Advanced Microwave Guided-Structures and Analysis
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Lecture 28
Radiation from a Magnetic Current Source (Contd.)

So, welcome to this session of lecture, we will be continuing with the radiation from the magnetic current source, which we had been discussing in the previous lecture, and we are also going to illustrate the significance of the magnetic current, its relevance and it is extremely important in electromagnetics particularly in the computation of Green's function for electromagnetic field problems.

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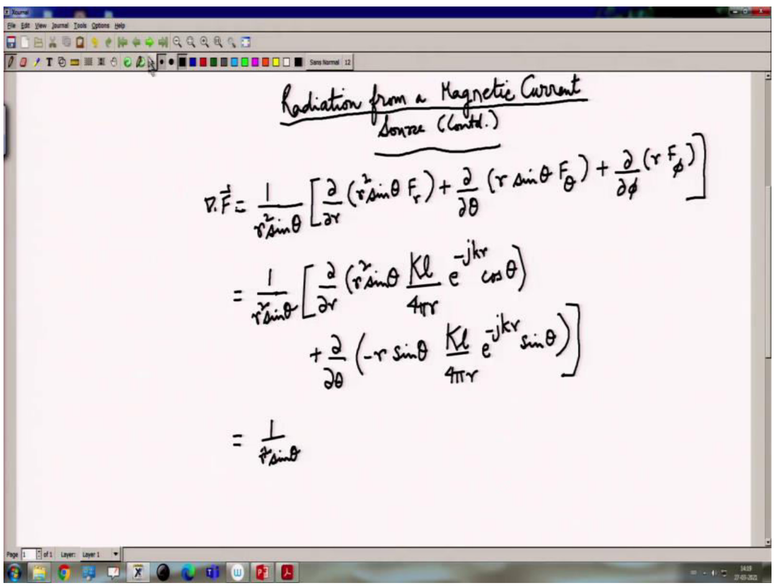

So, last time we had derived the electric field components for the magnetic current source, so now we are going to derive the magnetic field components. So, for derivation of the magnetic field components, we will be needing two operations, one is divergence of **F**, and another is gradient of divergence of **F**. So, let us compute the divergence of **F**.

So, the divergence of **F** will be $\frac{1}{r^2\sin(\theta)}\left[\frac{\partial}{\partial r}(r^2\sin(\theta)F_r)+\frac{\partial}{\partial\theta}(r\sin(\theta)F_\theta)+\frac{\partial}{\partial\phi}(rF_\phi)\right]$. So, now we substitute for the electric vector potentials, the different components of the electric vector

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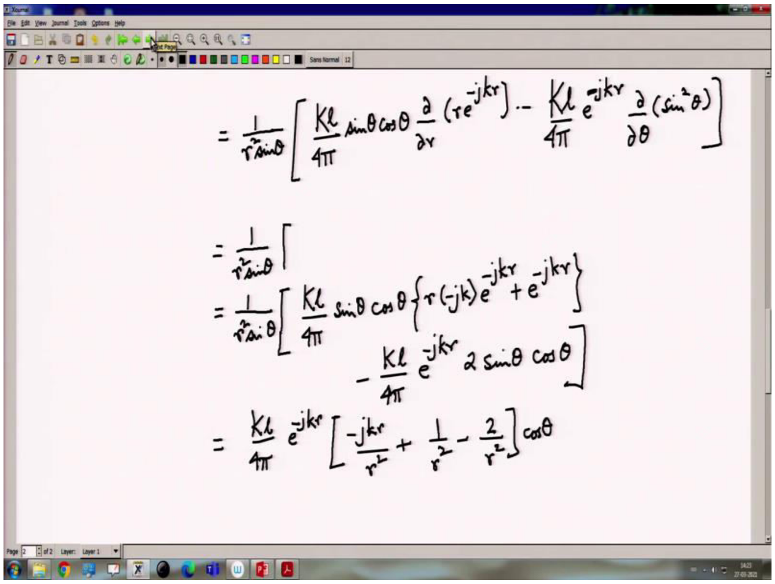

Potentials, so we get $\frac{kl}{4\pi}e^{-jkr}\left[\frac{-jkr}{r^2}+\frac{1}{r^2}-\frac{2}{r^2}\right]\cos\theta$

