a. When the capacitor is fully charged: energy in the E field is $\frac{Q_{\text{max}}^2}{2C}$.

b. When the capacitor is discharging, the current through the solenoid generates a B field with energy: $LI^2/2$.

c. When the capacitor is fully discharged all the energy is in the B field, and the current is maximum.

d. At this time the induced emf of the solenoid keeps the current going so that the capacitor is charged in the opposite direction.

e. And this keeps going and going and ....

f. Total energy of the system at any time:

$$U = \frac{Q_{\text{max}}^2}{2C} + LI^2/2$$

In a spring-mass system:

$$U = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$
LCR Circuits

Maxwell's Equations

\[ \oint E \cdot dA = \frac{q_{\text{in}}}{\epsilon_0} \]

\[ \oint B \cdot dA = 0 \]

\[ \oint B \cdot ds = \mu_0 I + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt} \]

\[ \oint E \cdot ds = -\frac{d\Phi_B}{dt} \]
Electro-Magnetic Waves

- Consider Maxwell’s equations in free space:

\[
\begin{align*}
\oint E \cdot dA &= 0 \\
\oint B \cdot dA &= 0 \\
\oint B \cdot ds &= \mu_0 \epsilon_0 \frac{d\Phi_B}{dt} \\
\oint E \cdot ds &= -\frac{d\Phi_E}{dt}
\end{align*}
\]

- Assume an Electric field aligned in the \( y \) direction and a Magnetic field aligned in the \( z \) direction. Faraday’s law and Ampère’s law reduce to:

\[
\begin{align*}
\frac{\partial^2 E}{\partial x^2} &= \mu_0 \epsilon_0 \frac{\partial^2 E}{\partial t^2} \\
\frac{\partial^2 B}{\partial x^2} &= \mu_0 \epsilon_0 \frac{\partial^2 B}{\partial t^2}
\end{align*}
\]