Transmission lines and electromagnetic waves
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Lecture - 18
Octave Simulation of Different Types of Polarization

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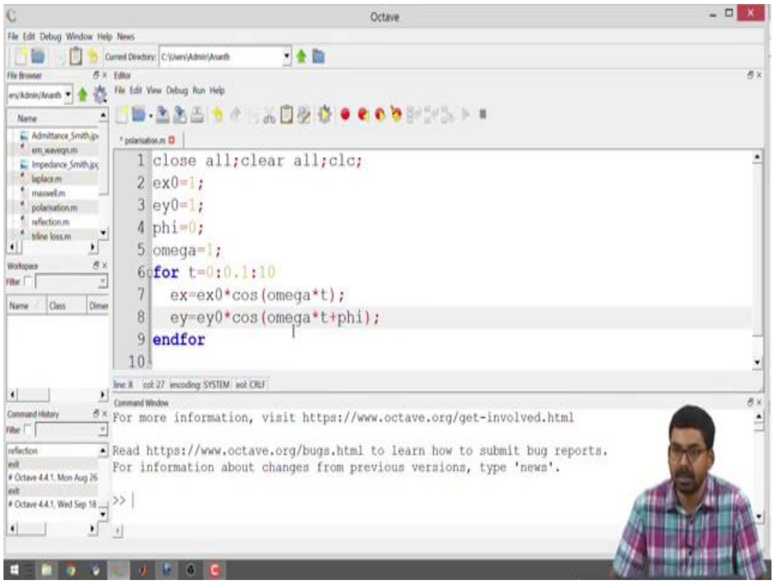

So, today we are going to be seeing the polarization in a little bit more detail ok, however, more visually. So, usually I am going to use an octave program to illustrate what we were talking about in the previous class ok. So, I will start with the comments that I use all the time and also save this program ok.

And previously we had a discussion that the electric field can have components, the transverse direction can have an x component and y component all right and the amplitudes and peak amplitudes are given by Ex_0 and Ey_0 in the class derivation. So, we will just start with simple cases Ex_0 ok is equal to 1, Ey_0 is equal to 1 all right. Let us say that the components are equal in both x and y direction right and if we have a look at the notes.

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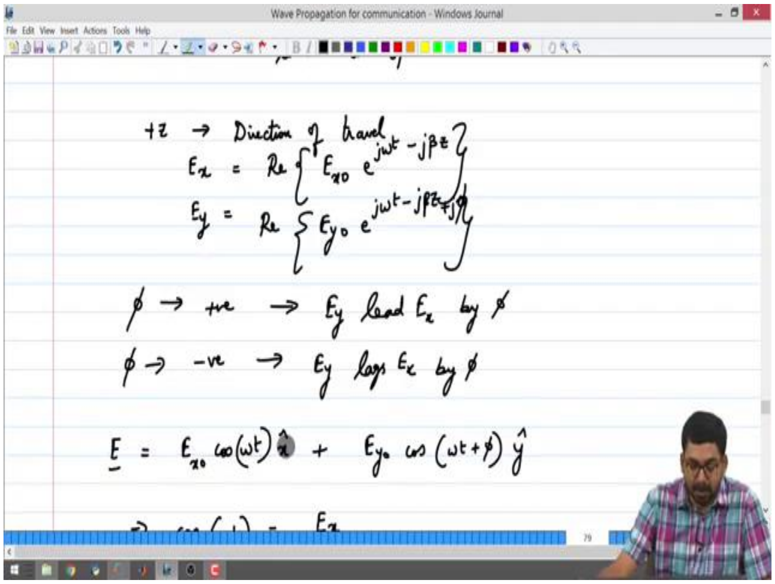

We saw that the electric field has an x component right that varies with respect to time and it has a y component that also varies with respect to time, however, it is not necessary that the y component is in phase with the x component. So, to indicate that there could be a phase difference between the two components we added a small phase over here ok. So, we are going to use only this equation to understand what is going on all right.

Because, the final equation that we got is actually too hard for people to visualize ok.

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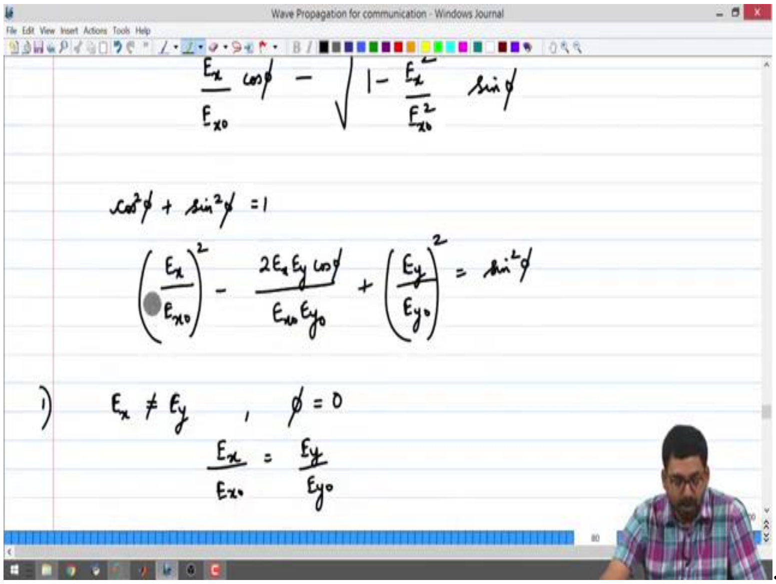

So, we will be using only this expression, trying to see what is exactly this phase difference, and what is the result and extra ok. So, what we are going to do is, we are going to write a program to just calculate E given Ex_0 ok and say given some constant value of ω for different instances of time all right and for diff for phase extra.

So, we are just going to use this equation and write the program for today right. So, I am going to be starting with defining the value of ϕ I am going to start with 0, later on we are going to tweak all these values to reflect what all situations can happen ok. And I am going to keep this simple ω is equal to 1 ok. So, 1 radian per second is what we are using as a value ok.

So, now that we have defined all the right hand side values that is Ex_0, Ey_0, ϕ and ω All we need to do is with respect to time we have to calculate the resultant electric field that is ok. So, I am going to take some amounts of time right for it starting at 0 ok say going in steps of 0.1 to 10 ok. So, time is going from 0 to 10. I am taking some finer steps. Instead of going from 0 to one to 10, just taking smaller steps you could always take larger steps. There is no issue at all.

so Ex right, we have to refer to our notes, Ex by Ex we mean this entire term over here, $Ex_0Cos(\omega t)$ ok this is what is meant by Ex. So, we go back to our program, we define Ex as Ex_0 $cos(\omega t)$.

This is the definition of Ex and Ey is $Ey_0Cos(\omega t + \phi)$ ok and we will see the effect of all these things in a moment ok ok. Now the first thing that I want to do is understand what is this Ex and Ey all right and what the phase difference is actually doing right. So, I am going to create a variety of plots ok, I am going to create some three or four plots, one of them will show how Ex is changing, one of them will show how Ey is changing, another one will show how the resultant is changing all right extra ok.

So, I am going to create a series of plots. So, I want to have four plots on the screen, two columns and two rows. So, I am starting with the subplot 2 comma 2 and the first plot that I want ok is a quiver plot simply showing a Ex and Ey right.

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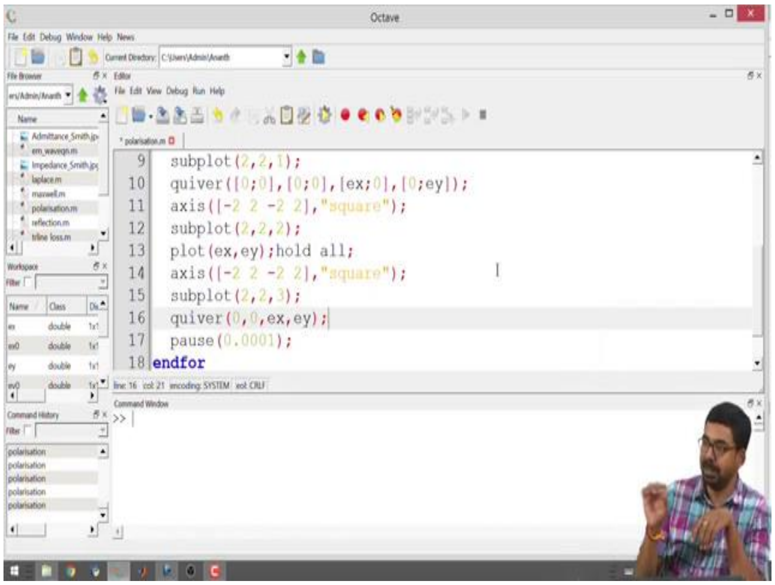

So, I will start with quiver. So, this is an arrow, I want to show the direction in which Ex and Ey are changing also ok. So, I want to just show a quiver plot ok. I am going to use some slightly complicated arguments over here, but they mean very simple things ok ok. So, I want this plot to start at 0 comma 0 ok and I will write down a draw an arrow to Ex 0 and 0 Ey ok.

I will explain this line ok. What we are saying is a, we want an arrow going from say 0 comma 0 to Ex comma 0 whatever is the value that you have calculated using this program will have some number ok and it has to plot an arrow going from 0 0 to that number in the x axis and 0 0 to 0 comma Ey that is in the y axis, it is it is just a slightly complicated quiver plot, but you will get used to it.

You can have a look at the reference manual for the octave of the quiver plot, but in essence whatever value of Ex we calculate from the origin to that calculated value I want to draw an arrow, 0 0 to that value. Same way 0 0 to Ey, I want to draw a vertical arrow. So, I switch the order 0 comma Ey extra that is all we are doing all right. For now what I will do is, I will start with this and build over it. I know that I want to observe this with time. So, I am going to pause it ok.

