Electromagnetism
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Lecture – 76
A tutorial on the magnetic dipole moment

Hello, now we discuss tutorial 7. In this tutorial, we are going to discuss a problem of involving magnetic dipole and another simple problem; very simple problem for you to solve. We will just state the problem.

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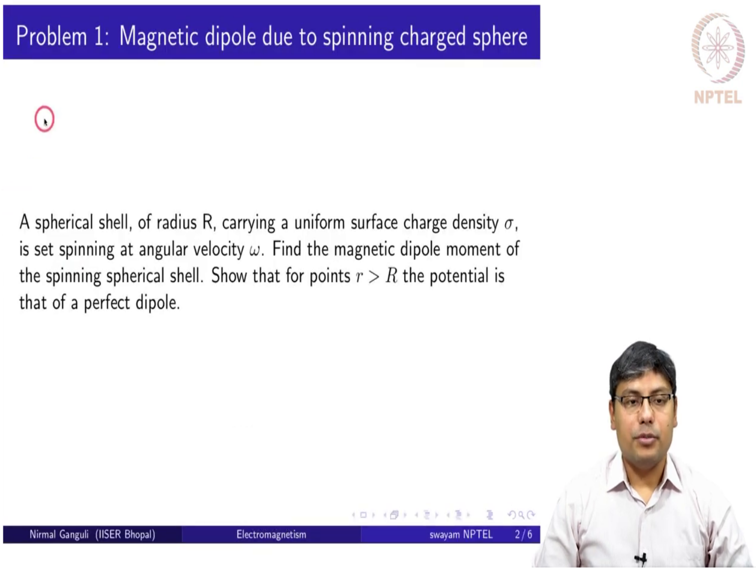

So, let us move on to the first problem the first problem is about the magnetic dipole due to a spinning charged sphere. So, you have a spherical shell of radius capital R and that carries the uniform surface charge density sigma. Now this sphere is set spinning the way earth spins about its axis at an angular velocity omega.

And you are supposed to find the magnetic dipole moment of this spinning spherical shell and you are supposed to show that for points small r that is the usual spherical coordinate r when it is greater than the radius; that means, if you have a point outside the sphere, the potential for this spinning sphere is that of a perfect dipole.

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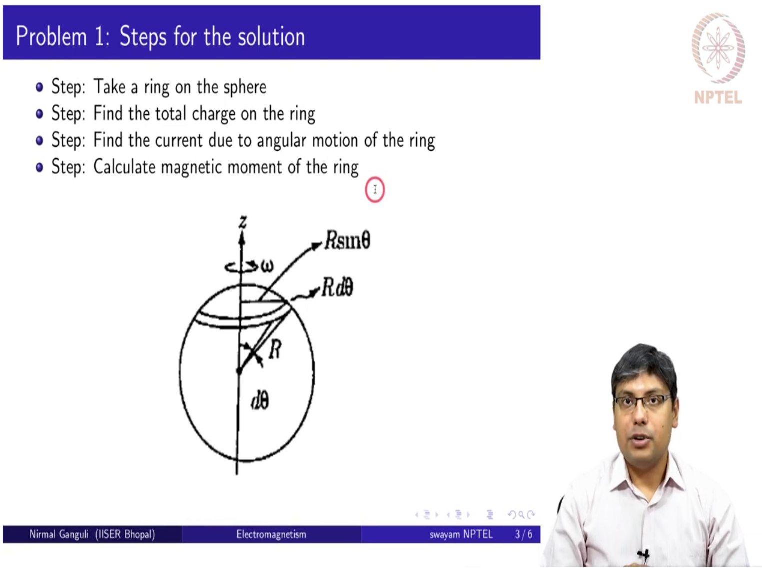

So, what are the steps involved in solving this problem? You are supposed to take a ring on the sphere first the ring. That is shown here in the picture and find the total charge on the ring. And then when you have this angular motion of the ring, you are supposed to find the current due to that motion of the ring, then calculate the magnetic moment of the ring. Here you can pause the video, try solving the problem yourself and restart the video if you need hints.

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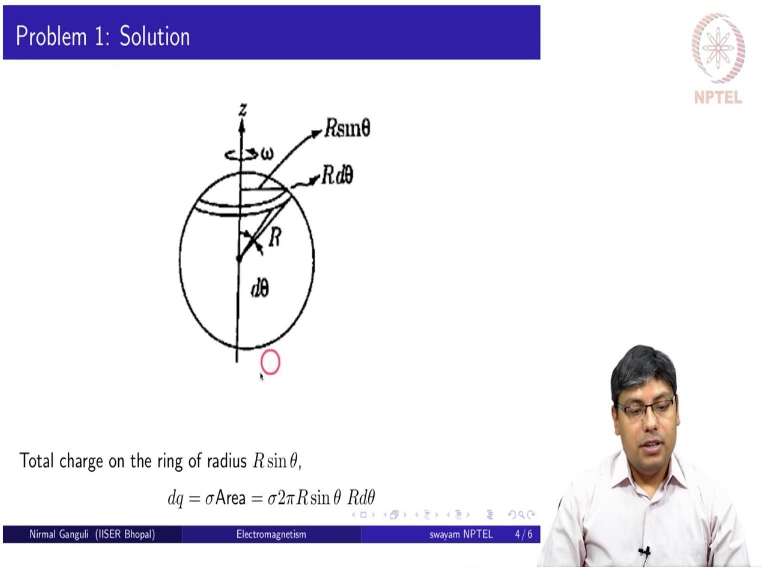

Let us solve the problem total charge on the ring of radius R sin theta. So, you can see that this radius is R sin theta. The total charge can be expressed d q as sigma that is the charge density uniform surface charge density times the area of this ring. The radius is R sin theta and this width is R d theta. So, R sin theta times R d theta is the area of sorry 2 pi R sin theta times R d theta is the area of this ring. And if we multiply that with sigma, we will get the elemental charge d q on the ring.

