1. (25 points) There are two concentric circular loops of extremely thin wire, one with $i_1$ and one with $i_2 = 3i_1$, as shown.

a. If the smaller loop has radius $a$ and the larger has radius $b$, find the magnetic field at the center.

b. How would the radii $a$ and $b$ have to be related in order for there to be no magnetic field at the center?
2. (25 points) Consider an infinitely long, hollow cylindrical wire. The wire has outer radius \( b \) and the cylindrical hole at its center has radius \( a \). A current \( i_1 \) flows from left to right and the current is uniformly spread over the region between \( a \) and \( b \). At the center of this wire is a very, very thin wire carrying a current \( i_2 \) from right to left.

Find the magnetic field at the point a distance \( c \) from the center such that the point is between \( a \) and \( b \).
3. (25 points) A circular loop of wire has resistance $R$. It is in the horizontal plane. There is a constant vertical magnetic field of magnitude $B_0$ pointing up. At time $t = 0$ the loop begins to mysteriously expand so that its radius is given by

$$r(t) = r_0(1 + \beta t)$$

where $\beta$ is a known constant. (The resistance does not change during this expansion.)

a. Find the current in the loop, including its direction, as a function of time. (Ignoring self inductance.)

b. Find the force that will be exerted on the each segment, $d\vec{s}_i$, of the loop by the magnetic field.

c. In ten words or less, how does this induced current obey Lenz's Law? Warning: One or more words over the limit of ten means no credit!
4. (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.

![Circuit Diagram]

a. **Derive**, starting with some law, the equation for the charge on the plates as a function of time if the self inductance of the circuit is $L$.

b. Solve the equation for the charge on the plates as a function of time assuming the resistance $R$ can be ignored. Clearly show your work.