Experimental Physics I
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Lecture – 08
Basic apparatus

So, today I will discuss about another Basic Apparatus.

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So that is Cathode Ray Oscilloscope CRO. So, all of you are quite familiar with this apparatus, and this is a very useful apparatus for the laboratory.

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So, CRO is I have taken pictures of one of our CRO in our lab. So, if you see the front panel of this CRO. So here you can see there are different parts, there are many knobs and one screens is there, one screen is their right one, screen is there. And then, this there are knobs here this one set of knobs ok, there is a demarcation ok. So, this is another set of knobs ok, and this lower part, this is this a again demarcated you see. So, this is another set of knobs and these fourth set of knobs is also demarcated right.

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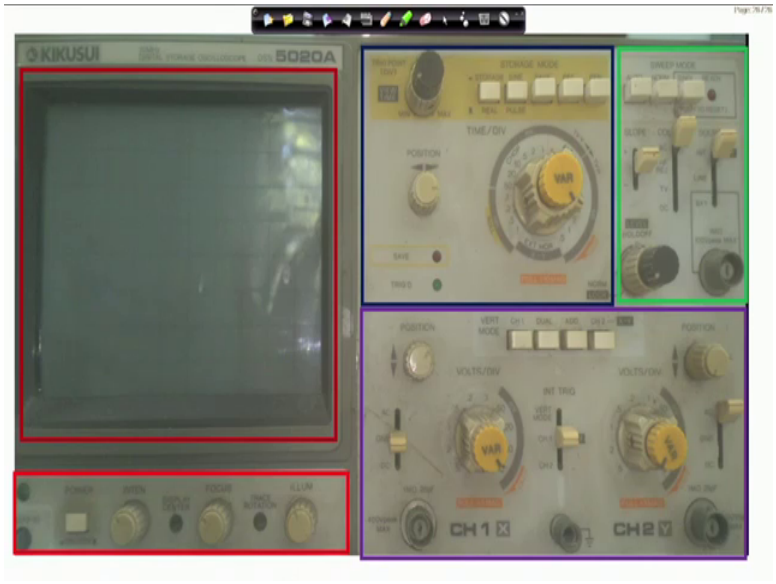

So, if you see the front panel of this CRO front panels of the CRO, so I can tell this is a front panel is basically arranged in a in four blocks. So, this I mark with a red color. So, this is a display, this is a display and display control, these knobs are basically to control the display on the screen whatever we will display on the screen, so that will be controlled by this four knob. So, I will tell what are those things.

And then second one is basically vertical control system, vertical controls so this so this one is this lower one these blocks ok. This is violet color this box. So, this is basically is for vertical controls of the display. And this part is basically horizontal control of the display, and this fourth block here so it is basically trigger or sweep control of the display.

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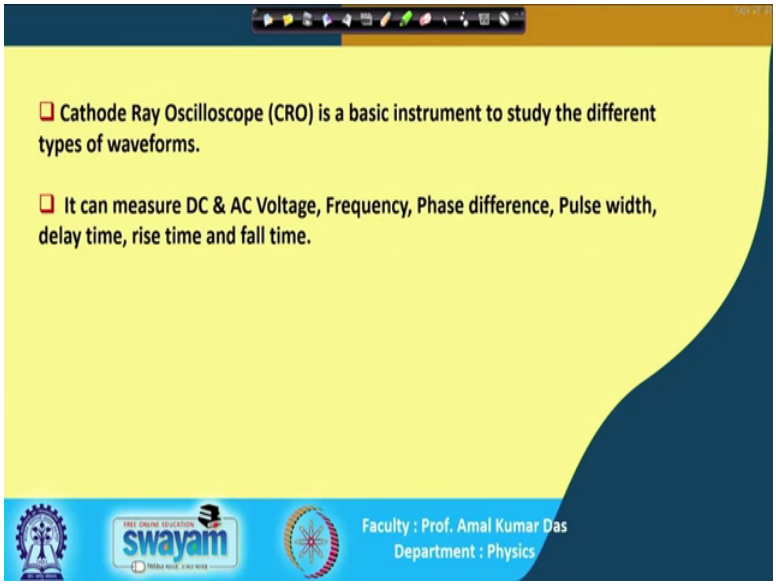

So, basically what is the use of this, let us see first; what is the use of this CRO; what we do with this CRO. So, CRO is a basic instrument to study the different types of waveforms ok, and it is used to measures DC and AC voltage frequency of the waveforms, phase difference, pulse width of waves, then delay time, rise time, fall time of the waveform of the waves, so that is the things one can do means we can display the wave forms on the screen.

