Definition of capacitance \[ C = \frac{q}{V} \]

Capacitors in parallel \[ C_{eq} = \sum_j C_j \]

Capacitors in series \[ \frac{1}{C_{eq}} = \sum_j \frac{1}{C_j} \]

Energy stored by a capacitor \[ U = \frac{q^2}{2C} = \frac{1}{2}CV^2 \]

Ohm’s law \[ V = iR \]

Resistance \[ R = \rho \frac{L}{A} \]

Resistors in series \[ R_{eq} = \sum_i R_i \]

Resistors in parallel \[ \frac{1}{R_{eq}} = \sum_i \frac{1}{R_i} \]

KVL: for a closed loop \[ \sum_i V_i = 0 \]

KCL: at a node \[ \sum_i i_i = 0 \]

Electric power \[ P = iV \]

Charging a capacitor \[ q = Ce \left( 1 - e^{-\frac{t}{RC}} \right) \]

Discharging a capacitor \[ q = q_0 e^{-\frac{t}{RC}} \]

Time constant \[ \tau = RC \]

Magnetic force on a moving charge \[ \vec{F}_n = q\vec{V} \times \vec{B} \]

Magnetic force on a current \[ \vec{F} = i\vec{L} \times \vec{B} \]
1. (15 pts) Determine the voltage and charge in $C_2$ when $C_1 = 15 \, \mu F$, $C_2 = 10 \, \mu F$, $C_3 = 20 \, \mu F$, and $V_0 = 18 \, V$. 

![Diagram of a capacitor circuit]
2. (15 pts) What is the magnitude of the potential difference across the 20-Ω resistor?
3 (20pt) Calculate the current through $R_1=10\,\Omega$, $R_2=10\,\Omega$, and $R_3=20\,\Omega$. What is the potential difference $V_b - V_a$.

\[ \varepsilon_1 = 10\,\text{V}, \quad \varepsilon_2 = 30\,\text{V}, \quad R_1 = 10\,\text{A}, \quad R_2 = 10\,\text{A}, \quad R_3 = 20\,\text{A} \]
4 (25 pts) In the following three circuits with $C=10 \, \mu F$, $R=1 \, k\Omega$, and $\varepsilon=3V$,
(1) (5pts) calculate the final charges on the capacitor long after the switch is closed.
(2) (6pts) calculate the time constant for three circuits
(3) (9 pts) calculate the current through each resistor right after the switch is close
(the charge on the capacitor is still zero)
(4) (5pts) calculate the current through each resistor after the capacitors are fully charged

![Circuit Diagrams](image-url)
5 (25pts) The figure shows the orientation of a rectangular loop consisting of 80 closely wrapped turns each carrying a current \( I \). The magnetic field in the region is \((40 \, \text{i})\) mT. For \( \theta = 30^\circ \), \( a = 0.40 \, \text{m} \), \( b = 0.30 \, \text{m} \), and \( I = 8.0 \, \text{A} \),

(a) What are forces on each arm (magnitude and directions)

(b) If the loop is fixed on and can turn about the \( y \) axis, what is the magnitude of the torque exerted on the loop?