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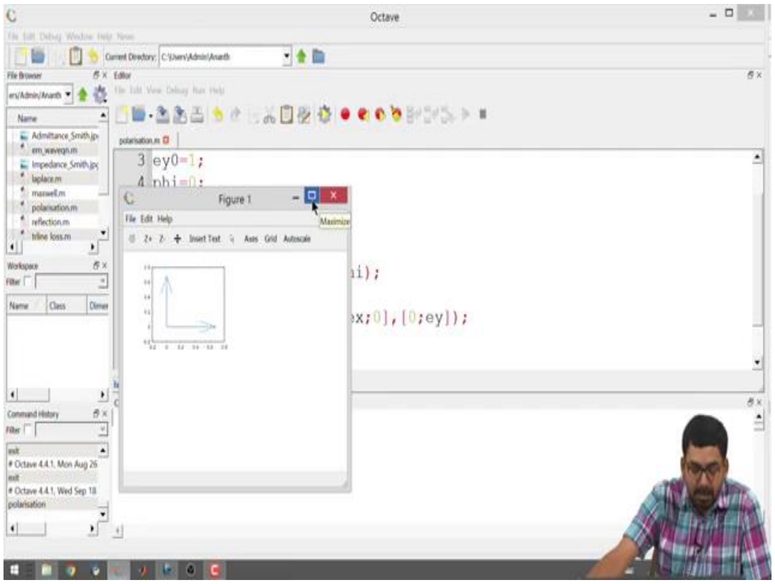

And I am going to run this program ok it is running, that is good news all right, but I observed that the arrows are changing, but the axis are also changing.

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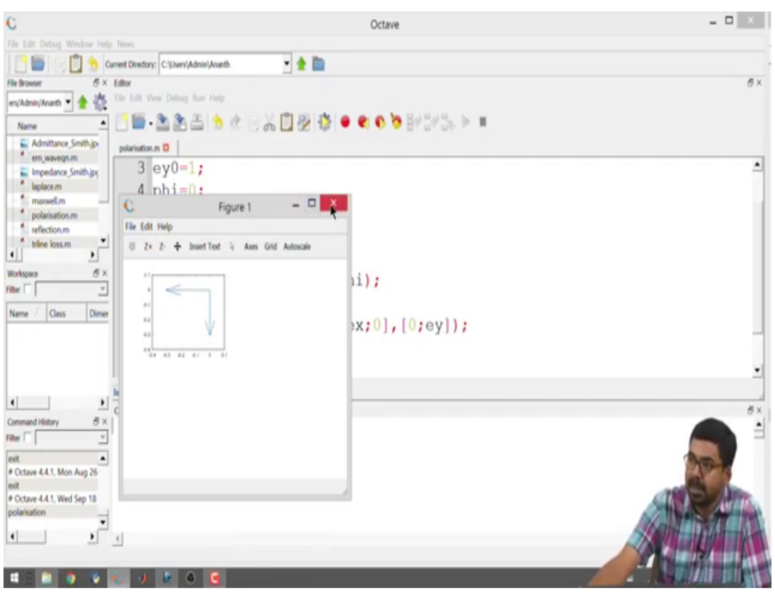

That means, we need to fix the axis to make any reasonable derivation. So, I will have some extra comments over here ok. So, I will just say that I want to fix the axis and minimum x value that I want to have in the axis is -2, maximum x value is +2. So, this covers the horizontal axis, minimum y value is -2 maximum value is +2, this covers the y axis ok.

On top of that there is a tendency for octave to use the maximum portion of the screen, since the screen is rectangular it tries to make the plots look rectangular ok. So, that is a, I wanted to look square -2 to 2, -2 to 2 should look like a square, so I can force that by saying that ok. Make the plot look like a square.

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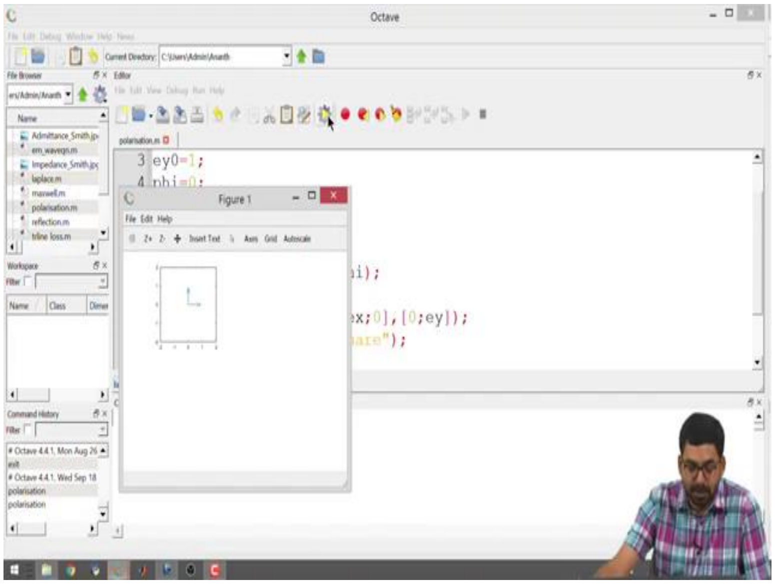

So, this will solve most of the issues that we have seen in the first run ok just maximize this ok. The horizontal arrow corresponds to Ex and the vertical arrow corresponds to Ey alright and with respect to time Ex and Ey are changing ok. This is the first thing that we have to notice.

Now, we have Ex and Ey changing with respect to time. We can start looking at a you know the resultant ok. So, I will plot 2 comma 2 comma to the second plot in 2 comma 2 right. I want to be able to plot so, the calculated value of Ex, calculated value of Ey I just want to place up point over there ok. Whatever is the calculated value I am just placing a point on the axis ok and what I want to do is this has to go with respect to time all right.

I wanted to change with respect to time and I also want to have all the previous values extra. So, I am just going to use hold all. So, it will retain the access and all the previous plotted points in this run right.

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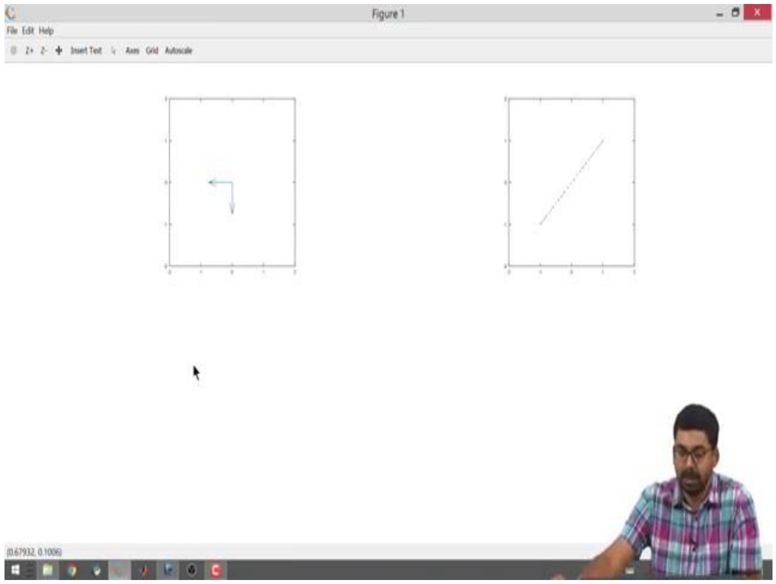

And once again the axis is going to be looking a little crazy. So, I am just doing the same axis command that I did before and I am pasting it over here ok. I am going to go ahead and run this. Now I get a second plot on the right side and if you notice, it is plotting some dots on the right side ok.

So, we have plotted Ex comma Ey which has been calculated and with respect to time what that indicates is just Ex along x axis Ey along y axis and the resultant is what you are plotting, you are just plotting the value of the resultant and the resultant is just going along a direction which is diagonal right. So, in this case Ex and Ey are equal, we have made it 1 and 1 and the phase difference that we have given is 0. So, let us look at this plot as to what is this phase that we are talking about. So, I will maximize.

So, if you look at the left hand side plot, you will notice that Ex and Ey reach the maximum and the 0 crossing at the same time. So, the arrows increase, they come to the 0 at the same time and then they continue, that means, that there is no phase difference between them, ok that is what is meant by the phase difference. Now we could also do a few other things. It is not necessarily that Ex and Ey have to be identical, they can also be not identical.

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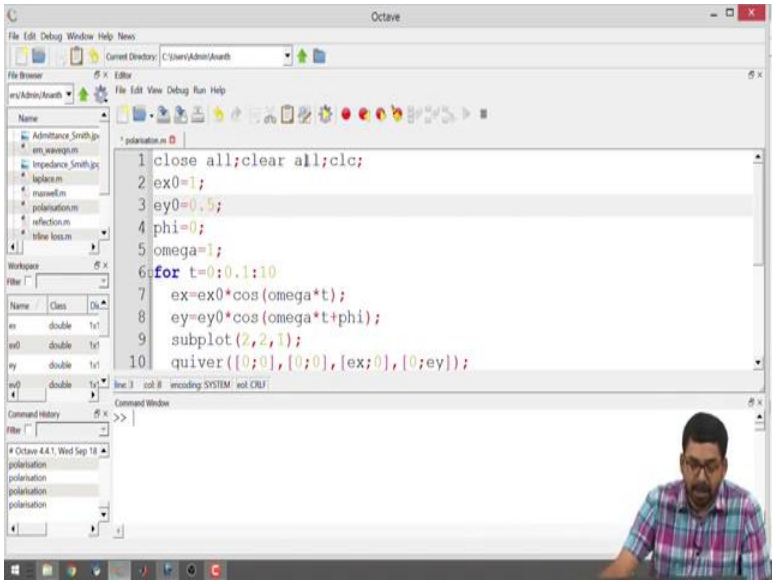

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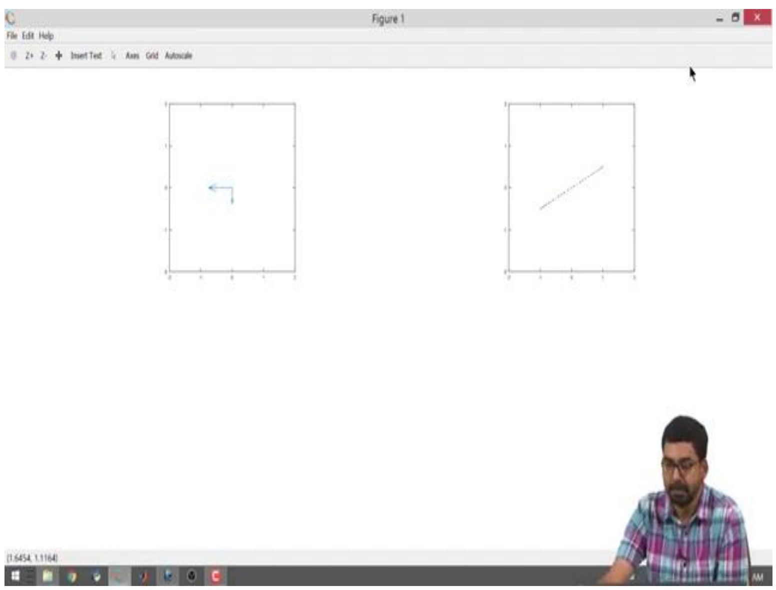

So, I can just make Ey as 0.5 right and Ex can remain at 1 and we can always see what happens all right. We can see that the peak value of the horizontal arrow is higher than the peak value of the vertical arrow, but they are still in phase, that is they do the 0 crossings at the same time, it is the maximum at the same time that is how you can understand what is happening with respect to the phase of these two components.

