

University of Rhode Island

DigitalCommons@URI

---

PHY 204: Elementary Physics II (2015)

Physics Open Educational Resources

---

11-19-2015

## E2. Previous Unit Exams 2

Gerhard Müller

University of Rhode Island, gmuller@uri.edu

Follow this and additional works at: [https://digitalcommons.uri.edu/elementary\\_physics\\_2](https://digitalcommons.uri.edu/elementary_physics_2)

### Abstract

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

Some of the slides contain figures from the textbook, Paul A. Tipler and Gene Mosca. *Physics for Scientists and Engineers*, 5<sup>th</sup>/6<sup>th</sup> editions. The copyright to these figures is owned by W.H. Freeman. We acknowledge permission from W.H. Freeman to use them on this course web page. The textbook figures are not to be used or copied for any purpose outside this class without direct permission from W.H. Freeman.

---

### Recommended Citation

Müller, Gerhard, "E2. Previous Unit Exams 2" (2015). *PHY 204: Elementary Physics II (2015)*. Paper 2. [https://digitalcommons.uri.edu/elementary\\_physics\\_2/2](https://digitalcommons.uri.edu/elementary_physics_2/2)[https://digitalcommons.uri.edu/elementary\\_physics\\_2/2](https://digitalcommons.uri.edu/elementary_physics_2/2)

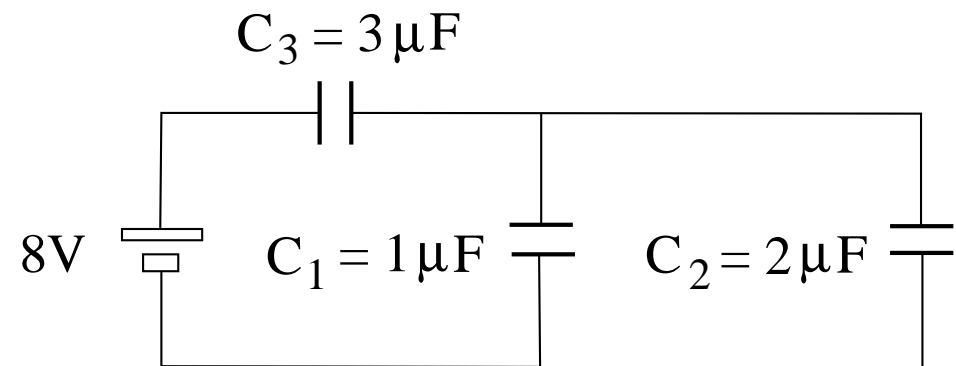
This Course Material is brought to you for free and open access by the Physics Open Educational Resources at DigitalCommons@URI. It has been accepted for inclusion in PHY 204: Elementary Physics II (2015) by an authorized administrator of DigitalCommons@URI. For more information, please contact [digitalcommons@etal.uri.edu](mailto:digitalcommons@etal.uri.edu).

## Intermediate Exam II: Problem #1 (Spring '05)



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  $C_2$ .

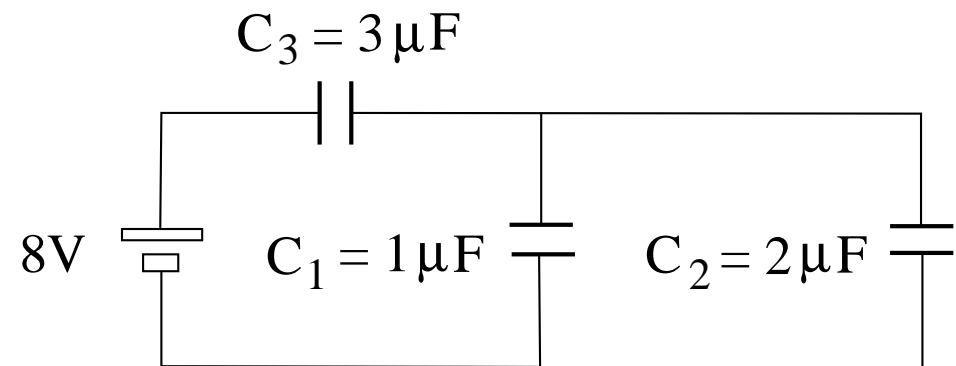


## Intermediate Exam II: Problem #1 (Spring '05)



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:**

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

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

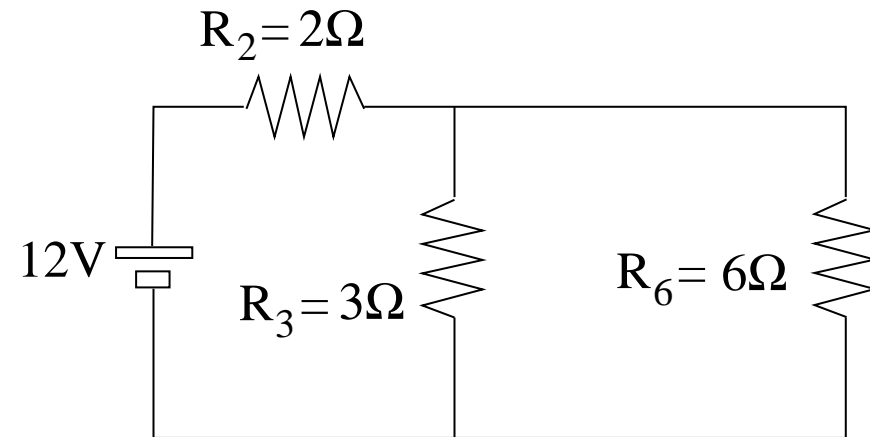
$$(c) \quad Q_2 = V_2 C_2 = 8\mu\text{C}.$$

## Intermediate Exam II: Problem #2 (Spring '05)



Consider the electrical circuit shown.