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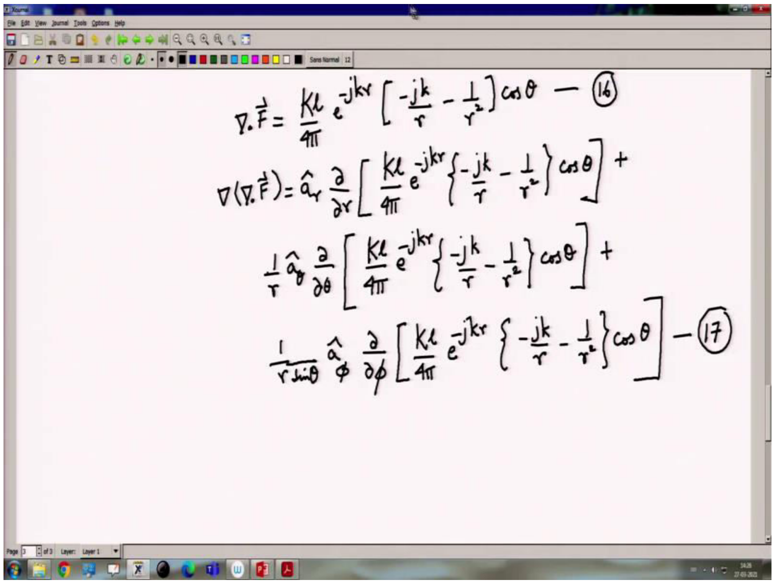

Which finally gives me divergence of **F** as $\frac{kl}{4\pi}e^{-jkr}\left[\frac{-jkr}{r^2}-\frac{1}{r^2}\right]\cos\theta$ and that is equation 16. Now we proceed to calculate grad of divergence of **F**. So, grad of divergence **F** equal to

$$\hat{a}_r \frac{\partial}{\partial r}\left[\frac{kl}{4\pi}e^{-jkr}\left\{\frac{-jkr}{r^2}-\frac{1}{r^2}\right\}\cos\theta\right]+\frac{1}{r}\hat{a}_\theta \frac{\partial}{\partial \theta}\left[\frac{kl}{4\pi}e^{-jkr}\left\{\frac{-jkr}{r^2}-\frac{1}{r^2}\right\}\cos\theta\right]$$
$$+\frac{1}{r\sin\theta}\hat{a}_\phi\left[\frac{kl}{4\pi}e^{-jkr}\left\{\frac{-jkr}{r^2}-\frac{1}{r^2}\right\}\cos\theta\right]$$

. So, that is 17. So, now we can calculate the value of the magnetic field all the r, theta and phi components of the magnetic field.

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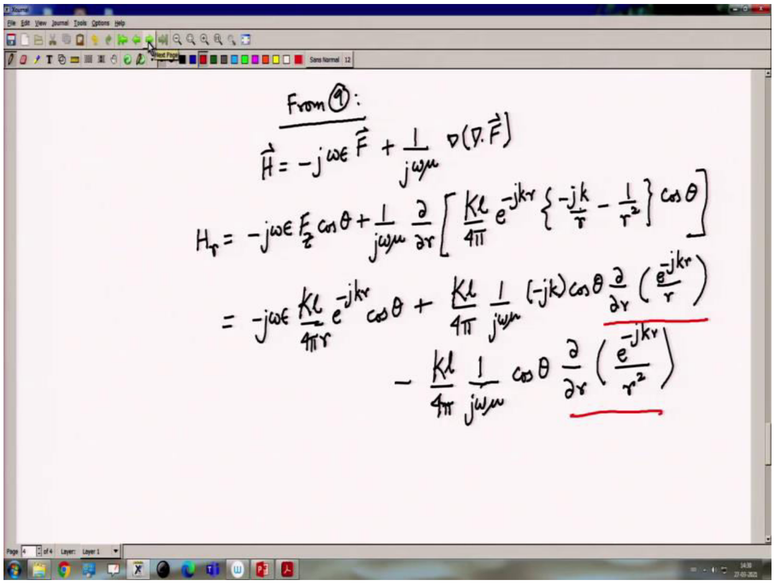