And then, from there we have different control to change to basically to manipulate along the x direction, along the y direction, an also time ok. We can manipulate and which helps to measure this parameters, whatever I told you ok. So basically if I give

input to the CRO, so I have taken pictures of this CRO right, here if you see, so these I think I should put this way then.

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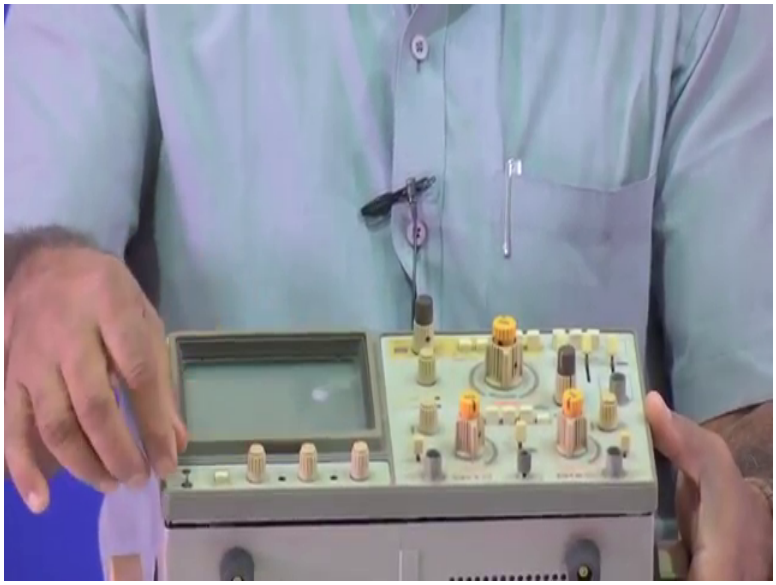

So, this same I have taken picture of this one, I think it will be difficult for you to see. So, this is the screen display screen, and then bottom of this one is basically the display control right. And this is lower that that block lower block ok. So, I think this the lower block ok, this part this two and other. So, this part is basically I think this the vertical control ok, along the y-axis vertical control. And this part is the horizontal control means along the x-axis horizontal control.

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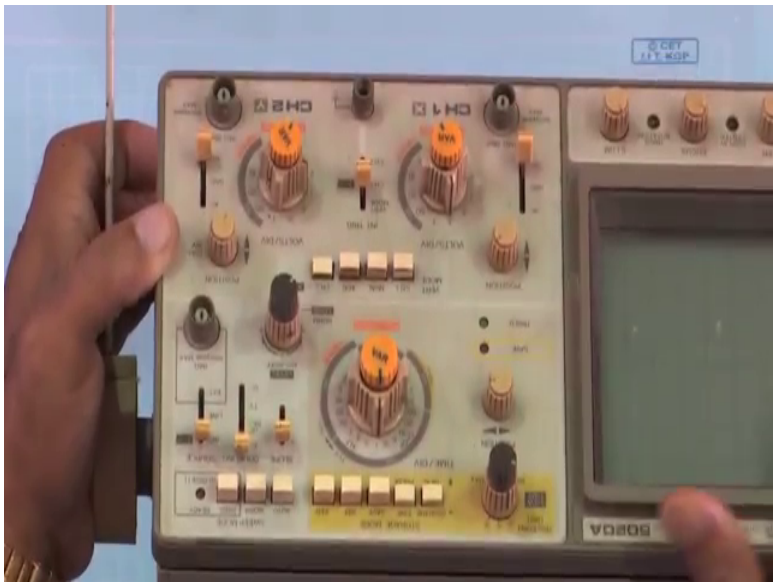