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

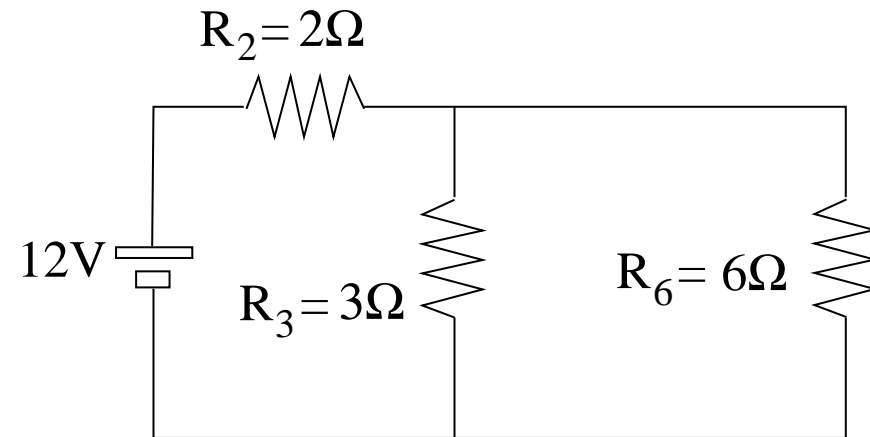


## Intermediate Exam II: Problem #2 (Spring '05)



Consider the electrical circuit shown.

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



**Solution:**

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

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

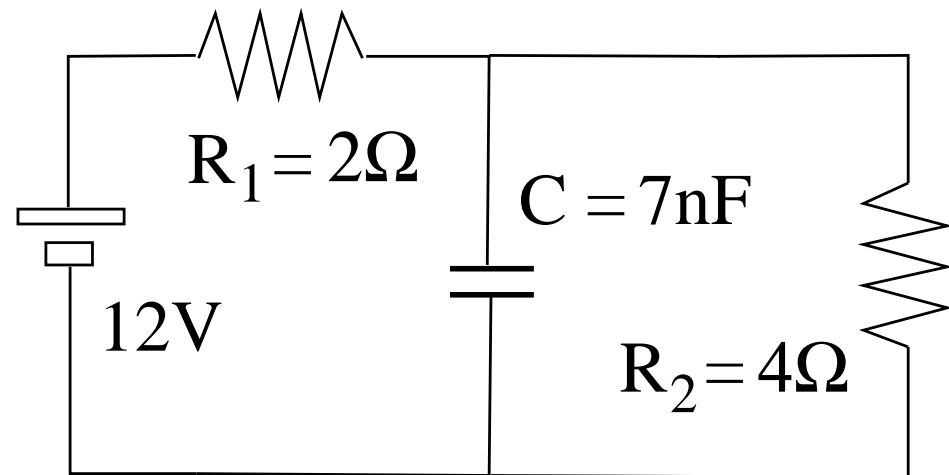
$$\Rightarrow V_3 = V_{36} = I_{36}R_{36} = 6V \quad \Rightarrow I_3 = \frac{V_3}{R_3} = 2A.$$

## Intermediate Exam II: Problem #3 (Spring '05)



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.

