Experimental Physics - II
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Lecture – 57
Experiment of photoelectric effect

now we will demonstrate the photoelectric effect that experiment in our laboratory.

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this is the experimental setup for photoelectric effect. what was the circuit diagram I showed you, the circuit diagram just, so always for when we are going to do experiment, we should have circuit diagram in our hand and then we should connect this all component accordingly.

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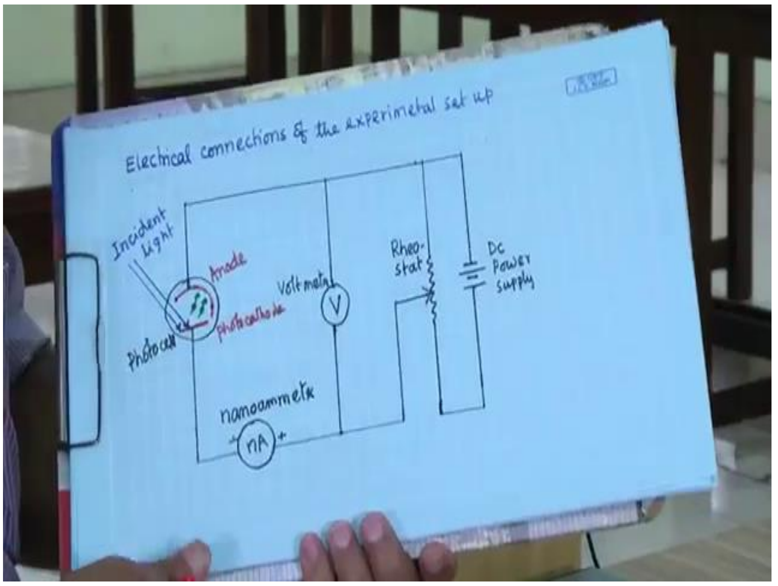

here, so this let us see which one is photocell, in this setup which one is photocell; this is photocell, so it is a photocell is inside

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inside this element is there. this is the cathode is written k, this is the cathode, and this is the anode it is inside the box, I cannot, we cannot see now. now light will fall on this cathode, so light will fall on this cathode. light will fall through this is the in turns of light. this is the in turns of light, Here we have put a filter, as I mentioned I have to, yes, so this filter. this is the in turns of light. we can, so inside there is a photocell; cathode and anode this just we just, because all the time we do not put this light on the photocell, so it is sensitivity will decrease. that is why we just closed it and then we just move it to I think this way yeah, you can close it, you can open it ok

light this mercury light from this source who is coming out from this source, light is coming out mercury source, it has different wavelength this we will put this way, so light will fall on this photocell through this in turns. actually, we want monochromatic light to fall on this photocell.

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we will use this; these are interference filter. it will only allow light of wavelength 405 nanometre that is the wavelength of light we will pass through this filter and other light will be stopped.

interference phenomena are used for this filter. such type of filter we have five filters. we have five filter; this is the another filter which is having 366 nanometer; and then I have three more, this is 436 nanometer, 546 nanometer.

it is a, I see this is looks yellow colour, you know 546 is the 500 you know this sodium D-lines, this wavelength is 500, 580, 589, I think 589 around 590; 590 is the wavelength of sodium D-lines. that is the yellow colour. it is looks yellowish, this bluish, wavelength is lower is bluish, this yes towards I think it is a green filter itself, because only that type of light is passing through it. that is why we are we are seeing that colour of the corresponding wavelength.

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and then I have another one going towards orange going towards orange; that means, higher wavelength. here you can see 578 nanometer. it is also we can tell yellowish, going towards red, orange

we have five filters, interference filters for selecting monochromatic light. I think I will start with the lowest wavelength, it is a 366 lowest wavelength higher frequency. this I will now put in front of this cell, yes now, I will turn it towards the light source

now light is falling on this filter, but this it is not entering into the cell, because it is a enters is closed; as I told this I have kept it in closed position. in this condition, now what we will do? light will fall on the cathode and then electron will emit, and that electron will fall on the anode and corresponding anode current will get. let us see this circuit.

now we see from here, this from inside I say this type of. this two end are coming here, this two end are coming here from here, so this two end; one is going towards the nano ammeter. one is going towards the nano ammeter. this is the nano ammeter and from nano ammeter other end; nano ammeter here this two end, one end is their connected here and another end is going towards the volt meters.