And this part is basically for trigger triggering or sweeping of the waveform ok. So, this the we tell triggering or sweep control for this oscilloscope. So, I will show you parts by parts. Now, now if I, so this is the here basically is a two you are seeing, this here is retain channel 1 and channel 2 is the vertical control, basically we signal we apply signal in vertical axis means along the y-axis. So, this signal we connect here. So, through BNC connectors ok, some signal connector we give the signal here.

So, basically two channels are there means two signal we can put. And there are here also, we can we can compare with; we can compare these two signals at a time. So, one signal you can use and you can measure the frequency etcetera, etcetera voltage right. So, we can analyze the one signal, one waveform ok, or if you want to compare, or if you want to multiply, or super impose this two and this like Lyases figure, we can studied the Lyases figure using oscilloscope.

So, now if we want to want to study the two waveform and their superposition etcetera, etcetera, so then you can give to signal in channel 1 and channel 2 ok. So, two channels are here ok. And here, if you see here whether you can see or not, I will show in picture so this volts per division, this written volt per division, here also this same thing volt per division for channel 1 and channel 2, and here this written time per division, time per division ok. So, this is the horizontal control, this part is horizontal control, this part is vertical control ok. What is control? What we are going to control.

So, if we put some signal here, it is displayed; if it is sinusoidal waveforms, so it will come in the screen, sinusoidal waveform it will come on the screen. And then I am just rotating the knob, reading the following the manual, just I am rotating the knob and measuring the things ok. But when I am rotating the knob, actually what is happening; what is inside in this CRO.

So, just when I am rotating. So, inside what is getting change, so that my display is affected display is getting change ok, so that is what I would like to tell you that when in front panel there are many knobs, and it has different function. And now, we will be able to use this function, just reading the manual of this oscilloscope without knowing when I am rotating the knob, what is happening inside? What is there in inside? So, what is the connection with this knob and this inside component, so that is what I would like to tell you, I would like to show you.

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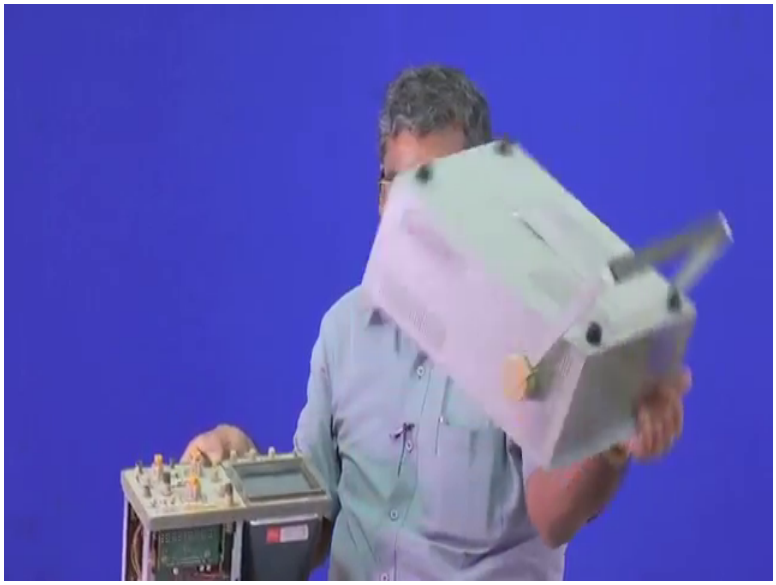

So, let us open this, open this box. So, I will open this box, just you know I think I have to just open. So, it was in cover. So, I have opened it. So, this is just only so cover. So, let me take it out. Now, I think I will.

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So, this is the front panel ok, I have shown you, this is the front panel. So, now I have opened it, when I opened it I can see this half of the portion of this, inside of this one is one tube ok. So, this tube is called the CRT Cathode Ray Tube, and it is basically is a it is basically with display.