If you look at the right hand side that you have calculated the resultant, now has a different angle with respect to the x axis all right. It is a more slope to the horizontal side because the Ex is more all right, but it does sweep a line ok, the locus of all the points for the resultant is still a line all right and in this case, the line goes from the first quadrant to the third quadrant ok. So, let me make it back to 1 and let me continue with a few more plots just to make it and a visually more interesting all right and a.

What I want to do is, I want to create a new plot, subplot (2, 2, 3) ok. In this case what I want to do is I want to draw a quiver plot, but going from 0 0 to the calculated value of Ex, Ey. So, from 0 comma 0 whatever is calculated previously, we had plotted some dots ok that instead of that dot it will plot an arrow going from the origin to that calculator dot ok.

Because that is the way we draw vector fields usually right. So, you just make that concept of the resultant clear, we just use this all right and once again I want to have previous values all in tax. So, I am just using a hold all and I want to keep the axis exactly the same as all the previous cases, so, I am just plotting just copying and pasting the axis command going from -2 to +2 for x and y axis ok.

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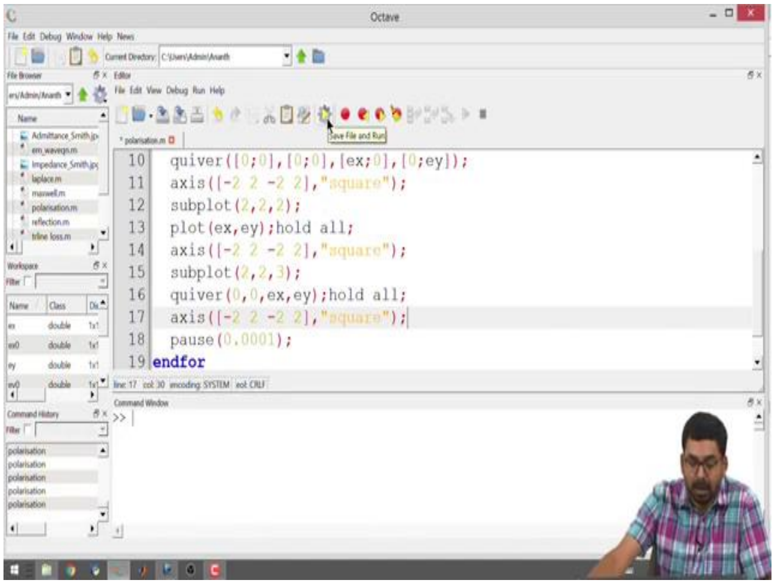

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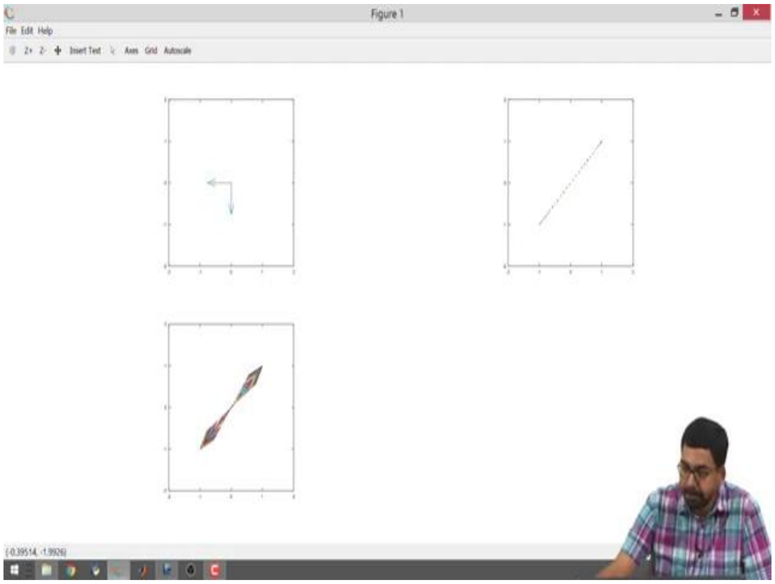

We are going to go ahead and run the program. I will have a third plot. Now the third plot is coming in the left hand side bottom, that shows the resultant, the calculated resultant right is going along this straight line. So, the electric field, net electric field with respect to time is oscillating about this line ok. So, specially it is about this line with respect to time, it is going periodically between these two endpoints ok that is what it means.

Now, this particular case is known as linear polarization ok. Now the condition for having linear polarization has to be examined in more detail ok, but a before that just for the sake of completeness, I will also have one more plot just. So, that we have a different visualization.

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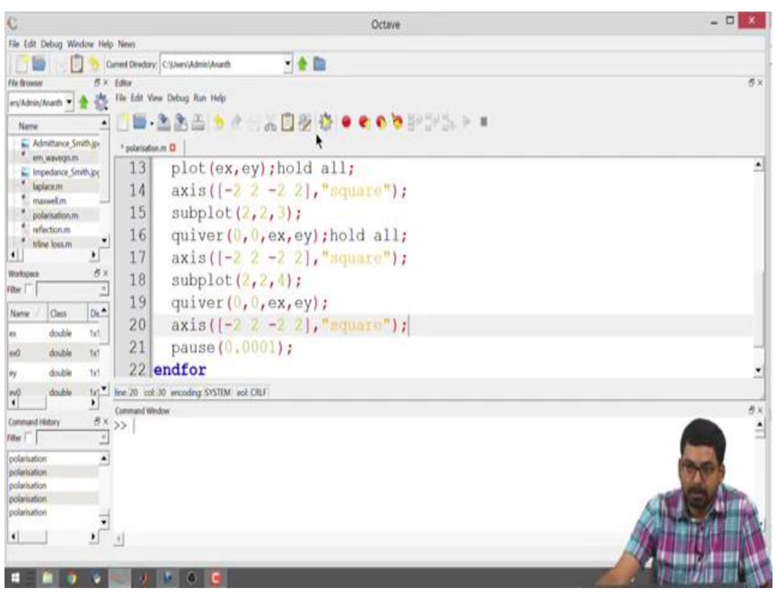

So, that it becomes very strong, might be right. So, I will just plot one more plot because I have some free space on the screen. I can just make another plot ok. So, I will make a subplot 2 comma 2 comma 4 and I will make another quiver plot ok.

Previously, I did quiver Ex, Ey and I did hold all that, held all the previous values, so the arrows were all visible. Now I am just going to keep it simple, the current calculated Ex, Ey whatever is the resultant I want to have that alone right. It is not a very informative plot compared to the previous one, but there is real estate sometimes this left hand side could get confusing and I want to have some clarity on what is happening at the current instant of time. So, that is about it right. So, once again this a I do not want to have a hold all I want to just have an access command to fix things ok

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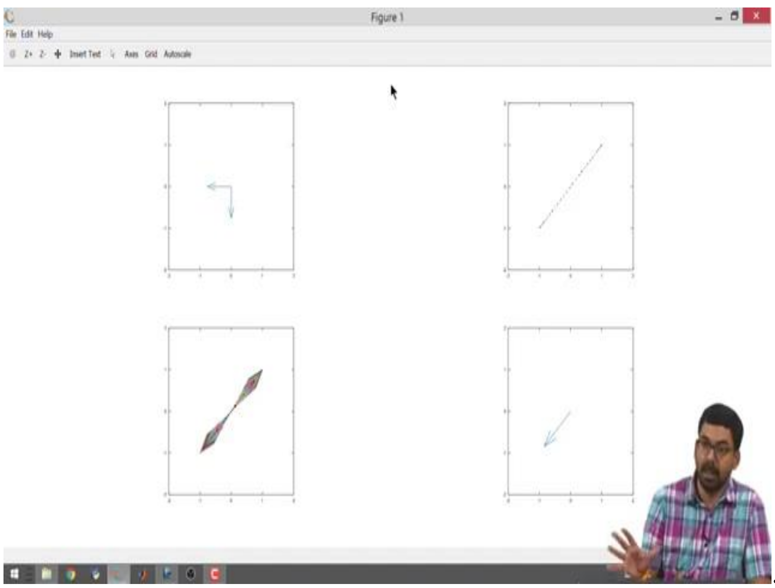

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Now I run this, I have a lot of information available. Now I can see the resultant only at the current instant of time on the right most a on the right bottom plot ok. So, it is going between the lines right ok.

So, now we are going to play with this program a little bit and try to understand all the other criteria. Remember that, we have not made use of that derivation that big equation that you got yet all right it means something what it means can be explained only if you play with this simple equation and just try to plot what is happening ok.

So, first since we are here let us observe all the criteria possible for linear polarization, linear polarization, now it should be you know starting point should be clear that Ex and Ey have to be in phase, they need not have the same peak values E_{x0} need not be equal to E_{y0} this is all we know ok.