So, we know from equation 9, **H** is minus j omega epsilon **F** plus 1 by j omega mu gradient of divergence **F**, so from which the radial component of the magnetic field or the **r** component of the magnetic field will be $-j\omega\varepsilon F_z \cos\theta + \frac{1}{j\omega\mu}\frac{\partial}{\partial r}\left[\frac{kl}{4\pi}e^{-jkr}\left\{\frac{-jkr}{r^2}-\frac{1}{r^2}\right\}\cos\theta\right]$. And that is equal to $-j\omega\varepsilon\frac{kl}{4\pi r}e^{-jkr}\cos\theta + \frac{kl}{4\pi}\frac{1}{j\omega\mu}(-jk)\cos\theta\frac{\partial}{\partial r}(\frac{e^{-jkr}}{r}) - \frac{kl}{4\pi}\frac{1}{j\omega\mu}\cos\theta\frac{\partial}{\partial r}(\frac{e^{-jkr}}{r^2})$. So, we now need to calculate these two terms.

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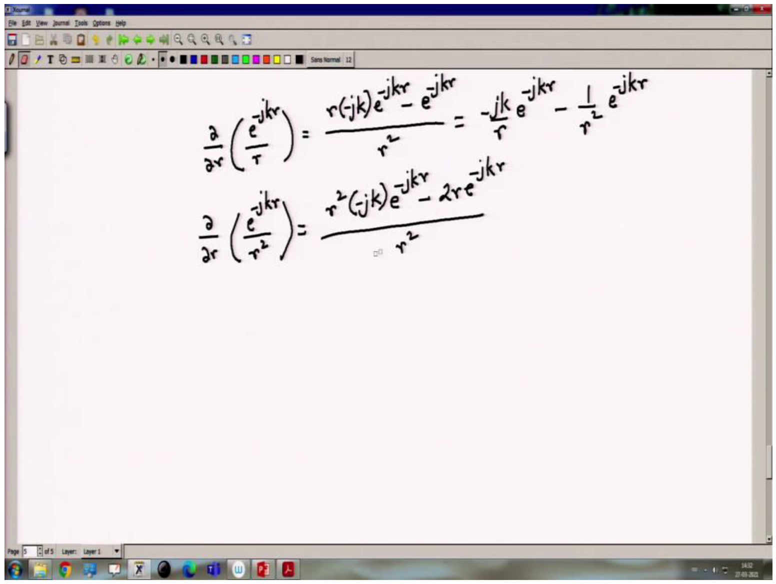

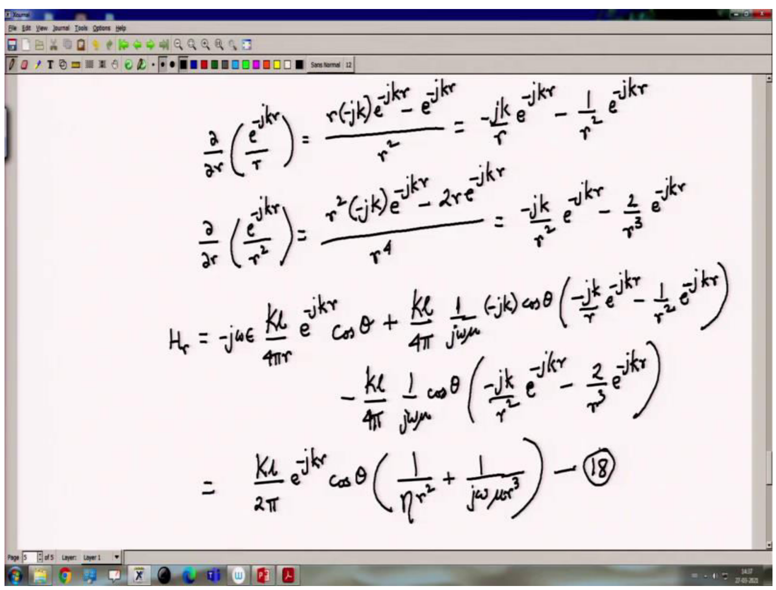

So, $\frac{\partial}{\partial r}(\frac{e^{-jkr}}{r})$ is $\frac{-jk}{r}e^{-jkr} - \frac{1}{r^2}e^{-jkr}$, and $\frac{\partial}{\partial r}(\frac{e^{-jkr}}{r^2})$ is $\frac{-jk}{r^2}e^{-jkr} - \frac{2}{r^3}e^{-jkr}$.