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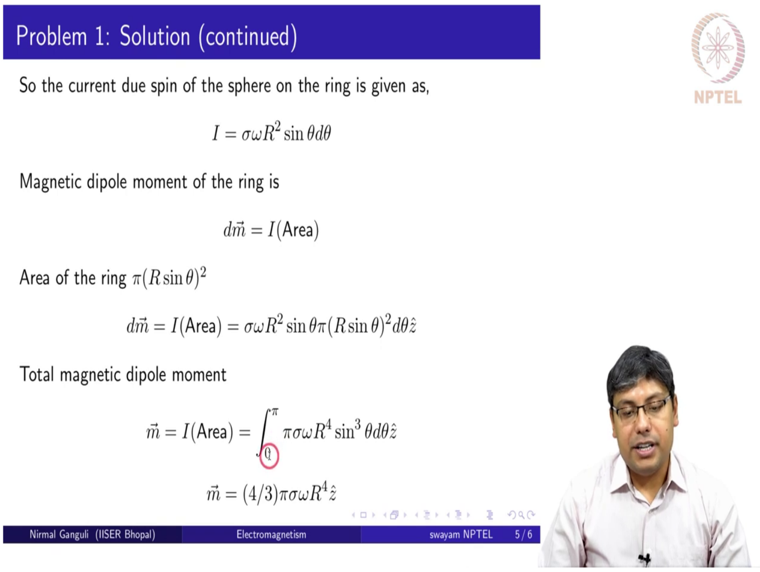

And once we have this elemental charge on the ring, the current due to the spinning sphere coming from this ring is I is given as sigma times omega times R squared sin theta d theta; that is obvious. Now the magnetic dipole moment that is given us current times the area. So, elemental magnetic dipole moment is d m and that is current times the area.

Area of the ring is pi times R sin theta whole squared and d m is given as sigma times omega times R squared sin theta pi R sin theta whole squared theta. It is along the z cap direction. So, the total magnetic dipole moment that can be found by integrating theta from 0 to pi sigma omega R to the power 4 sin cubed theta d theta, it is along z cap direction. So, the total magnetization magnetic moment of this spinning sphere would be 4 over 3 pi sigma omega R power 4 along the z cap direction.

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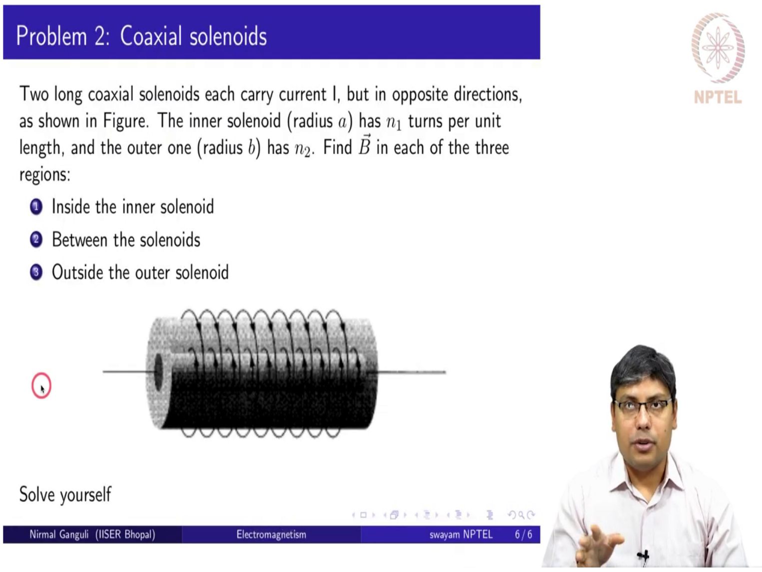

Now, let us come to the simple problem. Here we have two long coaxial solenoids, each carry a current I, but in opposite directions as shown in this figure. The inner solenoid that has radius a has n 1 number of turns per unit length and the outer solenoid with radius b has n 2 number of turns per unit length.

So, we know we have already worked out how magnetic field behaves inside the solenoid and outside the solenoid, we are going to apply that in this problem. So, in this problem you are supposed to find the magnetic field in three regions. One is inside the inner solenoid, two between the solenoids and outside the outer solenoid. That is what you are supposed to find from this problem.

And this problem is a simple one, just apply the expressions for the magnetic field in case of solenoid; infinitely long solenoid you must remember, otherwise the magnetic field would have some other kind of effect. But here we are ignoring those kind of effects of a finite solenoid; infinitely long uniform solenoid. So, the problem is rather simple and solve this problem solve this problem yourself. That is the end of this tutorial.