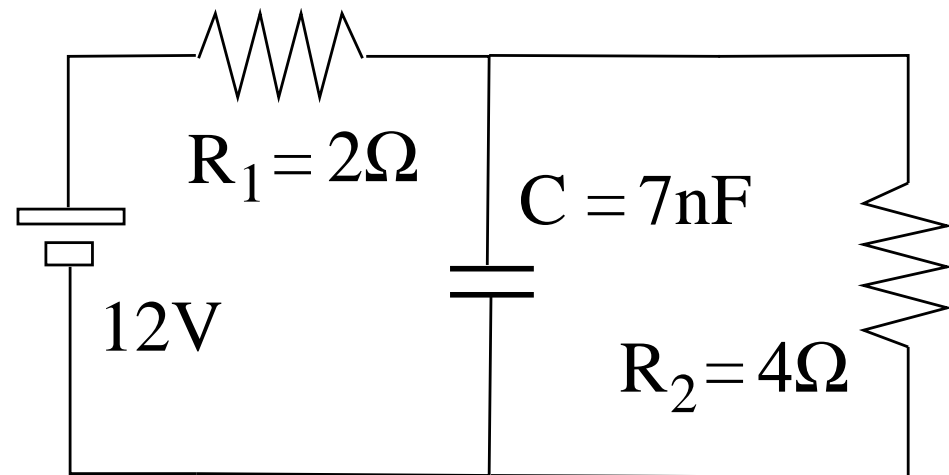


## Intermediate Exam II: Problem #3 (Spring '05)



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

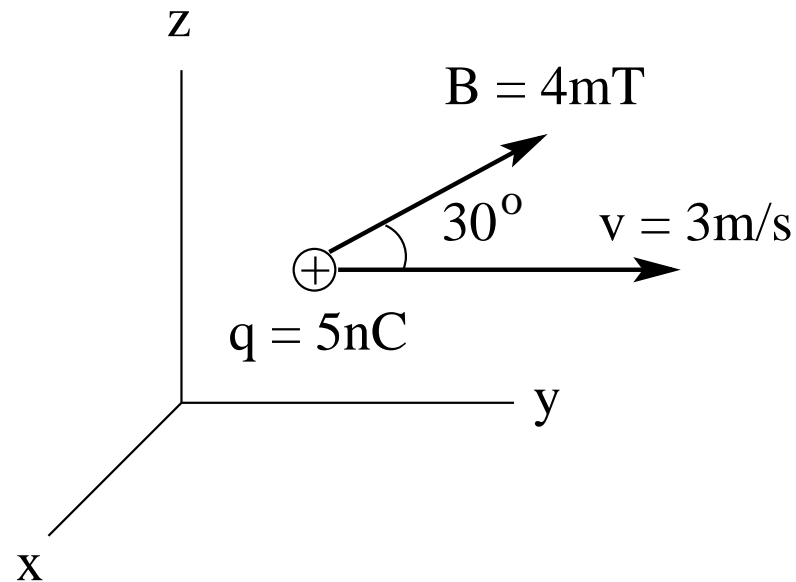
(b)  $V_C = V_2 = I_2 R_2 = (2\text{A})(4\Omega) = 8\text{V}$ .

## Intermediate Exam II: Problem #4 (Spring '05)



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.

- Find the direction of the magnetic force acting on the particle.
- Find the magnitude of the magnetic force acting on the particle.



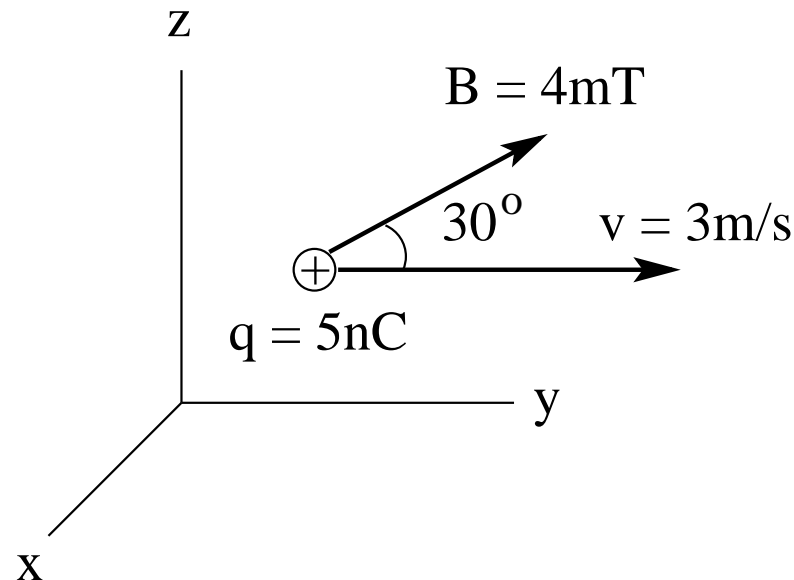


## Intermediate Exam II: Problem #4 (Spring '05)



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.

- Find the direction of the magnetic force acting on the particle.
- Find the magnitude of the magnetic force acting on the particle.



**Solution:**

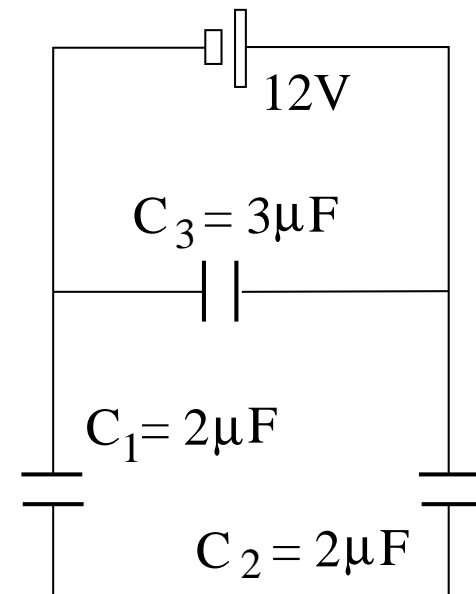
- Use the right-hand rule: positive  $x$ -direction (front, out of page).
- $F = qvB \sin 30^\circ = (5 \times 10^{-9}\text{ C})(3\text{ m/s})(4 \times 10^{-3}\text{ T})(0.5) = 3 \times 10^{-11}\text{ N}$ .

## Intermediate Exam II: Problem #1 (Spring '06)



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  $C_2$ .

