PHY2061
12-14-05

Name:_____ ___

Exam 3

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. Numerical 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: $S = 4\pi r^2$ $V = \frac{4}{3}\pi r^3$ $\pi = 3.1415927$ $e = 1.6022\times10^{-19}$ C $g = 9.8$ m/s^2

$1\ \mu\text{C} = 10^{-6}$ C $1\mu\text{F} = 10^{-6}$ F 1 pF $= 10^{-12}$ F 1 eV $= 1.6\times10^{-19}$ J

$K = \frac{1}{4\pi\varepsilon_0} = 9\times10^9$ N m^2/C^2 $\varepsilon_0 = 8.8542\times10^{-12}$ C^2/N m^2 $c = 3.0\times10^8$ m/s

$k = \frac{K}{c^2} = \frac{\mu_0}{4\pi} = 10^{-7}$ T·m/A $\mu_0 = 4\pi k = 1.257\times10^{-6}$ T·m/A $\mu_0\varepsilon_0 = \frac{1}{c^2}$

$\mathbf{F} = K\frac{q_1 q_2}{r^2}\hat{\mathbf{r}}_{12}$ $\mathbf{E} = \frac{\mathbf{F}}{q_0}$ $\Phi_E = \oint_S \mathbf{E}\cdot d\mathbf{A} = \frac{q_{\text{enc}}}{\varepsilon_0}$ $\Phi_B = \oint_S \mathbf{B}\cdot d\mathbf{A} = 0$

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

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

$R = \rho\frac{L}{A}$ $i = \frac{dq}{dt}$ $\tau_{RC} = RC$ $R_{\text{eff}} = R_1 + R_2$ $\frac{1}{R_{\text{eff}}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\Delta V = iR$ $P = Vi = i^2R = \frac{V^2}{R}$ $\mathbf{F} = q(\mathbf{E} + \mathbf{v}\times\mathbf{B})$ $\mathbf{F} = i\,\mathbf{L}\times\mathbf{B}$

$d\mathbf{B} = k\frac{i\,d\mathbf{s}\times\mathbf{r}}{r^3}$ $\boldsymbol{\mu} = i\mathbf{A}$ $\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F}$ $\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$ $U = -\boldsymbol{\mu}\cdot\mathbf{B}$ $F_z = \mu_z\frac{dB_z}{dz}$

$\Phi_B = \int_S \mathbf{B}\cdot d\mathbf{A}$ $\varepsilon = \oint_C \mathbf{E}\cdot d\mathbf{s} = -N\frac{d\Phi_B}{dt}$ $\oint_C \mathbf{B}\cdot d\mathbf{s} = \mu_0 i_{\text{enc}} + \mu_0\varepsilon_0\frac{d\Phi_E}{dt}$

$\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$ $\nabla\cdot\mathbf{B} = 0$ $\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$ $\nabla\times\mathbf{B} = \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t} + \mu_0\mathbf{j}$

$\int_V \nabla\cdot\mathbf{F}\,dV = \oint_S \mathbf{F}\cdot d\mathbf{A}$ $\int_S (\nabla\times\mathbf{F})\cdot d\mathbf{A} = \oint_C \mathbf{F}\cdot d\mathbf{s}$ $\nabla = \hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} + \hat{z}\frac{\partial}{\partial z}$

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

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

$$\tau_{LR} = \frac{L}{R} \qquad \omega_{LC} = \frac{1}{\sqrt{LC}} \qquad \tan\phi = \frac{X_L - X_C}{R}$$

$$X_L = \omega L \qquad X_C = \frac{1}{\omega C}$$

$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E}\times\mathbf{B} \qquad I = \frac{P}{A} = S_{\text{av}} \qquad I = I_0\cos^2\theta \qquad n_1\sin\theta_1 = n_2\sin\theta_2$$

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

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} = \frac{1}{r_2}\right) \qquad \frac{1}{f} = \frac{1}{p} + \frac{1}{i} \qquad m = -\frac{i}{p}$$

1. [8 points] A charged capacitor is connected across an inductor to form an LC circuit. When the charge on the capacitor is 0.4 C, the current is 0.4 A. If the period of the LC oscillations is 4 seconds, what is the maximum charge on the capacitor?

2. For a certain driven series RLC circuit, the inductance L = 80 mH, the resistance R = 40Ω, and the capacitance C = 0.4 μF. The generator provides a source of EMF that varies sinusoidally with a cyclic frequency of 1000 Hz.

(a) [6 points] If the peak voltage from the generator is 10 V, what is the peak current?

(b) [6 points] What is the phase constant between the generator voltage and the current? Does the current lead or lag the generator voltage?

3. [8 points] A uniform electric field points in the *z*-direction with a value given by the expression: $E_Z(t) = a + bt$, where a = 1800 V/m and b = 700 V / (m s). The electric field is confined to a circular region in the *x*-*y* plane with radius r = 5 m. What is the magnitude of the magnetic field at a point along the circumference of the circle at the time t = 2 s?

4. The electric field of an electromagnetic wave is given by

$$\mathbf{E} = \hat{\mathbf{y}}\left(3.90\times10^{2}\ \frac{\text{N}}{\text{C}}\right)\sin\left[\pi\left(7.20\times10^{6}\ \text{m}^{-1}\right)\left(x+3.0\times10^{8}t\right)\right]$$

(a) [6 points] What is the cyclic frequency of the wave (in Hz)?

(b) [6 points] Write down an equivalent expression for the magnetic field, including the polarization direction and the peak magnitude.

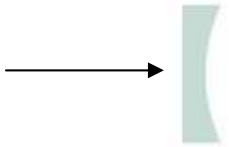
5. [8 points] What is the current density (direction and magnitude) in a region of space where the magnetic field is given by $\mathbf{B} = B_0 x\, \hat{\mathbf{y}}$ and there is no electric field present?

6. [8 points] A beam of unpolarized light is passed though a series of 3 polaroid filters. The first and third filters have their polarization directions 90° apart. The second one has its polarization direction oriented 30° relative to the first. What fraction of the intensity of the initially unpolarized light is transmitted after passing through the 3 filters?

7. [8 points] Consider the propagation of white light through an optical fiber. The core of the fiber is made of a material that exhibits chromatic dispersion and has an index of refraction that varies from 1.455 for red light to 1.460 for blue light. What is the spread in the arrival time between red and blue light at the end of 10 km of fiber? Assume that the light travels in a straight line in the fiber.

8. [8 points] An isotropic point source of light is located 4 m below the surface of a pool of water with index of refraction n = 1.33. The surface of the water is absolutely smooth. Find the radius of the largest circle on the pool's surface through which light coming directly from the source can emerge into the air above.

9. A lens has a shape as shown in the figure. For a light ray traveling from the left, the font face is flat and the rear face is convex with a radius of curvature of 0.8 m. The glass that makes the lens has an index of refraction of $n = 1.5$.



(a) [6 points] What is the focal length of the lens?

(b) [6 points] If an object is placed 0.8 m to the left of the lens, what is the distance to the image from the lens and is the image real or virtual?

10. [8 points] The reflection of perpendicularly incident white light by a soap film in air has an interference maximum at a wavelength of 600 nm and a minimum at 525 nm, with no minimum between 600 and 525 nm. If n = 1.43 for the film, what is the film thickness, assumed uniform?

11. [8 points] In a Young's double-slit experiment, light of wavelength 550 nm illuminates 2 slits that are separated by 0.15 cm. What is the separation between adjacent bright fringes on a screen 5 m from the slits?