



Electromagnetic waves

Physics 114

Concepts

- **EM waves – frequency and wave length**
- **EM spectrum**
- **Antennas**
- **Radio**
- **Amplitude and frequency modulations**

Maxwell's equations in vacuum

- **No charges, no currents**

$$\oint_{\text{closed surface}} \vec{E} dA = 0$$

$$\oint_{\text{closed surface}} \vec{B} dA = 0$$

- **Changing magnetic field creates electric field**

$$\oint_{\text{closed path}} \vec{E} dl = - \frac{d\Phi_B}{dt}$$

- **Changing electric field creates magnetic field**

$$\oint_{\text{closed path}} \vec{B} dl = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$$