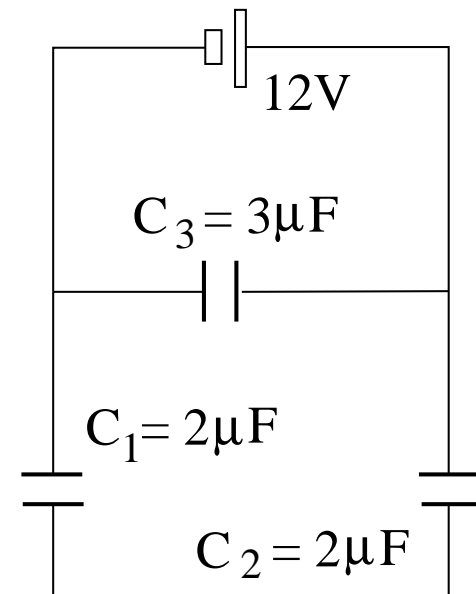


## Intermediate Exam II: Problem #1 (Spring '06)



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

- Find the charge  $Q_3$  on capacitor  $C_3$ .
- Find the charge  $Q_2$  on capacitor  $C_2$ .



**Solution:**

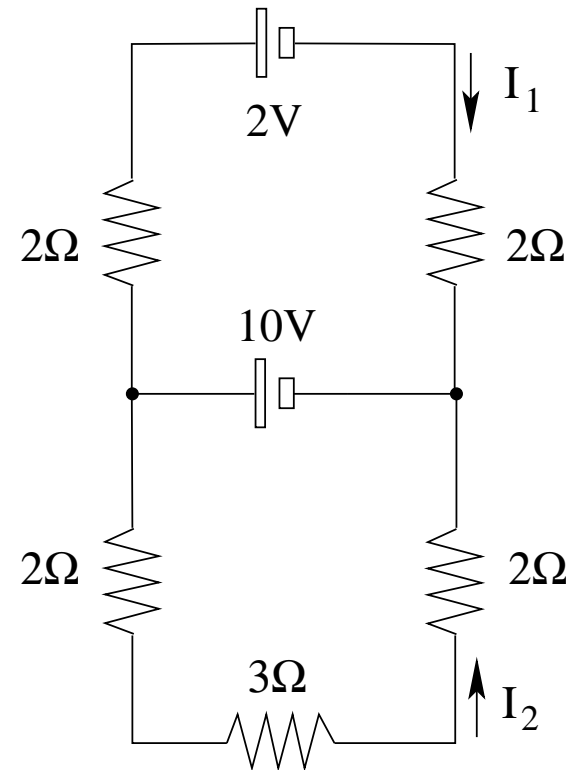
- $Q_3 = C_3(12\text{V}) = (3\mu\text{F})(12\text{V}) = 36\mu\text{C}$ .
- $Q_2 = Q_{12} = C_{12}(12\text{V}) = (1\mu\text{F})(12\text{V}) = 12\mu\text{C}$ .

# Intermediate Exam II: Problem #2 (Spring '06)



Consider the two-loop circuit shown.

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

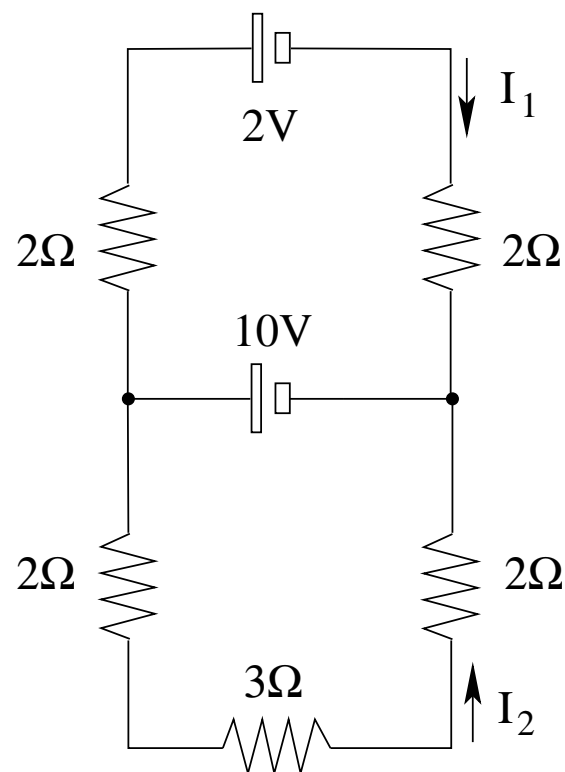


## Intermediate Exam II: Problem #2 (Spring '06)



Consider the two-loop circuit shown.

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



**Solution:**

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

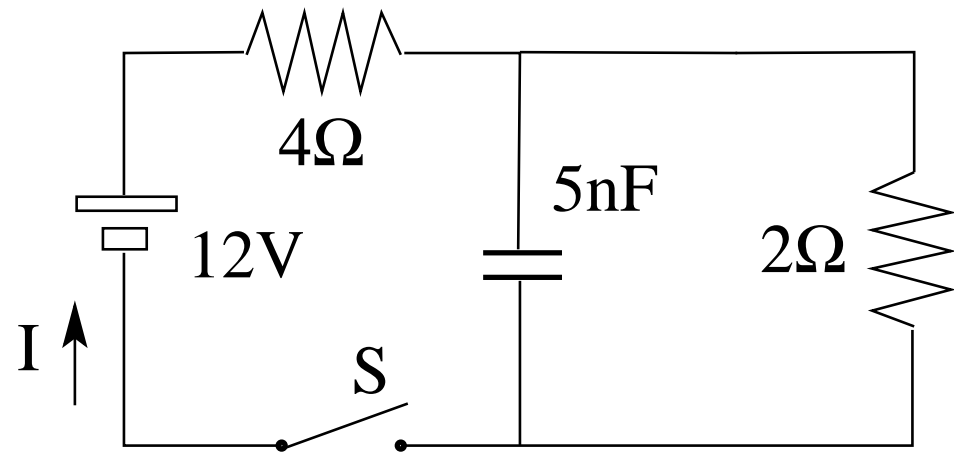
$$(b) \quad -(2\Omega)(I_2) + 10V - (2\Omega)(I_2) - (3\Omega)(I_2) = 0 \quad \Rightarrow \quad I_2 = \frac{10V}{7\Omega} = 1.43A.$$

## Intermediate Exam II: Problem #3 (Spring '06)



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.

