Electromagnetism
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Lecture – 47
Electric field due to a dipole

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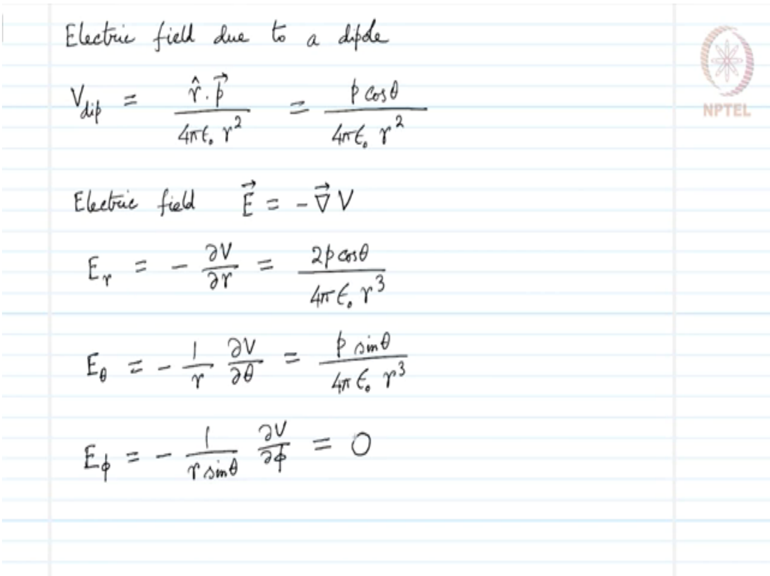

Now, we have calculated the potential due to a dipole. Let us try to find out the electric field due to a dipole. The we will use the expression for the potential that we have calculated earlier. The expression for potential is r cap dot the dipole movement p vector over 4 pi epsilon naught r squared. And r cap dot p vector that can be written as p cosine of theta over 4 pi epsilon naught r squared.

So, this is the scalar potential that we have. And this way we have converted into a function of r and theta. And we assume a symmetry along the azimuthal direction that is phi direction. If we consider the dipole, 2 charges are separated along z axis then that azimuthal symmetry will be there in our problem. Then we can write down the expression for electric field from the scalar potential as E equals the negative gradient of the scalar potential.

So, let us try to calculate the r component of this electric field that would be given as minus del v del r equals 2 p times cosine of theta over 4 pi epsilon naught r cubed. The theta component of the electric field can be given as minus 1 over r del v del theta which is p times sine theta over 4 pi epsilon naught r cubed. And let us try to calculate the phi component of the electric field which is minus one over r sin theta del v del phi. Now, we can see that our potential does not have a phi component that is its not a function of phi.

So, if it is not a function of phi then the partial derivative with respect to phi is going to give us a 0. So, the phi component of the electric field is always 0 given the way we have aligned our dipole.

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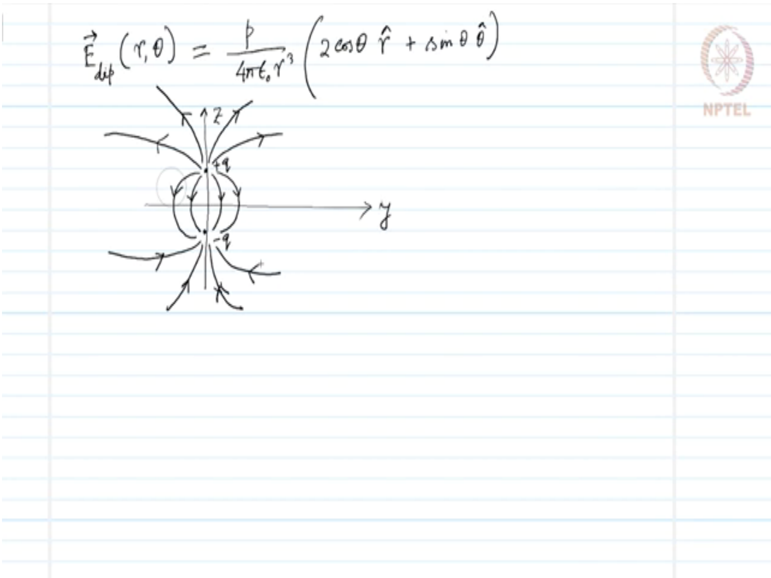

Then we can write the electric field due to dipole in its vector notation in spherical coordinate system as. So, let us write this subscript dip for dipole and its a function of r and theta that would be given as p over four pi epsilon naught r cubed twice cosine of theta r cap plus sin theta cap. Where p is the magnitude of the dipole movement for our charge arrangement ok.

So, after we have calculated the electric field coming from the dipole let us try drawing the electric field lines corresponding to this dipole that we are considering; one positive charge and one negative charge here. So, we have aligned our y axis in this direction and the z axis in this direction.

So, the electric field lines if we consider positive charge here and negative charge here, the electric field lines will go like this. And if we move far from this place, then it will go somewhat like this, this, this, this. Similarly, in this direction, but it will point towards the negative charge always like this. This will be the arrangement of the electric field lines.