Physics 202 MWF 10:20      Spring 2009 (Ford)

Name (printed)__________________________________________________________
Name (signature as on ID)_________________________________________________
Lab Section____________

Final Exam

Show all your work. Partial credit will be given if earned. Write your answers in the blanks provided.

(10 pts) 1. Negative point charge \( q_1 = -8.0 \times 10^{-6} \) C is at the origin and positive point charge \( q_2 = +6.0 \times 10^{-6} \) C is on the \(-x\)-axis at \( x = -0.20 \) m.

\[
\begin{array}{c}
\text{0.2 m} \\
\text{0.3 m} \\
\text{Y}
\end{array}
\]

\( q_2 \quad q_1 \quad P \quad x \)

a) What is the magnitude and direction (+x or -x) of the net electric field produced by these two charges at the point \( P \) that is on the +x-axis at \( x = +0.30 \) m?

Ans. \( E = \) ______________

direction ______________

b) What is the electric potential at point \( P \) produced by these two charges? (Take the potential to be zero at very larges distances from the charges.)

Ans. ______________
(10 pts) 2.
a) In a region of space there is a uniform electric field with magnitude 800 N/C and that is in the +x-direction. If the electric potential at the origin is 300 V, what is the electric potential at a point that is on the −x-axis at $x = -0.50$ m?

Ans. __________________

b) A particle with charge $q = -8.0 \times 10^{-3}$ C is released from rest at point $a$. When the particle reaches point $b$, 5.0 m to the right of point $a$, its kinetic energy is 4.0 J. The only force acting on the particle is the electric force. If the electric potential at point $a$ is 300 V, what is the electric potential at point $b$?

Ans. __________________
(12 pts) 3.

a) Three capacitors are connected to a battery as shown in the sketch. $C_1 = 4.0 \times 10^{-6}$ F, $C_2 = 2.0 \times 10^{-6}$ F, and $C_3 = 3.0 \times 10^{-6}$ F. The charge $Q_1$ on $C_1$ is $Q_1 = 6.0 \times 10^{-4}$ C. What is the charge on each of the other two capacitors and what is the emf of the battery?

![Capacitor Diagram]

Ans. $Q_2 =$

$Q_3 =$

emf =

b) Three resistors are connected to a battery as shown in the sketch. $R_1 = 4.0 \Omega$, $R_2 = 2.0 \Omega$, and $R_3 = 3.0 \Omega$. The voltage across $R_1$ is $V_1 = 36$ V. What is the voltage across each of the other two resistors and what is the emf of the battery?

![Resistor Diagram]

Ans. $V_2 =$

$V_3 =$

emf =
4. Consider the circuit shown in the sketch. Note that two currents are shown. Calculate the two battery emfs, $\varepsilon_1$ and $\varepsilon_2$.

\[ \begin{align*}
\text{Ans. } \varepsilon_1 & \quad & \varepsilon_2 \\
\end{align*} \]

5. Consider the circuit shown in the sketch. $C = 5.0 \times 10^{-6}$ F and $L = 0.30$ H. Initially the switch $S$ is open, there are no currents, and there is no charge on the capacitor. Then the switch is closed.

\[ \begin{align*}
\text{a) Just after the switch is closed, what is the voltage across the 3 } \Omega \text{ resistor?} \\
\text{Ans. } \\
\end{align*} \]

\[ \begin{align*}
\text{b) After the switch has been closed a long time, what is the voltage across the 3 } \Omega \text{ resistor?} \\
\text{Ans. } \\
\end{align*} \]
(8 pts) 6. A circular loop of wire has radius \( r = 0.20 \) m and resistance 40 \( \Omega \). The loop is in a uniform magnetic field that is directed out of the plane on the paper, as shown in the sketch. The magnetic field is decreasing at a constant rate of \( \Delta B/\Delta t = -0.050 \) T/s. What are the magnitude and direction (clockwise or counterclockwise) of the current that is induced in the loop?