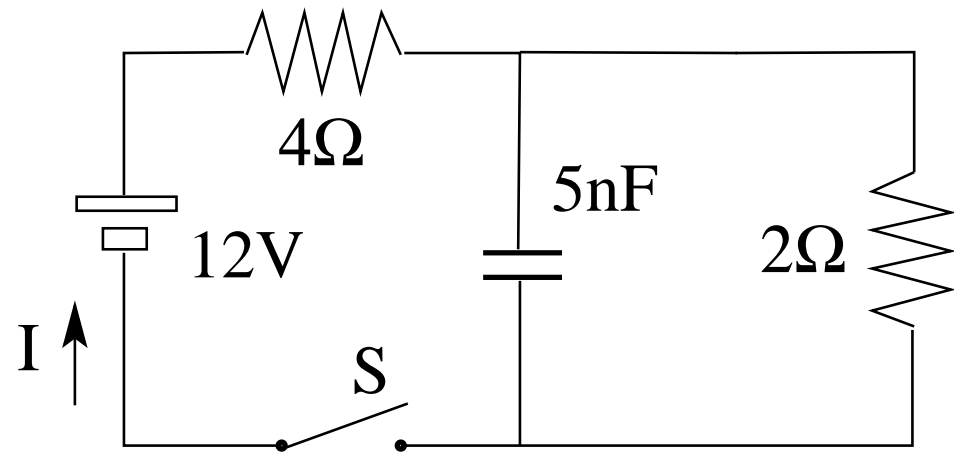


## Intermediate Exam II: Problem #3 (Spring '06)



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:**

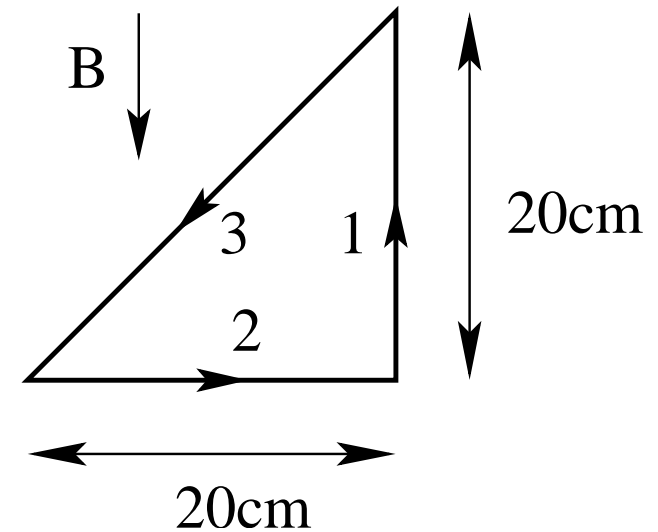
- (a) No current through  $2\Omega$ -resistor:  $I = \frac{12\text{V}}{4\Omega} = 3\text{A}$ .
- (b) No current through capacitor:  $I = \frac{12\text{V}}{6\Omega} = 2\text{A}$ .

## Intermediate Exam II: Problem #4 (Spring '06)



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.



