**Electromagnetism**
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**Lecture - 31**
**The Curl of an electric field**

Let us now consider the Curl of the electric field. We have already calculated the divergence of the electric field which is the Gauss law. Now let us consider evaluating the curl of the electric field.

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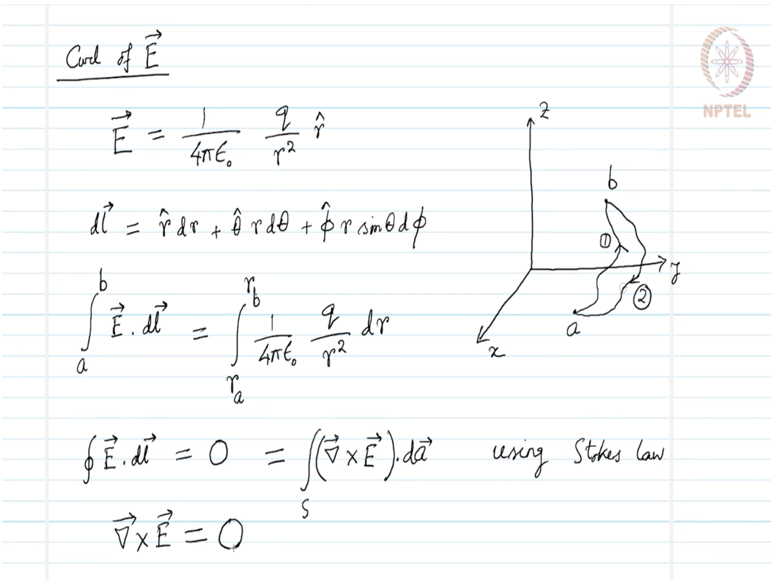


The expression for electric field is given as 1 over 4 pi epsilon naught q over r squared r cap. If we consider a point charge q located at the origin. And let us consider a coordinate system, right hand Cartesian coordinate system x, y, z. And we have two points point a here and point b here. We can consider an arbitrary line element connecting these two points.

So, we are moving from point a to point b, via this arbitrary line element. And if we write the line element dl in spherical coordinate system, we can write it as r cap dr plus theta cap rd theta plus phi cap r sin theta d phi. So, this is the general expression for a line element in spherical coordinate system. And if we integrate from a to b E dot dl, then we get because the electric field is not a function of theta and phi or the electric field does not have any theta or phi component it only has r component r cap. We will have only the dr part being relevant. So, we will have in the expression r from r a to r b 1 over 4 pi epsilon naught q over r squared d r this will be the integral.

And; that means, this integral does not really depend on which path we choose if our path were something like this, even then we would have got the same value of this integral. In other words, if we had gone from point a to point b via path 1 and came back from point b to point a via path 2; that means, we would have performed a cyclic integral cyclic line integral over E dot dl a closed line integral that would have been 0, if we come back to a.

That means, line integral over E dot dl does not depend on the path that we traverse. It only depends on the coordinates the point of starting and the end point that is all. And if that is true, then applying Stokes law we can write this quantity is equal to the surface integral over the curl of the electric field. Now, if this expression this equation has to be true for any arbitrary line and surface elements any arbitrary line and surface segments. Then we must have curl of the electric field going to 0; there is no other way of this expression being valid in general.