On the following problems show all your work. Partial credit will be given, if earned. Write your answers in the blanks provided.

(12 pts) 1. A small object has charge $q_1 = +8.00 \times 10^{-4} \text{ C}$ and held in place so it doesn’t move. Another small object with $q_2 = -3.00 \times 10^{-6} \text{ C}$ is moving directly toward $q_1$. When $q_2$ is 2.00 m from $q_1$ it has kinetic energy 40.0 J. What is the kinetic energy of $q_2$ when it is 0.500 m from $q_1$?

Ans.
(12 pts) 2. A positive point charge \( q_1 = +4.00 \times 10^{-9} \ \text{C} \) is located at the origin, a negative point charge \( q_2 = -5.00 \times 10^{-9} \ \text{C} \) is located on the +y-axis at \( y = +0.300 \ \text{m} \) and a negative point charge \( q_3 = -6.00 \times 10^{-9} \ \text{C} \) is located on the +x-axis at \( x = +0.400 \ \text{m} \). Point \( P \) is at the point \( x = +0.400 \ \text{m}, y = +0.300 \ \text{m} \). Calculate the \( x \) and \( y \) components of the resultant electric field at point \( P \) due to the three charges. Be sure to indicate if each component is positive or negative.

An. \( E_x = \)  

\[ E_y = \]
(12 pts) 3. In the capacitor network shown in the sketch, \( C_1 = 6.00 \ \mu F \), \( C_2 = 3.00 \ \mu F \), \( C_3 = 4.00 \ \mu F \) and \( C_4 = 8.00 \ \mu F \). After all the capacitors have their final charges, the voltage \( V_3 \) across capacitor \( C_3 \) is 40.0 V.

\[ \text{Diagram of capacitor network} \]

a) What are the voltages \( V_1 \) and \( V_2 \) across \( C_1 \) and \( C_2 \)?

Ans. \( V_1 = \) \\
\[ \]
\( V_2 = \)

b) What is the voltage \( V_4 \) across \( C_4 \)?

Ans. 

c) What is the battery emf?

Ans. 

(11 pts) 4. A thin film of transparent liquid is between two flat parallel sheets of glass. The liquid has refractive index \( n = 1.20 \) and the glass has \( n = 1.50 \). Light with wavelength 400 nm in air shines at normal incidence on the liquid film. What is the smallest nonzero thickness \( t \) of the film in order for there to be constructive interference between the light reflected at the top and bottom surfaces of the film, as shown in the sketch?

\[
\begin{array}{c}
glass \\
1.5 \\
\text{liquid} \\
1.2 \\
glass
\end{array}
\]

Ans. ________

---

(10 pts) 5. An \( R-L-C \) series ac circuit has \( R = 40.0 \, \Omega \), \( C = 8.00 \times 10^{-6} \, \text{F} \) and \( L = 0.500 \, \text{H} \). The ac voltage source has voltage amplitude 80.0 V. The frequency of the ac source is equal to the resonance frequency for the circuit.

a) What is the amplitude of the voltage across the capacitor and across the inductor?

Ans. \( V_C = \) ________

\[ V_L = \) ________

b) What is the average rate at which the ac voltage source is supplying electrical energy to the circuit?

Ans. ________
6. A long straight wire carries current $I = 12.0 \, \text{A}$ in the direction shown in the sketch. A small object with charge $q = -6.00 \times 10^{-4} \, \text{C}$ is moving near the wire. What force (magnitude and direction) does the wire exert on the charged object at the instant that the object is 0.200 m from the wire and is moving in the direction shown in the sketch with speed $v = 6.00 \times 10^5 \, \text{m/s}$. Specify the direction of the force as left, right, toward wire, away from wire, out of page or into page.

\[ \text{Ans. } F = \_ \_ \_ \_ \_ \_ \_ \_ \_ \_ \]

direction ______
(10 pts) 7. A 4.00 mm tall object is placed 24.0 cm to the left of a converging lens that has focal length $f_1 = +6.0$ cm. A diverging lens with focal length $f_2 = -8.0$ cm is placed 12.0 cm to the right of the converging lens. The final image is formed after the light from the object has passed through both lenses.

\[ \uparrow 4 \text{ mm} \]

\[ \rightarrow \quad 24 \text{ cm} \quad \rightarrow \quad 12 \text{ cm} \]

a) Is the final image upright or inverted?

Ans. 

b) What is the height of the final image?

Ans. 

(9 pts) 8.

a) The bar in the sketch is moving to the left on conducting rails in a magnetic field that is directed into the page. Which end of the resistor is at higher potential, \( a \) or \( b \)?

\[
\begin{array}{c}
\text{x} \\
\text{X} \\
\text{x} \\
\text{x} \\
\text{x} \\
\text{x} \\
\end{array}
\]

Ans. _________

b) The wire in the sketch has constant current \( I \) in the direction shown. The square conducting loop is moving away from the wire with constant speed \( v \). Is the current induced in the loop clockwise, counterclockwise or zero?

\[
\begin{array}{c}
\text{V} \\
\end{array}
\]

Ans. _______________

\[
\begin{array}{c}
\text{I} \\
\end{array}
\]


c) The wire has current \( I \) in the direction shown. The square conducting loop and the wire are both stationary. If the current in the wire is increasing at a constant rate, is the current induced in the loop clockwise, counterclockwise or zero?

\[
\begin{array}{c}
\text{I} \\
\end{array}
\]

Ans. _______________
9.

a) The isotope $^{10}_6\text{C}$ undergoes $\beta^+$ (positron) decay with a half-life of 19.1 s.

i) How many neutrons are in the daughter nucleus that is produced by the decay? Ans. ________

ii) What is the activity (in decays/s) of a sample that has 12.0 grams of $^{10}_6\text{C}$ nuclei?

Ans. ________

b) A fossil specimen from an animal that died 8000 years ago has an activity today of 560 counts/s from the $\beta^-$ decay of the $^{14}_6\text{C}$ nuclei in the specimen. How many $^{14}_6\text{C}$ were in the sample at the time when the animal died? (The half-life of $^{14}_6\text{C}$ is 5730 years. 1 year = $3.156 \times 10^7$ seconds)

Ans. ________