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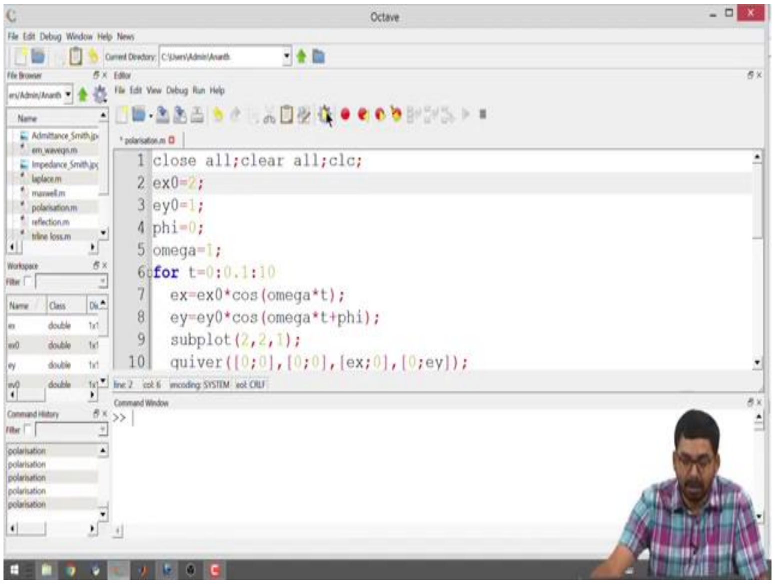

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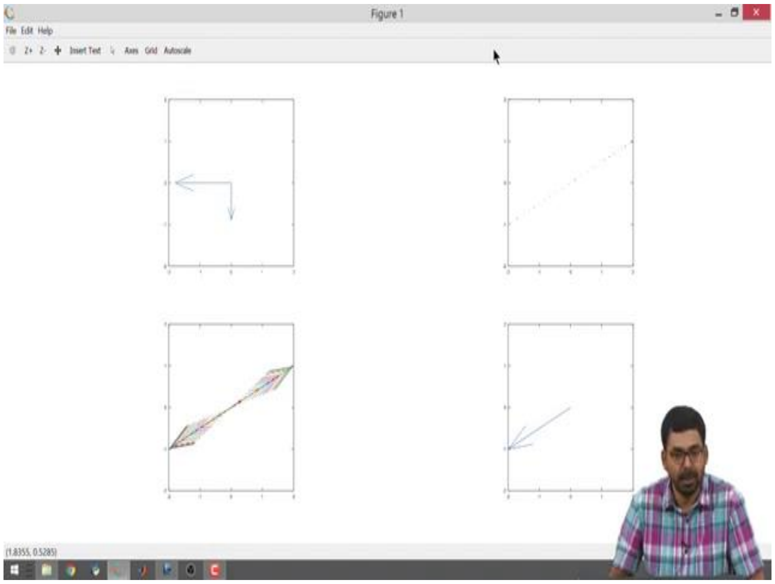

So, just to validate those things ok, we can always create E_{x0} to be 2, E_{y0} to be equal to 1 all right and you will still have you will still have a locus that is a line created in space ok with respect to time the electric field at any instant will be moving about this point right. That is what it means. So, the value of the electric field, it is going to change direction , is also going to change within the time period right.

So the condition for linear polarization is that the phase between the x and the y component is 0 ok, but is it necessarily the only criterion right. Now let us go back, let us have a look at our equation all right 0, ok phase is 0 ok, now 0 equivalently you can say that it is a periodic signal, you can also have 2 π to be your phase difference all right.

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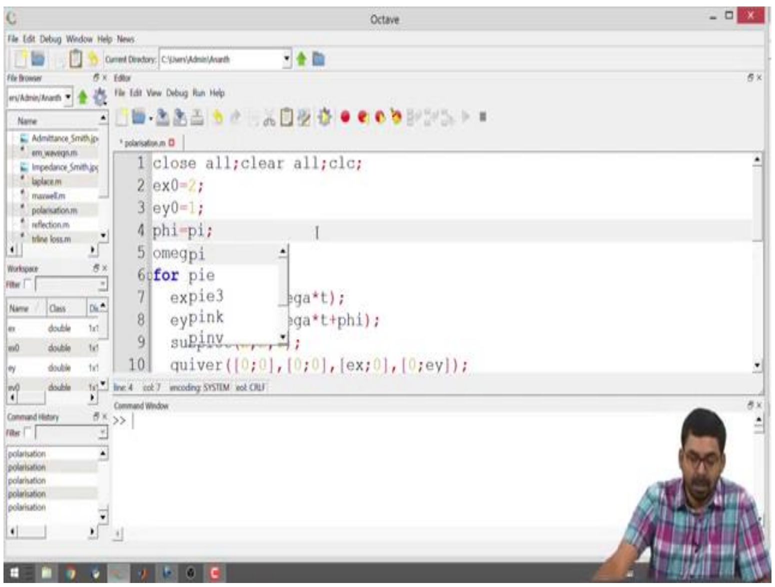

But what if I make it π it is also you know what if I make it π ok. If the Ex and Ey components are out of phase by π **radians** ok right.

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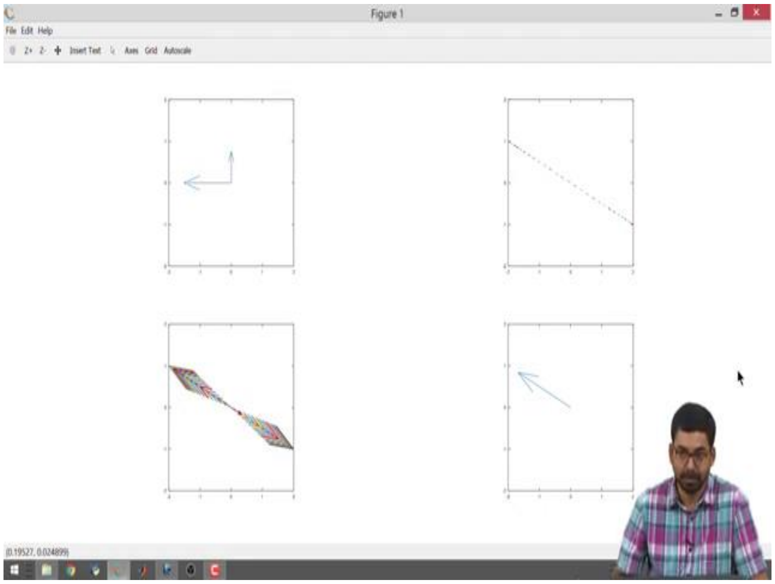

Then what happens? Ok. Now, one thing that we notices the angle has rotated by π ok, it is still linearly polarized ok. So, the criterion to be more precise for linear polarization is not that the phase is only 0, it could be multiples of π ok. If it is 2π ones again you will get back your original result, but if it is π it is fine it will go between the second and the fourth quadrant, but it is still a you know line that is swept by the resultant.

So, criterion for linear polarization is does not matter what your Ex_0 an Ey_0 are going to be all that it matters is whether you are phase difference between the x and the y components are going to be multiples of π ok, that is the most generic criterion ok, this should be very clear. If you did not have a y component at all right ok.

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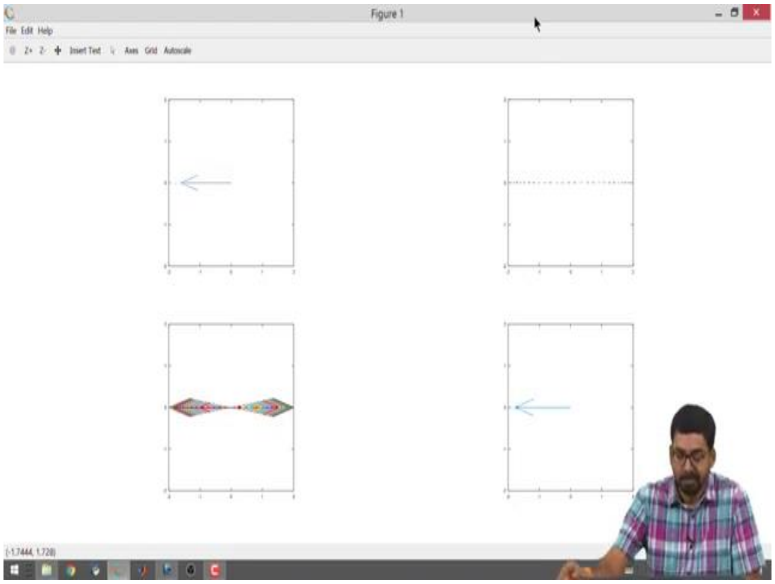

you will just be having the net electric field ok equal to the x component. So, it will look like it is doing this in space right. This means that it is taking some positive values at different instances of time and negative values at different instances of time. So, in this case, one can say that there is no Ey_0, right there is only Ex_0 or easily you can say that the electric field has only an x component right ok.

Now that this is clear, let us start looking at it in slightly different ways. We saw the case with 0 and π, we know that 2π will give exactly the same as 0 all right. So, all of these are clear for linear polarization.

