PHY2061
12-10-04

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Final Exam

Closed book exam. A calculator is allowed, as is one 8.5×11" sheet of paper with your own written notes. Please show all work leading to your answer to receive full credit. Answers should be calculated to 2 significant digits. Exam is worth 100 points, 25% of your total grade.

UF Honor Code: "On my honor, I have neither given nor received unauthorized aid in doing this exam."

Sphere: $S = 4\pi r^2$ $\quad V = \frac{4}{3}\pi r^2$ $\quad \pi = 3.1415927$ $\quad e = 1.6022\times10^{-19}$ C

$\mathbf{a}\cdot\mathbf{b} = a_x b_x + a_y b_y + a_z b_z$ $\quad \mathbf{a}\times\mathbf{b} = (a_y b_z - b_y a_z)\mathbf{x} - (a_x b_z - b_x a_z)\mathbf{y} + (a_x b_y - b_x a_y)\mathbf{z}$

$K = \frac{1}{4\pi\varepsilon_0} = 9\times10^9 \text{ N m}^2/\text{C}^2$ $\quad \varepsilon_0 = 8.8542\times10^{-12} \text{ C}^2/\text{N m}^2$ $\quad \mu_0 = 4\pi k = 1.257\times10^{-6} \text{ T}\cdot\text{m}/\text{A}$

$k = \frac{K}{c^2} = \frac{\mu_0}{4\pi} = 10^{-7} \text{ T}\cdot\text{m}/\text{A}$ $\quad c = 3.0\times10^8$ m/s $\quad \mathbf{F} = K\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}_{12}$ $\quad \mathbf{E} = \frac{\mathbf{F}}{q_0}$

$\Phi_E = \oint_S \mathbf{E}\cdot d\mathbf{A} = \frac{q_{\text{enc}}}{\varepsilon_0}$ $\quad \Phi_B = \oint_S \mathbf{B}\cdot d\mathbf{A} = 0$ $\quad \nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$ $\quad \nabla\cdot\mathbf{B} = 0$

$\varepsilon = -N\frac{d\Phi_B}{dt}$ $\quad \oint_C \mathbf{E}\cdot d\mathbf{s} = -\frac{d}{dt}\int_S \mathbf{B}\cdot d\mathbf{A}$ $\quad \nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$

$\oint_C \mathbf{B}\cdot d\mathbf{s} = \mu_0 i_{\text{enc}} + \mu_0\varepsilon_0\frac{d\Phi_E}{dt} = \mu_0\int_S \mathbf{j}\cdot d\mathbf{A} + \mu_0\varepsilon_0\frac{d}{dt}\int_S \mathbf{E}\cdot d\mathbf{A}$ $\quad \nabla\times\mathbf{B} = \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t} + \mu_0\mathbf{j}$

$\mathbf{E} = -\nabla V$ $\quad V = \frac{U}{q_0}$ $\quad W = -\Delta U = \int_C \mathbf{F}\cdot d\mathbf{s}$ $\quad \Delta V = -\int_C \mathbf{E}\cdot d\mathbf{s}$

$\nabla = \hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} + \hat{z}\frac{\partial}{\partial z}$ $\quad \nabla\cdot\mathbf{F} = div(\mathbf{F}) = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$

$\int_V \nabla\cdot\mathbf{F}\, dV = \oint_S \mathbf{F}\cdot d\mathbf{A}$ $\quad \int_S (\nabla\times\mathbf{F})\cdot d\mathbf{A} = \oint_C \mathbf{F}\cdot d\mathbf{s}$

$Q = C\Delta V$ $\quad U = \frac{1}{2}C(\Delta V)^2 = \frac{Q^2}{2C}$ $\quad C_{\text{eff}} = C_1 + C_2$ $\quad \frac{1}{C_{\text{eff}}} = \frac{1}{C_1} + \frac{1}{C_2}$

$\Delta V = iR$ $\quad P = Vi = i^2 R = \frac{V^2}{R}$ $\quad R_{\text{eff}} = R_1 + R_2$ $\quad \frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}$

$R = \rho\frac{L}{A}$ $\quad i = \frac{dq}{dt}$ $\quad \mathbf{F} = q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$ $\quad \mathbf{F} = i\,\mathbf{L}\times\mathbf{B}$ $\quad d\mathbf{B} = k\frac{i\,d\mathbf{s}\times\mathbf{r}}{r^3}$

$\boldsymbol{\mu} = i\mathbf{A}$ $\quad \boldsymbol{\tau} = \mathbf{r}\times\mathbf{F}$ $\quad \boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$ $\quad U = -\boldsymbol{\mu}\cdot\mathbf{B}$ $\quad F_z = \mu_z\frac{dB_z}{dz}$

$\Delta V_L = L\frac{di}{dt}$ $\quad L = \frac{N\Phi_B}{i}$ $\quad U = \frac{1}{2}Li^2$ $\quad u = \frac{U}{V} = \frac{B^2}{2\mu_0} + \frac{\varepsilon_0 E^2}{2}$

$\tau_{RC} = RC$ $\quad \tau_{LR} = \frac{L}{R}$ $\quad \omega_{LC} = \frac{1}{\sqrt{LC}}$ $\quad \Delta V_S = \frac{N_S}{N_P}\Delta V_P$

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$c = 3.0\times 10^8$ m/s $\quad$ 1 eV $= 1.6022\times 10^{-19}$ J

$\gamma = \dfrac{1}{\sqrt{1-v^2/c^2}}$ $\quad t = \gamma t_0$ $\quad L = \dfrac{L_0}{\gamma}$ $\quad x' = \gamma(x \pm vt)$ $\quad t' = \gamma(t \pm vx/c^2)$ $\quad y' = y$ $\quad z' = z$

$u_x{}' = \dfrac{u_x \pm v}{1 \pm \dfrac{vu_x}{c^2}}$ $\quad u_y{}' = \dfrac{u_y}{\gamma\left(1 \pm \dfrac{vu_x}{c^2}\right)}$ $\quad E = \gamma mc^2$ $\quad K = (\gamma - 1)mc^2$

$\mathbf{p} = \gamma m\mathbf{u}$ $\quad \mathbf{F} = d\mathbf{p}/dt$ $\quad m^2c^4 = E^2 - p^2c^2$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ $\quad \mathbf{S} = \dfrac{1}{\mu_0}\mathbf{E}\times\mathbf{B}$ $\quad I = \dfrac{P}{A} = S_{av}$

$\omega = 2\pi f$ $\quad k = \dfrac{2\pi}{\lambda}$ $\quad \lambda f = v$ $\quad v_n = \dfrac{c}{n}$ $\quad \sin\theta = \dfrac{\lambda}{d}$

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1. The electric field component of a traveling electromagnetic wave is described by $\mathbf{E} = E_0 \hat{\mathbf{z}} \sin(kx - \omega t)$, where E_0 is a positive constant.

   (a) [6 points] What is the magnetic field component, both magnitude and direction?

   (b) [6 points] What is the average intensity of the wave per unit area perpendicular to the direction of the travel?

   (c) [6 points] What is the wavelength of the traveling wave if the angular frequency $\omega = 10^{14}$ Hz?