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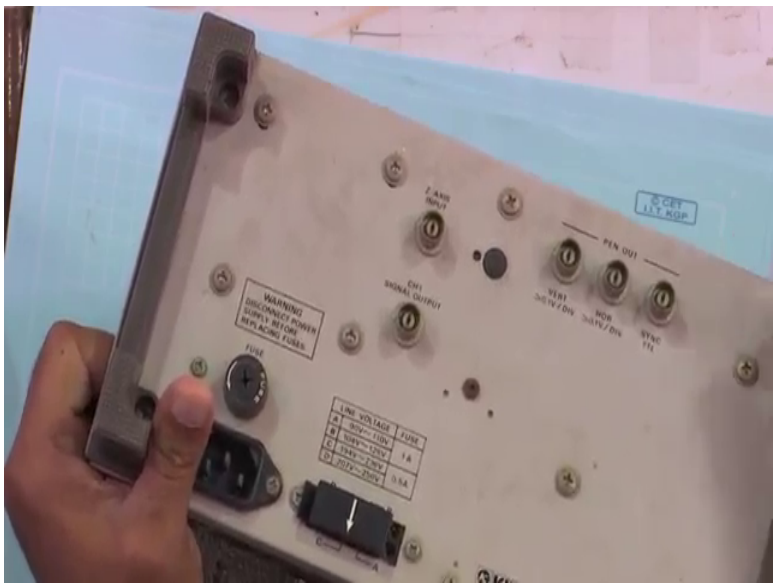

This tube end is basically the display. And this other end of the tube you see other end of the tube is just which it is a, this the back side panel. So, here you see this the power with power cord, we give power 220 volt and here some something, whether you are using

110 volt or 220 volt. So, depending on that there is a option to choose. So, in different country there are different line voltage. So, in our country it is 220 volt, so that option is there. So, according to one has to put.

So, this is basically jacket ok, this jacket. And here if we if we have 220 volt, so then you can use this here AB and CD, this two marking are there ok. So, for CD it is 220 volt, and for AV it is was there is a some range, 90 to 110 volt ok, 125 volt, and here 194 to 250 volt ok. So, in our country it is around 220 to 230 so CD so that range is suitable.

So, I think I just yes. So, one has to put accordingly. So, here we have put as per direction. So, it is the I have put so, it is I have selected 220 volt ok. So, this the power using power cord, so we give our line power here. So, this line power if you see the inside, if we see the inside, yes if we see the inside ok.

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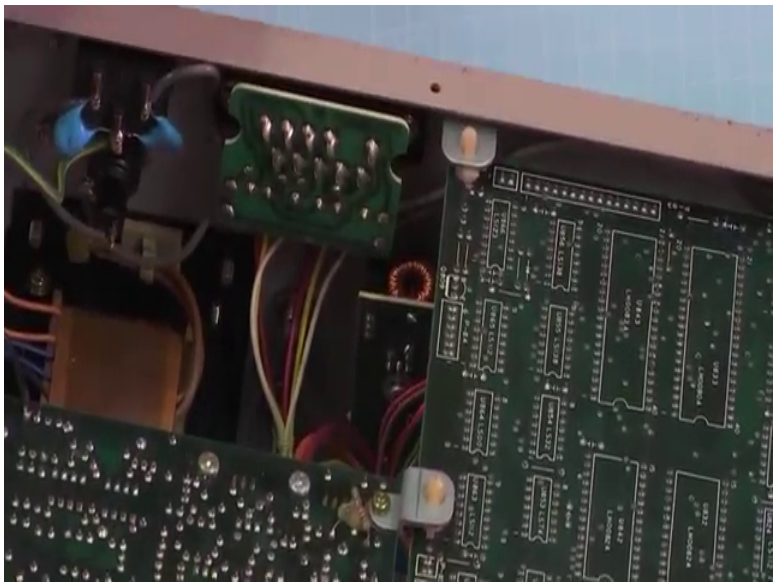

This power part, this a power here I have given power. Now, inside if you see, inside this power, here this power socket, here this power socket, here this power socket, and this power here inside this. So, this is going here ok. Now, from here one part is going to this side, another part is going to this I think why this CRO, CRO this other sides, CRO is the other side here.

