E2. Previous Unit Exams 2

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Abstract

Exam slides 2 for Elementary Physics II (PHY 204), taught by Gerhard Müller at the University of Rhode Island.

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The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the voltage $V_3$ across capacitor $C_3$.
(c) Find the charge $Q_2$ on capacitor $C_2$.

\[ C_1 = 1 \mu F \]
\[ C_2 = 2 \mu F \]
\[ C_3 = 3 \mu F \]
The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.

(b) Find the voltage $V_3$ across capacitor $C_3$.

(c) Find the the charge $Q_2$ on capacitor $C_2$.

Solution:

(a) $C_{12} = C_1 + C_2 = 3 \mu F$,  
    $C_{eq} = \left( \frac{1}{C_{12}} + \frac{1}{C_3} \right)^{-1} = 1.5 \mu F$.

(b) $Q_3 = Q_{12} = Q_{eq} = C_{eq}(8V) = 12 \mu C$  
    $\Rightarrow V_3 = \frac{Q_3}{C_3} = \frac{12 \mu C}{3 \mu F} = 4V$.

(c) $Q_2 = V_2 C_2 = 8 \mu C$. 

\[ C_3 = 3 \mu F \]
\[ C_1 = 1 \mu F \]
\[ C_2 = 2 \mu F \]
Consider the electrical circuit shown.

(a) Find the equivalent resistance $R_{eq}$.

(b) Find the current $I_3$ through resistor $R_3$. 

\[ R_2 = 2\Omega \]

\[ R_3 = 3\Omega \]

\[ R_6 = 6\Omega \]
Consider the electrical circuit shown.

(a) Find the equivalent resistance $R_{eq}$.
(b) Find the current $I_3$ through resistor $R_3$.

Solution:

(a) $R_{36} = \left( \frac{1}{R_3} + \frac{1}{R_6} \right)^{-1} = 2\Omega$, $R_{eq} = R_2 + R_{36} = 4\Omega$.

(b) $I_2 = I_{36} = \frac{12\text{V}}{R_{eq}} = 3\text{A}$

$\Rightarrow V_3 = V_{36} = I_{36}R_{36} = 6\text{V}$  $\Rightarrow I_3 = \frac{V_3}{R_3} = 2\text{A}$. 
This $RC$ circuit has been running for a long time.

(a) Find the current $I_2$ through the resistor $R_2$.
(b) Find the voltage $V_C$ across the capacitor.
This $RC$ circuit has been running for a long time.

(a) Find the current $I_2$ through the resistor $R_2$.

(b) Find the voltage $V_C$ across the capacitor.

Solution:

(a) $I_C = 0$, $I_2 = \frac{\mathcal{E}}{R_1 + R_2} = \frac{12V}{6\Omega} = 2A$.

(b) $V_C = V_2 = I_2 R_2 = (2A)(4\Omega) = 8V$. 
Consider a charged particle moving in a uniform magnetic field as shown. The velocity is in \(y\)-direction and the magnetic field in the \(yz\)-plane at \(30^\circ\) from the \(y\)-direction.

(a) Find the direction of the magnetic force acting on the particle.
(b) Find the magnitude of the magnetic force acting on the particle.
Consider a charged particle moving in a uniform magnetic field as shown. The velocity is in \( y \)-direction and the magnetic field in the \( yz \)-plane at 30° from the \( y \)-direction.

(a) Find the direction of the magnetic force acting on the particle.

(b) Find the magnitude of the magnetic force acting on the particle.

**Solution:**

(a) Use the right-hand rule: positive \( x \)-direction (front, out of page).

(b) \[ F = qvB \sin 30° = (5 \times 10^{-9} \text{ C})(3 \text{ m/s})(4 \times 10^{-3} \text{ T})(0.5) = 3 \times 10^{-11} \text{ N}. \]
The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the charge $Q_3$ on capacitor $C_3$.
(b) Find the charge $Q_2$ on capacitor $C_2$. 

![Diagram of the circuit with capacitors $C_1$, $C_2$, and $C_3$ connected to a 12V battery.]
The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the charge $Q_3$ on capacitor $C_3$.
(b) Find the charge $Q_2$ on capacitor $C_2$.

\[
\begin{align*}
12V \\
C_3 &= 3\mu F \\
C_1 &= 2\mu F \\
C_2 &= 2\mu F
\end{align*}
\]

Solution:

(a) $Q_3 = C_3(12V) = (3\mu F)(12V) = 36\mu C$.
(b) $Q_2 = Q_{12} = C_{12}(12V) = (1\mu F)(12V) = 12\mu C$. 
Consider the two-loop circuit shown.

(a) Find the current $I_1$.
(b) Find the current $I_2$. 
Consider the two-loop circuit shown.

(a) Find the current $I_1$.
(b) Find the current $I_2$.

Solution:

(a) $-(2\Omega)(I_1) + 10V - (2\Omega)(I_1) - 2V = 0 \quad \Rightarrow \quad I_1 = \frac{8V}{4\Omega} = 2A$.

(b) $-(2\Omega)(I_2) + 10V - (2\Omega)(I_2) - (3\Omega)(I_2) = 0 \quad \Rightarrow \quad I_2 = \frac{10V}{7\Omega} = 1.43A$. 
In this \( RC \) circuit the switch \( S \) is initially open as shown.

(a) Find the current \( I \) right after the switch has been closed.
(b) Find the current \( I \) a very long time later.
In this $RC$ circuit the switch $S$ is initially open as shown.

(a) Find the current $I$ right after the switch has been closed.
(b) Find the current $I$ a very long time later.

Solution:

(a) No current through $2\Omega$-resistor: $I = \frac{12\text{V}}{4\Omega} = 3\text{A}$.

(b) No current through capacitor: $I = \frac{12\text{V}}{6\Omega} = 2\text{A}$. 
A current loop in the form of a right triangle is placed in a uniform magnetic field of magnitude \( B = 30 \text{ mT} \) as shown. The current in the loop is \( I = 0.4 \text{ A} \) in the direction indicated.

(a) Find magnitude and direction of the force \( \vec{F}_1 \) on side 1 of the triangle.

(b) Find magnitude and direction of the force \( \vec{F}_2 \) on side 2 of the triangle.
A current loop in the form of a right triangle is placed in a uniform magnetic field of magnitude $B = 30\text{mT}$ as shown. The current in the loop is $I = 0.4\text{A}$ in the direction indicated.

(a) Find magnitude and direction of the force $\vec{F}_1$ on side 1 of the triangle.

(b) Find magnitude and direction of the force $\vec{F}_2$ on side 2 of the triangle.

Solution:

(a) $\vec{F}_1 = I\vec{L} \times \vec{B} = 0$ (angle between $\vec{L}$ and $\vec{B}$ is $180^\circ$).

(b) $F_2 = ILB = (0.4\text{A})(0.2\text{m})(30 \times 10^{-3}\text{T}) = 2.4 \times 10^{-3}\text{N}$.
   Direction of $\vec{F}_2$: $\otimes$ (into plane).
Consider the configuration of two point charges as shown.

(a) Find the energy $U_3$ stored on capacitor $C_3$.
(b) Find the voltage $V_4$ across capacitor $C_4$.
(c) Find the voltage $V_2$ across capacitor $C_2$.
(d) Find the charge $Q_1$ on capacitor $C_1$. 

\[ C_1 = 2 \mu F \quad C_2 = 2 \mu F \]
\[ C_3 = 3 \mu F \]
\[ C_4 = 5 \mu F \]

6V
Consider the configuration of two point charges as shown.

(a) Find the energy $U_3$ stored on capacitor $C_3$.
(b) Find the voltage $V_4$ across capacitor $C_4$.
(c) Find the voltage $V_2$ across capacitor $C_2$.
(d) Find the charge $Q_1$ on capacitor $C_1$.

Solution:

(a) $U_3 = \frac{1}{2} (3 \mu F)(6V)^2 = 54 \mu J$.
(b) $V_4 = 6V$.
(c) $V_2 = \frac{1}{2} 6V = 3V$.
(d) $Q_1 = (2 \mu F)(3V) = 6 \mu C$. 
Consider the electric circuit shown.

(a) Find the current $I$ when the switch $S$ is open.
(b) Find the power $P_3$ dissipated in resistor $R_3$ when the switch is open.
(c) Find the current $I$ when the switch $S$ is closed.
(d) Find the power $P_3$ dissipated in resistor $R_3$ when the switch is closed.
Consider the electric circuit shown.

(a) Find the current $I$ when the switch $S$ is open.
(b) Find the power $P_3$ dissipated in resistor $R_3$ when the switch is open.
(c) Find the current $I$ when the switch $S$ is closed.
(d) Find the power $P_3$ dissipated in resistor $R_3$ when the switch is closed.

Solution:

(a) $I = \frac{24\text{V}}{8\Omega} = 3\text{A}$.
(b) $P_3 = (3\text{A})^2(4\Omega) = 36\text{W}$.
(c) $I = \frac{24\text{V}}{6\Omega} = 4\text{A}$.
(d) $P_3 = (2\text{A})^2(4\Omega) = 16\text{W}$. 
Consider the two-loop circuit shown.

(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the potential difference $V_a - V_b$. 

