Physics 208: Electricity and Magnetism.
Final Exam, Secs. 525,810–812 4 May 2007
Instructor: Dr. George R. Welch, 301D Doherty Building, 845-1571

Print your name **neatly**:

**LAST** name: ________________________________

First name: ________________________________

Sign your name: ______________________________

Please fill in your Student ID number (UIN): _______–_______–_______–_______

**IMPORTANT**

Read these directions carefully:

- There are 8 problems totalling 200 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.

- **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.

- Put your name on each page it is asked for. You will lose credit if you fail to print your name on each page it is asked for.
Problem 1. (25 points)

Three charges, $q_1$, $q_2$, and $q_3$ are fixed in the $x$-$y$ plane as shown. The distance from $q_2$ to $q_1$ is $a$ and the distance from $q_2$ to $q_3$ is $b$. Assume that $a$ and $b$ are given constants.

Calculate the electric field vector at the point P shown in the figure. P is a distance $a$ directly above $q_3$.

Don’t forget to be neat.
Problem 2. (25 points)

A thin rod of length $L$ has charge $Q$ uniformly distributed along its length. Calculate the electric potential at the point $P$ shown in the figure, which is a distance $a$ directly above one end of the rod. Assume the potential is zero infinitely far from the rod.
Problem 3. (25 points)

A spherical insulating shell of radius $R$ has charge spread throughout so that the charge density is $\rho = cr^2$ where $r$ is the distance from the center, and $c$ is a given positive constant. This density is not a function of angle.

(a) Find the electric field $E$ as a function of $r$ for points inside the sphere ($r < R$).

(b) Find the electric field $E$ as a function of $r$ for points outside the sphere ($r > R$).

Express both answers in terms of $c$, $R$, physical constants, and numerical factors.

Make sure you are being neat. Working neatly will help you get it right.
Problem 4. (25 points)

Consider the circuit shown.

(a) Suppose the switch $S$ is in the “up” position as shown. Calculate the current flowing through the switch.

(b) Suppose the switch has been in the “down” position a long time. Calculate the charge on each of the four capacitor plates. Note that both capacitors have the same capacitance $C$. Do not use different symbols such as $C_1$ and $C_2$.

Express your answers in terms of $R_1$, $V_1$, $R_2$, $V_2$, and $C$. 

Did you work neatly? Neatness is important.
Problem 5. (25 points)

The region between two concentric conducting spheres with radii \(a\) and \(b\) (and \(a < b\)) is filled with a material with resistivity \(\rho\).

(a) Calculate the resistance between the spheres.

(b) Find the current density as a function of radius, in terms of the potential difference \(V_{ab}\) between the spheres.

Organize your thoughts, and write clearly. Otherwise I won’t give as many points.
A rectangular loop of wire is made to carry a current $i$. The dimensions of the loop are $a$ and $b$ and are shown in the figure. Calculate the magnetic field at the center of the loop (marked with an X in the figure).
A rectangular loop of wire with dimensions $a$ and $b$ as shown in the figure has total electric resistance $R$. The loop is partially in a region of uniform magnetic field $B$ aligned perpendicular to the loop (in the direction shown). A constant force $F$ is applied to the loop as shown (perpendicular to the magnetic field, and along the long axis of the rectangle) causing it to start to move in this direction.

(a) If the velocity of the loop at some instant of time is given to be $v$, then calculate the magnitude of the current flowing in the loop, and indicate if it is clockwise or counter-clockwise.

(b) After a while (but before the loop is fully removed from the field), the loop has constant velocity. Calculate this velocity.
Problem 8. (25 points)

(a) In the circuit shown, the switch has been in the “up” position for a very long time. If it is then switched “down” at \( t = 0 \) find the current in the resistor as a function of time. Ignore the self-inductance of the circuit. Express your answer in terms of \( V, R, L, \) and (of course) \( t \).

Show your steps and neatly indicate what you are doing. There will be no credit for just writing down the answer.
(b) In the circuit shown, the switch has been open a long time. If the switch is closed at $t = 0$, find the current in the resistor as a function of time. Ignore the self-inductance of the circuit. Express your answer in terms of $V$, $R$, $C$, and (of course) $t$. 

Continue to work neatly.
For two point particles  
\[ \vec{F} = \frac{1}{4\pi \epsilon_0} \frac{q_1 q_2}{r^2} \hat{r} \]

\[ V(\vec{r}_2) - V(\vec{r}_1) = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{E} \cdot d\vec{r} \]

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

\[ E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y} \]

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

\[ d\vec{B} = \frac{\mu_0 i}{4\pi} \frac{d\vec{s} \times \vec{r}}{r^3} \quad \oint \vec{B} \cdot d\vec{r} = \mu_0 i_{\text{enclosed}} \]

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

\[ \oint \vec{B} \cdot d\vec{A} = \pm Li \quad (\text{sign by Lenz}) \]

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

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

\[ \int \frac{dx}{(x^2 + c^2)^{3/2}} = \ln \left( x + \sqrt{x^2 + c^2} \right) + \text{Constant} \]

DO NOT WASTE TIME ON ARITHMETIC