Another end is going towards you see another end is going towards the voltmeter and one is going towards the voltmeter and other part is going to the rheostat; other part is going to the rheostat. this is the rheostat. other part connection here is rheostat. this connection and this connection are I showed you, now this anode this part is one will go to the voltmeter anode other side is this one, this one will go to the voltmeter and rheostat.

this one is going to yes; this one is going to the DC power supply; yes, it has come to the DC power supply. And also, from DC power supply or the rheostat other whatever, this should come to the voltmeter. I can see yes. this is coming from the other end, this is coming to voltmeter, this is coming to voltmeter one is from here and other is from here ok, so these two connections, so we have to check it

and rheostat other end of course, with the one is connected here, and another must be connected to the DC power supply whatever this one, it is their ok, it is a connected with this power supply by another end of the rheostat. this is the circuit diagram whatever we have drawn. exactly this circuit diagram is where here. always we should draw the circuit diagram before doing experiment and we should check the connection whatever we have made whether that is as per our drawing

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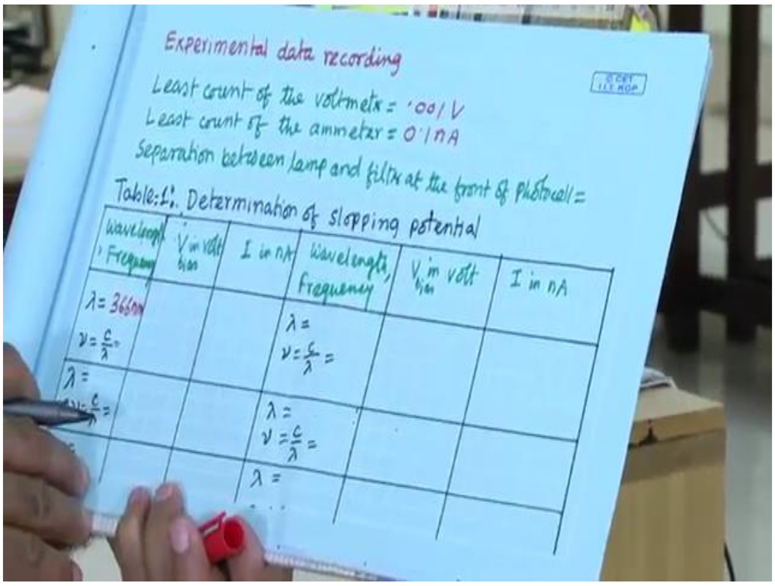

Now, we will do experiment as I describe. what the data I have to take, yeah experimental data recording, least count of voltmeter. find out the least count of volt meter here it is a, you can see this 0.00 it is the volt and this after decimal 2; that means, it is a 10 millivolt is the least count of this power supply oh sorry, it is the volt meter not that one, it is a here. voltmeter yes.

we have chosen this scale 2 volt you can get change, after decimal point 3; that means, 1 milli volt; 1 milli volt is the or 0.001 volt is the least count for voltmeter that we should note down. Then what is the least count of the ammeter, nano ammeter? Of course, it is we have taken 100 nanoampere. it is a showing 35 nanoampere point. 0.1 nano ampere is the least count.

