Electrical Measurement And Electronic Instruments
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Lecture – 29
Demonstration: 1. Eddy Current Braking
2. Creation of Magnetic Field Without Moving Objects

Welcome back. This is a Demonstration class, where we would like to help you in understanding how virtually moving magnetic field can be created without any physical object being moving. If the physics which we talked about in our previous class is clear to you, you can safely skip this video; else we would try to help you understand with the help of graphics and animation in this video ok.

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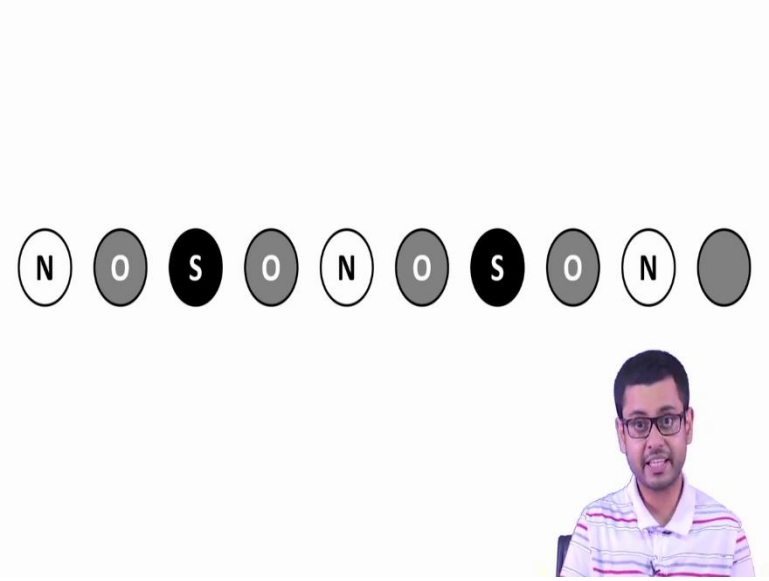

So, let us look at the screen. Imagine I have a set of bulbs. So, these are bulbs and they are fixed in their location. So, I have 1, 2, 3, 4, 5, 6, 10 bulbs and they do not move. They can only turn on or off. For example, here we see that there are 3 bulbs which are turned on. These white bulbs ok; these white bulbs mean that they are on and these gray bulbs mean they are off ok. So, out of 10 bulbs, we have 3 of them on and remaining off.

Now, we can turn these bulbs on and off sequentially in a particular pattern so that it will look like as if these set of bulbs are moving in one direction like this ok. Here you see the bulbs are being turned on and off sequentially in a manner so that let me repeat. So, that

you have an illusion that the bulb or the lighting arrangement is moving from left to right. Once again and you might have seen this trick in various occasions, we use just such lights for decorations ok. This is nothing new.

Now, let us consider a just a small variety, where once again I have a set of 10 bulbs so, 1, 2, 3, 4, 5, 6 so on. So, I have 10 bulbs and the bulbs now can glow with different intensities ok. So, they can be very bright like this, white. They can be very dark, like this black and they can be something in between gray ok. So, the bulbs can take 3 different colors. They do not move, they can only take 3 colors; white, black or gray or we can give them names like this. Like this bright color, we call as color N; black color we will call color S and the gray in between color, neutral color we will call it O or 0. So, the bulbs can take 3 values N, O or S. They do not move.

Now, if we turn these bulbs sequentially between 3 phases N, O and S, you will once again have an illusion as if this pattern is moving. Let us see how? See individual bulbs are only cycling. So, let us consider 1 bulb, it is only cycling through the phase like black-gray, white-gray, black-gray, white-gray which means O is O N like that ok. So, individual bulbs are only changing its color, changing its phase, but all together they create a illusion as if this the set is moving from left to right ok.

Now, let us see it with a faster motion like this. Here the bulbs are turning on off and neutral, faster and you see as if they are moving. So, this is the basic idea behind creating a magnetic field, virtually moving magnetic field without moving any physical object ok. So, let us see another demonstration where.