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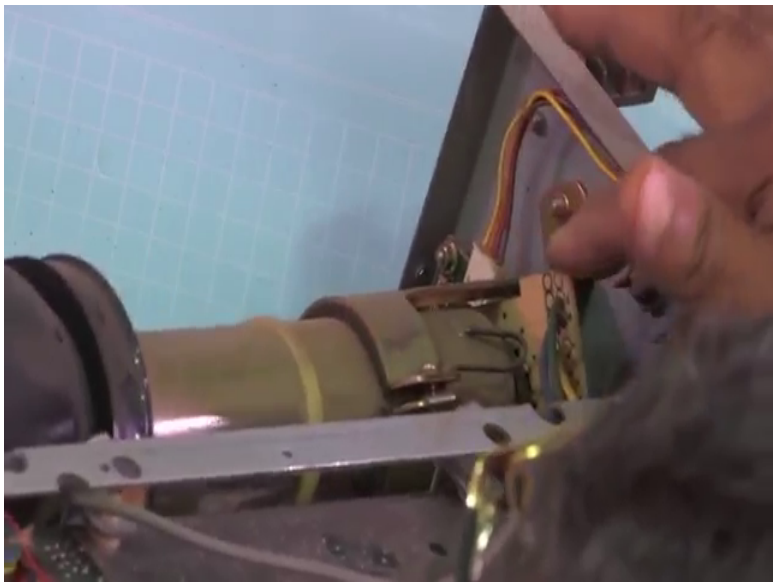

So, I have to see this power here you see, there is a bolt is connected to the CRT connected to the CRT – Cathode Ray Tube ok. So, this power this is coming from this basically from here it is. So, it is basically coming from here. So, power from here to all, all board it is going.

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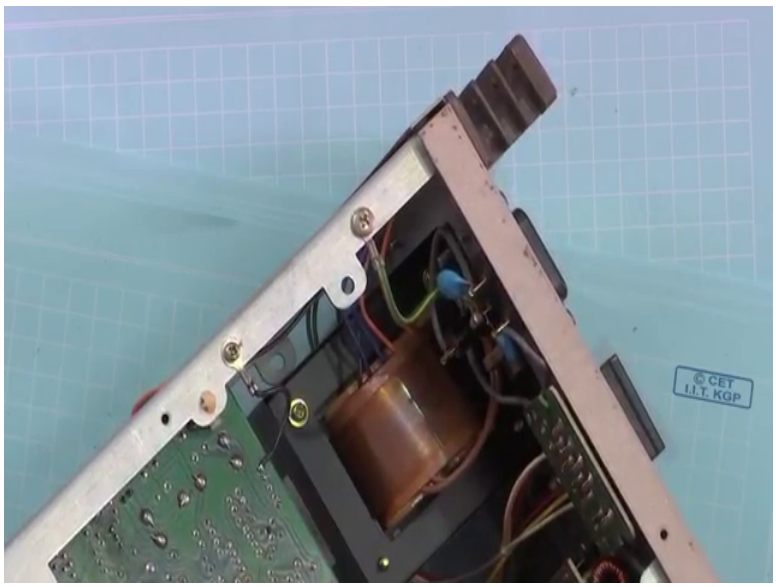

So, these one, this one is transformer. Now, in this for running for operating this CRO, we need very high voltage for CRT – Cathode Ray Tube ok. And for other component, this other control, horizontal control, vertical control, triggering so you need normal

power. So, here basically our normal line power, and from line power to its a one part it is going to the transformer, going to the transformer, and that that from that transformer this power we are giving to CRT – Cathode Ray Tube, because they are in we need very high voltage, its a in kilovolt range volt. So, it is going to CRT ok.