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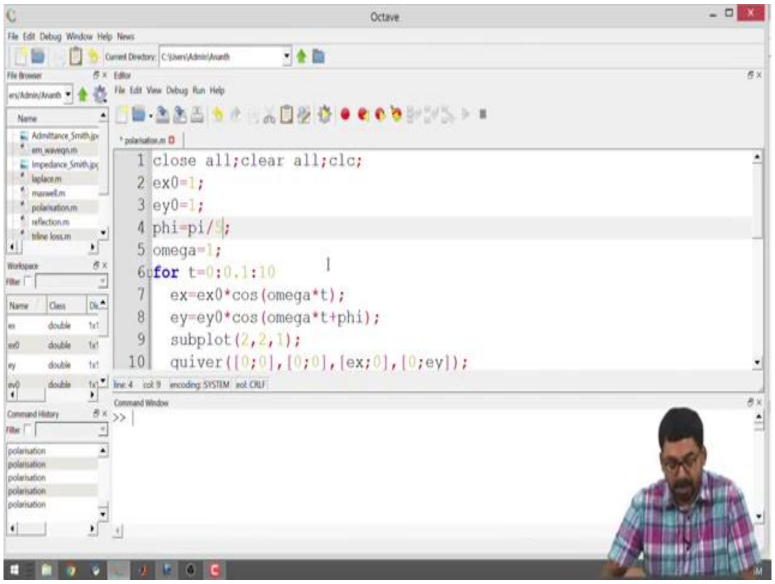

Now, we will go back to the simple case where both of them are equal ok, instead of a phase difference between them to be π ok previously it was 0, I will just make it say you know π by 4 ok or let us make it even weirder $\pi/5$ all right, it is some value ok. So, Ex_0 and Ey_0 are equal and the phase between them is $\pi/5$ ok

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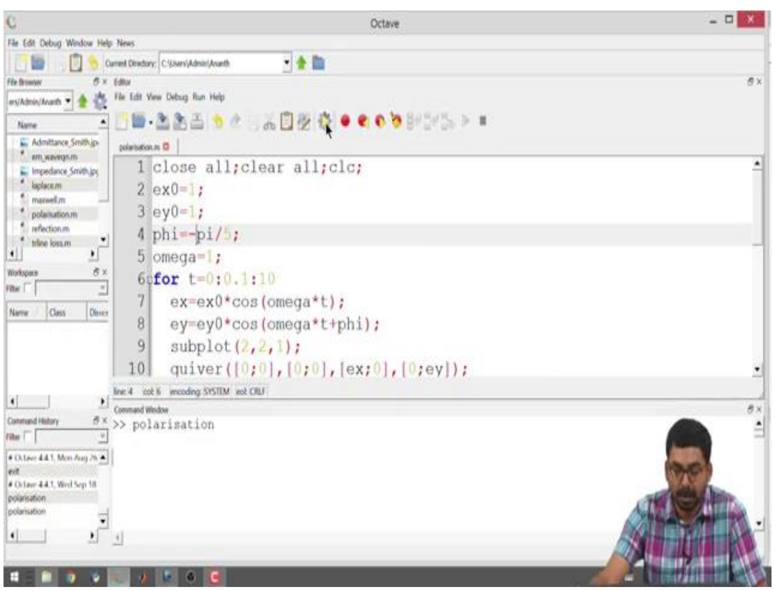

Now, another thing that also you can remember for this linear polarization before I do this is, you can also have minus quantities. You can say that there is a lead lead or there is a lag ok you could have $-\pi$ to be the phase difference, let still you will sweep ok

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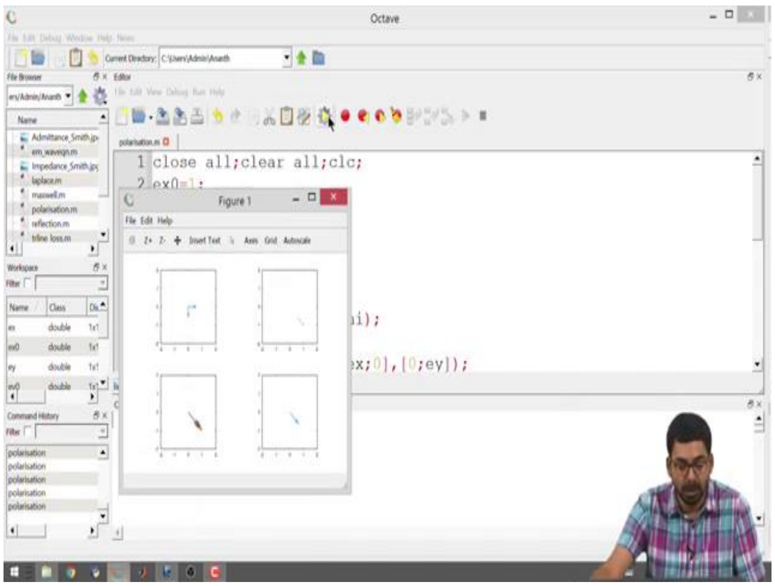

You will sweep a linear polarization ok. So, I just get a control c. It is perfectly possible to have positive or negative angles over here in radians. So, I will just go back to the case $\pi/5$ and I will just run this program to maximize this ok.

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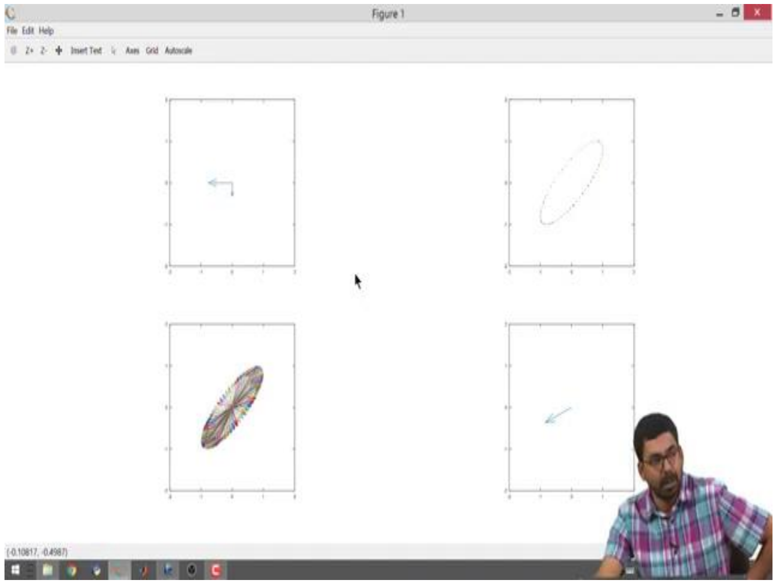

We are plotting the resultant electric field in the bottom left ok and at all instance of time on the top you can top right hand side you can see that the points that are plotted it's actually an ellipse and you can notice from the first top left plot that the 0 crossings of the x and the y component do not happen at the same time ok. So, there is a phase difference between them.

So, in the most general case, Ex and Ey can have different magnitudes where there can also be a phase difference between them. If there is a phase difference between them you will end up sweeping an ellipse all right, the ellipse will have a major and a minor axis. Now we can always argue that this is the most generic case ok. Why? Because the ellipse has a major and a minor axis ok. If you make the minor axis equal to 0, it becomes linear polarization ok. So, you can always say that linear polarization is some subset of this elliptical polarization ok. So, the most generic case that we argue about is elliptical polarization right.

It has both the x and the y components to have different values and it also has some arbitrary phase between them. So, the chance that you will sweep an ellipse very high ok and then depending upon the major and the minor axis values you can get either ellipse you could also get a line and soon we will be seeing that we could also get a circle ok. But before that I want you to have a look at one more thing when we are doing this ok. If you look at the top right diagram all right a the bottom right diagram and the bottom left diagram is very wow what happened there ok

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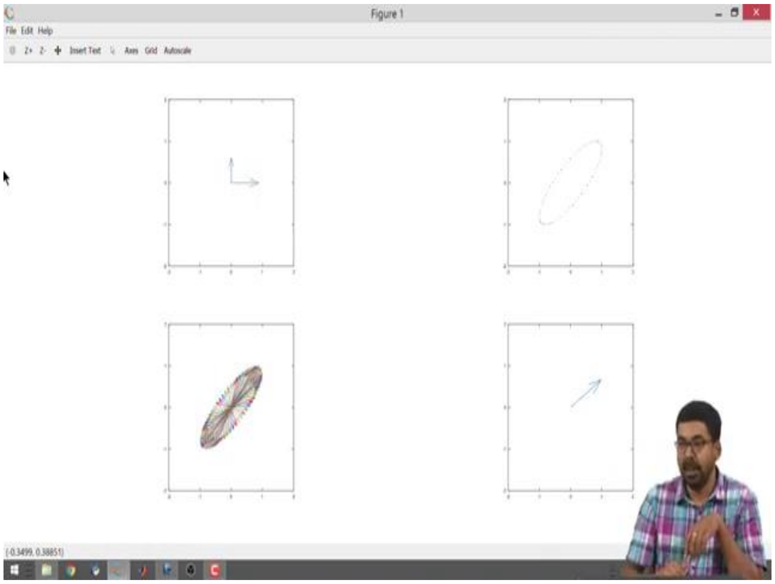

One of the things that we notice is that the resultant is sweeping in the clockwise direction ok. It is going in the clockwise direction. This is also something that we need to note, granted that it's sweeping an ellipse over a period of time, but it is sweeping the ellipses in some kind of a way. It is going in some clockwise direction all right. This is something that we have to look for ok.

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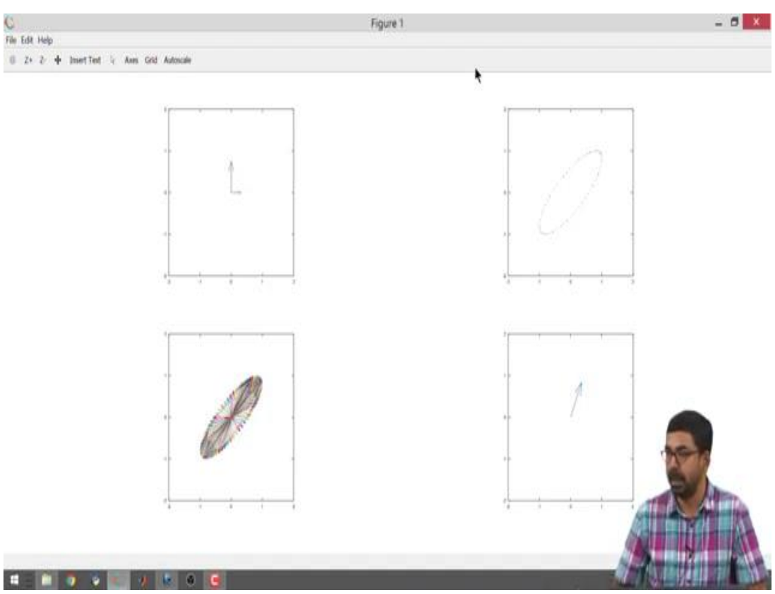

Now, I will make this minus $\pi/5$, we can immediately notice that it is going in the anticlockwise or the counter clockwise direction, sweeping an ellipse, the same ellipse with the same major and minor axis being swept in the opposite direction ok.