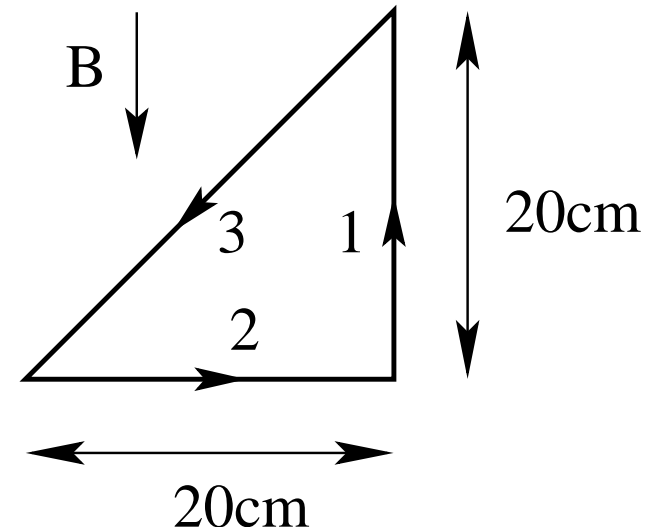


## Intermediate Exam II: Problem #4 (Spring '06)



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:**

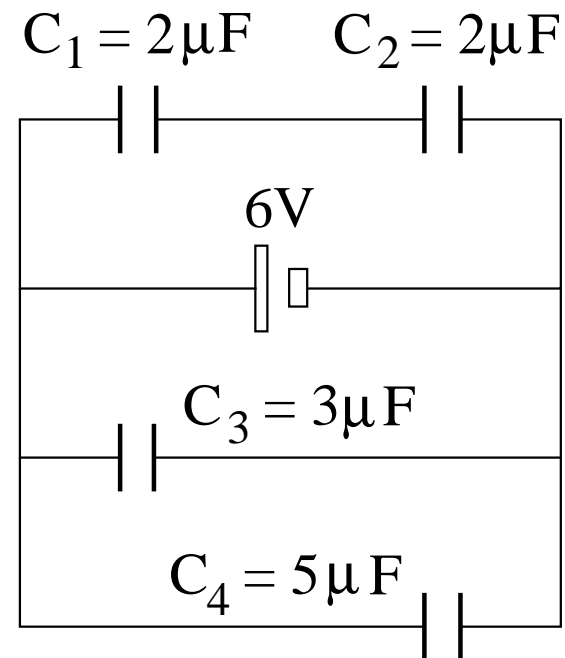
- (a)  $\vec{F}_1 = I\vec{L} \times \vec{B} = 0$  (angle between  $\vec{L}$  and  $\vec{B}$  is  $180^\circ$ ).
- (b)  $F_2 = ILB = (0.4\text{A})(0.2\text{m})(30 \times 10^{-3}\text{T}) = 2.4 \times 10^{-3}\text{N}$ .  
Direction of  $\vec{F}_2$ :  $\otimes$  (into plane).

## Unit Exam II: Problem #1 (Spring '07)



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  $C_1$ .



## Unit Exam II: Problem #1 (Spring '07)



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  $C_1$ .

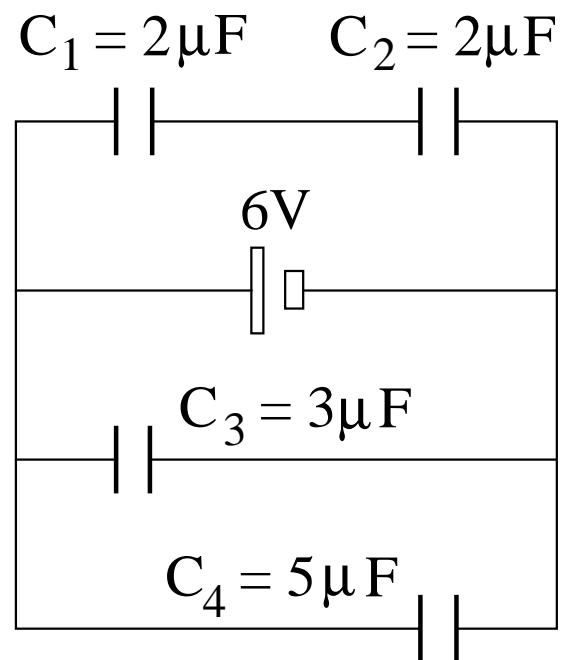
**Solution:**

(a)  $U_3 = \frac{1}{2}(3\mu\text{F})(6\text{V})^2 = 54\mu\text{J}.$

(b)  $V_4 = 6\text{V}.$

(c)  $V_2 = \frac{1}{2}6\text{V} = 3\text{V}.$

(d)  $Q_1 = (2\mu\text{F})(3\text{V}) = 6\mu\text{C}.$

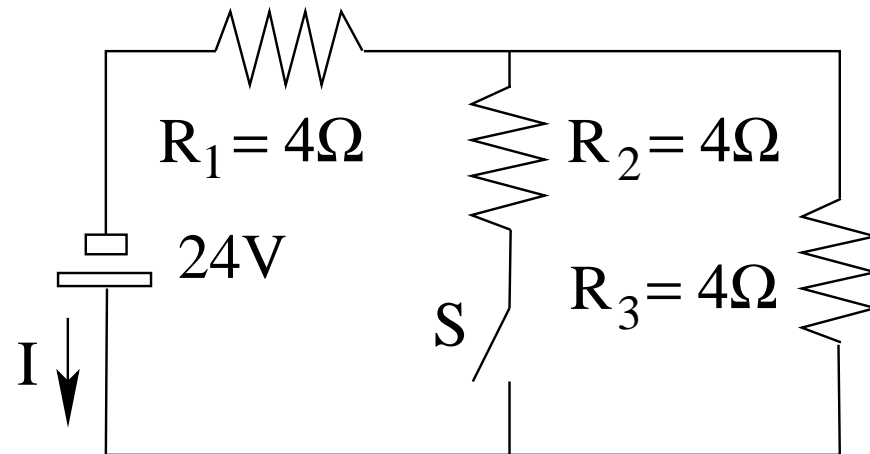


## Unit Exam II: Problem #2 (Spring '07)



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.



## Unit Exam II: Problem #2 (Spring '07)



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.