0.1; so, 0.1 nano ampere is the least count that we should note down yes. which scale you are choosing that we have to see, here 100 nanoampere that scale we have chosen and here reading showing 35 point it is a varying anyway. it should because some fluctuation of light and this something is happening and separation between lamp and filter at front of the photocell ok; separation between lamp, this is the lamp and the filter. this distance generally we note down, because that we should not change the distance during the experiment. we just take a scale and measure it This is the filter, and this is the phasal, just measure that you can note down that one

now we have to determine the stopping potential. we will choose particular wavelength, say lambda equal to; now what is the lambda I have chosen, this 366 probably 66 nano meter I will note down and corresponding frequency I will calculate, this is the c is the velocity of light 3 into 10 to the power 8; 3 into 10 to the power 8 meter per second

for that now what I will do, I have to change the voltage; this is the reading of voltmeter; reading of voltmeter and ammeter, nano ammeter we have to take, just I am showing I am not knowing. here that rheostat I have kept at, you see. between this to this whatever the resistance is included, so I have kept at 0 resistance. here that is why it showing this voltage is 0. there is a minor fluctuation ok, this voltage is 0. no, so this voltage is 0 it is not because of that there is no voltage applied to the anode, it is not because of that ok; we should get maximum current at this 0 voltage, because we will apply negative voltage. here it is 0, because this shatter is closed; now I will open the shatter, I will open the shatter have to be if other side.

I have open the shatter, but why voltage is 0 that is true; voltage I have applied 0. I conclude with the voltmeter and ammeter, nano ammeter. we have to look here voltage is 0, because I have kept it that is the resistance 0. no voltage is applied to the anode Now this time current you are getting that is 80 yeah 88.4 or 89 you note down that one, you note down. 0 voltage, I have applied 0 bias and this current is 88 nano ampere.

if I showed you the circuit, how this cathode and anode, the photocell are connected with nano volt meter, nano ammeter this volt meter, this is the volt meters this volt meter will give reading the voltage applied across the anode or between the cathode and anode it is a negative voltage will be applied. connection is made in that way. this is the constant power supply, DC power supply 2 volt and this is the rheostat.

now rheostat position, now here this it is showing 0 voltage 0 voltage is given to the anode and corresponding photocurrent earlier, so there was some problem in the circuit loose, loose circuit, so I have corrected it. actually, it is it will be not 88. it is reading is 0.5 ok, 0.5. Now, I will change the, I have to change the this voltage, it is a I am changing the rheostat resistance.

you see I am increasing the resistance; that means, voltage drop will increase ok, but again I am, so it is a current is decreasing; but somehow this fellow is not giving me reading. some where some, I think loose point is here now, it is giving reading. it should be 0 at this position, it should be more or less 0 at this position, it is digital one it always fluctuates ok, so it 0.

you have to give time to settle it down. it is more or less 0. Now, this current 105, now I am seeing just change applying voltage bias voltage, you see it is changing, it will change the voltage that, so I have to take this reading, I have to wait and actually wants to take, so this and note down this current. I have to make this current 0 and corresponding that voltage I have to find out.

I am changing and just looking at the current decreasing, increasing, bias voltage current decreasing. I should note down, but I am not noting down, just I will continue and just only I will note down the stopping voltage. current is decreasing; current is decreasing, voltage is increasing. at which voltage current will be 0 that I have to find out

I have done slightly more, I should see it is slightly hard it is more or less currently 0, yes; it is more or less currently 0 there is a fluctuation. this is the, it is 700, we can take this 700 as the stopping potential, it is a varying. I will note down this for this corresponding wavelength this stopping voltage is say 700 milli volt, because this is a 0.700. it is a millivolt but here I have written volt so I should write 0.700 volt and corresponding current is this is for this and corresponding current is 0 for different filter we should just do the experiment. I will do the experiment for next filter and we will put at the same place because intensity will keep constant, I will change this filter, I will go for the next one. 405 nanometer, I think I will go to the extreme one in between I will not do that is the I think 578 nanometer.

in this case current should be drastically fall at 0 bias voltage compare to this other filter and stopping voltage will be very small for this. In principle let see, because higher wavelength I will keep at the same distance we will expect that brightness will be intensity of light will be same I have to actually I have to keep it all the time starting from 0. here you see this I am not getting you see even at 0 voltage; I am not getting current

we are getting 105 nano ampere for the, for that filter for 405 not 405 36. it is the highest wavelength; so, this is the highest wavelength, 366 nanometer. energy is highest, we are getting 105 nanometer; you see when we are using this higher wavelength; that means, lower frequency.

