Useful Information

For two point particles

\[ F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \hat{r} \]

\[ d\vec{B} = \frac{\mu_0 i}{4\pi} \frac{d\vec{S} \times \vec{r}}{r^3} \]

\[ \frac{d\vec{r}}{dt} = \frac{dx}{dt} \hat{i}_x + \frac{dy}{dt} \hat{i}_y + \frac{dz}{dt} \hat{i}_z + r \frac{\frac{d\theta}{dt}}{r} \hat{i}_\theta \]

\[ \oint \vec{E} \cdot d\vec{r} = -\frac{d}{dt} \int \vec{B} \cdot d\vec{S} \]

\[ C = \frac{Q}{V} \quad R = \rho \frac{l}{A} \]

\[ \int \vec{B} \cdot d\vec{S} = \pm Li \]

\[ \oint \vec{B} \cdot d\vec{r} = \mu_0 i_{\text{enclosed}} \]
1. (25 points) An infinitely long wire carrying a current $i$ has a circular cross section of radius $W$. The current is uniformly spread over the cross sectional area. If the center of the wire is at the origin, find the points on the $x$ axis where the magnetic field has one half the magnitude of the magnetic field at the surface of the wire.

\[ i \quad \text{(into page)} \]

\[ \uparrow \]

\[ x = a \]
2. (25 points) A circular loop of very thin wire has radius R and carries a current i. It is in the y, z plane with its center at the origin.

a. Find the magnetic field produced by this wire at a point a distance $x$ away from the center of the wire along the $x$ axis.

\[ \text{\includegraphics{diagram1}} \]

b. Find the force that would be exerted by this current carrying wire on a particle with charge $q$ and mass $m$ travelling with velocity $v_0$ at the point a distance $x$ from the center.

\[ \text{\includegraphics{diagram2}} \]
3. (25 points) In the circuit below the capacitor is originally charged with $Q_0$ on the top plate and $-Q_0$ on the bottom. At $t = 0$ the switch is closed.
a. Find the charge on the plates as a function of time assuming the self inductance of the circuit can be ignored. Please note that all wires in this circuit have no resistance.

![Circuit Diagram]

b. In the circuit below the capacitor is initially uncharged. At $t = 0$ the switch is closed. Find the charges on the capacitor plates as a function of time assuming the self inductance of the circuit can be ignored.
4. (25 points) A rectangular loop is made of wire having resistivity \( \rho \) and cross sectional area \( A \). It has the dimensions shown below.

If there were a magnetic field that varied with time according to

\[
B = 6t^4 + 7t + 11
\]

and was directed perpendicular to the loop, pointing into the page, find the current that would flow in the loop, ignoring self inductance.