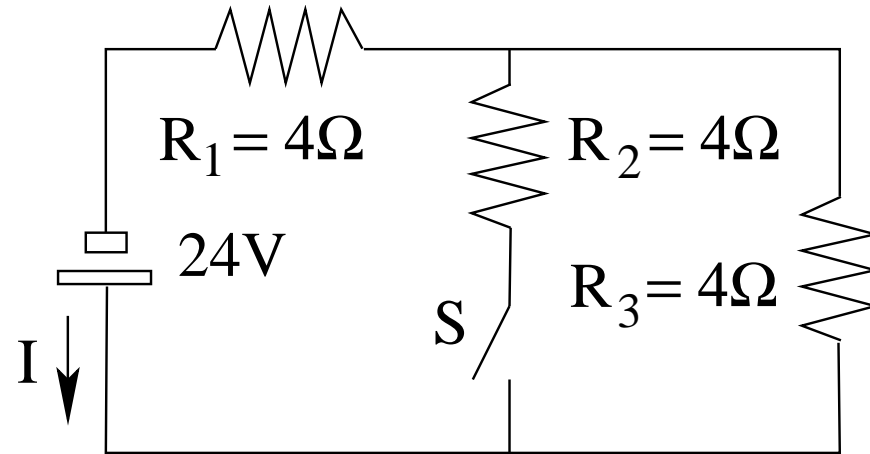
**Solution:**

$$(a) \quad I = \frac{24\text{V}}{8\Omega} = 3\text{A}.$$

$$(b) \quad P_3 = (3\text{A})^2(4\Omega) = 36\text{W}.$$

$$(c) \quad I = \frac{24\text{V}}{6\Omega} = 4\text{A}.$$

$$(d) \quad P_3 = (2\text{A})^2(4\Omega) = 16\text{W}.$$

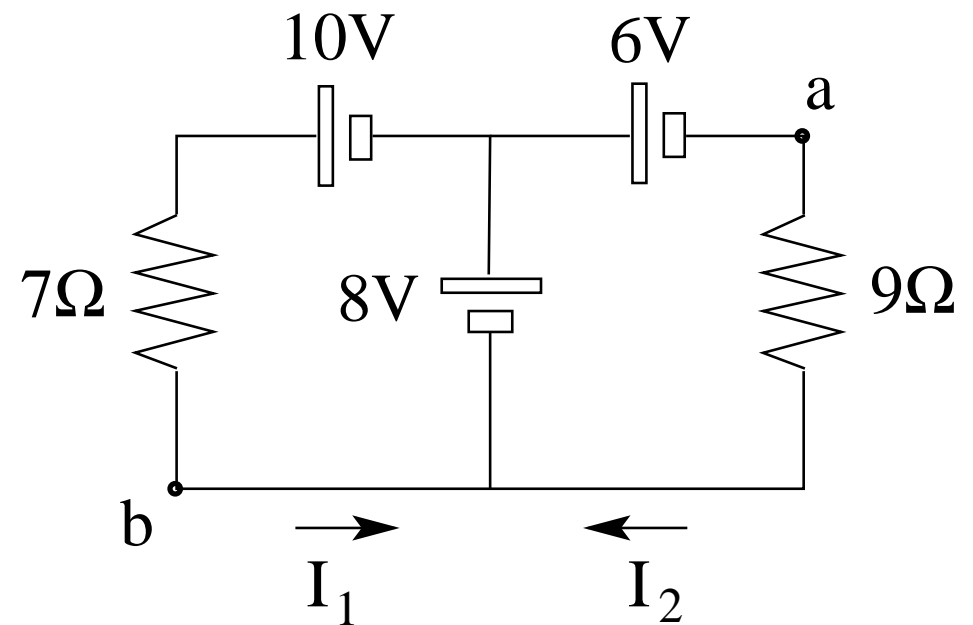


## Unit Exam II: Problem #3 (Spring '07)



Consider the two-loop circuit shown.

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



## Unit Exam II: Problem #3 (Spring '07)



Consider the two-loop circuit shown.

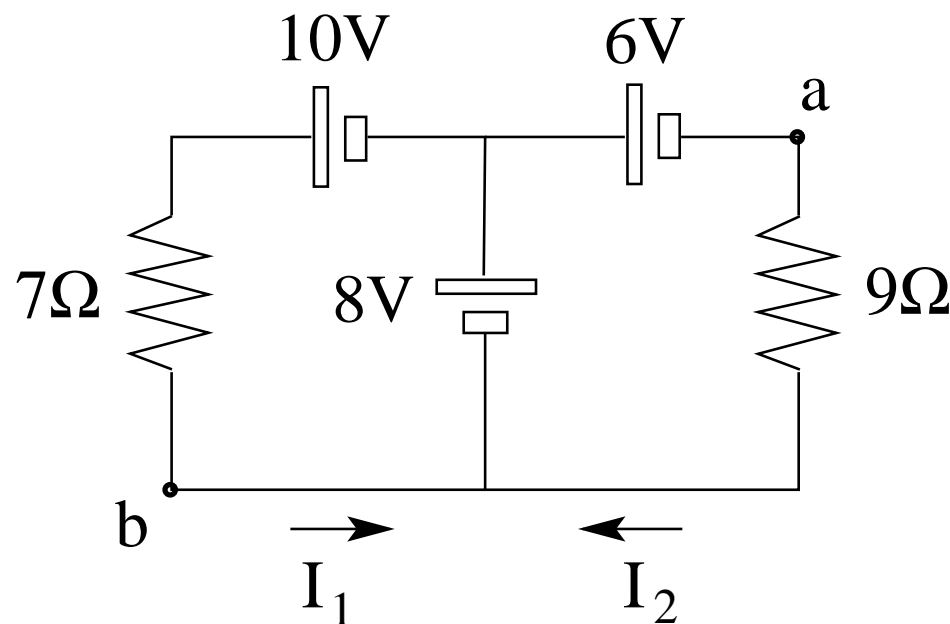
- (a) Find the current  $I_1$ .
- (b) Find the current  $I_2$ .
- (c) Find the potential difference  $V_a - V_b$ .

