot, light spot at this 0 position.

So, now, what I will do, I will pass current through it and for that current what is the deflection theta that I have to measure. Basically here I have to measure the small d then from theta equal to small d divided by 2d I will find out the theta. So, that theta so, basically R versus theta or one by theta that data will get.

So, now let me show you just experiment. So, I just close this two, ok. So, current will flow in a particular direction then I will make it opposite. So, current will be reverse. So, that will do after this experiment after this data. So, now, we say this still it is at 0 position. This still it is at 0 position because current is not flowing through it because these are. So, this key that is open that key is open, right.

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Now, we see just when I will close it, so, then let me just close it and then see you see the spot is come here or spot edge come here. So, that reading I have to take. What is the reading of the spot? What is the reading of the spot? So, this 10, ok. So, what is the maximum value that I have to take? Ok. So, it is the 10, it is the 10, ok. It is coming at steady state.

So, it was at 0, sorry it was at here. So, that 0 position. So, I have to take this top scale it is 10 11 12. So, 12 point I will take this 12.5 I will take this reading 12.5. So, for a particular this value of R, R is 1000 ohm I have to note down for that the small d is 12.5. Now, I will reverse the current I will reverse the current, ok. I will reverse the current actually I should I should take it.

So, I should break the circuit. I should take it to 0 position I should take it to 0 position, ok. So, , this across this galvanometer we have we should give option this one key 2 to short it. So, that will come to 0 position very quickly. So, just I will make it short; so it will come at 0 position. So, basically this way we are introducing very high damping. I will explain some times. So, then it is damped and come back to the 0. Yes, now you see this just it is. So, it is just 0 is on top is 0 is written on top is 0 is written, ok. So, we are taking this scale this top scale 0 1 2 3 this side 1 2 1 2 3 4 5 ok.

So, now, I will reverse the current. So, that means, I have to when I forgot it was where it was here or here anyway let me try in which direction it is going then I have to reverse, but I do not remember it was this side or it was here I think it was there. So, I have to just reverse it; so wherever it was there. So, I have to take this other way or vice versa. So, now, I will just close this one, ok, this circuit. So, you see where in which direction it is going , ok.

So, it has gone to this that reaction; that means; that means, this was earlier position, now I have to reverse this position to reverse this position and bring it back to this just to the 0 position. So, I have to shorten it; so basically this two just I am connecting here ok. So, introducing high damping so that it will come back to 0. So, hopefully it has come back to 0, yes it has come back to 0, ok. It has come back to 0.

Now, I have I have put in reverse direction, and then I have to close it I have to close it then current will flow you see. Yes, now deflection is in opposite direction. So, here I have to take. So, let us allow to come at steady position. So, as I told you should take maximum deflection known that that is not correct, we should take at this steady position. So, now, current steady current is flowing for that what is the deflection that we have to take.

So, this reading is now again 10, 11, 12, 12.5, ok. So, it is a perfectly symmetrical. So, just reversing current that side I got 12.5, this side also I got 12.5. So, basically mean of this two we have to take, ok. So, it is a mean is 12.5, ok. So, for this resistance R, that is 1000 so, I got small d that is 12.5 and corresponding theta. So, I know this distance I know the distance or you have to measure generally supplied. So, if you know this capital D, then you will find out the theta, ok. So, R and then corresponding theta and then 1 by theta you can note down you can calculate; so now, this is for 1000 now I will add.

So, I should break circuit I should brake circuit I should break circuit then take it at 0 position take it at 0 position take it at 0 position, ok. Yes, it has come at 0. So, now, I will do the experiment for I just added 500 more. So, it is now 1500. Now, R is 1500 then again I will repeat the experiment I repeat the experiment. So, you see what is the deflection that I have to find out what is the deflection I have to find out let us come to the steady state steady deflection. So, that I have to. So, basically I have to note down this value and then I will reverse the current and then other side deflection I have to see. So, then average of these two deflection we will take.

So, now reading you can note down I think it is the 9 it is the 9 or 9.2 you can note down 9.2.. So, just reverse the current I i should I should break it because we should not pass current for longer time then take it to the 0 take it to the 0, right. So, just now reverse the current again do the repeat the experiment and take the reading. So, this theta you will get or 1 by theta you will get for resistance R equal to 1500. Next I will do for say more 500 I will I will take at this resistance. So, for 2000 R equal to 2000. I repeat the experiment R equal 2500 R equal to 3000, just I will repeat the experiment.

Now, in this experiment so, we assume that P will be very very small compared to R and that is what P is 2 ohm whereas, this R we are taking in 1000 ohm 1500, 2000. So, it is really P is very very small that is why we neglected that one. Now, just you plot the graph 1 by theta along the y-axis versus this R. So, then from that curve basically find out the slope.

So, here just we did the experiment I will just show you I will just show you I have the plot I think coefficient, yes.