And this other part is going to the other electronics, which is use for controlling the x-axis, y-axis display and triggering of the display on the screen. So, these are the more or less, so here what I want to see, want to tell you this main part of this CRO is CRT – Cathode Ray Tube right, it is display.

And other there are other things, all are electronics for this other three control for one is for vertical control, another horizontal control, and third one fourth one is this triggering or sweep control ok. So, these the it is say that is the function of a other electrical, lot of things are there, but main part is CRT ok. So, this is the inside of the oscilloscope.

So, now, as I told that CRT, CRT is the main part of the CRO; CRT is the heart of the CRO; CRT means Cathode Ray Tube ok. So, let us learn it first, cathode ray tube. What is cathode ray tube?

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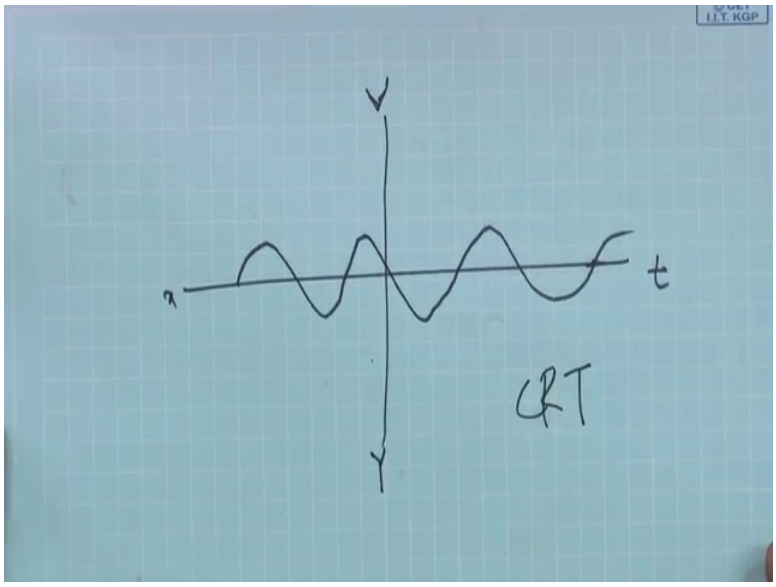

Now, in CRO we can display we can display the in CRO we can display the signal waveform say, whatever if it is sinusoidal waveform ok. So, this is the x-axis and this is the y-axis ok. So, what is wave waveform? So, just we get this kind of right.

So, if this is the signal, I want to measure this signal it has it has one is frequency means x-axis will be time scale time scale and y-axis will be voltage scale, y-axis will be voltage scale ok; y-axis, this is x-axis and this is y-axis ok. So, and it is a on the screen it is weak type of this their ok, scaling at the air ok, each one is 1 centimeter and in between 10 divisions at the heads.

So, and there is a calibration ok, time per division and volt for division as I showed you that is retain volt per division, time per division. So, this for horizontal case is a time per division ok, for vertical case y-axis is the time per volt per division. So that calibration is their or one has to calibrate, this calibrate we can also we calibrate also.

So, this the this is my signal ok, when I will put in this signal to the CRO through the through the channel 1 say, then on the screen just exactly I will see this type of this type of picture, this type of image as if someone is plotting. So, someone is plotting this variation on the on the on the CRO screen ok.

So, now who is plotting that one? How it is plotted? How we are seeing? So, basically we just see of the CRO this just light right, sweeping of light, sweeping of light or variation of light along the x and y-axis right; so now how it is happening, when I am giving the signal to the channel 1.

Now, on the screen this kind of things is displayed ok. So, how it is happening that if you want to know, then we have to know the function of CRT, we have to know the function of CRT right cathode ray tube. So, now for basic things this if you take, just whatever we know so far from basic physics.