![Circuit Diagram]
Consider the two-loop circuit shown.

(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the potential difference $V_a - V_b$.

Solution:
(a) $I_1 = \frac{8V + 10V}{7\Omega} = 2.57\, \text{A}$.
(b) $I_2 = \frac{8V - 6V}{9\Omega} = 0.22\, \text{A}$.
(c) $V_a - V_b = 8V - 6V = 2V$. 
The circuit of capacitors is at equilibrium.

(a) Find the charge $Q_1$ on capacitor 1 and the charge $Q_2$ on capacitor 2.
(b) Find the voltage $V_1$ across capacitor 1 and the voltage $V_2$ across capacitor 2.
(c) Find the charge $Q_3$ and the energy $U_3$ on capacitor 3.
The circuit of capacitors is at equilibrium.

(a) Find the charge $Q_1$ on capacitor 1 and the charge $Q_2$ on capacitor 2.
(b) Find the voltage $V_1$ across capacitor 1 and the voltage $V_2$ across capacitor 2.
(c) Find the charge $Q_3$ and the energy $U_3$ on capacitor 3.

**Solution:**

(a) $C_{12} = \left( \frac{1}{6\mu F} + \frac{1}{12\mu F} \right)^{-1} = 4\mu F$,

$Q_1 = Q_2 = Q_{12} = (4\mu F)(12V) = 48\mu C$.

(b) $V_1 = \frac{Q_1}{C_1} = \frac{48\mu C}{6\mu F} = 8V$,

$V_2 = \frac{Q_2}{C_2} = \frac{48\mu C}{12\mu F} = 4V$.

(c) $Q_3 = (5\mu F)(12V) = 60\mu C$,

$U_3 = \frac{1}{2} (5\mu F)(12V)^2 = 360\mu J$.  

![Diagram of capacitors](image-url)
Consider the electric circuit shown. Find the current $I_1$ through resistor 1 and the voltage $V_1$ across it

(a) when the switch $S$ is open,
(b) when the switch $S$ is closed.
(c) Find the equivalent resistance $R_{eq}$ of the circuit and the total power $P$ dissipated in it when the switch $S$ is closed.

\[ R_1 = 4 \Omega \]
\[ R_2 = 2 \Omega \]
\[ R_3 = 4 \Omega \]
\[ 12 \text{V} \]
Consider the electric circuit shown. Find the current \( I_1 \) through resistor 1 and the voltage \( V_1 \) across it
(a) when the switch \( S \) is open,
(b) when the switch \( S \) is closed.
(c) Find the equivalent resistance \( R_{eq} \) of the circuit and the total power \( P \) dissipated in it when the switch \( S \) is closed.

Solution:

(a) \( I_1 = \frac{12\text{V}}{4\Omega + 2\Omega} = 2\text{A}, \quad V_1 = (4\Omega)(2\text{A}) = 8\text{V}. \)

(b) \( I_1 = \frac{1}{2} \frac{12\text{V}}{2\Omega + 2\Omega} = 1.5\text{A}, \quad V_1 = (4\Omega)(1.5\text{A}) = 6\text{V}. \)

(c) \( R_{eq} = \left( \frac{1}{4\Omega} + \frac{1}{4\Omega} \right)^{-1} + 2\Omega = 4\Omega, \quad P = \frac{(12\text{V})^2}{4\Omega} = 36\text{W}. \)
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, and $I_3$

(a) with the switch $S$ open,
(b) with the switch $S$ closed.
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, and $I_3$

(a) with the switch $S$ open,
(b) with the switch $S$ closed.

**Solution:**

(a) $I_1 = \frac{8V - 12V}{4\Omega} = -1A$,
$I_2 = -I_1 = +1A$.
$I_3 = 0$.

(b) $I_1 = \frac{8V - 12V}{4\Omega} = -1A$,
$I_3 = \frac{6V - 12V}{2\Omega} = -3A$.
$I_2 = -I_1 - I_3 = +4A$. 

\[\text{Diagram of the circuit}\]
Both capacitor circuits are at equilibrium. 
(a) In the circuit on the left, the voltage across capacitor 1 is $V_1 = 8\,\text{V}$. Find the charge $Q_1$ on capacitor 1, the charge $Q_2$ on capacitor 2, and the voltage $V_2$ across capacitor 2. Find the emf $\mathcal{E}_A$ supplied by the battery.
(b) In the circuit on the right, the charge on capacitor 3 is $Q_3 = 6\,\mu\text{C}$. Find the voltage $V_3$ across capacitor 3, the voltage $V_4$ across capacitor 4, and the charge $Q_4$ on capacitor 4. Find the emf $\mathcal{E}_B$ supplied by the battery.
Both capacitor circuits are at equilibrium.

(a) In the circuit on the left, the voltage across capacitor 1 is $V_1 = 8V$. Find the charge $Q_1$ on capacitor 1, the charge $Q_2$ on capacitor 2, and the voltage $V_2$ across capacitor 2. Find the emf $\mathcal{E}_A$ supplied by the battery.

(b) In the circuit on the right, the charge on capacitor 3 is $Q_3 = 6\mu C$. Find the voltage $V_3$ across capacitor 3, the voltage $V_4$ across capacitor 4, and the charge $Q_4$ on capacitor 4. Find the emf $\mathcal{E}_B$ supplied by the battery.

Solution:

(a) $Q_1 = (1\mu F)(8V) = 8\mu C$, 
$Q_2 = Q_1 = 8\mu C$,
$V_2 = \frac{8\mu C}{2\mu F} = 4V$, 
$\mathcal{E}_A = 8V + 4V = 12V$.

(b) $V_3 = \frac{6\mu C}{3\mu F} = 2V$, 
$V_4 = V_3 = 2V$,
$Q_4 = (2V)(4\mu F) = 8\mu C$, 
$\mathcal{E}_B = V_3 = V_4 = 2V$. 
Consider the resistor circuit shown.
(a) Find the equivalent resistance $R_{eq}$.
(b) Find the power $P$ supplied by the battery.
(c) Find the current $I_4$ through the $4\Omega$-resistor.
(d) Find the voltage $V_2$ across the $2\Omega$-resistor.
Consider the resistor circuit shown.
(a) Find the equivalent resistance $R_{eq}$.
(b) Find the power $P$ supplied by the battery.
(c) Find the current $I_4$ through the $4\Omega$-resistor.
(d) Find the voltage $V_2$ across the $2\Omega$-resistor.

Solution:

(a) $R_{eq} = 8\Omega$.

(b) $P = \frac{(24V)^2}{8\Omega} = 72W$.

(c) $I_4 = \frac{1}{2} \frac{24V}{8\Omega} = 1.5A$.

(d) $V_2 = (1.5A)(2\Omega) = 3V$.
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, $I_3$, and $I_4$. 

![Circuit Diagram]

1Ω 1Ω

1Ω 1Ω

1Ω 1Ω

1Ω 1Ω
Consider the electric circuit shown.
Find the currents $I_1$, $I_2$, $I_3$, and $I_4$.

Solution:
Use loops along quadrants in assumed current directions.
Start at center.

\[ +3V - I_1(1\Omega) - 1V = 0 \quad \Rightarrow \quad I_1 = 2A. \]
\[ +3V - I_2(1\Omega) + 2V = 0 \quad \Rightarrow \quad I_2 = 5A. \]
\[ -2V - I_3(1\Omega) + 5V = 0 \quad \Rightarrow \quad I_3 = 3A. \]
\[ +1V - I_4(1\Omega) + 5V = 0 \quad \Rightarrow \quad I_4 = 6A. \]
Both capacitor circuits are at equilibrium.
(a) Find the charge $Q_1$ on capacitor 1.
(b) Find the voltage $V_3$ across capacitor 3.
(c) Find the charge $Q_2$ on capacitor 2.
(d) Find the energy $U_4$ stored on capacitor 4.
Both capacitor circuits are at equilibrium.
(a) Find the charge $Q_1$ on capacitor 1.
(b) Find the voltage $V_3$ across capacitor 3.
(c) Find the charge $Q_2$ on capacitor 2.
(d) Find the energy $U_4$ stored on capacitor 4.

**Solution:**

(a) $C_{13} = \left( \frac{1}{C_1} + \frac{1}{C_3} \right)^{-1} = 0.75\text{pF}$, $Q_1 = Q_3 = Q_{13} = (24\text{V})(0.75\text{pF}) = 18\text{pC}$.

(b) $V_3 = \frac{Q_3}{C_3} = \frac{18\text{pC}}{3\text{pF}} = 6\text{V}$.

(c) $Q_2 = (24\text{V})(2\text{pF}) = 48\text{pC}$.

(d) $U_4 = \frac{1}{2}C_4V_4^2 = \frac{1}{2}(4\text{pF})(24\text{V})^2 = 1152\text{pJ}$. 
Consider the resistor circuit shown.
(a) Find the current $I_L$ on the left.
(b) Find the current $I_R$ on the right.
(c) Find the equivalent resistance $R_{eq}$ of all four resistors.
(d) Find the power $P_2$ dissipated in resistor 2.
Consider the resistor circuit shown.
(a) Find the current $I_L$ on the left.
(b) Find the current $I_R$ on the right.
(c) Find the equivalent resistance $R_{eq}$ of all four resistors.
(d) Find the power $P_2$ dissipated in resistor 2.

