

Topics: Displacement Current & Energy Flow

Related Reading:

Course Notes (Liao et al.): Chapter 13

Serway and Jewett: Chapter 34

Giancoli: Chapter 32

Topic Introduction

Today we will put into practice the ideas of displacement current and the Poynting Vector.

Displacement Current

Recall that the displacement current is what we call the ability to create a magnetic field by allowing an electric field to change in time. Although calling it a “current” isn’t strictly

accurate (there is no flowing charge), the displacement current $I_{d\Box} = \epsilon_0 \frac{d\Phi_{E\Box}}{dt\Box}$ does act very

much like a current, creating a magnetic field that curls around it. We derived the idea from thinking about a capacitor. In a capacitor, no current flows between the plates, but when the capacitor is charging or discharging (with a current I flowing onto/off of the capacitor plates) then the electric field between the plates changes, and the displacement current looks like a current I as well, uniformly distributed across the plates and flowing between them.

Energy and the Poynting Vector

The Poynting Vector $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$ describes how much energy passes through a given area per unit time, and points in the direction of energy flow. Although this is commonly used when thinking about electromagnetic radiation, it generically tells you about energy flow, and is particularly useful in thinking about energy in circuit components. For example, consider a cylindrical resistor. The current flows through it in the direction that the electric field points. The B field curls around. The Poynting vector thus points radially *into* the resistor – the resistor consumes energy. In today’s problem solving session you will calculate the Poynting vector in a capacitor, and will find that if the capacitor is charging then \vec{S} points in towards the center of the capacitor (energy flows into the capacitor) whereas if the capacitor is discharging \vec{S} points outwards (it is giving up energy).

Important Equations

Displacement Current: $I_{d\Box} = \epsilon_0 \frac{d\Phi_{E\Box}}{dt\Box}$

Poynting Vector: $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$