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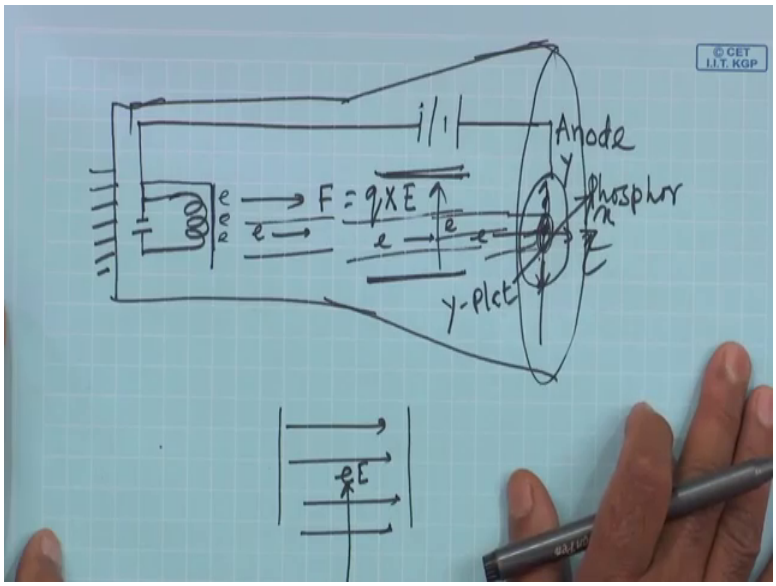

You know this if you take a filament, if you take a filament right. So, in our in our in our home this bulb, we are using bulb 50, 60 watt bulb, 100 watt bulb and there in inside bulb we have seen there is a filament. Now, so if this filament glows, then we get light right.

Actually filaments when it is heated so that means, some current you have to you have to you have to pass to this filament ok, low current. So, then it will glow, and it will emit electron. So, this filament will emit electron and that in front of it generally we put some cathode, you tell cathode some cathode material ok. So, is with lower work function. So, this electron emitted from this filament, it will heat this cathode. Cathode is a lower function this it is a work function is low. So, from the surface of the cathode lot of electron will come out, lot of electron will come out right. So, basically is the you can tell this the thermal initial kind of things ok. So, lot of electrons will come out.

Now, if I apply very high very high voltage between a screen between a screen and the cathode. So, this screen we tell this a anode, it is a anode ok. So, if we apply very high voltage between these cathode and anode, then there is a huge potential difference between cathode and anode.

So, now this electron will be accelerated and move towards the anode right. Why, why because it will this electrons you know this Lorentz force due to electric field, so that force is q into electric field, q into electric field. So, here we have applied voltage. So,

electric field will be generated along this direction, and thus electric field is a voltage by this distance ok, so that will be electric field.

So, due to this electric field, this charge will get force ok, and due to this force this charge will be accelerated, this charge will be accelerated, the charge will be accelerated. And this is electrons will come and hit this anode.

Now, this anode surface is coated with some phosphor material, phosphor material phosphor material if it is quoted with some phosphor material of fluorescent material, then when electron will hit this screen, this anode is basically in this case if it is screen and that screen is correct with the phosphor or fluorescent material. So, when electron will hit this screen, then wherever it will hit so it will be illuminated. So, we will see light there.

So, basically on the screen whatever we are seeing the light that is nothing but the position of the electron ok, position of the electron. So, basically these electrons from the cathode it is accelerated and hitting the hitting the screen. Basically due to so you will get a beam of electron, you will get a beam of electron, you will get a beam of electron. So, it will hit the screen.

Now, now so what you will see, you will see basically a spot on you will see a spot on the screen ok. So, there is a light spot there is basically the electron, electron spot of the electron beam ok. So, now this spot on the screen, and now you want to manipulate this spot on the on the screen ok. You want to take on of or means along the x-axis, if you want to take this towards left or towards right along the x-axis ok, see if I take this is y-axis and this is x-axis ok.

So, if you want to take spot x-axis y-axis ok, how I can do that ok. So, or this spot is not at centered ok, it is not exactly at center, I have to bring this spot at the center it is off centered. So, I have to bring the spot, so to manipulate the position of the beam along the x-axis or along the y-axis or for in any direction ok. So, I need basically some arrangement ok, so that is basically what about this I told this vertical control and horizontal control.