Solution:

(a) $I_L = \frac{24V}{1\Omega + 3\Omega} = 6A$.
(b) $I_R = \frac{24V}{4\Omega} = 6A$.
(c) $R_{eq} = \left( \frac{1}{1\Omega + 3\Omega} + \frac{1}{2\Omega} + \frac{1}{4\Omega} \right)^{-1} = 1\Omega$.
(d) $P_2 = \frac{(24V)^2}{2\Omega} = 288W$. 

\[\text{Diagram of the circuit with labels: } R_1 = 1\Omega, R_2 = 2\Omega, R_3 = 3\Omega, R_4 = 4\Omega.\]
Consider the electric circuit shown.
(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the current $I_3$.
(d) Find the potential difference $V_a - V_b$. 
Consider the electric circuit shown.
(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the current $I_3$.
(d) Find the potential difference $V_a - V_b$.

Solution:

(a) $12V + 3V - I_1(10\Omega) = 0 \Rightarrow I_1 = \frac{15V}{10\Omega} = 1.5A$.

(b) $-6V + 12V - I_2(5\Omega) = 0 \Rightarrow I_1 = \frac{6V}{5\Omega} = 1.2A$.

(c) $I_3 = I_1 + I_2 = 2.7A$.

(d) $V_a - V_b = -6V + 12V = 6V$. 
Find the equivalent capacitances $C_{eq}$ of the two capacitor circuits.
Find the equivalent capacitances $C_{eq}$ of the two capacitor circuits.

Solution:

- $C_{eq} = 3nF + \left( \frac{1}{3nF} + \frac{1}{3nF} + \frac{1}{3nF} \right)^{-1} = 4nF.$

- $C_{eq} = \left( \frac{1}{2\mu F} + \frac{1}{2\mu F + 2\mu F} + \frac{1}{2\mu F} \right)^{-1} = \frac{4}{5} \mu F.$
Consider a parallel-plate capacitor of capacitance $C = 6\text{pF}$ with plates separated a distance $d = 1\text{mm}$ and a potential difference $V = V_+ - V_- = 3\text{V}$ between them. 

(a) Find the magnitude $E$ of the electric field between the plates.  
(b) Find the amount $Q$ of charge on each plate.  
(c) Find the energy $U$ stored on the capacitor.  
(d) Find the area $A$ of each plate.
Consider a parallel-plate capacitor of capacitance $C = 6\text{pF}$ with plates separated a distance $d = 1\text{mm}$ and a potential difference $V = V_+ - V_- = 3\text{V}$ between them.

(a) Find the magnitude $E$ of the electric field between the plates.
(b) Find the amount $Q$ of charge on each plate.
(c) Find the energy $U$ stored on the capacitor.
(d) Find the area $A$ of each plate.

Solution:

(a) $E = \frac{V}{d} = \frac{3\text{V}}{1\text{mm}} = 3000\text{V/m}$.

(b) $Q = CV = (6\text{pF})(3\text{V}) = 18\text{pC}$.

(c) $U = \frac{1}{2}QV = 0.5(18\text{pC})(3\text{V}) = 27\text{pJ}$.

(d) $A = \frac{Cd}{\epsilon_0} = \frac{(6\text{pF})(1\text{mm})}{8.85 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}} = 6.78 \times 10^{-4}\text{m}^2$. 
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, $I_3$, and $I_4$. 
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, $I_3$, and $I_4$

Solution:

- $I_1 = \frac{12\text{V}}{2\Omega + 4\Omega} = 2\text{A}$.
- $I_2 = \frac{12\text{V}}{2\Omega} = 6\text{A}$.
- $I_3 = I_4 = I_1 + I_2 = 8\text{A}$. 
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, and $I_3$. 
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, and $I_3$

\[ 12 \text{V} + 6 \text{V} - (8 \Omega)I_1 = 0 \quad \Rightarrow \quad I_1 = \frac{9}{4} \text{A} = 2.25 \text{A}. \]

\[ 6 \text{V} - 3 \text{V} - (4 \Omega)I_2 = 0 \quad \Rightarrow \quad I_2 = \frac{3}{4} \text{A} = 0.75 \text{A}. \]

\[ I_3 = I_1 + I_2 = 3.00 \text{A}. \]
Consider the capacitor circuit shown at equilibrium.
(a) Find the equivalent capacitance \( C_{eq} \).
(b) Find the total energy \( U \) stored in the four capacitors.
(c) Find the voltage \( V_* \) across the capacitor marked by an asterisk.
Consider the capacitor circuit shown at equilibrium.
(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the total energy $U$ stored in the four capacitors.
(c) Find the voltage $V_*$ across the capacitor marked by an asterisk.

Solution:

$$C_{eq} = \left( \frac{1}{5nF + 1nF} + \frac{1}{6nF} + \frac{1}{6nF} \right)^{-1} = 2nF$$

$$U = \frac{1}{2} (2nF)(10V)^2 = 100nJ$$

$$V_* = \frac{10}{3} V = 3.33V$$

$$C_{eq} = \left( \frac{1}{4nF + 5nF} + \frac{1}{9nF} + \frac{1}{9nF} \right)^{-1} = 3nF$$

$$U = \frac{1}{2} (3nF)(20V)^2 = 600nJ$$

$$V_* = \frac{20}{3} V = 6.67V$$
Consider the resistor circuit shown.
(a) Find the equivalent resistance $R_{eq}$.
(b) Find the current $I$ flowing through the battery.
(c) Find the voltage $V_*$ across the resistor marked by an asterisk.
Consider the resistor circuit shown.
(a) Find the equivalent resistance $R_{eq}$.
(b) Find the current $I$ flowing through the battery.
(c) Find the voltage $V_\ast$ across the resistor marked by an asterisk.

\[ R_{eq} = \left( \frac{1}{8\Omega} + \frac{1}{8\Omega} \right)^{-1} + 3\Omega + 3\Omega = 10\Omega \]
\[ I = \frac{20V}{10\Omega} = 2A \]
\[ V_\ast = (1A)(8\Omega) = 8V \]

\[ R_{eq} = \left( \frac{1}{6\Omega} + \frac{1}{6\Omega} \right)^{-1} + 1\Omega + 1\Omega = 5\Omega \]
\[ I = \frac{20V}{5\Omega} = 4A \]
\[ V_\ast = (2A)(6\Omega) = 12V \]
Consider the $RC$ circuit shown. The switch has been closed for a long time.

(a) Find the current $I_B$ flowing through the battery.
(b) Find the voltage $V_C$ across the capacitor.
(c) Find the charge $Q$ on the capacitor.
(d) Find the current $I_3$ flowing through the $3\Omega$-resistor right after the switch has been opened.
Consider the $RC$ circuit shown. The switch has been closed for a long time.

(a) Find the current $I_B$ flowing through the battery.
(b) Find the voltage $V_C$ across the capacitor.
(c) Find the charge $Q$ on the capacitor.
(d) Find the current $I_3$ flowing through the $3\Omega$-resistor right after the switch has been opened.

Solution:

$$I_B = \frac{12V}{2\Omega + 4\Omega} = 2A$$

$$V_C = (2A)(2\Omega) = 4V$$

$$Q = (4V)(10nF) = 40nC$$

$$I_3 = \frac{4V}{2\Omega + 3\Omega} = 0.8A$$

$$I_B = \frac{12V}{3\Omega + 1\Omega + 4\Omega} = 1.5A$$

$$V_C = (1.5A)(3\Omega + 1\Omega) = 6V$$

$$Q = (6V)(10nF) = 60nC$$

$$I_3 = \frac{6V}{3\Omega + 1\Omega} = 1.5A$$
Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. The charge on capacitor $C_1 = 6 \text{pF} \ [8 \text{pF}]$ is $Q_1 = 18 \text{pC} \ [16 \text{pF}]$ and charge on capacitor $C_4 = 8 \text{pF} \ [4 \text{pF}]$ is $Q_4 = 16 \text{pC} \ [12 \text{pF}]$.
(a) Find the voltage $V_2$ across capacitor $C_2 = 4 \text{pF}$.
(b) Find the emf $\mathcal{E}_A$ supplied by the battery.
(c) Find the charge $Q_3$ on capacitor $C_3 = 3 \text{pF}$.
(d) Find the emf $\mathcal{E}_B$ supplied by the battery.
Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. The charge on capacitor $C_1 = 6\text{pF}$ is $Q_1 = 18\text{pC}$ and charge on capacitor $C_4 = 8\text{pF}$ is $Q_4 = 16\text{pC}$.

(a) Find the voltage $V_2$ across capacitor $C_2 = 4\text{pF}$.
(b) Find the emf $\varepsilon_A$ supplied by the battery.
(c) Find the charge $Q_3$ on capacitor $C_3 = 3\text{pF}$.
(d) Find the emf $\varepsilon_B$ supplied by the battery.