So, that means, even in this most generic case of elliptical polarization, you can have differences in the ways your electric field is going to sweep the ellipse, could be in the clockwise direction or it could be in the anti clockwise direction ok. Now, people distinguish between these two also ok. What people do is, you usually point your thumb in the direction of propagation all right. In this case you are having x axis to be horizontal, y axis to be you know vertical.

So, you can take your right hand and keep your x axis like this y axis like this and then you can say that the propagation direction this is your electric field components your propagation direction is going to be a thumb all right. If the thumb is like this then it is slightly confusing because then what they do is, they take the left hand all right and then they point the thumb to the direction of propagation and then they look at whether you can curl like this all right.

If you are curling like this, it is given some name, if you are curling like this it is given some other name what it means is whether you sweep the ellipse clockwise or anticlockwise ok. So, they will say that one of them is left handed polarization, another one is right handed polarization a terminology that is also used is a you know clockwise counterclockwise extra.

But most of the time unless you specify some reference, it is very confusing to figure out what is clockwise, what is anticlockwise, what is left, what is right extra. But it is enough to know that these are two different kinds of polarization, one is going this way and the other one is sweeping this way ok, both are possible right.

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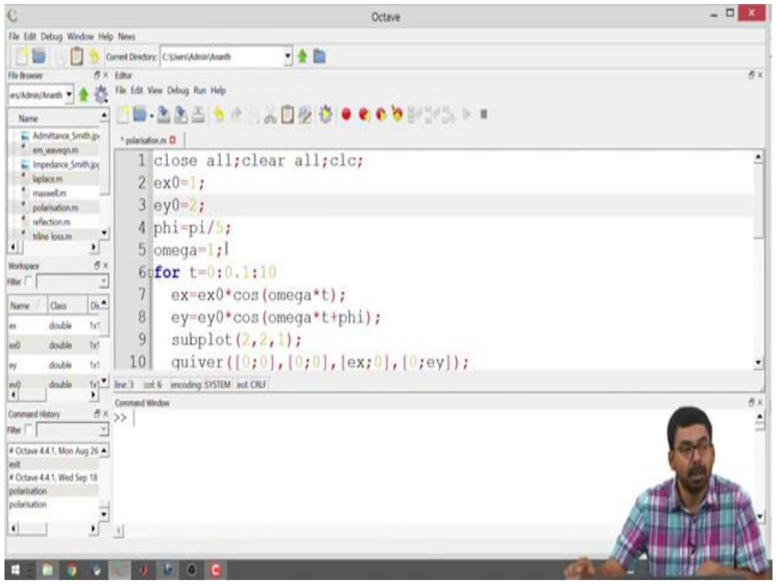

So, then what happens if I go back to my case right and I just make these unequal ok this is first thing that we will see I made it $\pi/5$ again ok.

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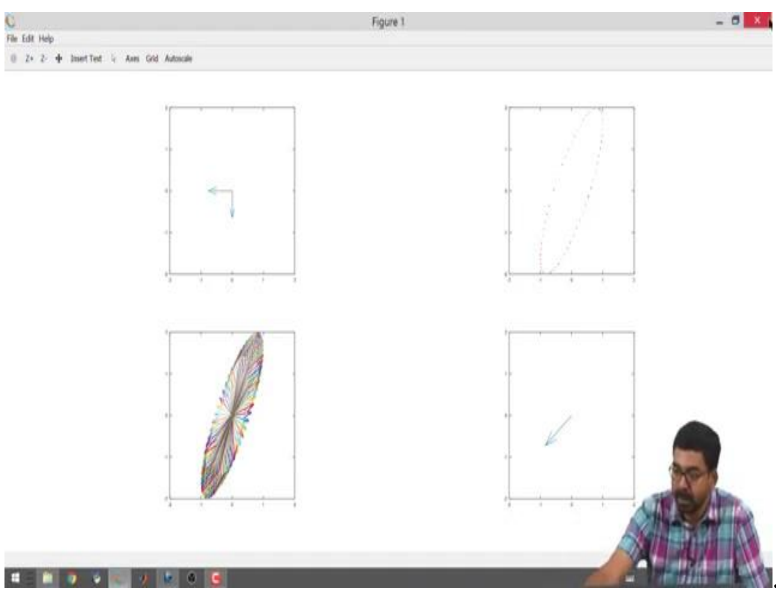

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Still is an ellipse, in this case, it's going in the counterclockwise direction all right. So, I can always point the left hand thumb to be going out and it is doing this. So, one can say that in the way I am observing it is a left hand elliptical polarization right ok. So, the criterion for left hand elliptical polarization should become clear you can have some value of Ex_0 Ey_0, the angle is not 0 or π or 2π, it is some other angle, if it is a positive angle, you will have what is known as left hand polarization. If it is a negative angle say negative $\pi/5$ you will have the ellipse being swept in the opposite direction and that is known as the right hand.

So, these are some things that you may have to remember over a period of time, but if you do not remember you can always figure out with respect to time what is happening and then come to a conclusion as to whether this polarization is left hand elliptical, right hand elliptical extra ok. Now we will go to another case ok, let us keep it as it is Ex_0 is 1 Ey not is 2.

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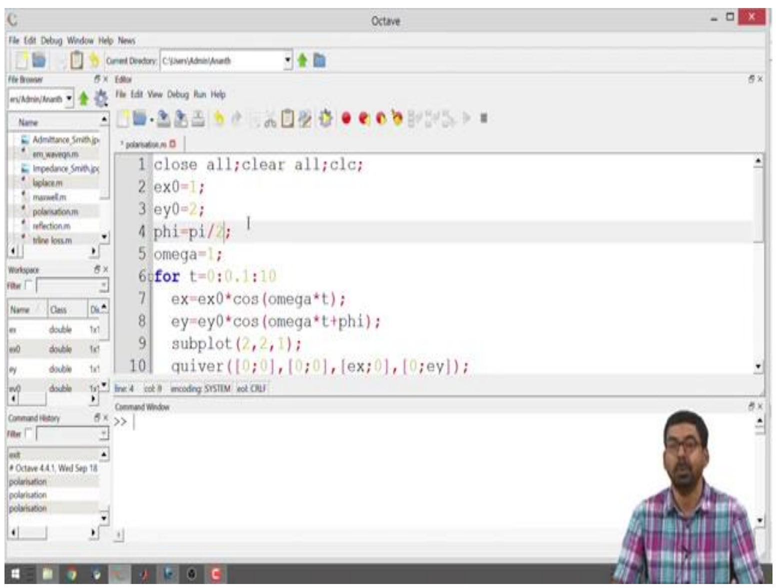

And let us just look at the case where it is $\pi/2$ ok. So, 0, π, 2π is something we have seen, we have seen some other random angle $\pi/5$, let us have a look at $\pi/2$ also all right and let us run this.

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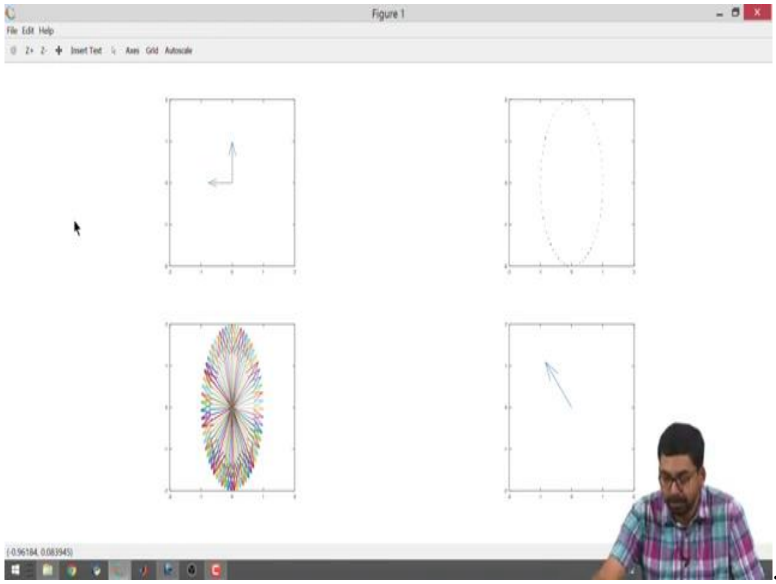

Now, π by two means that on the left hand side, x will reach 0, y will reach the maximum at the same time ok. So, the top first top left plot you will notice that whenever y reaches maximum, x will reach 0 ok. And whenever x reaches maximum the y component will reach 0 that is what the phase difference of $\pi/2$ means. It did sweep an ellipse again ok and in this case the ellipse is going like this.

So, I can curl my fingers like this pointing to the direction of propagation, I can say that this is left hand elliptical propagation all right. And I can say that the major axis is aligned like this, minor axis is aligned along this direction extra I can give more parameters if needed ok.