So, now therefore the radial component of the magnetic field becomes $\frac{kl}{2\pi}e^{-jkr}\cos\theta(\frac{1}{\eta r^2} + \frac{1}{j\omega\mu r^3})$

. So, we call this equation 18.

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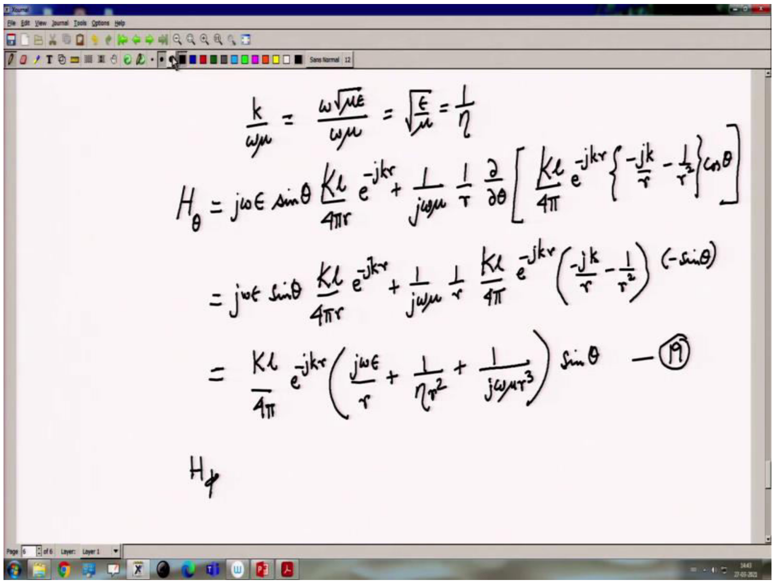

In equation 18 the term k by omega mu equal to omega root mu epsilon by omega mu that is root of epsilon by mu that is 1 by eta. Similarly, we will get H theta as

$$\frac{kl}{4\pi} e^{-jkr}\left(\frac{j\omega\varepsilon}{r} + \frac{1}{\eta r^2} + \frac{1}{j\omega\mu r^3}\right)\sin\theta$$

So, that is 19 and.

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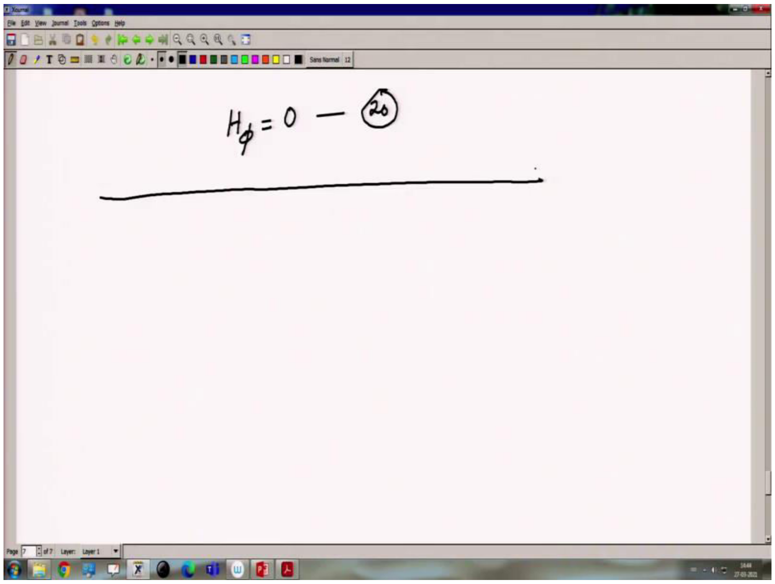

And H phi will be 0 that is equation 20. So, these are all the electric and the magnetic field components for the magnetic dipole, and these can be compared with those for the electric dipole and they will be found to be duals of each other. So, let us stop this topic here, we will be next investigating the significance of the magnetic current and its relevance in the computation of electromagnetic fields. Thank you.