Course Instructor
Dr. Raymond C. Rumpf
Office: A-337
Phone: (915) 747-6958
E-Mail: rcrumpf@utep.edu

Maxwell's Equations:

Statics & Dynamics

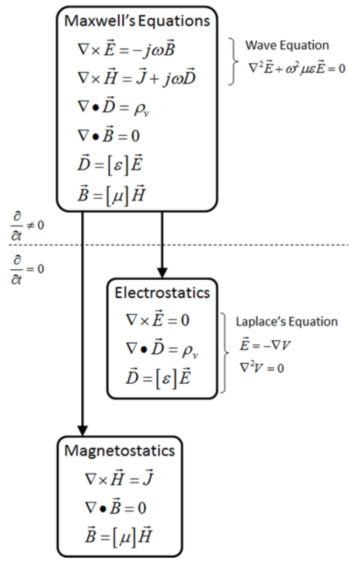
EE-3321

Electromagnetic Field Theory

Outline

- Conditions to apply static approximation
- Consequences of static approximation

Summary of Statics & Dynamics



Conditions to Apply Static Approximation

Condition for Static Fields

At DC, there exists no fluctuations in the electric and magnetic fields and we can make the following approximations:

$$\omega \to 0 \qquad\qquad \frac{\partial}{\partial t} \to 0$$

Very often we can make the static approximation when the size of the problem is much less than the wavelength. Circuit theory for AC signals makes this approximation.

Consequences of Static Approximation

Maxwell's Equations for Static Fields

	Integral Form	Differential Form
Time-Domain	$\oint\!\!\oint_S \vec{D}\bullet d\vec{s} = \iiint_V \rho_v dv$ $\oint\!\!\oint_S \vec{B}\bullet d\vec{s} = 0$ **Most general form** $\oint_L \vec{E}\bullet d\vec{\ell} = 0$ $\oint_L \vec{H}\bullet d\vec{\ell} = \iint_S \vec{J}\bullet d\vec{s}$	$\nabla\bullet\vec{D} = \rho_v$ $\nabla\bullet\vec{B} = 0$ $\nabla\times\vec{E} = 0$ $\nabla\times\vec{H} = \vec{J}$
Frequency-Domain	$\oint\!\!\oint_S \vec{D}\bullet d\vec{s} = \iiint_V \rho_v dv$ $\oint\!\!\oint_S \vec{B}\bullet d\vec{s} = 0$ $\oint_L \vec{E}\bullet d\vec{\ell} = 0$ $\oint_L \vec{H}\bullet d\vec{\ell} = \iint_S \vec{J}\bullet d\vec{s}$	**Most common form** $\nabla\bullet\vec{D} = \rho_v$ $\nabla\bullet\vec{B} = 0$ $\nabla\times\vec{E} = 0$ $\nabla\times\vec{H} = \vec{J}$

Constitutive Relations: $\vec{D} = \varepsilon\vec{E}$ $\vec{B} = \mu\vec{H}$

Electric and Magnetic Fields are Decoupled

After observing the results on the previous slide, we see that Maxwell's equations have decoupled into two independent sets of equations. One set describes electrostatics and the other describes magnetostatics.

Electrostatics

$$\oint\!\!\oint_S \vec{D}\bullet d\vec{s} = \iiint_V \rho_v dv \qquad \nabla\bullet\vec{D} = \rho_v$$

$$\oint_L \vec{E}\bullet d\vec{\ell} = 0 \qquad \nabla\times\vec{E} = 0$$

$$\vec{D} = \varepsilon\vec{E}$$

- Charges must be present to get a nontrivial solution.
- $\nabla\times\vec{E} = 0$ says E is irrotational and forms mostly straight lines.
- The electric fields are not affected by permeability.

Magnetostatics

$$\oint\!\!\oint_S \vec{B}\bullet d\vec{s} = 0 \qquad \nabla\bullet\vec{B} = 0$$

$$\oint_L \vec{H}\bullet d\vec{\ell} = \iint_S \vec{J}\bullet d\vec{s} \qquad \nabla\times\vec{H} = \vec{J}$$

$$\vec{B} = \mu\vec{H}$$

- Current must be present to get a nontrivial solution.
- $\nabla\bullet\vec{B} = 0$ says B is solenoidal and forms loops.
- The magnetic fields are not affected by permittivity.