Solution:

(a) $Q_2 = Q_1 = 18\text{pC}$, $V_2 = \frac{Q_2}{C_2} = 4.5\text{V}$.
(b) $\varepsilon_A = V_1 + V_2 = 3\text{V} + 4.5\text{V} = 7.5\text{V}$.
(c) $V_3 = V_4 = \frac{Q_4}{C_4} = 2\text{V}$, $Q_3 = V_3C_3 = 6\text{pC}$.
(d) $\varepsilon_B = V_3 = V_4 = 2\text{V}$.
Consider the resistor circuit shown with $R_1 = 2\Omega$ [3Ω], $R_2 = 3\Omega$ [2Ω], and $R_3 = 1\Omega$.
(a) Find the current $I_2$ through resistor $R_2$.
(b) Find the voltage $V_3$ across resistor $R_3$.
(c) Find the power $P_1$ dissipated in resistor $R_1$.
(d) Find the equivalent resistance $R_{eq}$. 
Consider the resistor circuit shown with $R_1 = 2\Omega$ [3Ω], $R_2 = 3\Omega$ [2Ω], and $R_3 = 1\Omega$.

(a) Find the current $I_2$ through resistor $R_2$.
(b) Find the voltage $V_3$ across resistor $R_3$.
(c) Find the power $P_1$ dissipated in resistor $R_1$.
(d) Find the equivalent resistance $R_{eq}$.

Solution:

(a) $I_2 = \frac{12V}{3\Omega + 1\Omega} = 3A$  
\[
\left[ \frac{12V}{2\Omega + 1\Omega} = 4A \right].
\]

(b) $V_3 = (3A)(1\Omega) = 3V$  
\[
[4A)(1\Omega) = 4V].
\]

(c) $P_1 = \frac{(12V)^2}{2\Omega} = 72W$  
\[
\left[ \frac{(12V)^2}{3\Omega} = 48W \right].
\]

(d) $R_{eq} = \left(\frac{1}{2\Omega} + \frac{1}{3\Omega + 1\Omega}\right)^{-1} = \frac{4}{3} \Omega$  
\[
\left[ \left(\frac{1}{3\Omega} + \frac{1}{2\Omega + 1\Omega}\right)^{-1} = \frac{3}{2} \Omega \right].
\]
Consider the electric circuit shown. Find the currents $I_1$, $I_2$, $I_3$, $I_4$ when ...

(a) only switch $S_A$ is closed,
(b) only switch $S_B$ is closed,
(c) switches $S_A$ and $S_B$ are closed.

(a) only switch $S_C$ is closed,
(b) only switch $S_B$ is closed,
(c) switches $S_B$ and $S_C$ are closed.
Consider the electric circuit shown. Find the currents $I_1, I_2, I_3, I_4$ when ...

(a) only switch $S_A$ is closed,
(b) only switch $S_B$ is closed,
(c) switches $S_A$ and $S_B$ are closed.

(a) only switch $S_C$ is closed,
(b) only switch $S_B$ is closed,
(c) switches $S_B$ and $S_C$ are closed.

Solution:

(a) $I_1 = 0.6A$, $I_2 = -0.6A$, $I_3 = 0$, $I_4 = 0$.
(b) $I_1 = 0$, $I_2 = 0.2A$, $I_3 = -0.2A$, $I_4 = 0$.
(c) $I_1 = 0.6A$, $I_2 = -0.4A$, $I_3 = -0.2A$, $I_4 = 0$.

(a) $I_1 = 0$, $I_2 = 0$, $I_3 = -0.4A$, $I_4 = 0.4A$.
(b) $I_1 = 0$, $I_2 = 0.2A$, $I_3 = -0.2A$, $I_4 = 0$.
(c) $I_1 = 0$, $I_2 = 0.2A$, $I_3 = -0.6A$, $I_4 = 0.4A$. 
Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. Each of the six capacitors has a 2pF capacitance.
(a) Find the equivalent capacitance of the circuit on the left.
(b) Find the voltages $V_1$, $V_2$, $V_3$ across capacitors $C_1$, $C_2$, $C_3$, respectively.
(c) Find the equivalent capacitance of the circuit on the right.
(d) Find the charges $Q_4$, $Q_5$, $Q_6$ on capacitors $C_4$, $C_5$, $C_6$, respectively.
Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. Each of the six capacitors has a 2pF capacitance.

(a) Find the equivalent capacitance of the circuit on the left.
(b) Find the voltages $V_1$, $V_2$, $V_3$ across capacitors $C_1$, $C_2$, $C_3$, respectively.
(c) Find the equivalent capacitance of the circuit on the right.
(d) Find the charges $Q_4$, $Q_5$, $Q_6$ on capacitors $C_4$, $C_5$, $C_6$, respectively.

Solution:

(a) $C_{eq} = 2\text{pF} + \left(\frac{1}{2\text{pF}} + \frac{1}{2\text{pF}}\right)^{-1} = 3\text{pF}$.

(b) $V_1 = 12\text{V}$, $V_2 = V_3 = 6\text{V}$

(c) $C_{eq} = \left(\frac{1}{2\text{pF} + 2\text{pF}} + \frac{1}{2\text{pF}}\right)^{-1} = \frac{4}{3}\text{pF}$.

(d) $Q_{45} = Q_6 = C_{eq}(12\text{V}) = 16\text{pC}$ $\Rightarrow$ $Q_4 = Q_5 = 8\text{pC}$.
Consider the resistor circuit shown with $R_1 = 5\Omega$, $R_2 = 1\Omega$, and $R_3 = 3\Omega$.

(a) Find the equivalent resistance $R_{eq}$.

(b) Find the currents $I_1$, $I_2$, $I_3$ through resistors $R_1$, $R_2$, $R_3$, respectively.

(c) Find the voltages $V_1$, $V_2$, $V_3$ across resistors $R_1$, $R_2$, $R_3$, respectively.
Consider the resistor circuit shown with $R_1 = 5\Omega$, $R_2 = 1\Omega$, and $R_3 = 3\Omega$.

(a) Find the equivalent resistance $R_{eq}$.

(b) Find the currents $I_1$, $I_2$, $I_3$ through resistors $R_1$, $R_2$, $R_3$, respectively.

(c) Find the voltages $V_1$, $V_2$, $V_3$ across resistors $R_1$, $R_2$, $R_3$, respectively.

\[
R_{eq} = \left( \frac{1}{1\Omega + 3\Omega} + \frac{1}{5\Omega} \right)^{-1} = \frac{20}{9} \Omega = 2.22\Omega.
\]

\[
I_1 = \frac{12V}{5\Omega} = 2.4A, \quad I_2 = I_3 = \frac{12V}{1\Omega + 3\Omega} = 3A.
\]

\[
V_1 = R_1 I_1 = 12V, \quad V_2 = R_2 I_2 = 3V, \quad V_3 = R_3 I_3 = 9V.
\]
Consider the two-loop circuit shown.
(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the potential difference $V_a - V_b$. 

\[
\begin{align*}
\text{4V} & \quad \text{2V} \\
5\Omega & \quad 6V \\
3\Omega
\end{align*}
\]
Consider the two-loop circuit shown.
(a) Find the current $I_1$.
(b) Find the current $I_2$.
(c) Find the potential difference $V_a - V_b$.

Solution:
(a) $I_1 = \frac{6V - 4V}{5\Omega} = 0.4A$.
(b) $I_2 = \frac{6V + 2V}{3\Omega} = 2.67A$.
(c) $V_a - V_b = 6V + 2V = 8V$. 
Both capacitor circuits are at equilibrium.
(a) Find the charge $Q_1$ on capacitor 1.
(b) Find the energy $U_3$ stored on capacitor 3.
(c) Find the charge $Q_2$ on capacitor 2.
(d) Find the voltage $V_4$ across capacitor 4.
Both capacitor circuits are at equilibrium.
(a) Find the charge $Q_1$ on capacitor 1.
(b) Find the energy $U_3$ stored on capacitor 3.
(c) Find the charge $Q_2$ on capacitor 2.
(d) Find the voltage $V_4$ across capacitor 4.

Solution:

(a) $Q_1 = C_1 V_1 = (1 \text{pF})(24 \text{V}) = 24 \text{pC}$.

(b) $U_3 = \frac{1}{2} C_3 V_2^2 = \frac{1}{2} (3 \text{pF})(24 \text{V})^2 = 864 \text{pJ}$.

(c) $C_{24} = \left( \frac{1}{C_2} + \frac{1}{C_4} \right)^{-1} = \frac{4}{3} \text{pF}$,

$Q_2 = Q_4 = Q_{24} = C_{24} V_{24} = \left( \frac{4}{3} \text{pF} \right)(24 \text{V}) = 32 \text{pC}$.

(d) $V_4 = \frac{Q_4}{C_4} = \frac{32 \text{pC}}{4 \text{pF}} = 8 \text{V}$. 

\[\text{C}_3 = 3 \text{pF}\]
\[\text{C}_1 = 1 \text{pF}\]
\[\text{C}_4 = 4 \text{pF}\]
In the two resistor circuits shown find the equivalent resistances $R_{123}$ (left) and $R_{456}$ (right). Then find the currents $I_1, I_2, I_3$ through the individual resistors on the left. and the currents $I_4, I_5, I_6$ through the individual resistors on the right.
In the two resistor circuits shown find the equivalent resistances $R_{123}$ (left) and $R_{456}$ (right). Then find the currents $I_1, I_2, I_3$ through the individual resistors on the left. and the currents $I_4, I_5, I_6$ through the individual resistors on the right.

