IMPORTANT

Read these directions carefully:

• There are 4 problems totalling 100 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.

• There is potentially useful information on the last page.

• Indicate what you are doing! We cannot give full credit for merely writing down the answer. Neatness counts! I will give generous partial credit if I can tell that you are on the right track. This means you must be neat and organized.

• Each problem with its associated figure is self explanatory. If you must ask a question, then come to the front, being as discrete as possible so as not to disturb others.
Problem 1. 25 points.

(a) There are three very long, extremely thin, parallel wires. One with current $i_1$ and one with $i_2$ and one with $i_3$. In cross-section, the wires are located at the corners of a square of side $W$. If all currents flow into the page, find the magnetic field vector at the fourth corner.

(b) What would be the force on a length $H$ of wire if it was parallel to the other wires at the fourth corner and had a current $i_4$ coming out of the page?

Be neat. Neatness helps. Work neatly.
Problem 2. 25 points.

A very long thin wire carries a current $i$. It has the shape and dimensions shown below.

Find the magnetic field at the point $P$. 

If you work neatly I will find more partial credit for you!
Problem 3. 25 points.

A rectangular circuit containing a capacitor $C$ is located near an infinitely long narrow wire carrying a current $i_0 \cos \omega t$ where $i_0$ and $\omega$ are constants. The circuit has no resistance and its self-inductance can be ignored. Find the charge on the top capacitor plate as a function of time.

Long straight wire, current $i = i_0 \cos \omega t$
Problem 4. (25 points)

(a) 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 $S$ is closed. Please note that all wires in this circuit have no resistance.

Derive the equation for the charge on the capacitor as a function of time assuming the self-inductance of the circuit can be ignored. Solve the equation.

(b) 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 $S$ is closed. Derive the equation for the charge on the plates as a function of time if the self-inductance of the circuit is $L$ and the resistance of the circuit is negligible. Solve the equation.
\[ \vec{F} = \frac{1}{4\pi \epsilon_0} \frac{q_1 q_2}{r^2} \hat{r} \]

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

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

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

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

For parallel plates \( C = \frac{\Delta \omega}{d} \)

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

\[ \oint \vec{B} \cdot d\vec{r} = \mu_0 i_{\text{enclosed}} \]

\[ \vec{F} = q(\vec{v} \times \vec{B} + \vec{E}) \quad d\vec{F} = i(d\vec{s} \times \vec{B}) \]

POTENTIALLY USEFUL INTEGRALS

\[ \int \frac{dx}{(x^2 + C)^{\frac{3}{2}}} = \frac{x}{C(x^2 + C)^{\frac{1}{2}}} + \text{Constant} \]

\[ \int \frac{xdx}{(x^2 + C)^{\frac{3}{2}}} = -\frac{1}{(x^2 + C)^{\frac{1}{2}}} + \text{Constant} \]

DO NOT WASTE TIME ON ARITHMETIC