this h nu, here h nu corresponding this wavelength ok, corresponding this frequency, so that is now that is even less than the this that is e V, not e V what I should tell this h nu whatever this energy of this photons, that energy is less than the work function. no electrons are emitted.

that is why this is happening but let me check using this one whether my setup is working well or any due to any problem that current is not showing. this I am using 405 nanometer earlier it was 600 something, 578 now it is a. I should get current, yes, I am getting current; it is a you see 18, it is around 18; 17 18 nano ampere.

now here wavelength is higher than the 366 nanometer. for 366 nanometer 105 we are getting; whereas for this we are getting 18 we will increase the wavelength and we are getting the current, we are getting the current lower current; that means, ejection of the electron, although intensity are same because that distance although light intensity are same, but different wavelength; because of the different wavelength ejection of the electron from the metal surface are different, so that is why plate current are different.

Even we are we have not applied any negative bias at 0 voltage this current is decreasing. that is what. for all thin, so one as to note down and find out the stopping potential for this also one as to find out the stopping potential ok; I have to make it 0. it is a decreasing, that voltage is increasing, yes. one has to do properly. it is a more or less 0 current and for that corresponding stopping voltage is 0.412. you should note down what is the wavelength.

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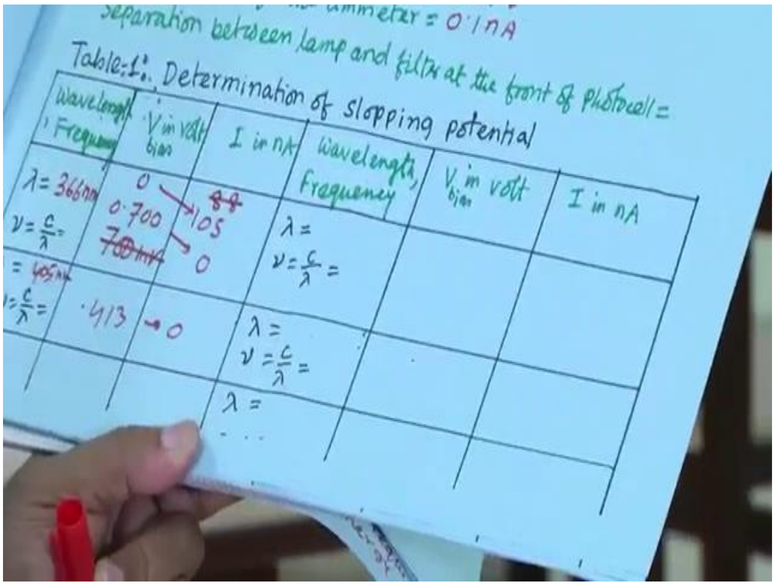

this next wavelength is 405 nanometer and stopping voltage is 0.413 for 0 current

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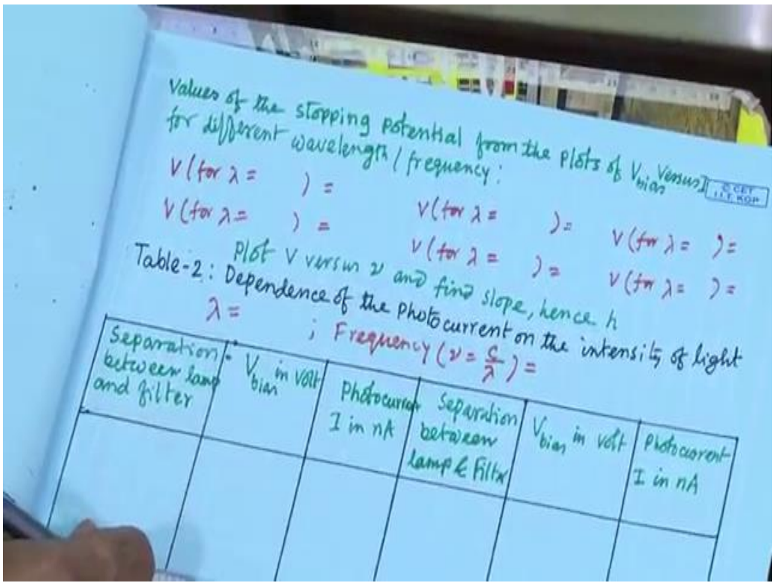

we will note down this for all filter, we will note down and get the stopping voltage versus this wavelength or corresponding frequency. We will plot the graph V versus nu and from there we have to find the how to find out slope we must be knowing this experiment is done and this I will not, just I will show you that is a how to do this one dependence of photocurrent on the intensity of light, so intensity of light.

