Some (possibly useful) relations for 8.02 Final Exam, May 22, 2001

You may use these freely unless the problem specifically prescribes a different approach.

$\mathbf{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\,\hat{\mathbf{r}}$; $\mathbf{F} = q\mathbf{E}$	$\boxed{\oiint \mathbf{E}\cdot d\mathbf{A} = \frac{q_{in}}{\varepsilon_0}}$ $\boxed{\oiint \mathbf{B}\cdot d\mathbf{A} = 0}$	$V(b) - V(a) \equiv -\int_a^b \mathbf{E}\cdot d\mathbf{s}$
$\varepsilon_0 \cong 9\times 10^{-12}\ \mathrm{C^2\,N^{-1}\,m^{-2}}$	$C \equiv \frac{Q}{\Delta V}$ $\quad \Phi_E = \iint \mathbf{E}\cdot d\mathbf{A}$	$\mathbf{E} = -\left(\frac{\partial V}{\partial x}\hat{\mathbf{x}} + \frac{\partial V}{\partial y}\hat{\mathbf{y}} + \frac{\partial V}{\partial z}\hat{\mathbf{z}}\right)$
$\frac{1}{4\pi\varepsilon_0} \cong 9\times 10^{9}\ \mathrm{N\,m^2\,C^{-2}}$	$U_E = \frac{C(\Delta V)^2}{2} = \frac{Q^2}{2C}$	$u_E = \frac{1}{2}\varepsilon_0\,\mathbf{E}\cdot\mathbf{E} = \frac{1}{2}\varepsilon_0\,\lvert\mathbf{E}\rvert^2$
$\mathbf{E} = \rho\,\mathbf{j}$; $R = \rho\, l/A$; $V = iR$ $P = iV = i^2R = V^2/R$	$i = \iint \mathbf{j}\cdot d\mathbf{A}$	$\Phi_E = \iint \mathbf{E}\cdot d\mathbf{A}$
$\mathbf{F} = q\,(\mathbf{v}\times\mathbf{B})$	$i = dq/dt$; $d\mathbf{F} = i\,(d\mathbf{s}\times\mathbf{B})$	$\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$; $\lvert\boldsymbol{\mu}\rvert = N\,i\,A$
$\boxed{\oint \mathbf{B}\cdot d\mathbf{s} = \mu_0\left(i_{\mathrm{encl}} + \varepsilon_0\frac{d\Phi_E}{dt}\right)}$	$\mu_0 = 4\pi\times 10^{-7}\ \frac{\mathrm{T\cdot m}}{\mathrm{A}}$ $\lvert\mathrm{B}\rvert = \mu_0\, n\, i$	$d\mathbf{B} = \frac{\mu_0\, i}{4\pi}\frac{d\mathbf{s}\times\mathbf{r}}{r^3}$
$\boxed{\oint \mathbf{E}\cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}}$	$\mathcal{E} = -N\frac{d\phi_B}{dt}$	$L = \frac{N\,\phi}{i}$; $M_{2,1} = \frac{N_2\,\phi_{2,1}}{i_1}$
$\mathcal{E} = -L\frac{di}{dt}$; $\mathcal{E}_2 = -M\frac{di_1}{dt}$	$\tau = RC$; $\tau = L/R$	$u_B = \frac{\mathbf{B}\cdot\mathbf{B}}{2\mu_0} = \frac{\lvert\mathbf{B}\rvert^2}{2\mu_0}$
$U_L = \frac{1}{2}L\,i^2$	$X_L = \omega L$; $X_C = \frac{1}{\omega C}$	$\omega_0 = (LC)^{-1/2}$
$i_m = \frac{\mathcal{E}_m}{Z} = \frac{\mathcal{E}_m}{\left[R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2\right]^{1/2}}$	$\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$	$\mathcal{E} = \mathcal{E}_m \sin\omega t$; $i = i_m \sin(\omega t - \phi)$
$\frac{\omega}{k} = (\mu_0\varepsilon_0)^{-1/2} = 3\times 10^{8}\ \mathrm{m/s} \equiv c$	$\mathbf{S} = \frac{\mathbf{E}\times\mathbf{B}}{\mu_0}$	$\Delta p = \Delta U/c$; $P = \frac{\lvert\mathbf{S}\rvert}{c}$
$\frac{E_m}{B_m} = c$; $\boxed{\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}}$	$\boxed{\nabla\cdot\mathbf{B} = 0}$; $\boxed{\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}}$	$\boxed{\nabla\times\mathbf{B} = \mu_0\,\mathbf{j} + \mu_0\varepsilon_0\frac{\partial\mathbf{E}}{\partial t}}$
$\frac{\partial^2 E_z}{\partial x^2} = \mu_0\varepsilon_0\frac{\partial^2 E_z}{\partial t^2}$	$v = \frac{\omega}{k} = \frac{2\pi\ \nu}{2\pi/\lambda} = \lambda\nu$	$\oint \mathbf{G}\cdot d\mathbf{s} = \iint (\nabla\times\mathbf{G})\cdot d\mathbf{A}$
$\nabla\times\mathbf{G} = \begin{vmatrix} \hat{\mathbf{x}} & \hat{\mathbf{y}} & \hat{\mathbf{z}} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ G_x & G_y & G_z \end{vmatrix}$	$\nabla\cdot\mathbf{G} = \frac{\partial G_x}{\partial x} + \frac{\partial G_y}{\partial y} + \frac{\partial G_z}{\partial z}$	$\oiint \mathbf{G}\cdot d\mathbf{A} = \iiint (\nabla\cdot\mathbf{G})\,dV$