Solution:

- $R_{23} = 2\Omega + 2\Omega = 4\Omega$, \[ R_{123} = \left( \frac{1}{2\Omega} + \frac{1}{4\Omega} \right)^{-1} = \frac{4}{3}\Omega \]

- $R_{45} = \left( \frac{1}{2\Omega} + \frac{1}{2\Omega} \right)^{-1} = 1\Omega$, \[ R_{456} = R_{45} + R_6 = 3\Omega \]

- $I_1 = \frac{14V}{2\Omega} = 7A$, \[ I_2 = I_3 = \frac{14V}{4\Omega} = 3.5A \]

- $I_6 = I_{45} = \frac{14V}{3\Omega} = 4.67A$, \[ I_4 = I_5 = \frac{1}{2}I_6 = 2.33A \]
In the circuit shown find the currents $I_1, I_2$, and the potential difference $V_b - V_a$

(a) if the switch S is open,
(b) if the switch S is closed.
In the circuit shown find the currents $I_1, I_2$, and the potential difference $V_b - V_a$

(a) if the switch S is open,
(b) if the switch S is closed.

Solution:

(a) $I_1 = I_2 = \frac{12V}{5\Omega} = 2.4A$

$V_b - V_a = 8V - (2.4A)(2\Omega) = -4V + (2.4A)(3\Omega) = 3.2V$.

(b) $I_1 = \frac{8V}{2\Omega} = 4A, \quad I_2 = \frac{4V}{3\Omega} = 1.33A, \quad V_b - V_a = 0$. 
Consider the capacitor circuit shown at equilibrium. (a) Find the equivalent capacitance $C_{eq}$. (b) Find the total energy $U$ stored in the three capacitors. (c) Find the voltage $V_*$ across the capacitor marked by an asterisk. (d) Find the voltage $V_1$ across the 1nF-capacitor.
Consider the capacitor circuit shown at equilibrium. (a) Find the equivalent capacitance $C_{eq}$. (b) Find the total energy $U$ stored in the three capacitors. (c) Find the voltage $V_*$ across the capacitor marked by an asterisk. (d) Find the voltage $V_1$ across the 1nF-capacitor.

Solution:

(a) $C_{eq} = \left( \frac{1}{1\text{nF} + 2\text{nF}} + \frac{1}{3\text{nF}} \right)^{-1} = 1.5\text{nF}$

(b) $U = \frac{1}{2}(1.5\text{nF})(6\text{V})^2 = 27\text{nJ}$

(c) $V_* = \frac{1}{2}6\text{V} = 3\text{V}$

(d) $V_1 = 6\text{V} - 3\text{V} = 3\text{V}$

(a) $C_{eq} = \left( \frac{1}{3\text{nF} + 1\text{nF}} + \frac{1}{4\text{nF}} \right)^{-1} = 2\text{nF}$

(b) $U = \frac{1}{2}(2\text{nF})(8\text{V})^2 = 64\text{nJ}$

(c) $V_* = \frac{1}{2}8\text{V} = 4\text{V}$

(d) $V_1 = 8\text{V} - 4\text{V} = 4\text{V}$
Consider the resistor circuit shown. (a) Find the equivalent resistance $R_{eq}$. (b) Find the currents $I_1$ and $I_2$. (c) Find the power $P$ supplied by the battery.
Consider the resistor circuit shown. (a) Find the equivalent resistance $R_{eq}$. (b) Find the currents $I_1$ and $I_2$. (c) Find the power $P$ supplied by the battery.

Solution:

(a) $R_{eq} = \left( \frac{1}{4\Omega} + \frac{1}{4\Omega} \right)^{-1} + 3\Omega = 5\Omega$

(b) $I_1 = \frac{6V}{5\Omega} = 1.2A$, $I_2 = \frac{1}{2}I_1 = 0.6A$

(c) $P = (1.2A)(6V) = 7.2W$

(a) $R_{eq} = \left( \frac{1}{2\Omega} + \frac{1}{2\Omega} \right)^{-1} + 3\Omega = 4\Omega$

(b) $I_1 = \frac{8V}{4\Omega} = 2A$, $I_2 = \frac{1}{2}I_1 = 1A$

(c) $P = (2A)(8V) = 16W$
Consider the electric circuit shown.
Find the currents $I_1, I_2, I_3$. 

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{circuit_diagram.png}
\end{figure}
Consider the electric circuit shown.
Find the currents $I_1, I_2, I_3$.

\[
\begin{align*}
12V - I_2(2\Omega) - 3V &= 0 \\
\Rightarrow I_2 &= \frac{9V}{2\Omega} = 4.5A
\end{align*}
\]

\[
\begin{align*}
12V - I_3(3\Omega) + 3V &= 0 \\
\Rightarrow I_3 &= \frac{15V}{3\Omega} = 5A.
\end{align*}
\]

$I_1 = I_2 + I_3 = 9.5A$

\[
\begin{align*}
12V - I_2(2\Omega) + 3V &= 0 \\
\Rightarrow I_2 &= \frac{15V}{2\Omega} = 7.5A.
\end{align*}
\]

\[
\begin{align*}
12V - I_3(3\Omega) - 3V &= 0 \\
\Rightarrow I_3 &= \frac{9V}{3\Omega} = 3A.
\end{align*}
\]

$I_1 = I_2 + I_3 = 10.5A$
The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.

(b) Find the total energy $U$ stored in the three capacitors.

(c) Find the charge $Q_6$ on the capacitor on the left.

(d) Find the voltages $V_2$ and $V_4$ across the two capacitor on the right.
The circuit of capacitors connected to a battery is at equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.

(b) Find the total energy $U$ stored in the three capacitors.

(c) Find the charge $Q_6$ on the capacitor on the left.

(d) Find the voltages $V_2$ and $V_4$ across the two capacitors on the right.

Solution:

(a) $C_{eq} = \left( \frac{1}{\frac{2\mu F}{2\mu F} + \frac{1}{4\mu F}} + \frac{1}{\frac{6\mu F}{6\mu F}} \right)^{-1} = 3\mu F$.

(b) $U = \frac{1}{2} (3\mu F)(8V)^2 = 96\mu J$.

(c) $Q_6 = (8V)(3\mu F) = 24\mu C$.

(d) $V_2 = V_4 = \frac{1}{2} (8V) = 4V$. 

\[ \text{Diagram of the circuit} \]

\[ 6\mu F \quad 8V \quad 4\mu F \]

\[ 2\mu F \]
Consider the electrical circuit shown.

(a) Find the current $I_1$ when the switch $S$ is open.
(b) Find the currents $I_1$ and $I_2$ when the switch $S$ is closed.
Consider the electrical circuit shown.

(a) Find the current $I_1$ when the switch $S$ is open.
(b) Find the currents $I_1$ and $I_2$ when the switch $S$ is closed.

Solution:

(a) $I_1 = \frac{6V - 4V}{4\Omega + 5\Omega + 3\Omega + 2\Omega} = 0.143 \text{A}$.

(b) $I_1 = \frac{6V}{4\Omega + 5\Omega} = 0.667 \text{A}$, $I_2 = \frac{4V}{3\Omega + 2\Omega} = 0.8 \text{A}$. 
This $RC$ circuit has been running for a long time with the switch open.

(a) Find the current $I$ while the switch is still open.
(b) Find the current $I$ right after the switch has been closed.
(c) Find the current $I$ a long time later.
(d) Find the charge $Q$ on the capacitor also a long time later.
This $RC$ circuit has been running for a long time with the switch open.

(a) Find the current $I$ while the switch is still open.
(b) Find the current $I$ right after the switch has been closed.
(c) Find the current $I$ a long time later.
(d) Find the charge $Q$ on the capacitor also a long time later.

Solution:

(a) $I = \frac{12V}{2\Omega + 4\Omega} = 2A$.

(b) $I = \frac{12V}{2\Omega} = 6A$.

(c) $I = \frac{12V}{2\Omega + 4\Omega} = 2A$.

(d) $Q = (8V)(7nF) = 56nC$. 

The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

(a) the voltage $V_2$ across capacitor $C_2$,  
(b) the energy $U_5$ on capacitor $C_5$,  
(c) the charge $Q_3$ on capacitor $C_3$,  
(d) the equivalent capacitance $C_{eq}$.

(a) the voltage $V_4$ across capacitor $C_4$,  
(b) the energy $U_7$ on capacitor $C_7$,  
(c) the charge $Q_6$ on capacitor $C_6$,  
(d) the equivalent capacitance $C_{eq}$. 

![Circuit Diagram]

**Circuit Diagram**

- $V = 12V$
- $C_5 = 5 \mu F$
- $C_6 = 6 \mu F$
- $C_3 = 3 \mu F$
- $C_2 = 2 \mu F$

- $C_4 = 4 \mu F$
- $C_3 = 3 \mu F$
- $C_6 = 6 \mu F$
- $C_7 = 7 \mu F$
- $V = 18V$
The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

(a) the voltage $V_2$ across capacitor $C_2$,  
(b) the energy $U_5$ on capacitor $C_5$,  
(c) the charge $Q_3$ on capacitor $C_3$,  
(d) the equivalent capacitance $C_{eq}$.

