Massachusetts Institute of Technology  
Department of Physics – Physics 8.022 – Fall 2002

Prof P. Fisher  
Prof E. Katsavounidis

**Currents, Magnetism and Relativity Formulae for Quiz #2**

**Ohm’s Law:** \( \vec{J} = \sigma \vec{E}, V = IR \)

**Magnetic charges:** \( \nabla \cdot \vec{B} = 0 \)

**Biot-Savart’s Law:** \( d\vec{B} = \frac{I d\vec{r} \times \vec{r}}{4\pi r^2} \)

**Ampere’s Law:** \( \oint \vec{B} \cdot d\vec{l} = \frac{4\pi}{c} I_{\text{enc}} = \frac{4\pi}{c} \int_S \vec{J} \cdot d\vec{a}, \nabla \times \vec{B} = \frac{4\pi}{c} \vec{J} \)

**Faraday’s Law:** \( \mathcal{E} = \oint \vec{E} \cdot d\vec{l} = -\frac{1}{c} \frac{\partial \Phi}{\partial t}, \nabla \times \vec{E} = -\frac{1}{c} \frac{\partial \vec{B}}{\partial t} \)

**Mutual Inductance:** \( M_{12} = M_{21} = \frac{\Phi_{21}}{c I}, \mathcal{E}_{21} = -M_{21} \frac{dI_2}{dt} \)

**Self Inductance:** \( L = \frac{\Phi}{c I}, \mathcal{E} = -L \frac{dI}{dt} \)

**Magnetic Field Energy Density:** \( \frac{d\Phi}{dv} = u_B = \frac{B^2}{8\pi} \)

**Relativistic Transformations:**  
All primed quantities measured in the frame \( F' \) which is moving in the positive \( x \) direction with velocity \( u = \beta c \) as seen from \( F \):

\[
\begin{align*}
x' &= \gamma (x - \beta ct)  \\
p' &= \gamma (p - \beta \frac{E}{c})  \\
t' &= \gamma (t - \beta \frac{z}{c})  \\
E'_x &= E_x  \\
E'_y &= \gamma (E_y - \beta B_z)  \\
E'_z &= \gamma (E_z + \beta B_y)  \\
B'_x &= B_x  \\
B'_y &= \gamma (B_y + \beta E_z)  \\
B'_z &= \gamma (B_z - \beta E_y)
\end{align*}
\]

**Relativistic Mass, Energy:** \( m = \gamma m_0, E = mc^2 \)

**Relativistic Doppler Effect:** \( f_o = \left[ \frac{1 - (u/c)}{1 + (u/c)} \right]^{1/2} f_s \), u along the line joining \( o \) and \( s \) and u positive when \( s \) recedes from \( o \).