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

Useful Constants

speed of light $c = 2.998 \times 10^8 m/s$
basic unit of charge $e = 1.602 \times 10^{-19}\ C$
$\epsilon_o = 8.854 \times 10^{-12}\ C^2/(N\ m^2) = 8.854\ pF/m$
$k = \frac{1}{4\pi\epsilon_o} = 8.988 \times 10^9\ N\ m^2/C^2$
$\mu_o = 4\pi \times 10^{-7} T\ m/A$
acc to due gravity (standard) $g = 9.80\ m/s^2$
Energy units: $1\ eV = 1.602 \times 10^{-19}\ J$

Geometry:

circle: $C = 2\pi r$, $A = \pi r^2$
sphere: $C = 2\pi r$, $A = 4\pi r^2$, $V = \frac{4}{3}\pi r^3$
cylinder: $A = 2\pi rh$, $V = \pi r^2 h$

Capacitance

$C = Q/V$
parallel plates: $C_o = \epsilon_o A/d$
spherical capacitor: $C_o = 4\pi\epsilon_o \frac{r_a r_b}{r_b - r_a}$
cylindrical capacitor: $C_o = 2\pi\epsilon_o l/ln(r_b/r_a)$
series: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$
parallel: $C = C_1 + C_2 + \cdots$
energy stored: $U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$
energy density: $u = \frac{1}{2}\epsilon_o E^2$
dielectrics: $C = C_o K \qquad E = E_o/K$

Kirchhoff

$\Sigma I_{in} = \Sigma I_{out} \qquad \Sigma \Delta V = 0$

Common Integrals:

$\int x^n dx = \frac{x^{n+1}}{n+1}$ for $n \neq -1$
$\int \frac{1}{x} dx = ln(x)$
$\int e^{ax} dx = \frac{1}{a} e^{ax}$

Current, Resistance...

$I = dQ/dt = n|q|v_d A \qquad J = I/A = n|q|v_d$
resistivity: $\rho = E/J$
temperature variation: $\rho = \rho_o[1 + \alpha(T - T_o)]$
Ohm's law: $V_{ab} = IR$ where $R = \rho l/A$
parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
series: $R = R_1 + R_2 + \cdots$
EMF ξ: ideal output of source
battery internal resistance: $V_{ab} = \xi - Ir$
Power: $P = V_{ab} I = I^2 R = V_{ab}^2/R$
AC: $V = V_o \sin(\omega t) \qquad I = I_o \sin(\omega t)$
$P_{avg} = I_{rms} V_{rms} = I_{rms}^2 R = V_{rms}^2/R$
$V_{rms} = \frac{1}{\sqrt{2}} V_o \qquad I_{rms} = \frac{1}{\sqrt{2}} I_o$

RC circuits: $\tau = RC$
charging: $Q = C\xi(1 - e^{-t/\tau}) \qquad I = +dQ/dt = \frac{\xi}{R} e^{-t/\tau} \qquad V_C = \xi(1 - e^{-t/\tau})$
discharging: $Q = Q_o e^{-t/\tau} \qquad I = -dQ/dt = I_o e^{-t/\tau} \qquad V_C = Q/C = V_o e^{-t/\tau}$

$1\ Tesla = 10{,}000\ Gauss \qquad B_{earth} \approx 0.5\ G$ (more or less to the north)

Ampere's law: $\oint \vec{B} \cdot d\vec{l} = \mu_o I_{encl}$
Long wire: $B = \frac{\mu_o}{2\pi} \frac{I}{r}$
Interior of a solenoid: $B = \mu_o I \frac{N}{l}$
Center of circular loop: $B = \frac{\mu_o I}{2\pi r}$
Biot-Savart : $\vec{B} = \frac{\mu_o I}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2}$

Force: $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$
Long wire: $\vec{F} = I\vec{l} \times \vec{B}$
Segment: $d\vec{F} = Id\vec{l} \times \vec{B}$
Cyclotron: $r = \frac{mv}{qB} \qquad f = (qB)/(2\pi m)$
2 parallel currents: $F/l = \frac{\mu_o}{2\pi} \frac{I_1 I_2}{d}$