(a) the voltage $V_4$ across capacitor $C_4$,  
(b) the energy $U_7$ on capacitor $C_7$,  
(c) the charge $Q_6$ on capacitor $C_6$,  
(d) the equivalent capacitance $C_{eq}$.

Solution:

(a) $V_2 = 12V$.

(b) $U_5 = \frac{1}{2} (5\mu F)(12V)^2 = 360\mu J$.

(c) $C_{36} = 2\mu F$
   \[
   \Rightarrow Q_3 = Q_{36} = (12V)(2\mu F) = 24\mu C.
   \]

(d) $C_{eq} = C_5 + C_{36} + C_2 = 9\mu F$.

(a) $V_4 = 18V$.

(b) $U_7 = \frac{1}{2} (7\mu F)(18V)^2 = 1134\mu J$.

(c) $C_{36} = 2\mu F$
   \[
   \Rightarrow Q_6 = Q_{36} = (18V)(2\mu F) = 36\mu C.
   \]

(d) $C_{eq} = C_4 + C_{36} + C_7 = 13\mu F$. 

1/5/2019 [tsl538 – 43/60]
This resistor circuit is in a state of steady currents. Find ...

(a) the voltage $V_2$ across resistor $R_2$,  
(b) the power $P_4$ dissipated in resistor $R_4$,  
(c) the current $I_3$ flowing through resistor $R_3$  
(d) the equivalent resistance $R_{eq}$.

(a) the voltage $V_3$ across resistor $R_3$,  
(b) the power $P_6$ dissipated in resistor $R_6$,  
(c) the current $I_4$ flowing through resistor $R_4$,  
(d) the equivalent resistance $R_{eq}$.
This resistor circuit is in a state of steady currents. Find ...

(a) the voltage $V_2$ across resistor $R_2$,  
(b) the power $P_4$ dissipated in resistor $R_4$,  
(c) the current $I_3$ flowing through resistor $R_3$  
(d) the equivalent resistance $R_{eq}$.

(a) the voltage $V_3$ across resistor $R_3$,  
(b) the power $P_6$ dissipated in resistor $R_6$,  
(c) the current $I_4$ flowing through resistor $R_4$,  
(d) the equivalent resistance $R_{eq}$.

Solution:

(a) $V_2 = 18V$.  
(b) $P_4 = \frac{18V^2}{4\Omega} = 81W$.  
(c) $I_3 = \frac{18V}{3\Omega + 1\Omega} = 4.5A$.  
(d) $R_{eq} = \left(\frac{1}{4\Omega} + \frac{1}{1\Omega + 3\Omega} + \frac{1}{2\Omega}\right)^{-1} = 1\Omega$.  

(a) $V_3 = 12V$.  
(b) $P_6 = \frac{12V^2}{6\Omega} = 24W$.  
(c) $I_4 = \frac{12V}{2\Omega + 4\Omega} = 2A$.  
(d) $R_{eq} = \left(\frac{1}{3\Omega} + \frac{1}{2\Omega + 4\Omega} + \frac{1}{6\Omega}\right)^{-1} = 1.5\Omega$.  

1/5/2019 [tsl539 – 44/60]
This two-loop resistor circuit is in a state of steady currents. Find ...
(a) the current $I_1$,
(b) the current $I_2$,
(c) the potential difference $V_a - V_b$. 

\[ I_1 \downarrow \quad 5V \quad 8\Omega \quad 6\Omega \quad I_2 \downarrow \]

\[ I_1 \uparrow \quad 7V \quad 11V \quad I_2 \uparrow \]
This two-loop resistor circuit is in a state of steady currents. Find ...
(a) the current $I_1$, 
(b) the current $I_2$, 
(c) the potential difference $V_a - V_b$.

Solution:

(a) $I_1 = \frac{5V + 7V}{8\Omega} = +1.5A$. 
(b) $I_2 = \frac{5V + 11V}{6\Omega} = +2.67A$. 
(c) $V_a - V_b = -7V + 11V = +4V$. 
(a) $I_1 = \frac{7V - 5V}{6\Omega} = +0.333A$. 
(b) $I_2 = \frac{5V + 11V}{8\Omega} = +2A$. 
(c) $V_a - V_b = 7V + 11V = +18V$. 
The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

(a) the charge \( Q_4 \) on the 4pF-capacitor,
(b) the energy \( U_7 \) on the 7pF-capacitor,
(c) the voltage \( V_{10} \) across the upper 10pF-capacitor,
(d) the equivalent capacitance \( C_{eq} \).

(a) the charge \( Q_3 \) on the 3pF-capacitor,
(b) the energy \( U_5 \) on the 5pF-capacitor,
(c) the voltage \( V_8 \) across the lower 8pF-capacitor,
(d) the equivalent capacitance \( C_{eq} \).
The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

(a) the charge $Q_4$ on the 4pF-capacitor,  
(b) the energy $U_7$ on the 7pF-capacitor,  
(c) the voltage $V_{10}$ across the upper 10pF-capacitor,  
(d) the equivalent capacitance $C_{eq}$.

(a) the charge $Q_3$ on the 3pF-capacitor,  
(b) the energy $U_5$ on the 5pF-capacitor,  
(c) the voltage $V_8$ across the lower 8pF-capacitor,  
(d) the equivalent capacitance $C_{eq}$.

Solution:

(a) $Q_4 = (6V)(4pF) = 24pC$.  
(b) $U_7 = \frac{1}{2}(7pF)(6V)^2 = 126pJ$.  
(c) $V_{10} = \frac{1}{2}6V = 3V$.  
(d) $C_{eq} = 4pF + 7pF + 5pF = 16pF$.

(a) $Q_3 = (9V)(3pF) = 27pC$.  
(b) $U_5 = \frac{1}{2}(5pF)(9V)^2 = 202.5pJ$.  
(c) $V_8 = \frac{1}{2}9V = 4.5V$.  
(d) $C_{eq} = 3pF + 5pF + 4pF = 12pF$. 
Consider this circuit with two terminals, four resistors, and one switch.

(a) Find the equivalent resistance $R_{eq}^{(open)}$ when the switch is open.

(b) Find the equivalent resistance $R_{eq}^{(closed)}$ when the switch is closed.
Consider this circuit with two terminals, four resistors, and one switch.

(a) Find the equivalent resistance $R_{\text{eq}}^{(\text{open})}$ when the switch is open.
(b) Find the equivalent resistance $R_{\text{eq}}^{(\text{closed})}$ when the switch is closed.

Solution:

\[
R_{\text{eq}}^{(\text{open})} = \left( \frac{1}{1\Omega + 2\Omega} + \frac{1}{1\Omega + 2\Omega} \right)^{-1} = \frac{3}{2} \Omega.
\]

\[
R_{\text{eq}}^{(\text{closed})} = \left( \frac{1}{1\Omega + 3\Omega} + \frac{1}{1\Omega + 3\Omega} \right)^{-1} = 2\Omega.
\]

\[
R_{\text{eq}}^{(\text{open})} = \left( \frac{1}{1\Omega + 2\Omega} + \frac{1}{1\Omega + 2\Omega} \right)^{-1} = \frac{3}{2} \Omega.
\]

\[
R_{\text{eq}}^{(\text{closed})} = \left( \frac{1}{1\Omega + 3\Omega} + \frac{1}{1\Omega + 3\Omega} \right)^{-1} = \frac{3}{2} \Omega.
\]
Consider this circuit with two batteries, two resistors, and one switch.
(a) Find the current $I$ when the switch is open.
(b) Find the current $I$ when the switch is closed.
(c) Find the potential difference $V_a - V_b$ when the switch is open.
(d) Find the potential difference $V_a - V_b$ when the switch is closed.
Consider this circuit with two batteries, two resistors, and one switch.
(a) Find the current $I$ when the switch is open.
(b) Find the current $I$ when the switch is closed.
(c) Find the potential difference $V_a - V_b$ when the switch is open.
(d) Find the potential difference $V_a - V_b$ when the switch is closed.

Solution:

(a) $I = \frac{15\text{V}}{5\Omega} = 3\text{A}$.
(b) $I = \frac{15\text{V}}{5\Omega} + \frac{12\text{V}}{6\Omega} = 3\text{A} + 2\text{A} = 5\text{A}$.
(c) $V_a - V_b = 12\text{V}$.
(d) $V_a - V_b = 0$.

(a) $I = \frac{16\text{V}}{2\Omega} = 8\text{A}$.
(b) $I = \frac{16\text{V}}{2\Omega} + \frac{15\text{V}}{5\Omega} = 8\text{A} + 3\text{A} = 11\text{A}$.
(c) $V_a - V_b = 15\text{V}$.
(d) $V_a - V_b = 0$. 
This circuit is at equilibrium.

- Find the charge $Q_7$ on capacitor $C_7$ [$Q_5$ on $C_5$].
- Find the energy $U_5$ on capacitor $C_5$ [$U_7$ on $C_7$].
- Find the voltages $V_2$, $V_4$ across capacitors $C_2$, $C_4$ [$V_3$, $V_6$ across $C_3$, $C_6$].
This circuit is at equilibrium.