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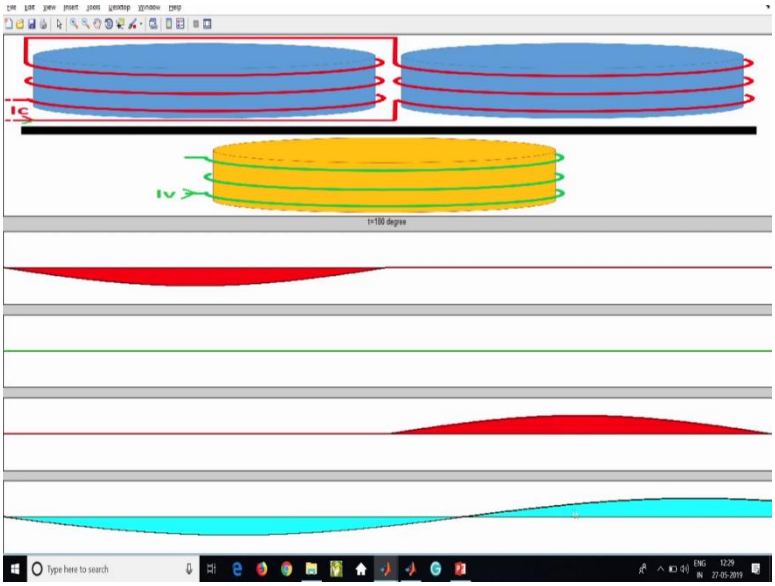

So, this diagram might be familiar to you. We have drawn something similar in our previous class. We have 3 coils you see 1, 2 and 3. 2 coils, these 2 rate coils are connected in series and 1 coil is a separate coil which is this green coil. Now, this to coil they are connected in such a way so that see this this current I am calling as IC; if IC is flowing in this direction, then the flux generated by this coil will be upwards and the flux is generated by this coil will be in the opposite direction, downwards ok. If this flux is upwards, then this flux will be downwards.

So, it is in such a way. So, this coil starts from here, it goes like this, then it comes like this and it returns through this. Similarly, I have another coil here and these 2 coils carry current which are 90 degree out of phase. So, say if this current is positive, then this coil will have a current if I apply say right hand rule. I will see the flux is upwards key and ok. So, if current is entering like this, the here the flux will be upwards and here, I think the connection may be not proper.

So, you should connect it in a way so that if this flux is upward, this should be downwards. If this is downwards, if then this will be upwards. Please check whether this diagram is correct or not, it might have a small mistake. So, the idea is if this flux is upwards, this should be downwards. If this is downwards, this should be upwards. Check it; check it please yourself and if a correction is required, please tell that in the forum ok.

Now, in this curve ok. So, this curve looked at only this curve, where I am moving my cursor this red one. This is the special distribution of the flux density ok. So, left to right is the space; from left to right x axis ok. So, here we see at some instant, the flux density due to this rate coil is like this. It is upwards and flux density due to this, this rate coil this one is downwards, here.

So, this third graph, this red one indicates the flux density due to this coil. This flux density is her. This flux density is here ok. So, this is upwards you see this is upwards, this is downwards. Now, if I press this button time will increase. So, the here you can see the value of time. Time has increased from 0 to 10 degree, it can go to 20, 30, 40 so on and as it happens, you see that this flux is changing; it is reducing. So, you see this flux is reducing and then it is becoming negative here and then, once again its reducing to 0 and then positive and so on.

Similarly, this flux is also reducing, 0, positive, again reducing to 0 and positive as time is increasing. Similar thing is happening to this green flux which is due to this green coil ok. So, again you see as time is increasing, this flux changes sinusoidal it increases; then, 0, decreases and then 0, then increases so on. The thing to note is that this flux and this flux, they are 180 degree out of phase. If this is negative, then this is positive. However, this red and green flux, they are 90 degree out of phase. So, when this is negative, this is almost 0. Now, this is becoming 0 and this is becoming negative; after that this is becoming positive and this is becoming 0, then this is again becoming 0, this is becoming positive.

So, the red and green flux are 90 degree out of phase ok. So, I think the meaning of this curve and this curve is clear. This is the flux density created by this and this coil and the green curve is the flux density created by this green coil. Now, I can add up these three curves here. This last curve is the sum of these three individual curves ok. So, for example, say now at this moment at this instant here, I have a negative flux density, here 0, here 0. So, if I add negative with 0 with 0, I have some negative value. So, here you see the summation is negative. Here you see, I have some negative value 0 and 0. So, this summation will be 0 plus 0 plus sorry, this is positive; 0 plus 0 plus positive is positive.