So, to manipulate this beam spot of this spot on the screen; so we use these two we need this to control horizontal control and vertical, what is that it is a nothing but you know

this I have shown you, as that is what I told you. This if I apply electric field you know, this if I have a two parallel plate ok, if I have a two parallel plate, now if I apply voltage in these two parallel plate, so then I will get electric field ok, I will get electric field along this right.

Now, if charged particle comes, if charged particle enters into this, so it will get force due to this electric field along this that is E ok, Q E or e E ok. So, due to this force it will move along the electric field direction right. So, if I arrange here along the y-axis, if I arrange here, I think yeah if I arrange here to plate to metal plate and apply voltage applied voltage. So, it will give electric field along this direction ok.

Now, this charge vertical this charge whatever beam electron beam is going. So, it will it will get another force along the y-axis along the y-axis. So, this electron beam will not go straight, but it will bend ok. So, this way you can change the position of the electron beam up and down ok. So, this one has to choose the polarity. So, if you want to take down if this is the zero position ok, so then for going up and down one has to take polarity change of polarity, so this. Along the y-axis similarly you have to put, you have to put two plate, you have to put two plate.

So, basically here the way so this is x-axis and this then it will be y-axis. So, I have to I have to took one plate in bottom and one plate is up ok. So, this will give you these another electric field. So, two sets are so these for Y – plate, Y – plate and another sets is X – plate. So, this X – plate so voltage will be apply so due to electric field along the x direction and if I take this is the anyway. So, I think here I could draw in different way x - axis not this on x-axis, and this I could take as a z-axis, and x-axis maybe this way yes x maybe this way anyway.

So, this will give you this electric field in along the x direction, this is giving the electric field in along the y direction ok; so two sets of plates along the x-axis and along the y-axis. So, this is use so this arrangement is there in the CRT tube ok; to manipulate the beams spot on the along the x-axis.

So, this x control vertical control sorry, y control this vertical control and x control means horizontal control. So, this two parts in front panel I showed if there are two parts, two blocks are there. And yes, now this whole thing so this arrangement is there.

Now, this whole things is put in a basically in a vacuum tube, in a vacuum tube. And this power it is given through the pin ok, it is a its called heat through ok. So, through heat through we give power to this to inside what the plate, capacitor plate, and the filament, and the and the power between the voltage between the cathode and anode ok. So, all power is going through this feed through and so all things.

So, why we need vacuum, why not is in here; because if it is here, so what will happen is this there will be collision with the air molecules, and then before reaching to the to the screen, it will be deflected in different directions. Then and also it will glow, because it may due to collision with these air molecules. So, it will glow inside itself ok, before reaching this. So, this tube will glow basically if it is filled with the air. So, we need vacuum just you want this, this electron emitted from the filament of cathode. It should reach without deviation if should reach on the screen ok.

So, this CRT tube is a Cathode Ray Tube, this cathode ray so this electron beam it is called basically cathode ray. So, because it is coming from the cathode so that is why it will it will cathode ray. And this ray, basically CRT tube produce the ray of electrons beam of electrons, and it hits the anode, it hits the screen coated with the phosphor ok. And then wherever it will hit, so there it will glow. So, we will see the spot.

Now, that spot can be moved along the x along the x direction or along the y direction, applying the electric field in those directions. So, how we are applying the electric field? So we are applying electric field using the capacitor, using the metal plate.

So, and also you know this also if we use the magnetic field, then also you can this electron beam will deflect in electric field, so that I think that also one can use. So, to deflect the electric charge, moving charge one can use the electric field, one can use also magnetic field ok.

So; obviously in electric field it is there so because of that we get current ok. In magnetic field also you know this due to the Lorentz force, q equals b because of that force ah. So, there will be because of that force on the electric charge. So, depending on this direction of the force it will, it will move towards that ok. So, I think yes, I will demonstrate, I will show you this CRT tube and demonstrate this how we are getting the spot on the screen from the CRT.

So, I will stop here and I will continue in next class.

Thank you.