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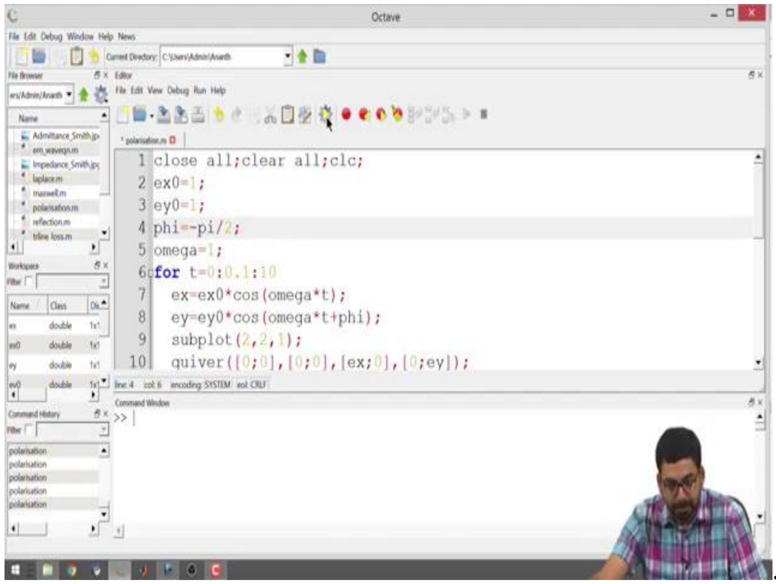

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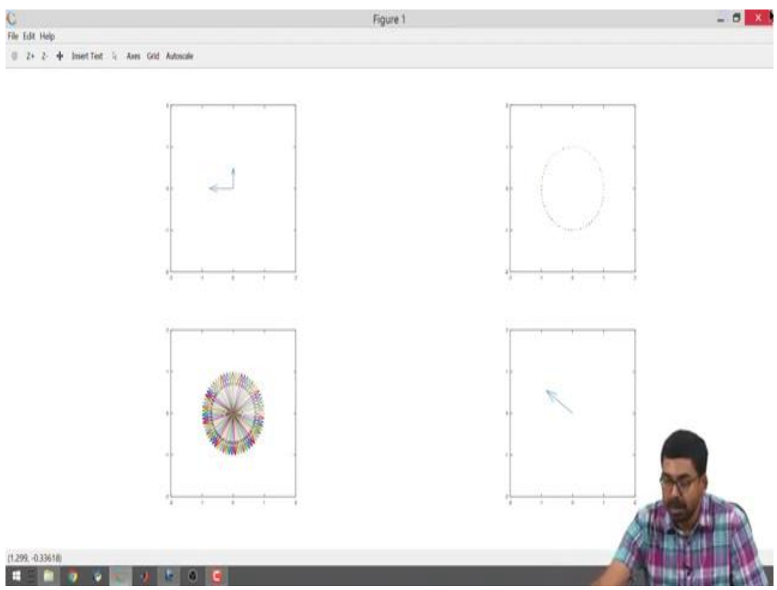

Now, one thing I can do is, I can see suppose I make Ex and Ey to be identical ok, clearly on the top left plot I can see that they are 90 degrees out of phase. So, whenever the maximum happens for the x component, minimum happens for the y component all right and vice versa. And we notice that the locus that is swept by the resultant is actually a circle, the circle is once again a special case of an ellipse just means that the major and the minor axis are identical. So, in this case Ex_0 was equal to Ey_0.

So, you ended up having an ellipse with equal major and minor axes. So, this is a circle. Once again the circle is being swept in this direction which means that you will have to see which way your fingers will curl all right your hands will curl like this right. If you wanted your hands to curl the other way you can always make it minus $\pi/2$ ok.

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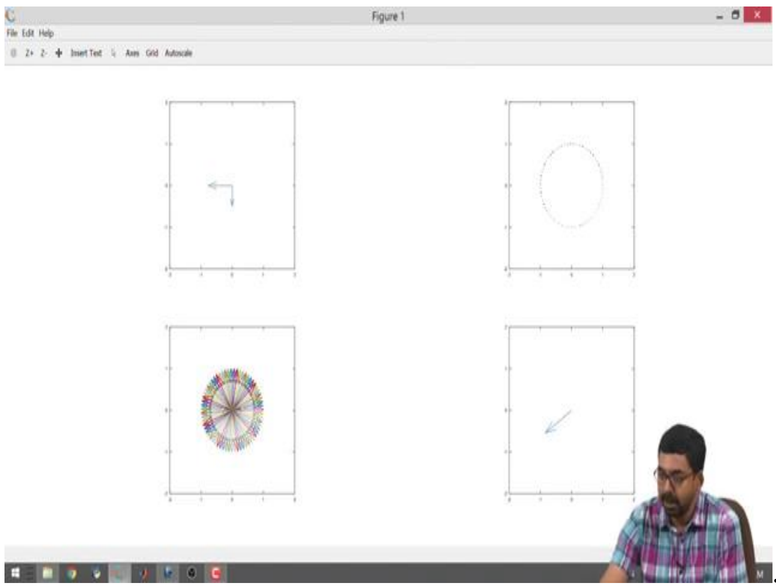

Now what happens is going the other way. So, I cannot curl my left hand fingers this way. So, instead you point your right hand thumb to the direction of propagation and see where your finger bends. So, you call this as circular polarization or right hand circular polarization ok. So, I think this should give you a clear picture on what the polarization of the electromagnetic wave is very clearly ok.

Now, it is not necessary that the angle is exactly $\pi/2$ or $-\pi/2$, it can be $2\pi + \pi/2$ can be $\pi + \pi/2$, it can be $3\pi/2$. So, let us see I have $3\pi/2$ right.

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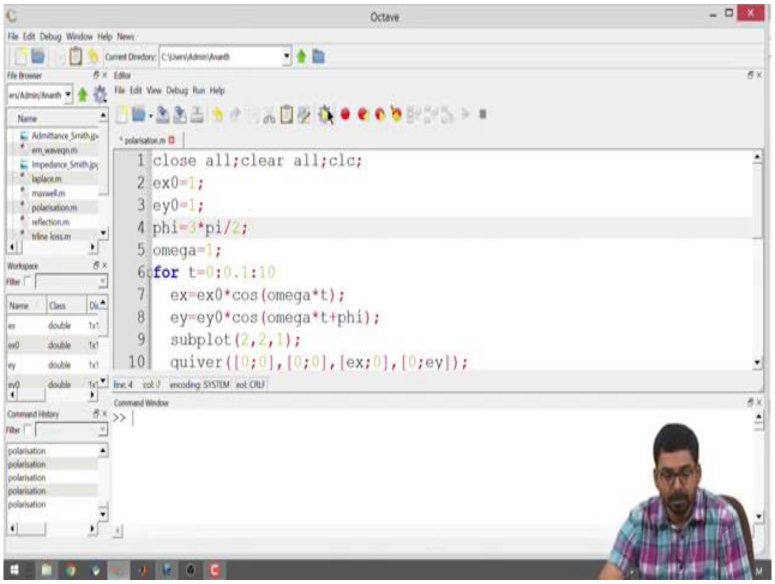

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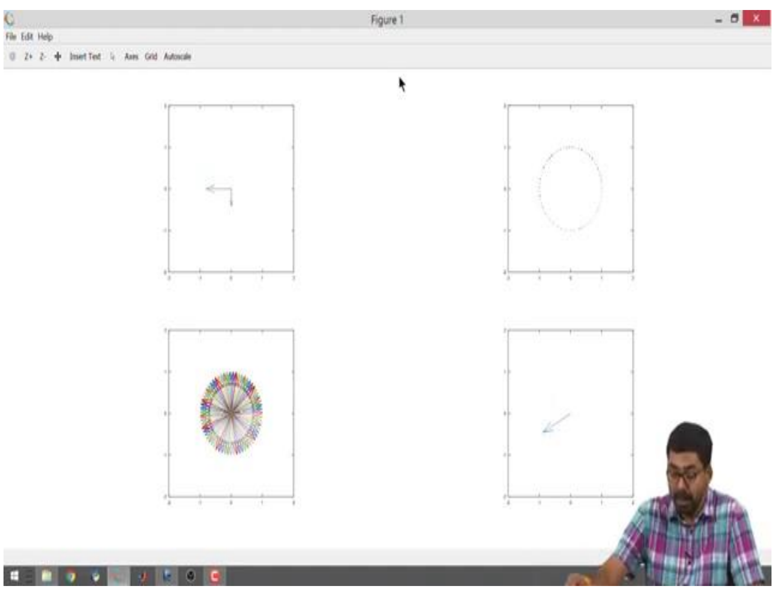

So it just needs to be an odd multiple of $\pi/2$ right for it to sweep the circle and Ex and Ey have to be identical. So, I think even if you do not remember the equation of the ellipse that we got before. So, finally, at the end of last lecture we had written down an

$$\left(\frac{E_x}{E_{x0}}\right)^2 - \frac{2E_xE_yCos(\phi)}{E_{x0}E_{y0}} + \left(\frac{E_y}{E_{y0}}\right)^2 = Sin^2\phi$$

This is the equation of an ellipse.

But the way it is presented to many people may be finding it difficult to figure out that this is an equation of an ellipse all right, but this is what it is right. And the ellipse is the most general case Ex not equal to Ey is a general condition can be equal to Ey also and when the phase difference is equal to 0, π, 2π.

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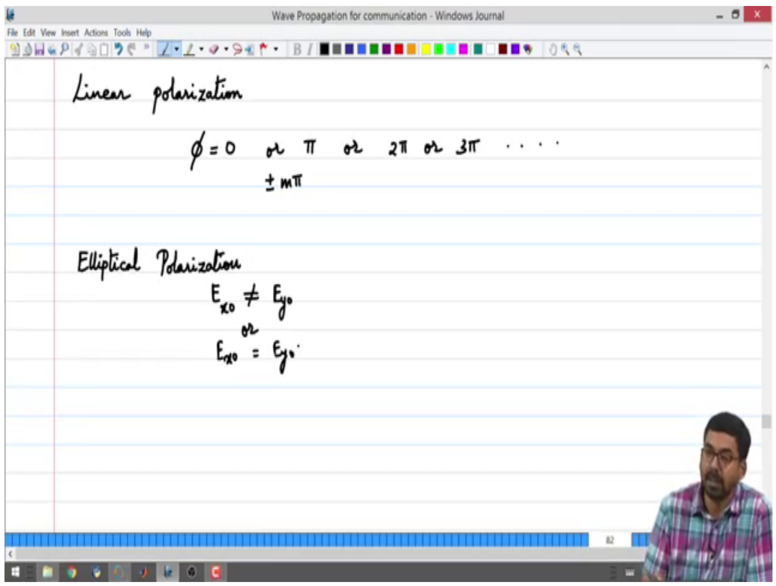

So, let us go ahead refine our observations with whatever we have seen and make this a little bit more concrete ok. So, that you are able to remember the things that are going on in the simulation ok. So, whatever we have seen, we will summarize first ok ok.

