1. (10 points) Each of the resistors in the diagram is 12 Ω. The resistance of the entire circuit is:

\[
\begin{align*}
R &= \frac{12}{4} + \frac{12}{4} + \frac{12}{4} + \frac{12}{4} + \frac{12}{4} \\
&= 12 + 12 + 12 + 12 + 12 \\
&= 60 Ω
\end{align*}
\]

2. (10 points) In the circuit shown, the capacitor is initially uncharged. \( V = 9 \) Volts. At time \( t = 0 \), switch \( S \) is closed. If \( \tau \) denotes the time constant, the approximate current through the 3 Ω resistor when \( t = \frac{\tau}{100} \) is:

Final charge on capacitor is zero as case where resistors are not present (resistors only show rate at which current can decay charge on capacitor).

Final charge on capacitor is zero as case where resistors are not present (resistors only show rate at which current can decay charge on capacitor).

3. (10 points) At one instant an electron (charge = \(-1.6 \times 10^{-19}\) C) is moving in the \( xy \) plane. The components of its velocity being \( \mathbf{v}_x = 5 \times 10^4 \) m/s and \( \mathbf{v}_y = 3 \times 10^4 \) m/s. A magnetic field of 0.8 T is in the positive \( z \) direction. At that instant the magnitude of the magnetic force on the electron is:

\[
\begin{align*}
F &= qE \\
&= (1.6 \times 10^{-19}) \times (5 \times 10^4) \times 10^5 \\
&= 8 \times 10^{-14} \text{ N}
\end{align*}
\]
4. (10 points) A loop of wire carrying a current of 2.0 A is in the shape of a right triangle with two equal sides, each 10 cm long. A 0.7 T uniform magnetic field is in the plane of the triangle and is perpendicular to the hypotenuse. The resultant magnetic force on the two sides has a magnitude of:

$$F = B_l I_1 = \frac{B_l l_1}{2} \times \frac{l_1}{2} + \frac{B_l l_2}{2} \times \frac{l_2}{2} = \frac{B_l l_1 l_2}{4} \cos \theta + \frac{B_l l_1 l_2}{4} \cos \theta$$

5. (10 points) Two parallel wires, 4 cm apart, carry currents of 2 A and 4 A respectively, in opposite directions. The force per unit length in N/m of one wire on the other is:

(A) 1 x $10^{-3}$, repulsive
(B) 1 x $10^{-4}$, attractive
(C) 4 x $10^{-4}$, repulsive
(D) 4 x $10^{-5}$, attractive
(E) none of these

6. (10 points) Two long straight wires enter a room through a window. One carries a current of 3.0 A into the room while the other carries a current of 5.0 A out. The magnitude in T m of the path integral $\int B \cdot dl$ around the window frame is:

(A) 2.5 x $10^{-4}$
(B) 3.0 x $10^{-4}$
(C) 6.3 x $10^{-4}$
(D) 1.8 x $10^{-4}$
(E) none of these

7. (10 points) A single loop of wire with a radius of 7.5 cm rotates about a diameter in a uniform magnetic field of 1.6 T. The axis of rotation is perpendicular to the magnetic field. To produce a maximum emf of 1.0 V, it should rotate at:

(A) 0
(B) 2.7 rad/s
(C) 5.6 rad/s
(D) 11 rad/s
(E) none of these

$$\varepsilon = \frac{d(\Phi_B)}{dt} = \frac{d(\Phi_B)}{d\theta} \times \frac{d\theta}{dt} = \frac{B_l d}{dt} = \frac{B_l I_1}{\cos \theta}$$

$\varepsilon_{max} = B_l I_1$ and $f_{max} = \frac{B_l I_1}{2\pi R}$

$$\omega = \frac{\varepsilon_{max}}{B_l I_1} = \frac{1.0 \text{ V}}{1.6 \text{ T} \times 7.5 \text{ cm}} = 3.33 \text{ rad/s}$$
8. (10 points) A 6.0 mH inductor and a 3.0 Ω resistor are wired in series to a 12 V ideal battery. A switch in the circuit is closed at time 0, at which time the current is zero. 2.0 ms later the energy stored in the inductor is:

Find current is some time when inductor is not present so

\[ i(t) = \frac{13V}{2\pi R} \times 6A \]

For series R-L circuit:

(A) \( 0 \) J
(B) \( 1.92 \times 10^{-4} \) J
(C) \( 1.1 \times 10^{-3} \) J
(D) \( 1.8 \times 10^{-3} \) J
(E) \( 2.2 \times 10^{-3} \) J

\[ U = \frac{1}{2} L i^2 = \frac{1}{2} \left( 2.5 \times 10^{-3} \right) x \left( 6 \times 10^{-2} \right) = 1.917 \times 10^{-5} J \]

9. (10 points) An LC circuit has a capacitance of 30 μF and an inductance of 15 mH. At time \( t = 0 \) the charge on the capacitor is 10 μC and the current is 20 mA. The maximum current is:

\[ i(t) = \frac{1}{2} \frac{Q^2}{L C} \]

\[ u = \frac{1}{2} L i^2 + \frac{1}{2} C \]

(A) \( 18 \) mA
(B) \( 20 \) mA
(C) \( 25 \) mA
(D) \( 35 \) mA
(E) \( 42 \) mA

\[ \phi = \frac{1}{2} \int_{0}^{t} i^2 dt = \left( \frac{10 \times 10^{-6} C}{0.015 \times 10^{-3} H} \right) \cdot 0.00549 A \]

10. (10 points) What resistance \( R \) should be connected in series with an inductance \( L \) = 2.2 mH and capacitance \( C = 12.0 \) μF for the maximum charge on the capacitor to decay to 99.5% of its initial value in 0.0 cycles? (Assume \( \omega = 2 \pi \omega \))

\[ R = \frac{\omega^2}{\omega^2 + \omega} \left( \omega^2 + \omega \right) \]

\[ A = 4.33 \times 10^{-5} Ohms \]

\[ B = 4.33 \times 10^{-5} Ohms \]

\[ C = 4.33 \times 10^{-5} Ohms \]

\[ D = 8.66 \times 10^{-5} Ohms \]

\[ E = 9.37 \times 10^{-5} Ohms \]

\[ \phi = \frac{1}{2} \int_{0}^{t} i^2 dt = \left( \frac{10 \times 10^{-6} C}{0.015 \times 10^{-3} H} \right) \cdot 0.00549 A \]

\[ e^{-R/L} = 0.99 \Rightarrow e^{-0.99 \times 10^{-5} \times 0.015 \times 10^{-3}} \approx 32 \text{ mH} \]

\[ R = \frac{1}{N \times 10^{-6}} \ln(99) \approx 8.66 \times 10^{-5} \text{ Ohms} \]