So, here I have a positive value. Now, as time progresses this two becomes 0 and I have only this green one which is negative. So, now, if I add you see at this region, 0 plus negative plus 0 is negative; here everything is 0. So, summation is 0, once again here

everything is 0. So, summation is 0. So, the last curve is the sum of this three ok. So, this is the flux density due to this coil. This is the flux density due to green coil. This is the flux density due to this light red coil and this is the sum. Now, if I increase time, you can see the time value here 280, 290, 300, 350 and then 0. So, it is cyclically changing and then, this is the sum.

So, you see as I increase the time, the sum so you see the sum the sum summation is moving from left to right. There is a illusion of this sum being moving from left to right. You see now the peak is here and the peak is moving like this, it goes out. Then another peak is coming which is positive, it is moving from left to right and then, going out. Then, you see another negative peak is coming, moving from left to right, going out. Then another positive peak is coming, moving from left to right and going out. So, this is how the resultant or summation of flux density moves from left to right without any coil physically moving ok.

So, now I can show you some more funny things, if I make the phase difference between the green and the red current ok. So, previously I had these green and the red current 90 degree out of phase, now I have made the phase difference same. So, you see that when this red flux is at its peak, the green flux is also at its peak and as time progresses, they together go to 0 and they together go to negative, again they together go to 0.

So, this difference between this two the phase of these 2 fluxes is now 0 and now, if you see the resultant flux, you see that let us see how it is changing. It is not moving at all ok, it is only pulsating. So, this is now negative, it is becoming 0, then positive and again then 0, negative. It is, but the peak is at the same region, it is not moving. You see the peak is not moving or you see these 0 values, this is also not moving; it is only pulsating. So, when I make the difference between these two phases, 0 the motion of the resultant flux is gone. It is no longer moving.

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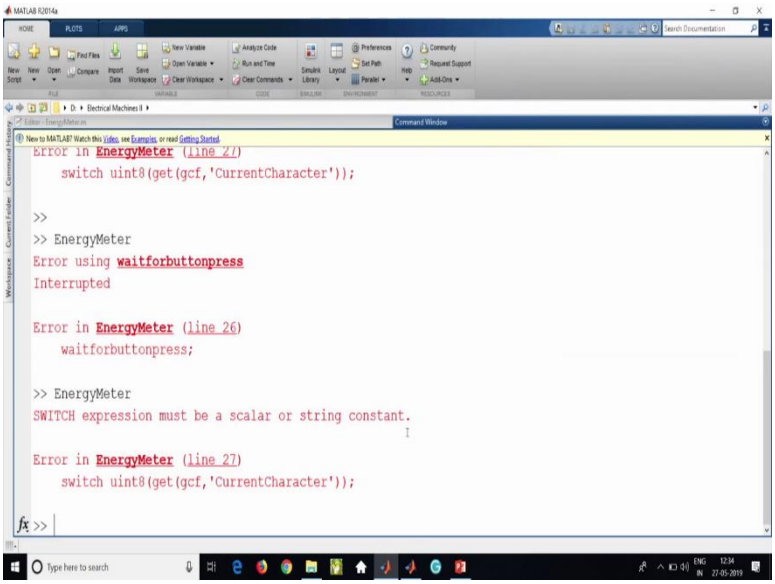

Similarly, I can make the phase difference between them opposite. So, previously green coil was lagging by 90 degree, now it is leading by 90 degree. Now, if I run this program, you will see that the resultant flux is moving from right to left. Previously, it was moving from left to right, now it was moving, now it will moving move in the opposite direction.

You see as time progresses, this peak is going from right to left. See, it is go it has gone from right to left; another peak is coming, it is again going from right to left. Another one right to left ok. So, by changing this phase angle, I can change the direction of the motion of the resultant flux. So, in this demonstration therefore, we have seen how we can chain how we can create a moving magnetic field without any physical object being moving, without any physical magnet been moving or without any coil moving, nothing is moving only the magnetic field is virtually moving.

