35.31. Model: Use the Galilean transformation of fields. Assume that the electric and magnetic fields are uniform inside the capacitor.

Visualize: Please refer to Figure P35.31. The laboratory frame is the S frame and the proton's frame is the S′ frame.

Solve: **(a)** The electric field is directed downward, and thus the electric force on the proton is downward. The magnetic field $\vec{B}$ is oriented so that the force on the proton is directed upward. Use of the right-hand rule tells us that the magnetic field is directed into the page. The magnitude of the magnetic field is obtained from setting the magnetic force equal to the electric force, yielding the equation $evB = eE$. Solving for B,

$$B = \frac{E}{v} = \frac{1.0\times10^5 \text{ V/m}}{1.0\times10^6 \text{ m/s}} = 0.10 \text{ T}$$

Thus $\vec{B}$ = (0.10 T, into page).

(b) In the S′ frame, the magnetic and electric fields are

$$\vec{B}' = \vec{B} - \frac{1}{c^2}\vec{V}\times\vec{E} = -0.10\hat{k} \text{ T} - \frac{\left(1.0\times10^6\,\hat{j} \text{ m/s}\right)\times\left(1.0\times10^5\,\hat{i} \text{ V/m}\right)}{\left(3.0\times10^8 \text{ m/s}\right)^2} \approx -0.10\hat{k} \text{ T}$$

$$\vec{E}' = \vec{E} + \vec{V}\times\vec{B} = 1.0\times10^5\,\hat{i}\ \frac{\text{V}}{\text{m}} + \left(1.0\times10^6\,\hat{j} \text{ m/s}\right)\times\left(-0.10\hat{k} \text{ T}\right) = 0\ \frac{\text{V}}{\text{m}}$$

(c) There is no electric force in the proton's frame because $E' = 0$, and there is no magnetic force because the proton is at rest in the S′ frame.

35.37. Model: Use Equation 35.21 for the definition of the displacement current.

Solve: The current in a conductor arises from the electric field E in the conductor. From Equation 31.18,

$$J = \frac{I}{A} = \sigma E \Rightarrow \frac{dI}{dt} = \frac{d}{dt}(\sigma E A) = \sigma \frac{d}{dt}(EA) = \sigma \frac{d}{dt}\Phi_{\text{e}} = \sigma \frac{I_{\text{disp}}}{\varepsilon_0}$$

where $\Phi_{\text{e}} = EA$ is the electric flux through the wire and, by definition, $I_{\text{disp}} = \varepsilon_0 \, d\Phi_{\text{e}}/dt$. Thus $I_{\text{disp}} = (\varepsilon_0/\sigma)\, dI/dt$.

(b) Using the value for the conductivity of copper wire from Table 31.2,

$$I_{\text{disp}} = \frac{\varepsilon_0}{\sigma}\frac{dI}{dt} = \frac{8.85\times10^{-12}\ \text{C}^2/\text{N m}^2}{6.0\times10^{7}\Omega^{-1}\ \text{m}^{-1}}\left(1.0\times10^{6}\ \text{A/s}\right) = 1.48\times10^{-13}\ \text{A}$$

35.49. Model: The laser beam is an electromagnetic wave.

Solve: The maximum intensity of the laser beam is determined by the maximum electric field strength in air. Thus the maximum power delivered by the beam is

$$P = IA = \frac{c\varepsilon_0}{2} {E_0}^2 A$$

$$= \frac{\left(3\times10^8 \text{ m/s}\right)\left(8.85\times10^{-12} \text{ C}^2/\text{Nm}^2\right)}{2}\left(3.0\times10^6 \text{ V/m}\right)^2 \pi\left(0.050 \text{ m}\right)^2$$

$$= 9.4\times10^7 \text{ W/m}^2$$