"The Fundamentals of Electromagnetic Theory"

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Chapter 10 Maxwell's Equations and Electromagnetic Waves

Computer Assisted Instruction

Interactive Examples

Example 10.1 & Example 10.2

The displacement current. At a certain instant, a parallel plate capacitor, rated at 17.4 μF, has a potential of 50.0 V across its plates. The area of the plate is 5.00 x 10^{-2} m^2. If it takes a time of 0.500 s to reach this 50.0-V potential, find (a) the charge deposited on the plates of the capacitor, (b) the average conduction current at that time, (c) the average displacement current at that time, and (d) the rate at which the electric field between the plates is changing at that time.

Initial Conditions

C =	1.74E-05	F	V =	50	V
A =	0.05	m^2	dt =	0.5	s
ε_o =	8.85E-12	$(C^2)/(N\ m^2)$			

Solution.

a. The charge deposited on the plates, found from chapter 6, equation 6.15, is

$$q = C\ V$$

$$q = (\ 1.74\text{E-}05\ F)\quad x \quad (\ 50\ V)$$

$$q = 8.70\text{E-}04\ C$$

b. The current in the circuit, corresponding to that amount of charge flowing in 0.500 s, found from the definition of the conduction current, is

$$I_C = dq\ /\ dt$$

$$I_C = (\ 8.70\text{E-}04\ C)\quad /\quad (\ 0.5\ s)$$

$$I_C = 1.74\text{E-}03\ A$$

c. The displacement current across the capacitor is equal to the conduction current entering the capacitor, therefore

$$I_D = I_C = 1.74\text{E-}03\ A$$

d. The rate at which the electric field between the plates is changing with time is given by rearranging equation 10.5 to

$$dE / dt = I_D / \varepsilon_0 A$$

$$dE / dt = (1.74E-03 \text{ A}) / [(8.85E-12 \text{ (C}^2\text{)/(N m}^2\text{)} \times (5.00E-02 \text{ m}^2)]$$

$$dE / dt = 3.93E+09 \text{ (N/C)/s}$$

Example 10.2

A changing electric field with time creates a magnetic field. Find the magnetic field a distance of 20.0 cm from the center of the parallel plate capacitor in example 10.1

Initial Conditions

$r =$ 0.20 m

$\varepsilon_o =$ 8.85E-12 $(C^2)/(N\ m^2)$

$\mu_o =$ 1.26E-06 (T m)/A

Solution.

The area of the plates of the capacitor ($A = \pi R^2$) was given as 0.05 m^2
hence the radius of the plate is

$$R = \text{sqrt}[A / \pi] = \text{sqrt}[(0.05 \text{ m}^2) / (3.14159)] = 0.126157 \text{ m}$$

The changing electric field, found in example 10.1, is dE/dt = 3.93E+09 (N/C)/s
Hence, the magnetic field at a distance of 20.0 cm from the center of the capacitor, found from equation 10.10, is

$$B = [\mu_0\ \varepsilon_0\ R^2\ dE / dt] / [2 r]$$

$$B = [(1.26E-06 \text{ T m)/A)} \times (8.85E-12 \text{ (C}^2\text{)/(N m}^2\text{)} \times (0.12616 \text{ m})^2$$

$$\times (3.93E+09 \text{ N/C)/s)}] / [2 (0.2 \text{ m})]$$

$$B = 1.74E-09 \text{ T}$$

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1. If you are using this from a CD, then close Excel by clicking on the X in the very top right-hand corner of this screen. If you are asked to save the document, say no. When Excel closes, you will be returned to the example in the textbook.

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