Chapter 31 Question 2
What is the direction of the displacement current in Fig. 31–3?
(Note: The capacitor is discharging.)

Solution
The displacement current is to the right.

Chapter 31 Question 5
The electric field in an EM wave traveling north oscillates in an east–west plane. Describe the direction of the magnetic field vector in this wave.

Solution
The magnetic field vector will oscillate up and down, perpendicular to the direction of propagation and to the electric field vector.

Chapter 31 Question 7
Can EM waves travel through a perfect vacuum? Can sound waves?

Solution
EM waves are self-propagating and can travel through a perfect vacuum. Sound waves are mechanical waves which require a medium, and therefore cannot travel through a perfect vacuum.

Chapter 31 Question 9
Are the wavelengths of radio and television signals longer or shorter than those detectable by the human eye?

Solution
The wavelengths of radio and television signals are longer than those of visible light.

Chapter 31 Question 12
In the electromagnetic spectrum, what type of EM wave would have a wavelength of 10³ km; 1 km; 1 m; 1 cm; 1 mm; 1 μm?

Solution
10³ km: radio wave; 1 km: radio wave; 1 m: microwave; 1 cm: microwave; 1 mm: microwave or infrared; 1 μm: infrared.
Chapter 31 Problem 4
A 1500-nF capacitor with circular parallel plates 2.0 cm in diameter is accumulating charge at the rate of 38.0 mC/s at some instant in time. What will be the induced magnetic field strength 10.0 cm radially outward from the center of the plates? What will be the value of the field strength after the capacitor is fully charged?

Chapter 31 Problem 7
Suppose that a circular parallel-plate capacitor has radius $R_0=3.0\text{cm}$ and plate separation $d=5.0\text{mm}$. A sinusoidal potential difference $V=V_0\sin(2\pi f t)$ is applied across the plates, where $V_0=150\text{V}$ and $f=60\text{Hz}$. (a) In the region between the plates, show that the magnitude of the induced magnetic field is given by $B=B_0(R)\cos(2\pi f t)$ where $R$ is the radial distance from the capacitor’s central axis. (b) Determine the expression for the amplitude $B_0(R)$ of this time-dependent (sinusoidal) field when $R<R_0$ and when $R>R_0$. (c) Plot $B_0(R)$ in tesla for the range $0<R<10\text{cm}$.

Chapter 31 Problem 11
The electric field of a plane EM wave is given by $E_x = E_0 \cos(kz + \omega t)$.
Determine (a) the direction of propagation and (b) the magnitude and direction of $B$.

Chapter 31 Problem 19
How long would it take a message sent as radio waves from Earth to reach Mars (a) when nearest Earth, (b) when farthest from Earth?

Chapter 31 Problem 23
The magnetic field in a traveling EM wave has an rms strength of 22.5 nT. How long does it take to deliver 335 J of energy to 1.00 cm$^2$ of a wall that it hits perpendicularly?

Chapter 31 Problem 26
If the amplitude of the $B$ field of an EM wave is $2.5 \times 10^{-7} \text{T}$ (a) what is the amplitude of the $E$ field? (b) What is the average power per unit area of the EM wave?

Chapter 31 Problem 30
A high-energy pulsed laser emits a 1.0-ns-long pulse of average power $1.83 \times 10^9 \text{W}$. The beam is $2.2 \times 10^{-3} \text{m}$ in radius. Determine (a) the energy delivered in each pulse, and (b) the rms value of the electric field.
Given:

\[ C = 1500 \times 10^{-9} \, \text{F} \]
\[ d = 2.0 \times 10^{-2} \, \text{m} \]
\[ \frac{\text{d}Q}{\text{d}t} = 3.0 \times 10^{-3} \, \text{C/s} \] (E)

a) \( B(r = 0 \, \text{cm}) = ? \)

b) when the capacitor is fully charged, \( B = ? \)

Solution

a) Ampere's Law

\[ \oint B \, \text{d}l = \mu_0 I \]

\[ = 2 \pi r \, B = \mu_0 I \]

\[ \Rightarrow B = \frac{\mu_0 I}{2 \pi R} = \frac{\mu_0}{2 \pi R} \frac{\text{d}Q}{\text{d}t} = \frac{7.6 \times 10^{-1}}{8} \]

b) when the capacitor is fully charged, \( \frac{\text{d}Q}{\text{d}t} = 0 \)

\[ \Rightarrow B = 0 \]
**Chapter 31: Problem 1**

\[ E_x = E_0 \cos (kz + wt) \]

a) direction of propagation
b) magnitude & direction of \( B \)

**Solution**

w) The cosinusoidal term is \( k_z + wt = \frac{wt}{\varepsilon} \),

Thus it propagates in the negative \( z \)-direction.

Look at discussion on page 820 – 821

b) \( B_0 = \frac{E_0}{c} \) (always!)

direction will be \( \perp \) to \( E_x \) & \( -z \)

\( \therefore \) using right hand rule

\[ \hat{y} \text{ or } -y \text{-direction} \]
Chapter 3.1: Problem 19

Solution

\[ \Delta t = \frac{0d}{c} = \frac{2.77 \times 10^8}{3.0 \times 10^8} \text{ m} \]

\[ = (2.77 \times 10^8 \text{ m} \pm 144.6 \times 10^9 \text{ m}) \]

\[ = (2.77 \times 10^8 \text{ m}) \]

\[ t_{\text{near}} = 261 \text{ s} \]

\[ t_{\text{far}} = 1260 \text{ s} \]
Chapter 31 Problem 23

Given

\[
\begin{align*}
B_{\text{rms}} &= 22.5 \times 10^{-9} \ T \\
U &= 38.5 \ J \\
A &= 1.00 \ cm^2 = 1.0 \times 10^{-4} \ m^2
\end{align*}
\]

Solution

\[
S = \frac{cB^2}{\mu_0} = \frac{AU}{ADt}
\]

\[
\Rightarrow \quad \Delta t = \frac{\mu_0 AU}{ACB^2} = 2.7 \times 10^7 \ s
\]

(almost a year!)

(a year is 3.15 \times 10^7 \ s)
Chapter 31, Problem 26

**Given**

\[ B = 2.5 \times 10^{-3} \ T \]

a) \( E = ? \)  

b) \[ P = \frac{\overrightarrow{P} \cdot (\text{average power})}{A \cdot \text{area}} \]

**Solution**

a) \( E = cB \)  
\[ = 7.5 \text{ V/m} \]

b) \[ \frac{\overrightarrow{P}}{A} = I \frac{E_0 B_0}{2 \mu_0} = 7.5 \text{ W/m}^2 \]

"Boy, this is stupid!"
Chapter 31 Problem 30

Given:
\[ t = 10 \times 10^{-9} \text{s} \]
\[ P = 1.83 \times 10^{-3} \text{W} \]
\[ q = 2.2 \times 10^{-3} \text{m} \]

a) \[ \hat{u} = 3 \]

b) \[ E_{rms} = ? \]

Solution:

\[ E_{rms} = \sqrt{\frac{P}{Ac_{e_0}}} \]
\[ = 2.0 \times 10^{9} \text{V/m} \]

(Note: For all, \[ s = \frac{P}{A} = \frac{c_0 E^2}{A} \])