for a particular light here 405 we have used let me put it at 0 bias Now, if I change that this from the source, if I change the distance of the filter. keep at higher distance here current at; I think for this doing this experiment it is better to take this. it will better to take this higher lower wavelength, higher yeah, this one 366. it was 105, see depends on distance you know 105.

you see for this now intensity I am just changing the distance and I am getting the variation of the current you know; because intensity of light is decreasing, falling on the photocell because the distance from the source to the photocell are changing. if I increase this way ok, you are getting yeah it is increasing

for a particular distance, here for a particular distance; now what is the stopping potential for that one, if you want to find out let us find out to make it 0. to make it 0, so if you change. one has to it is become hot and then changes you know. earlier for 366 nanometer stopping potential we noted down this 700, around 700 millivolt and for now it is coming around 800 millivolt anyway.

But this is for 366, if I increase the by it intensity. this stopping potential whatever I. this stopping potential should note down change much make it 0. it is the 100. earlier I kept at 105 the reading, the distance I kept at 105 yeah, around this point I can keep 105 and this voltage applied 0.

Now, what is the value I am getting for stopping voltage, just let me check it to make it 0 It is a around 900 ok; it is the around 900; now keeping that to make it 0, it is a around 1 volt, but it is a sensitive one, one has to around 900 ok, around slightly more than 900 anyway it is fluctuating. Now, if I change the distance what happen; intensity incident density I am changing, you see I change it. to make it 0, how much I have to change? it is around 700

for that distance this stopping voltage is 700. for different distance you can find out the stopping voltage; find out the stopping voltage, starting from this of course, here; starting from this of course, here at that distance, so at 0 voltage, so this is the 33. And now for this stopping voltage what will be the, so at different distance. this we will we will note down as I told this separation between the lamp and filter you are varying.

you are noting down the photocurrent for 0 voltage and then voltage you are changing and getting the stopping voltage. for different distance means, intensity for different intensity for the same wavelength. how the photocurrent is changing? that is what one can see from this data. just I showed you how to do it and this longer time this light falls on this photocell; it is current fluctuate. we should quickly take data or when you are not taking, so we have to closed it. that unnecessary light will not fall on the photocell. that is the precaution one should take.

I think this is the experiment for, yes, it is for photoelectric effect. clearly you are able to demonstrate that, the frequency, the current we are getting; led current or anode current, so that depends on the frequency of the light, it does not, it is very sensitive to the frequency of light. Because when we use this higher wavelength, then we saw there is no current ok; and when you are using lower wavelength, we are getting higher current and wavelength are increasing, current is decreasing and also intensity that current is decrease with the distance with the intensity. there is a number of photons.

if number of photons increased on the cathode, so then what will happen; if the energy of that h nu is higher than the threshold work function, so we will get current, current will increase intensity is increasing, current will increase; but if for red light whatever I showed you, for red light, this light, this wavelength is 578 for that one I showed you that for that. we are not getting, we are getting 0 current, we are getting 0 current

even putting at 0 bias means there is no, so stopping voltage there is no question of stopping voltages; even without negative voltage to the anode we are getting 0 current. And if you change the distance nothing will happen; if you increase the intensity also does not, it is a does not matter. there will not be any current in the nanometer will see that the ammeter; because there will not any ejection of the electron from the material from the cathode surface,

it since it is nano ammeter. it is a, they are very sensitive we have to take reading that there will be fluctuation, we have to try to take reading that it is fluctuating from plus minus something, so average reading you should take. And I think this experiment if you find out the slope and you can calculate the h Planck’s constant, and this very keep very good accurate result a from this measurement. I think I will stop here.

Thank you for your attention.