- Find the charge $Q_7$ on capacitor $C_7$ [$Q_5$ on $C_5$].
- Find the energy $U_5$ on capacitor $C_5$ [$U_7$ on $C_7$].
- Find the voltages $V_2$, $V_4$ across capacitors $C_2$, $C_4$ [$V_3$, $V_6$ across $C_3$, $C_6$].

Solution:

- $Q_7 = (24\text{V})(7\mu\text{F}) = 168\mu\text{C}$  [$Q_5 = (24\text{V})(5\mu\text{F}) = 120\mu\text{C}$]
- $U_5 = \frac{1}{2}(5\mu\text{F})(24\text{V})^2 = 1440\mu\text{J}$  [$U_7 = \frac{1}{2}(7\mu\text{F})(24\text{V})^2 = 2016\mu\text{J}$]
- $V_2 + V_4 = 24\text{V}$,  $V_2C_2 = V_4C_4$  $\Rightarrow$  $V_2 = 16\text{V}$,  $V_4 = 8\text{V}$
  [$V_3 + V_6 = 24\text{V}$,  $V_3C_3 = V_6C_6$  $\Rightarrow$  $V_3 = 16\text{V}$,  $V_6 = 8\text{V}$]
Consider the resistor circuit on the left [right].
Find the currents $I_1$, $I_2$ [$I_3$, $I_4$] and the potential difference $V_a - V_b$ [$V_c - V_d$]

(a) when the switch $S_w$ [$S_y$] is open,
(b) when the switch $S_w$ [$S_y$] is closed
Consider the resistor circuit on the left. Find the currents $I_1, I_2 [I_3, I_4]$ and the potential difference $V_a - V_b [V_c - V_d]$.

(a) when the switch $S_w [S_y]$ is open,

(b) when the switch $S_w [S_y]$ is closed

**Solution:**

(a) $I_1 = I_2 = \frac{3V + 6V}{5\Omega + 3\Omega} = 1.125A$, $V_a - V_b = 9V.$

$$I_3 = I_4 = \frac{2V + 5V}{6\Omega + 4\Omega} = 0.7A, \quad V_c - V_d = 7V.$$  

(b) $I_1 = \frac{3V}{5\Omega} = 0.6A$, $I_2 = \frac{6V}{3\Omega} = 2A$, $V_a - V_b = 9V.$

$$I_3 = \frac{5V}{4\Omega} = 1.25A, \quad I_4 = \frac{2V}{6\Omega} = 0.333A, \quad V_c - V_d = 7V.$$
The switch S of this circuit has been open for a long time. The capacitor has capacitance $C = 6\text{pF}$ [$C = 4\text{pF}$]. Each resistor has resistance $R = 6\Omega$ [$R = 4\Omega$].

(a) Find the currents $I_1, I_2, I_3$ right after the switch has been closed.

(b) Find the currents $I_1, I_2, I_3$ a long time later.
The switch $S$ of this circuit has been open for a long time. The capacitor has capacitance $C = 6\, \text{pF}$ [$C = 4\, \text{pF}$]. Each resistor has resistance $R = 6\, \Omega$ [$R = 4\, \Omega$].

(a) Find the currents $I_1, I_2, I_3$ right after the switch has been closed.
(b) Find the currents $I_1, I_2, I_3$ a long time later

**Solution:**

(a) no voltage across capacitor: $R_{eq} = 9\, \Omega$ [i.e., $R_{eq} = 6\, \Omega$]

\[
I_3 = I_1 + I_2 = \frac{36\, \text{V}}{9\, \Omega} = 4\, \text{A}, \quad I_1 = I_2 = 2\, \text{A} \quad \left[ I_3 = I_1 + I_2 = \frac{36\, \text{V}}{6\, \Omega} = 6\, \text{A}, \quad I_1 = I_2 = 3\, \text{A} \right].
\]

(b) no current through capacitor: $R_{eq} = 12\, \Omega$ [i.e., $R_{eq} = 8\, \Omega$]

\[
I_1 = I_3 = \frac{36\, \text{V}}{12\, \Omega} = 3\, \text{A}, \quad I_2 = 0, \quad \left[ I_1 = I_3 = \frac{36\, \text{V}}{8\, \Omega} = 4.5\, \text{A}, \quad I_2 = 0 \right].
\]
The circuit shown has reached equilibrium. The specifications are $E = 12\text{V}$, $C_1 = C_2 = C_3 = 5\text{nF}$.

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charge $Q_2$ on capacitor $C_2$.
(c) Find the voltage $V_3$ across capacitor $C_3$.
(d) Find the total energy $U$ stored in the capacitors.
The circuit shown has reached equilibrium. The specifications are $E = 12\, \text{V}$, $C_1 = C_2 = C_3 = 5\, \text{nF}$.

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charge $Q_2$ on capacitor $C_2$.
(c) Find the voltage $V_3$ across capacitor $C_3$.
(d) Find the total energy $U$ stored in the capacitors.

Solution:

(a) $C_{12} = C_1 + C_2 = 10\, \text{nF}$. 
   $$C_{eq} = \left( \frac{1}{C_{12}} + \frac{1}{C_3} \right)^{-1} = \frac{10}{3} \, \text{nF} \left[ \frac{8}{3} \, \text{nF} \right].$$

(b) $Q_3 = Q_{12} = E C_{eq} = 40\, \text{nC}$, $Q_1 = Q_2 = \frac{1}{2} Q_{12} = 20\, \text{nC}$.

(c) $V_3 = \frac{Q_3}{C_3} = 8 \, \text{V}$, $V_1 = V_2 = \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = 4 \, \text{V}$.

(d) $U = \frac{1}{2} C_{eq} E^2 = 240 \, \text{nJ}$.
The circuit shown is in a steady state. The specifications are $\mathcal{E} = 12\text{V}$, $R_1 = R_2 = R_3 = 5\Omega$.

(a) Find the equivalent resistance $R_{eq}$.
(b) Find the currents $I_1$ through resistor $R_1$.
(c) Find the voltage $V_3$ across resistor $R_3$.
(d) Find the power $P$ produced by the battery.
The circuit shown is in a steady state. The specifications are $\mathcal{E} = 12\text{V}$ [18V], $R_1 = R_2 = R_3 = 5\Omega$ [4\Omega].

(a) Find the equivalent resistance $R_{eq}$.
(b) Find the currents $I_1$ through resistor $R_1$.
(c) Find the voltage $V_3$ across resistor $R_3$.
(d) Find the power $P$ produced by the battery.

Solution:

(a) $R_{12} = \left( \frac{1}{R_1} + \frac{1}{R_3} \right)^{-1} = 2.5\Omega$ [2.0\Omega], $R_{eq} = R_{12} + R_3 = 7.5\Omega$ [6.0\Omega].

(b) $I_3 = I_{12} = \frac{\mathcal{E}}{R_{eq}} = 1.6\text{A}$ [3.0A], $I_1 = I_2 = \frac{1}{2}I_{12} = 0.8\text{A}$ [1.5A].

(c) $V_3 = R_3I_3 = 8\text{V}$ [12V], $V_1 = V_2 = R_1I_1 = R_2I_2 = 4\text{V}$ [6V].

(d) $P = \frac{\mathcal{E}^2}{R_{eq}} = R_{eq}I_3^2 = 19.2\text{W}$ [54.0W].
This circuit is in a steady state with the switch $S$ either open or closed.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.
(b) Find the currents $I_1$ and $I_2$ when the switch is closed.
(c) Find the voltages $V_a - V_b$ and $V_b - V_c$ when the switch is open.
(d) Find the voltages $V_a - V_b$ and $V_b - V_c$ when the switch is closed.
This circuit is in a steady state with the switch $S$ either open or closed.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.

(b) Find the currents $I_1$ and $I_2$ when the switch is closed.

(c) Find the voltages $V_a - V_b$ and $V_b - V_c$ when the switch is open.

(d) Find the voltages $V_a - V_b$ and $V_b - V_c$ when the switch is closed.

Solution:

(a) $I_1 = I_2 = \frac{6V + 8V - 3V - 2V}{3\Omega + 4\Omega} = \frac{9}{7}A = 1.29A$.

(b) $I_1 = \frac{8V - 3V}{4\Omega} = \frac{5}{4}A = 1.25A, \quad I_2 = \frac{6V - 2V}{3\Omega} = \frac{4}{3}A = 1.33A$.

(c) $V_a - V_b = 8V - (1.29A)(4\Omega) = 2.84V, \quad V_b - V_c = 6V - (1.29A)(3\Omega) = 2.13V$.

(d) $V_a - V_b = 3V, \quad V_b - V_c = 2V$. 
The circuit shown has reached equilibrium. The specifications are $E = 12\text{V}$ [14V], $C_1 = C_2 = C_3 = 7\text{nF}$ [5nF]

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charges $Q_1, Q_2, Q_3$ on capacitors 1, 2, 3, respectively.
(c) Find the voltages $V_1, V_2, V_3$ across capacitors 1, 2, 3, respectively.
The circuit shown has reached equilibrium.
The specifications are $E = 12\text{V}$ [14V], $C_1 = C_2 = C_3 = 7\text{nF}$ [5nF]

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charges $Q_1, Q_2, Q_3$ on capacitors 1, 2, 3, respectively.
(c) Find the voltages $V_1, V_2, V_3$ across capacitors 1, 2, 3, respectively.