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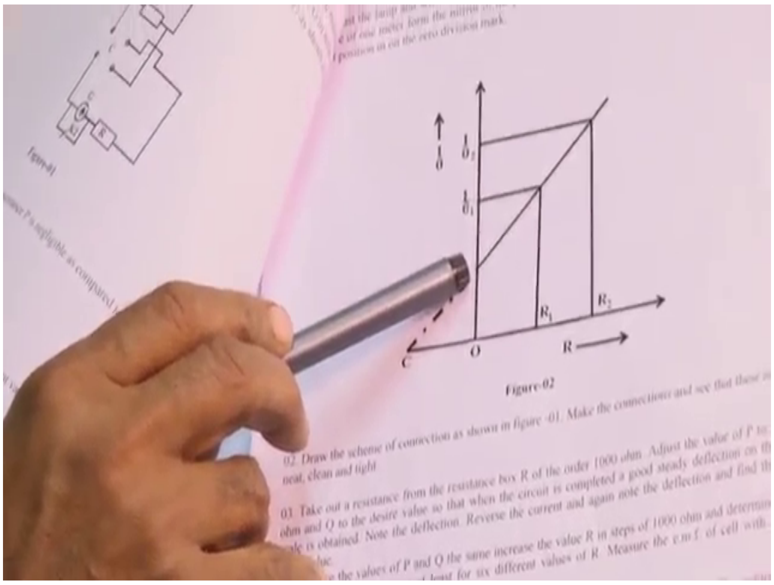

Yes, basically you have to plot this 1 by theta versus this resistance R, ok. Then basically you are getting this type of straight line this type of straight line. Now, yes. So, just choose find out the gradient you know how to find out the gradient just choose to two point two point and then straight line. So, basically you are getting here from or just from here it is a one is take as R 1 another is take as R 2 corresponding 1 by theta 1, 1 by theta

2. So, you will get basically 1 by theta 2 minus 1 by theta 1 and corresponding R 2 minus R 1 and then slope we find out this by this. So, that will be the slope that you will use for your experiment.

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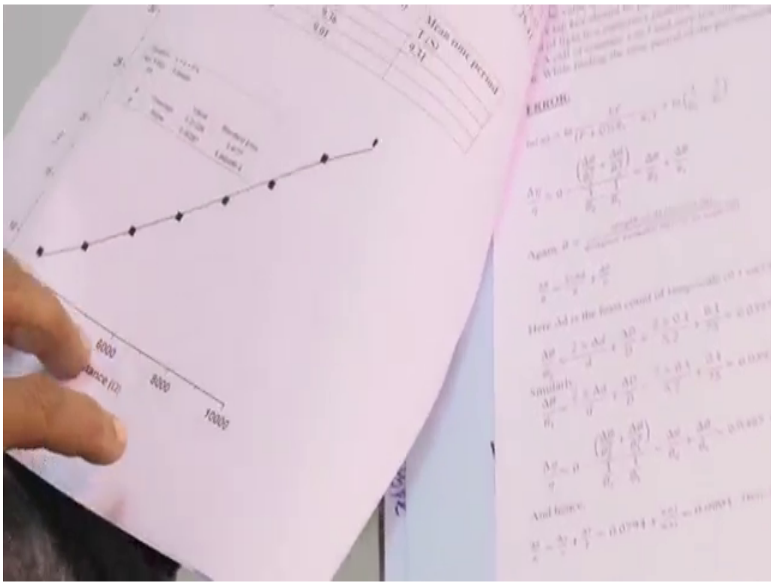

Actually we did for real data we have plotted here and one has to find out this graph this slope from this graph. So, and then there are some yeah; so then you can find out eta that is basically current sensitivity.

Now, for charge sensitivity what I will do. So, just I have to measure the oscillation of this coil. So, basically I have to find out the oscillation of this of this light spot, right. Time period of this of this light spot because this light spot this oscillation is same as the oscillation of this coil, it is related with the mirror and that is reflected light.

So, for that what I have to do? So, this some charge; so some charge momentarily some charge I should pass through this through this through this galvanometer, right. So, so what I will do just I will closed and then again I will open it; then it will start to oscillate. So, let me start; so, I closed it and then I just open it. Now, I have to I have to take stopwatch. So, now, I have to just start and then count this number of oscillation.

So, if I start from here; so then 1, 2 ok. So, we will get few 2, 3, 4, 5 we will get and for that you will get time from here. So, stop it and then just this time divide by this number. So, that will be basically time for a for a one oscillation. So, that is the time period that is the time period and T is known to you. Now, so, T you have measured from here. So, now, T is known to you so, that is K the charge sensitivity is basically charge sensitivity is basically eta into T by 2 pi. So, t you will get from this measurement and then you can calculate the charge sensitivity.

So, I think rest of the things error analysis and this discussion precaution that you should do yourself for this experiment and sometimes we will discuss in our tutorial class also. So, this a very nice experiment, it is simple, but one can learn lot of things from this experiment about the mainly about the galvanometer and its sensitivity right figure of merit which is basically the current sensitivity.

And, one has to understand the basically circuit this simple circuit, but what is the purpose of this different arrangement that one should understand then things will be very easy and one should also understand the working formula how it has come what are the assumption like in this experiment P we have to take very very small compared to Q that condition has to fulfill during the experiment. So, that also we have check. So, these are the precaution one has to write writing precaution or discussion we should mention this points; so I think I will stop here.

Thank you.