(10 pts) 1. A negative point charge \( q_1 = -8.00 \, \mu C \) is at the origin. A positive point charge \( q_2 = +5.00 \, \mu C \) is on the +x-axis at \( x = 0.40 \, m \). Point \( P \) is on the +y-axis at \( y = +0.30 \, m \). What are the \( x \) and \( y \) components of the net electric field at point \( P \) due to \( q_1 \) and \( q_2 \)? Be sure to indicate whether each component is positive or negative.

\[
\text{Ans. } E_x = -1.44 \times 10^5 \frac{N}{C} \\
E_y = -6.92 \times 10^5 \frac{N}{C}
\]
(10 pts) 2. Three capacitors are connected to a battery, as shown in the sketch. $C_1 = 2.00 \mu F$, $C_2 = 4.00 \mu F$ and $C_3 = 5.00 \mu F$. Capacitor $C_1$ has charge $Q_1 = 6.00 \mu C$.

![Diagram of three capacitors connected to a battery.]

a) What is the voltage $V_2$ across capacitor $C_2$?  
Ans. $1.5 \text{ V}$

b) What is the charge $Q_3$ on capacitor $C_3$?  
Ans. $22.5 \mu C$

c) What is the emf of the battery?  
Ans. $4.5 \text{ V}$
3. The plates of an air-filled parallel plate capacitor are separated by 0.0500 m. At a point midway between the two plates the electric field due to the charge on the plates has magnitude 800 N/C and is directed toward plate \( b \), as shown in the sketch. What is the potential difference \( V_{ab} \) between the two plates and which plate, \( a \) or \( b \), is at higher potential?

\[ \text{Ans. } V_{ab} = 40 \text{ V} \]

plate at higher potential is \( a \)

4. The nucleus \(^{25}\text{Al}\) undergoes positron decay to \(^{25}\text{Mg}\). The atomic mass of a neutral \(^{25}\text{Al}\) atom is 24.990432 u and the atomic mass of a neutral \(^{25}\text{Mg}\) atom is 24.985839 u. What is the total kinetic energy of the decay products, the energy released in the decay? Express your answer in MeV.

\[ \text{Ans. } 3.26 \text{ MeV} \]
5. As shown in the sketch, a resistor $R = 4.00 \, \Omega$ is connected between the terminals $a$ and $b$ of a battery that has emf 12.0 V and internal resistance $r$. With $R$ connected the terminal voltage $V_{ab}$ of the battery is measured to be 10.4 V. What is the internal resistance $r$ of the battery?

Ans. $0.615 \, \Omega$

6. The circuit shown in the sketch contains a battery with emf 48.0 V and zero internal resistance, two resistors and an inductor. There is a switch $S_1$ next to the battery. After the switch has been closed a long time, it is opened. Just after the switch has been opened, what is the voltage $V_1$ across resistor $R_1$?

Ans. $24 \, V$
(12 pts) 

a) A long straight wire carries current \( I \) that is toward the bottom of the page, as shown in the sketch. Point \( P \) is to the left of the wire. What is the direction of the magnetic field at point \( P \) that is produced by the current? (Your answer should be one of the following: to the left, to the right, toward the top of the page, toward the bottom of the page, into the page or out of the page.)

\[ \text{Ans. into page} \]

b) A negative point charge is moving in a uniform magnetic field that is directed toward the top of the page, as shown in the sketch. If the point charge has velocity directed to the right, what is the direction of the force that the magnetic field exerts on the charge? (Your answer should be one of the following: to the left, to the right, toward the top of the page, toward the bottom of the page, into the page or out of the page.)

\[ \text{Ans. into page} \]

c) A circular metal ring is in a region of uniform magnetic field that is increasing at a constant rate. In the sketch, is the current induced in the ring clockwise or counterclockwise?

\[ \text{Ans. counterclockwise} \]

d) A long straight wire carries current \( I \) that is to the right. As shown in the sketch, a small rectangular metal loop is moving away from the wire. Is the current induced in the loop clockwise or counterclockwise?

\[ \text{Ans. clockwise} \]
(10 pts) 8. A series ac circuit has a voltage source with angular frequency $\omega = 200 \text{ rad/s}$, a resistor $R = 400 \text{ } \Omega$ and a capacitor $C = 5.00 \times 10^{-3} \text{ } \text{F}$. The amplitude of the voltage across the resistor is 800 V.

![Circuit Diagram]

a) What is the voltage amplitude of the source?  
Ans. $824 \text{ V}$

b) Does the source voltage lag or lead the current?  
Ans. lags

(10 pts) 9. An object that is 2.00 mm tall is placed to the left of a converging lens that has $f = +20.0 \text{ cm}$. The image formed by the lens is also to the left of the lens and is 6.00 mm tall.

a) Is the image upright or inverted?  
Ans. upright

b) What is the distance of the object from the lens?  
Ans. $13.3 \text{ cm}$
10 pts) 10. A thin plastic film is placed on the surface of a flat piece of glass. There is air above the film. The film has refractive index $n = 1.2$ and the glass has refractive index 1.4. Light with wavelength 600 nm in air is at normal incidence to the film. What is the smallest nonzero thickness $t$ of the film for which light reflected from the top and bottom surfaces of the film will interfere destructively?

\[
\text{Ans. } 125 \text{ nm}
\]

10 pts) 11. For a certain metal surface, light of wavelength 80.0 nm produces photoelectrons with a maximum kinetic energy of 4.0 eV. What is the longest wavelength of light that will produce photoelectrons from this surface?

\[
\text{Ans. } 108 \text{ nm}
\]