Solution:

(a) $C_{13} = \left( \frac{1}{C_1} + \frac{1}{C_3} \right)^{-1} = \frac{7}{2}\text{nF} \left[ \frac{5}{2}\text{nF} \right]$.

$C_{eq} = C_{13} + C_2 = \frac{21}{2}\text{nF} \left[ \frac{15}{2}\text{nF} \right]$.

(b) $Q_1 = Q_3 = E C_{13} = 42\text{nC}$ [35nC], $Q_2 = E C_2 = 84\text{nC}$ [70nC].

(c) $V_1 = \frac{Q_1}{C_1} = 6\text{V}$ [7V], $V_2 = \frac{Q_2}{C_2} = 12\text{V}$ [14V], $V_3 = \frac{Q_3}{C_3} = 6\text{V}$ [7V].
The circuit shown is in a steady state. The specifications are \( \mathcal{E} = 12 \text{V} \) [14V], \( R_1 = R_2 = R_3 = 7 \Omega \) [5Ω].

(a) Find the equivalent resistance \( R_{eq} \).
(b) Find the currents \( I_1, I_2, I_3 \) through resistors 1, 2, 3, respectively.
(c) Find the voltages \( V_1, V_2, V_3 \) across resistors 1, 2, 3, respectively.
The circuit shown is in a steady state. The specifications are \( E = 12\,\text{V} \) [14V], \( R_1 = R_2 = R_3 = 7\,\Omega \) [5\,\Omega].

(a) Find the equivalent resistance \( R_{eq} \).
(b) Find the currents \( I_1, I_2, I_3 \) through resistors 1, 2, 3, respectively.
(c) Find the voltages \( V_1, V_2, V_3 \) across resistors 1, 2, 3, respectively.

**Solution:**

(a) \( R_{13} = R_1 + R_3 = 14\,\Omega \) [10A], \( R_{eq} = \left( \frac{1}{R_{13}} + \frac{1}{R_2} \right)^{-1} = 4.67\,\Omega \) [3.33A].

(b) \( I_1 = I_3 = \frac{E}{R_{13}} = 0.857\,\text{A} \) [1.40A], \( I_2 = \frac{E}{R_2} = 1.71\,\text{A} \) [2.80A].

(c) \( V_1 = R_1 I_1 = 6\,\text{V} \) [7V], \( V_2 = R_2 I_2 = 12\,\text{V} \) [14V], \( V_3 = R_3 I_3 = 6\,\text{V} \) [7V].
This circuit is in a steady state with the switch $S$ either open or closed. The specifications are $\varepsilon_1 = 4\text{ V} [3\text{ V}], \varepsilon_2 = 6\text{ V} [7\text{ V}], \varepsilon_3 = 10\text{ V} [9\text{ V}], R = 7\Omega [11\Omega]$.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.
(b) Find the currents $I_1$ and $I_2$ when the switch is closed.
(c) Find the voltages $V_b - V_a$ when the switch is open.
(d) Find the voltages $V_b - V_a$ when the switch is closed.

\[ I_1 \quad S \quad b \quad R \quad I_2 \]

\[ \varepsilon_1 \quad R \quad \varepsilon_2 \quad \varepsilon_3 \]

\[ I_1 \quad S \quad I_2 \]
This circuit is in a steady state with the switch $S$ either open or closed. The specifications are $\mathcal{E}_1 = 4\text{V} [3\text{V}]$, $\mathcal{E}_2 = 6\text{V} [7\text{V}]$, $\mathcal{E}_3 = 10\text{V} [9\text{V}]$, $R = 7\Omega [11\Omega]$.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.
(b) Find the currents $I_1$ and $I_2$ when the switch is closed.
(c) Find the voltages $V_b - V_a$ when the switch is open.
(d) Find the voltages $V_b - V_a$ when the switch is closed.

Solution:

(a) $I_1 = I_2 = \frac{10\text{V} - 4\text{V}}{7\Omega + 7\Omega} = 0.429\text{A}$

\[
\begin{align*}
I_1 &= I_2 = \frac{9\text{V} - 3\text{V}}{11\Omega + 11\Omega} = 0.273\text{A}
\end{align*}
\]

(b) $I_1 = \frac{6\text{V} - 4\text{V}}{7\Omega} = 0.286\text{A}$, $I_2 = \frac{10\text{V} - 6\text{V}}{7\Omega} = 0.571\text{A}$

\[
\begin{align*}
I_1 &= \frac{7\text{V} - 3\text{V}}{11\Omega} = 0.364\text{A}, & I_2 &= \frac{9\text{V} - 7\text{V}}{11\Omega} = 0.182\text{A}
\end{align*}
\]

(c) $V_b - V_a = (0.429\text{A})(7\Omega) + 4\text{V} = 10\text{V} - (0.429\text{A})(7\Omega) = 7\text{V}$

\[
\begin{align*}
V_b - V_a &= (0.273\text{A})(11\Omega) + 3\text{V} = 9\text{V} - (0.273\text{A})(11\Omega) = 6\text{V}
\end{align*}
\]

(d) $V_b - V_a = 6\text{V}$ $[V_b - V_a = 7\text{V}]$
The circuit shown has reached equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charges $Q_1, Q_2, Q_3, Q_4$ on the four capacitors.
(c) Find the voltages $V_1, V_2, V_3, V_4$ across the four capacitors.
The circuit shown has reached equilibrium.

(a) Find the equivalent capacitance $C_{eq}$.
(b) Find the charges $Q_1, Q_2, Q_3, Q_4$ on the four capacitors.
(c) Find the voltages $V_1, V_2, V_3, V_4$ across the four capacitors.

Solution:

(a) $C_{34} = C_3 + C_4 = 2 \text{pF}$, $C_{eq} = \left( \frac{1}{C_1} + \frac{1}{C_{34}} + \frac{1}{C_2} \right)^{-1} = \frac{1}{2} \text{pF}$.

(b) $Q_1 = Q_2 = Q_{34} = C_{eq}(6 \text{V}) = 3 \text{pC}$, $Q_3 = Q_4 = \frac{1}{2}Q_{34} = 1.5 \text{pC}$.

(c) $V_1 = \frac{Q_1}{C_1} = 1.5 \text{V}$, $V_2 = \frac{Q_2}{C_2} = 3 \text{V}$, $V_3 = \frac{Q_3}{C_3} = 1.5 \text{V}$, $V_4 = \frac{Q_4}{C_4} = 1.5 \text{V}$. 
The circuit shown is in a steady state with the switch S either open or closed.

(a) Find the equivalent resistance $R_{eq}$ when the switch is open.
(b) Find the currents $I_1$ and $I_2$ when the switch is open.
(c) Find the equivalent resistance $R_{eq}$ when the switch is closed.
(d) Find the currents $I_1$ and $I_2$ when the switch is closed.
The circuit shown is in a steady state with the switch S either open or closed.

(a) Find the equivalent resistance $R_{eq}$ when the switch is open.
(b) Find the currents $I_1$ and $I_2$ when the switch is open.
(c) Find the equivalent resistance $R_{eq}$ when the switch is closed.
(d) Find the currents $I_1$ and $I_2$ when the switch is closed.

Solution:

(a) $R_{eq} = 2\Omega + 3\Omega + 3\Omega + 2\Omega = 10\Omega$.

(b) $I_1 = 0$, $I_2 = \frac{18V}{10\Omega} = 1.8A$.

(c) $R_{eq} = 2\Omega + \left(\frac{1}{3\Omega} + \frac{1}{3\Omega + 3\Omega}\right)^{-1} + 2\Omega = 6\Omega$.

(d) $I_1 = \frac{6V}{3\Omega} = 2A$, $I_2 = \frac{6V}{3\Omega + 3\Omega} = 1A$. 
This circuit is in a steady state with the switch S either open or closed.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.
(b) Find the voltage $V_a - V_b$ when the switch is open.
(c) Find the currents $I_1$ and $I_2$ when the switch is closed.
(d) Find the voltage $V_a - V_b$ when the switch is closed.
This circuit is in a steady state with the switch S either open or closed.

(a) Find the currents $I_1$ and $I_2$ when the switch is open.
(b) Find the voltage $V_a - V_b$ when the switch is open.
(c) Find the currents $I_1$ and $I_2$ when the switch is closed.
(d) Find the voltage $V_a - V_b$ when the switch is closed.

Solution:

(a) $I_1 = I_2 = \frac{4V + 6V}{1\Omega + 4\Omega} = 2A$.
(b) $V_a - V_b = -(1\Omega)(2A) + 4V = 2V,$ $V_a - V_b = -6V + (4\Omega)(2A) = 2V$.
(c) $I_1 = \frac{6V - 2V}{4\Omega} = 1A,$ $I_2 = \frac{4V + 2V}{1\Omega} = 6A$.
(d) $V_a - V_b = -2V$. 

\[ \text{Diagram of circuit with current directions indicated} \]