University Physics, PHYS 227/232 Final Exam Mon May 5, 2014

Useful Equations/Concepts: Electrostatics

Electric (Coulomb) force $\vec{F}$ between two point charges: $\vec{F} = \left(\frac{kq_1q_2}{r^2}\right)\hat{r}$

Electric field $\vec{E}$ of a point charge or charged sphere: $\vec{E} = \left(\frac{kq}{r^2}\right)\hat{r}$

Electric potential V of a point charge or charged sphere (relative to V=0 at $r = \infty$): $V = \frac{kq}{r}$

Electric potential energy U of a point charge at electric potential V: $U = qV$

Flux Φ and Gauss's Law: $\Phi = \int \vec{E} \cdot d\vec{A} = \int EdA\cos\theta$ $\Phi_{closed\,surface} = 4\pi k q_{\text{enclosed}}$

Useful Equations/Concepts: Electronics

Definition of capacitance: $C \equiv \frac{Q}{V}$ Ohm's Law, voltage drop across a resistor: $V = IR$

Capacitance of a parallel plate capacitor: $C = \kappa\frac{A}{4\pi kd}$ (κ: dielectric constant)

Definition of current: $I \equiv \frac{dQ}{dt}$ Energy stored in capacitor: $U_{\text{stored}} = \frac{1}{2}CV^2$

Power dissipated by a resistor: $P = IV = I^2R$ (1 Watt = (1 Coulomb)(1 Volt))

Capacitors in parallel: $C_{\text{equiv}} = C_1 + C_2 + \ldots$ Capacitors in series: $\frac{1}{C_{\text{equiv}}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

Resistors in series: $R_{\text{equiv}} = R_1 + R_2 + \ldots$ Resistors in parallel: $\frac{1}{R_{\text{equiv}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

Useful Equations/Concepts: Magnetism

Bar magnet magnetic field lines go from North to South (outside magnet)

Force on charged particle from magnetic field: $\vec{F} = q\vec{v} \times \vec{B}$

Force on current from magnetic field: $\vec{F} = I\vec{l} \times \vec{B}$

Cyclotron radius: $r = \frac{mv}{qB}$ Cyclotron frequency: $f = \frac{qB}{2\pi m}$

Biot-Savart Law: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l}\times\vec{r}}{r^2}$ Ampere's Law: $\int \vec{B} \cdot d\vec{r} = \mu_0 I_{\text{enclosed}}$

Magnetic field of infinite line current: $B = \frac{\mu_0 I}{2\pi r}$ in right hand circles around current

Magnetic field at x along centerline of loop of radius a: $B = \frac{\mu_0 I a^2}{2x^3}$

Magnetic field of a solenoid with n turns/unit length: $B = \mu_0 n I$

Faraday's Law: $\mathcal{E} = V = -\frac{d\Phi_{\text{B}}}{dt}$ Magnetic flux: $\Phi_{\text{B}} \equiv \int \vec{B} \cdot d\vec{A} = BA\cos\theta$

Figuring out induced current direction: (1) I$\rightarrow$B (2) B$\rightarrow$ Φ (3) $\Delta\Phi$? (4) Fight the change!
(5) Induced I direction needed?

Self-Inductance: $L \equiv \frac{\Phi_{\text{B}}}{I}$ Voltage/EMF across Inductor: $\mathcal{E}_{\text{L}} = -L\frac{dI}{dt}$

Self-Inductance of solenoid of length l, cross-section area A: $L = \mu_0 n^2 A l$

Useful Equations/Concepts: Optics

Reflection: $\theta_{\text{incident}} = \theta_{\text{reflected}}$ (measured relative to *normal* to surface)

Index of refraction: $n \equiv \frac{c}{v}$ (where $c = 3.0 \times 10^8$ m/s is the speed of light in a vacuum)

Snell's Law for refraction: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

Mirror/Lens equation: $1/s_{\text{object}} + 1/s_{\text{image}} = 1/f$ (where f is focal length)

Mirror/Lens magnification: $M \equiv h_{\text{image}}/h_{\text{object}} = -s_{\text{image}}/s_{\text{object}}$

For a mirror with a circular arc: $s_{\text{center}} = 2f$

Lensmaker's equation: $\frac{1}{f} = \left(\frac{n_{\text{lens}}}{n_{\text{medium}}} - 1\right)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

Double-slit interference, bright fringes: $d\sin\theta_{\text{bright}} = m\lambda$ $x_{\text{bright}} \approx \frac{m\lambda L}{d}$

Double-slit interference, dark fringes: $d\sin\theta_{\text{dark}} = \left(m + \frac{1}{2}\right)\lambda$ $x_{\text{dark}} \approx \frac{\left(m+\frac{1}{2}\right)\lambda L}{d}$

Useful Geometry Equations

Circle circumference: $2\pi r$ Circle area: πr^2

Sphere surface area: $4\pi r^2$ Sphere volume: $\frac{4}{3}\pi r^3$

Cylinder surface area: $2\pi r^2$ (ends) $+ 2\pi rL$ (side) Cylinder volume: $\pi r^2 L$

Useful Constants and Units

Acceleration of gravity: $g = 9.8\,\mathrm{m/s^2}$

Speed of light: $c = 2.998 \times 10^8\,\mathrm{m/s}$

$k = 9.00 \times 10^9\,\mathrm{N\,m^2/C^2}$

$\epsilon_0 = \frac{1}{4\pi k} = 8.85 \times 10^{-12}\,\mathrm{C^2/N\,m^2}$

Electron charge: $e = -1.6 \times 10^{-19}\,\mathrm{C}$ Electron mass: $m_\mathrm{e} = 9.11 \times 10^{-31}\,\mathrm{kg}$

Proton charge: $+1.6 \times 10^{-19}\,\mathrm{C}$ Proton mass: $m_\mathrm{p} = 1.67 \times 10^{-27}\,\mathrm{kg}$

$\mu_0 = 4\pi \times 10^{-7}$ T-m/A

Voltage/Electric Potential: Volt [V]

Electric Current: Ampere [A, 1 A = 1 C/s]

Magnetic Field: Tesla [T, 1 T = 10^4 Gauss]

Inductance: Henry [H]

Magnetic Flux: Weber [Wb, 1 Wb = 1 T m^2 = 1 V s]

Useful SI Prefixes and Indexes of Refraction

Prefix	Symbol	Multiplier
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Material	Index of Refraction
air	1.000
water	1.333
glass	1.500