So for the linear polarization, it does not matter what your Ex_0 Ey_0 was ok one could be 0 another one could be anything, one could be a more than the other extra, but the most important thing that we found out was the phase could be 0 or π or 2π 3π extra could also be negative numbers it could be $-\pi$, -2π, -3π extra ok. So, it just means that you have a positive or a negative integer multiplied with π ok. So, I will just write down that positive or negative integer ok. This is what is meant by linear polarization ok.

Second case that we saw was elliptical polarization ok, it is a general case ok. So, we say that Ex_0 is not equal to Ey0 ok making a general case ok, but Ex_0 could be equal to Ey_0 also all right, which means that this condition is absurd, you can remove this condition totally all right. So, it could be any value whether it is equal or not does not matter.

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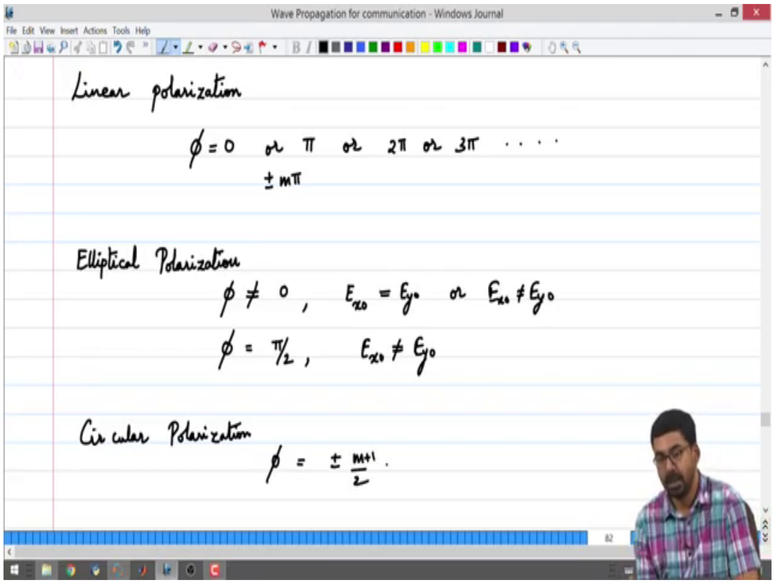

ϕ is not equal to right. 0 or π or 2π, 3π extra that corresponds to linear polarization all right. So, ϕ is not equal to ok 0. Now this case ϕ not equal to 0 all right. We write down that a ok you could have both the components to be equal, you could have both the components to be unequal you will end up sweeping some kind of an ellipse ok.

Now, when we say ϕ not equal to 0 ,π is also something like that right, $\pi/2$ is also something like that. So, we have to say that suppose it happens that ϕ is equal to $\pi/2$, the only it way we call this an elliptical polarization is all right, if ϕ is equal to $\pi/2$ ok. We know that it can sweep a circle and in general case a circle is an ellipse with major and minor axes equal, but people find it confusing to call the ellipsis circle.

So, we just say that Ex_0 is equal to $Ex_0 \neq Ey_0$ and the phase is $\pi/2$ then, you will still end up getting an ellipse ok. And the last part is circular polarization, here it is abundantly clear that ϕ is some odd multiple ok, same by two plus 1 ok.

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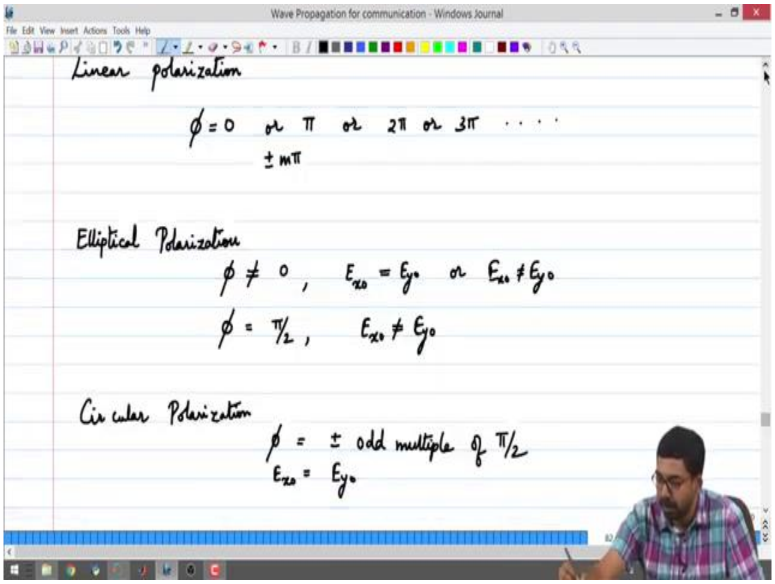

It is some odd multiple it is an integer ok, it is an odd multiple to be very clear I will just make this odd multiple of $\pi/2$ could be plus or it could be minus and the other condition is Ex_0 is equal to Ey_0 ok. In the case of linear polarization, we do not have anything known as left hand linear polarization or right hand linear polarization because it is just going along one direction. In the case of an ellipse and circle you could have a left hand or right hand. It depends on the frame of reference that you are using.

So, it is very tough to explain directly right without making some diagram and saying that this is the direction of propagation and you have to curl your hands this way right. And when somebody says counterclockwise clockwise, it becomes confusing because you have to give a point of reference ok. What it is clockwise from this side will look like a counter clockwise on the other side and all that. So, the frame of reference in all these cases has to be very very clear then only it makes sense otherwise absolute specification is much better ok say the Ex, Ey, so much phases so much, then I think people will be able to reproduce what is going on rather than saying left hand right hand and all these things.

Now, there are some uses of this polarization compared to say transmission lines, there are some different uses over here right polarization is a property that we manipulate on a day to day basis ok. a If you buy some sunglasses ok, you will have something known as polarizing sunglasses ok, which means that uh definitely it has got a film that allows some polarization to pass through some polarization to not pass through ok.

In fact, the LCD screens that you will have in phones, LCD not AMOLED screens LCD screens ok and TFT LCD panels. All of them emit only at one polarization, if you did have a polarizing sunglass all right. And if you hold it in front of you in between the screen and you and you rotate this glass you will notice that there will be a point where the screen will appear only white you will not be able to see what is written ok. So, a simple test to figure out whether the sunglass sold to you is a polarizing sunglass or not is all right.

So, all it means is that we manipulate it on a day to day basis and there are also some observations which are interesting. The reason for having this polarizing sunglasses seems that most of the time the glare that comes from shiny metallic objects has some polarization, the rest of the useful information is of some other polarization.

So, to avoid this shiny thing coming to your eyes and blocking your field of view, what they do is, they allow you to have a polarization axis which will allow you to pass electric fields only of some specific polarization. Of course, these are materials made in some way. We are not going to be dealing with them, but it is possible to make materials which will allow polarization only in one direction and those are known as polarizers ok.

Also, it is quite possible that when we are talking about glasses to have some polarization on the left side and some other polarization on the right side of the eye ok or the left and the right eyes could have glasses which have different polarization. For example, you could have only the glare coming to one eye and the information coming to another eye all right. And the way the mind reproduces this image, so I will look slightly complicated. Because, we have stereoscopic vision right which means that we make some information about space with these eyes, we all say or try to estimate the depth with these eyes ok. So, you can change the depth perception by playing with polarization and all that.

So one of the common techniques that people use while making movies is a long time back, not now. Long time back, they used to shoot a scene of a movie with, say , multiple cameras. One camera will have a polarizer that will allow one direction of polarization and the other camera placed in a different angle, we will capture the other polarization and then they put together and then they project it with some coherent source. Then what happens is, when you wear these kinds of glasses with one polarization here another polarization here you start getting slightly different information through your glasses and your mind will try to create a depth information that is different from watching a conventional movie. So, people have played with it in the past to create 3 D movies ok.

But, one of the things I said was, it was done a long time back. Now remember that when we talk about polarizing glasses extra, we talk about a horizontal or vertical polarization itself. So, it will have a specific axis along which the electric field will be allowed all the other axis it may not allow the maybe the other axis it will not allow any electric field to be passed at all. That is the property of the material that is being made. And it was found that it is not particularly suited for movies when you use linear polarization because you will have to stay with your head rigid at a fixed position.

Once you start rotating your head this way or that way you start getting very different kinds of information right. So, long back for the preliminary demonstrations that you can play with the depth perception, linear polarizations were used. Later on people started using right and left circular polarized waves for cheating the depth perception of your eyes.

So so, that even if you rotate your head one way or the other. You do not miss the depth perception that the producers wanted you to have ok. So, nowadays they make use of circular one eye will get a left hand circular polarized and the other other eye will get right hand circular polarized and your mind will start putting these together in different ways. Of course, they are shot in different ways. So, you will get a different depth perception. So, polarization is a property that we do manipulate quite often all right. It is a, I think a very interesting property because there are also findings that certain types of things have only certain kinds of polarization.

It is also interesting that in the older ages, not sure about now. We used to have two ways of mass communication, one was radio and the other one was television all right and the TV was analog ok. And one of the things that we would notice is that when you hold a radio in front of you the antenna always goes up perpendicular to the ground, that is how you will catch a radio signal. Whereas, if you looked at the rooftops of the houses in early days before your cable TV thing, there used to be antennas right. It used to have two rods and some kind of a loop going in between them that was always parallel to the ground all right.

So, the radios had antennas going up and the TV had antennas going parallel to the ground. Why did people not mount this way or the other way extra all right. Why did everybody mount parallel to the ground on the roof tops? That should give you some idea that it has got to do something with polarization ok.

So, the TV signals where using some polarization, radio signals where using some orthogonal polarization right and that is why they were being used in different ways ok which means that you have to adjust your antenna to a specific angle or orientation with respect to the ground in order to receive maximum signal for that particular information ok.

This can also lead to very interesting thoughts on how to perform some emergency communication in a practical setting. We will take up a problem in the next class and we will see how this can be used ok. So, we will see how a combination can be used, but at this stage, I think you should understand that polarization is a property that can be manipulated right and there are practical uses of these for several years right. And if you did have some polarizing sunglasses and if you did have non AMOLED that is a TFT LCD based screen you can always put it in front rotate your glasses and you will find that everything is distracted only the backlight will come ok, you could try these small small things right.