Physics Quiz 3 Formulas

$\mu_0 = 4\pi \cdot 10^{-7}\mathrm{N/A^2}$, $\epsilon_0 = 8.854 \cdot 10^{-12}\mathrm{C^2/Nm^2}$

$$\vec{F}^{\mathrm{B}} = q(\vec{v} \times \vec{B}) = I\vec{\ell} \times \vec{B} \tag{1}$$

$$\text{Electric field of Parallel Plates: } E = \frac{q}{\epsilon_0 A}$$

$$\text{Power in a circuit: } P = VI = RI^2 = \frac{V^2}{R}$$

Maxwell's Equations

$$\textbf{Gauss' Law for Electricity: } \Phi_E = \oint_A \vec{E} \cdot d\vec{A} = \oint_V (\nabla \cdot \vec{E}) \cdot d\vec{V} = \frac{q_{\mathrm{enc}}}{\epsilon_0} \tag{2}$$

$$\textbf{Gauss' Law for Magnetism: } \Phi_B = \oint_A \vec{B} \cdot d\vec{A} = \oint_V (\nabla \cdot \vec{B}) \cdot d\vec{V} = 0 \tag{3}$$

$$\textbf{Faraday's Law: } \oint_L \vec{E} \cdot d\vec{l} = \oint_A (\nabla \times \vec{E}) \cdot d\vec{A} = -\frac{d\Phi_B}{dt} \tag{4}$$

$$\textbf{Ampere's Law: } \oint_L \vec{B} \cdot d\vec{l} = \oint_A (\nabla \times \vec{B}) \cdot d\vec{A} = \mu_0 \left(I_{\mathrm{int}} + I_{\mathrm{disp}}\right) = \mu_0 \left(I_{\mathrm{int}} + \epsilon_0 \kappa \frac{d\Phi_E}{dt}\right) \tag{5}$$

Chapter 29

$$\textbf{Inductance: } \mathcal{E}_{\mathrm{ind}} = -L\frac{dI}{dt} \qquad \textbf{Solenoid: } L = \frac{\mu_0 N^2 A}{l} \qquad \textbf{Toroid: } L = \frac{\mu_0 N^2}{2\pi} \ln\left(\frac{R_{\mathrm{out}}}{R_{\mathrm{in}}}\right) h \tag{6}$$

where A is the inner area, l is the length, R_{out} and R_{in} are the outer and inner radius, h is the height, and N is the number of windings.

$$\textbf{Magnetic Potential Energy: } U^B = \frac{1}{2}LI^2 \tag{7}$$

$$\textbf{Magnetic Potential Energy Density: } u_B = \frac{1}{2}\frac{B^2}{\mu_0} \tag{8}$$

Chapter 30

$$\textbf{EM Waves: } E(z,t) = E_0 \sin(kz - \omega t)\hat{\imath} \qquad \text{and} \qquad B(z,t) = B_0 \sin(kz - \omega t)\hat{\jmath} \tag{9}$$

$$\textbf{Poynting Vector: } \vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}, \quad S_{\mathrm{av}} = \frac{1}{\mu_0} E_{\mathrm{rms}} B_{\mathrm{rms}} = \frac{1}{2\mu_0} E_{\mathrm{max}} B_{\mathrm{max}} \tag{10}$$

$$\textbf{Electromagnetic Wave Power: } P = \iint \vec{S} \cdot d\vec{A} \tag{11}$$

$$\textbf{Speed of Light: } c = \frac{E_0}{B_0} = \frac{1}{\sqrt{\epsilon_0 \mu_0 \kappa}} = 3.0 \cdot 10^8 \text{ m/s} \tag{12}$$

$$\textbf{Root Mean Squared: } E_{\mathrm{rms}}^2 = \frac{1}{2}E_{\mathrm{max}}^2 \qquad \text{and} \qquad B_{\mathrm{rms}}^2 = \frac{1}{2}B_{\mathrm{max}}^2 \tag{13}$$

$$\textbf{Electromagnetic Energy Density in a wave: } u = u_{\mathrm{E}} + u_{\mathrm{B}} = \frac{1}{2}\epsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0} = \sqrt{\frac{\epsilon_0}{\mu_0}} EB \tag{14}$$