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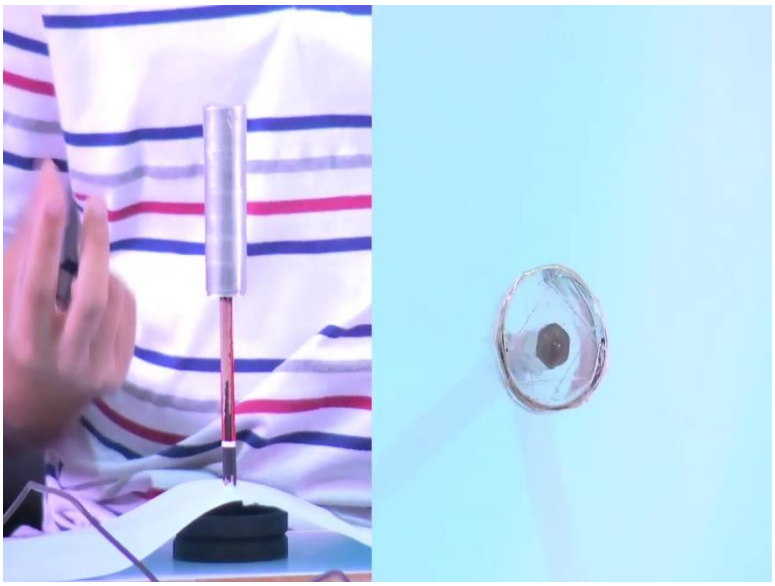

So, we will now see another interesting experimental demonstration about this eddy current motoring and braking and so, we have this simple arrangement. I have a pencil which is kept vertically which acts like a stand for this alume a for this aluminum cylinder ok. So, this is the aluminum seat which is rolled into a cylinder ok. You can see this is just the aluminum sheet which is rolled into a cylinder and this is not any magnetic material. I have a magnet. So, this is a magnet and this can attract other magnetic materials like keys.

So, it attracts a bunch of keys ok. So, this is a magnet, but it does not attract this aluminum foil. You see it falls. Once again, you see it falls. So, it is not at all iron or any magnetic material. It is aluminum ok. But now what I do? I just put this aluminum foil on top of this pencil stand. So, I have some transparent tape covering this side. So, that it can. So, some sellotape. So, it can hang on that selected.

Now, what I will do? I will hold this magnet, this magnet. I think you can see this this black magnet, near this cylinder and I will move it without touching this cylinder and you see what happens? The cylinder starts to rotate and I am not at all touching this cylinder at all. So, this is what? This is eddy current motoring. What is the reason? Why is it moving? Because when I am a when I am moving this magnet near this say near this aluminum cylinder ok.

So, if I move near this it will cause some flux lines intersecting these aluminum cylinder. So, it is up some EMF will be generated. You need some eddy current will be created and

this eddy current will flow in such a direction so that it will try to oppose the relative motion between these two ok. According to Lenz's law no relative motion should be there between these two no relative motions. So, then Lenz's law tells me that the force will act in a direction so that the relative motion will try to get eliminated.

Now, similarly I can show you another experiment, where say I rotate it first sorry. So, let me rotate it, say it keeps rotating for a while ok. It keeps rotating for a while, but now if I rotate it and bring this magnet close to it, it stops immediately. Once again, let us do it sorry not that turbulent I should do it. So, it is rotating now, bringing it close it stops. Once again rotating, bringing it close stops and if I do not bring it close, it rotates for a long-time longer time, it keeps rotating. As soon as I bring it, it stops. What is this? This is eddy current breaking. Why? Once again according to the Lenz's law, the eddy current induced in this aluminum cylinder will try to eliminate the relative velocity or relative motion between the magnet and this cylinder.

So, if you try to rotate the cylinder without rotating the magnet, it will get stopped that is eddy current breaking and if you rotate the magnet without rotating the cylinder, the cylinder will also rotate that is called eddy current motoring. So, thank you for watching these demonstrations. We have learnt two important physical phenomena in this video namely number 1 is that relative motion between a conductor, nonmagnetic conductor and a magnet is not allowed. In a sense, if you if you create a relative motion between them, eddy current will be induced in the conductor which will try to oppose the relative motion.

And the other phenomena which you have seen previously is that we can create virtually moving magnetic field without moving any physical object ok, without moving any magnet physically like I am doing now, I can create a virtually moving magnetic field by using varying current AC current which you have seen in the previous demonstration.

Thank you.