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6. (II) Suppose an air-gap capacitor has circular plates of radius $R = 2.5\,\text{cm}$ and separation $d = 1.6\,\text{mm}$. A 76.0-Hz emf, $\mathcal{E} = \mathcal{E}_0 \cos \omega t$, is applied to the capacitor. The maximum displacement current is $35\,\mu\text{A}$. Determine (*a*) the maximum conduction current I, (*b*) the value of $\mathcal{E}_0$, (*c*) the maximum value of $d\Phi_E/dt$ between the plates. Neglect fringing.

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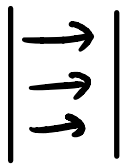
a. Max $I = 35\,\mu A$



b. $Q = CV = C\mathcal{E}_0 \cos \omega t$

$$I = \frac{dQ}{dt} = \frac{d}{dt}\left(C\mathcal{E}_0 \cos \omega t\right) = C\mathcal{E}_0\left(-\sin \omega t \cdot \omega\right)$$

$$= -\omega C \mathcal{E}_0 \sin \omega t \qquad I_{max} = \omega C \mathcal{E}_0$$

$$\mathcal{E}_0 = \frac{I_{max}}{\omega C} = \frac{I_{max}\, d}{2\pi A f \varepsilon_0} = \frac{(35\times10^{-6}\,A)(1.6\times10^{-3}\,m)}{2\pi(76.\,Hz)\pi(0.025\,m)^2(8.85\times10^{-12}\,C^2/N_{m^2})}$$

$$= 6749\,V$$

c. $I_D = \varepsilon_0 \frac{d\Phi_E}{dt}$

$$\left(\frac{d\Phi_E}{dt}\right)_{max} = \frac{(I_D)_{max}}{\varepsilon_0} = \frac{35\times10^{-6}\,A}{8.85\times10^{-12}\,C^2/Nm^2} = 4.0\times10^6\ V\cdot m/s$$