\[ \text{Ans. } I = \quad \]  
\[ \text{direction } \]  

(9 pts) 7. Two long, straight parallel wires carry currents as shown in the sketch. The distance between the wires is 0.040 m. A small object with negative charge \( q = -5.0 \times 10^{-4} \) C is moving parallel to the wires, in the opposite direction to the currents, with speed \( v = 7.0 \times 10^{-4} \) m/s. What are the magnitude and direction of the net force that the magnetic field of the two wires exerts on \( q \)?

\[ \text{Ans. } F = \quad \]  
\[ \text{direction } \]  

\[ \rightarrow I_1 = 6 \text{ A} \]
\[ \rightarrow I_2 = 8 \text{ A} \]
(9 pts) 8. A series ac circuit has a source with voltage amplitude $V = 120 \, \text{V}$ and angular frequency $\omega = 50 \, \text{rad/s}$, a resistor with $R = 15 \, \Omega$ and an inductor with $L = 0.40 \, \text{H}$.

\[ V \quad \omega \]

\[ R \quad L \]

a) What is the current amplitude?

Ans. ________________

b) What is the phase angle? Does the source voltage lag or lead the current?

Ans. phase angle ________________

lag or lead ________________

c) What is the rate at which the source is delivering electrical energy to the circuit?

Ans. ________________
(6 pts) 9. An object that is 2 mm tall is placed 40 cm to the left of a thin lens that has $f = +30$ cm.

a) Is the image real or virtual?

Ans. __________________

b) Is the image upright or inverted?

Ans. __________________

c) What is the height of the image?

Ans. __________________

(8 pts) 10. An oil film that is 400 nm thick is on top of water. The oil has $n = 1.2$ and the water has $n = 1.33$. White light in air is incident normal to the surface of the oil. What wavelengths in air within the limits of the visible spectrum ($\lambda = 400$ nm to 700 nm) have destructive interference between the light that is reflected from the upper and lower surfaces of the oil film?

Ans. __________________
(6 pts) 11. A portion of Table 30.2 Atomic Masses of Light Elements from the textbook is reproduced below. Use the information in the table to calculate the total binding energy of the nucleus $^9\text{Be}$. 

**TABLE 30.2 Atomic masses of light elements**

<table>
<thead>
<tr>
<th>Element</th>
<th>Atomic number, Z</th>
<th>Neutron number, N</th>
<th>Atomic mass, u</th>
<th>Mass number, A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen, H</td>
<td>1</td>
<td>0</td>
<td>1.007825</td>
<td>1</td>
</tr>
<tr>
<td>Deuterium, H</td>
<td>1</td>
<td>1</td>
<td>2.014101</td>
<td>2</td>
</tr>
<tr>
<td>Helium, He</td>
<td>2</td>
<td>1</td>
<td>3.016029</td>
<td>3</td>
</tr>
<tr>
<td>Helium, He</td>
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<td>2</td>
<td>4.002603</td>
<td>4</td>
</tr>
<tr>
<td>Lithium, Li</td>
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<td>3</td>
<td>6.015123</td>
<td>6</td>
</tr>
<tr>
<td>Lithium, Li</td>
<td>3</td>
<td>4</td>
<td>7.016005</td>
<td>7</td>
</tr>
<tr>
<td>Beryllium, Be</td>
<td>4</td>
<td>5</td>
<td>9.012182</td>
<td>9</td>
</tr>
</tbody>
</table>

(8 pts) 12. The gold nucleus $^{198}_{79}\text{Au}$ undergoes $\alpha$-decay with a half-life of 2.70 days.

a) How many neutrons are there in the daughter nucleus that is produced by this decay? 

Ans. ________________

b) What is the activity in Bq (decays/sec) of a sample that contains 5.0 grams of $^{198}_{79}\text{Au}$ nuclei?

Ans. ________________