Physics 8.03
Vibrations and Waves

Lecture 15

EM waves meet conductors

Transmission Lines

Last time

- Radiation from accelerating charges
  - Dipole approximation

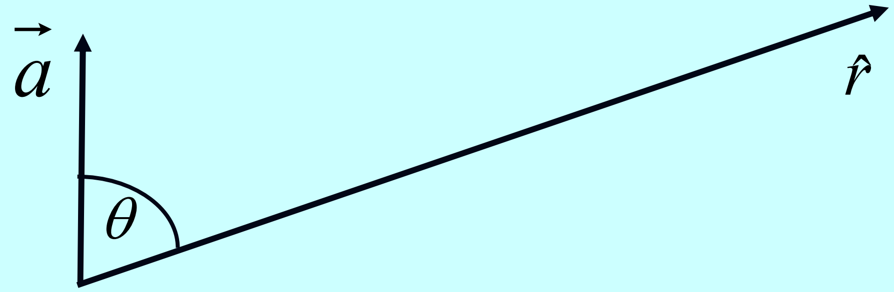
$$\vec{E}_{rad}(\vec{r},t) = \frac{-q\vec{a}_n(t-r/c)}{4\pi\varepsilon_0 rc^2}$$

$$\vec{B}_{rad}(\vec{r},t) = \frac{1}{c}\hat{r}\times\vec{E}_{rad}$$

$$\vec{S}_{rad}(\vec{r},t) = \frac{1}{\mu_0}\vec{E}_{rad}\times\vec{B}_{rad}$$

$$u << c$$
$$r >> \lambda$$
$$d << \lambda$$

Last time: oscillating dipole



$$\vec{z}(t) = z_0 \cos(\omega t)\hat{z}$$
$$\vec{a}(t) = -\omega^2 z_0 \cos(\omega t)\hat{z}$$
$$\vec{a}_n(t - r/c) = -\omega^2 z_0 \cos(\omega t - kr)\sin\theta.(-\hat{x}\cos\theta + \hat{z}\sin\theta)$$

$$\vec{E}_{rad}(\vec{r},t) = \frac{-q\left|\vec{a}(t')\right|\sin\theta}{4\pi\varepsilon_0 r c^2}\hat{\theta} = \frac{q z_0 \omega^2 \cos(\omega t - kr)\sin\theta}{4\pi\varepsilon_0 r c^2}(-\hat{x}\cos\theta + \hat{z}\sin\theta)$$

$$\vec{B}_{rad}(\vec{r},t) = \frac{-q\left|\vec{a}(t')\right|\sin\theta}{4\pi\varepsilon_0 r c^3}\hat{\phi} = \frac{q z_0 \omega^2 \cos(\omega t - kr)\sin\theta}{4\pi\varepsilon_0 r c^3}\hat{y}$$

$$\vec{S}_{rad}(\vec{r},t) = \frac{q^2 a^2(t')\sin^2\theta}{16\pi^2\varepsilon_0 r^2 c^3}\hat{r} = \frac{q^2 z_0^2 \omega^4 \cos^2(\omega t - kr)\sin^2\theta}{16\pi^2\varepsilon_0 r^2 c^3}\hat{k}$$

- Dipole radiation contd…
  - Total power radiated
  - Scattering
- EM waves near perfect conductors
  - Boundary conditions
  - Transmission lines