Magnetic flux: $\Phi_B = \int \vec{B} \cdot d\vec{A}$ Faraday's law: $\xi = -N \frac{d\Phi_B}{dt}$ (or $\xi_{avg} \approx -N\Delta\Phi_B/\Delta t$)

Lenz's law: a current produced by an induced EMF moves in a direction so that the magnetic field created by that current opposes the original change in flux

Rotating coil: $\xi = NBA\omega \sin(\omega t) = \xi_o \sin(\omega t)$ Moving conductor: $|\xi| = Blv$

(A/C) Transformer: $V_s = N_s d\Phi_B/dt$ $V_p = N_p d\Phi_B/dt$ so $V_s = V_p * (N_s/N_p)$
Assuming nearly 100% efficiency, $P_p = P_s$ so $P = IV$ implies: $I_s = I_p * (N_p/N_s)$

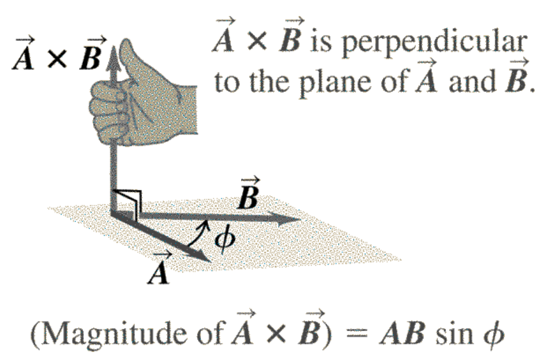
Mutual inductance: $\xi_2 = -M dI_1/dt$; $M = M_{21} = N_2 \Phi_{21}/I_1$
Two concentric solenoids: $M = \mu_o N_1 N_2 A/l$
Rectangular loop near long wire: $M = \frac{\mu_o N l}{2\pi} ln(r_2/r_1)$
Self inductance: $\xi = -L dI/dt$; $L = N\Phi_B/I$
single solenoid: $L = \mu_o N^2 A/l$
coaxial cable: $L = \frac{\mu_o l}{2\pi} ln(r_2/r_1)$
circular loop of radius R and wire radius r: $L \approx N^2 \mu_o R[ln(\frac{8R}{r}) - 2]$
Energy stored: $U = \frac{1}{2} L I^2$; energy density: $u = \frac{1}{2}\frac{B^2}{\mu_o}$
L-R circuit (charging) : $I = \frac{V_o}{R}(1 - e^{-t/\tau})$, where $\tau = L/R$
L-R circuit (discharging) : $I = I_o e^{-t/\tau}$, with $I_o = V_o/R$
L-C circuit (oscillating) : $Q(t) = Q_o \cos(\omega t + \phi)$, $I = -dQ/dt = I_o \sin(\omega t + \phi)$, with $I_o = \omega Q_o$
where $\omega = 2\pi f = 1/\sqrt{LC}$.

AC (single element) with applied $V = V_o \cos(\omega t)$
Resistor: $I_o = V_o/R$ $I(t) = I_o \cos(\omega t)$
Inductor: $I_o = V_o/X_L$ $X_L = \omega L$ $I(t) = I_o \cos(\omega t - 90^o)$
Capacitor: $I_o = V_o/X_C$ $X_C = 1/(\omega C)$ $I(t) = I_o \cos(\omega t + 90^o)$

R-L-C with common $I = I_o \cos(\omega t)$
overall $V(t) = V_o \cos(\omega t + \phi)$ with $V_o = I_o Z$ where:
$Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\tan\phi = (X_L - X_C)/R$
resistor: $V_R = I_o R$ inductor : $V_L = I_o X_L$ capacitor: $V_C = I_o X_C$
$P_{avg} = V_{rms} I_{rms} \cos\phi$ Resonant frequency: $\omega_o = \frac{1}{\sqrt{LC}}$

Cross Products
$\vec{C} = \vec{A} \times \vec{B}$
magnitude: $C = AB \sin\phi$
direction: RHR from A to B.
$C_x = A_y B_z - A_z B_y$
$C_y = A_z B_x - A_x B_z$
$C_z = A_x B_y - A_y B_x$

$$\vec{C} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$



Be familiar with the various right-hand rules involved in magnetism. Review the **rhr.pdf** file on Canvas. These will NOT be provided during the test.