**Solution:**

(a) 
$$I_1 = \frac{8V + 10V}{7\Omega} = 2.57A.$$

(b) 
$$I_2 = \frac{8V - 6V}{9\Omega} = 0.22A.$$

(c) 
$$V_a - V_b = 8V - 6V = 2V.$$

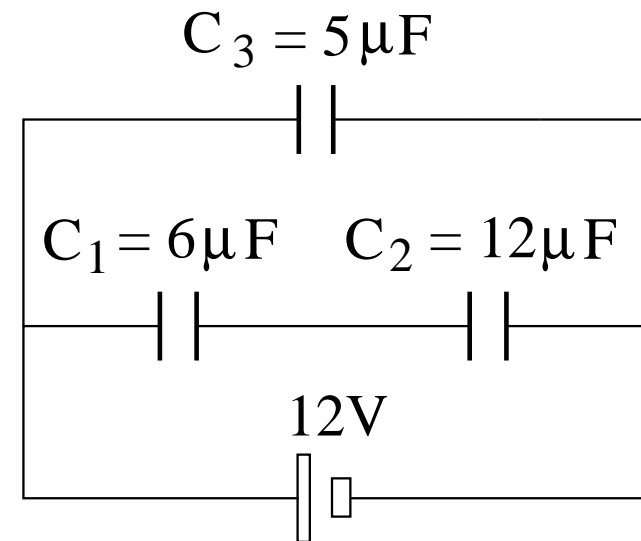


## Unit Exam II: Problem #1 (Spring '08)



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.





## Unit Exam II: Problem #1 (Spring '08)



The circuit of capacitors is at equilibrium.

- Find the charge  $Q_1$  on capacitor 1 and the charge  $Q_2$  on capacitor 2.
- Find the voltage  $V_1$  across capacitor 1 and the voltage  $V_2$  across capacitor 2.
- Find the charge  $Q_3$  and the energy  $U_3$  on capacitor 3.

**Solution:**

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

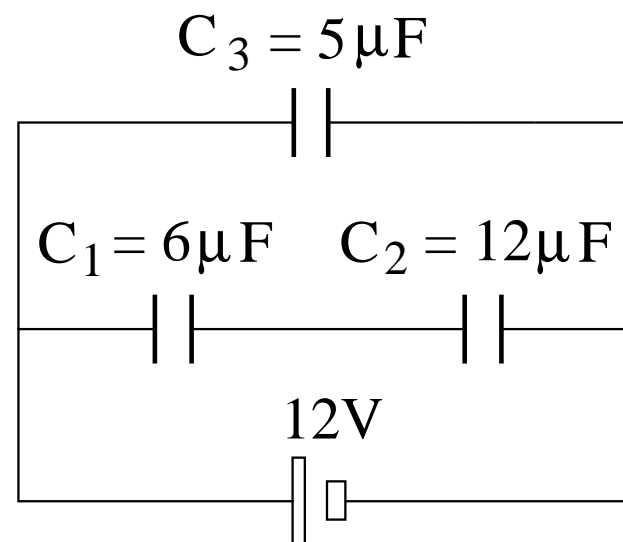
$$Q_1 = Q_2 = Q_{12} = (4\mu\text{F})(12\text{V}) = 48\mu\text{C}.$$

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

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

$$(c) \quad Q_3 = (5\mu\text{F})(12\text{V}) = 60\mu\text{C},$$

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

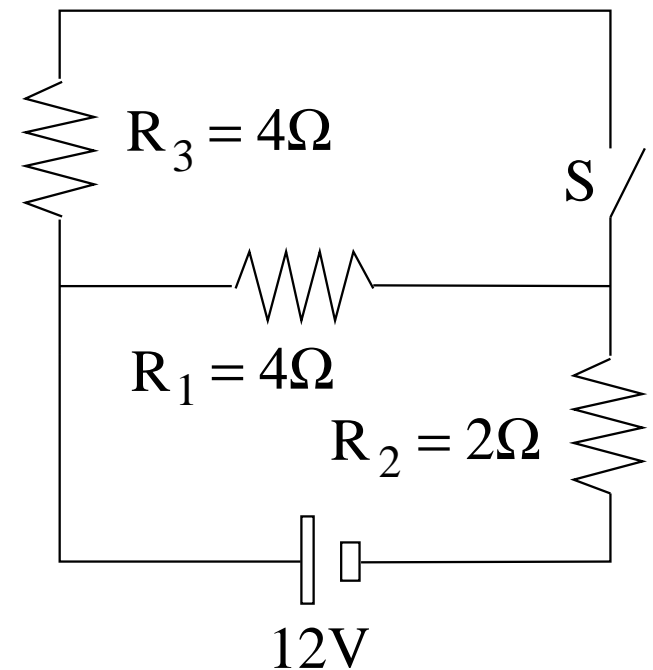


## Unit Exam II: Problem #2 (Spring '08)



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.



## Unit Exam II: Problem #2 (Spring '08)



Consider the electric circuit shown. Find the current  $I_1$  through resistor 1 and the voltage  $V_1$  across it

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

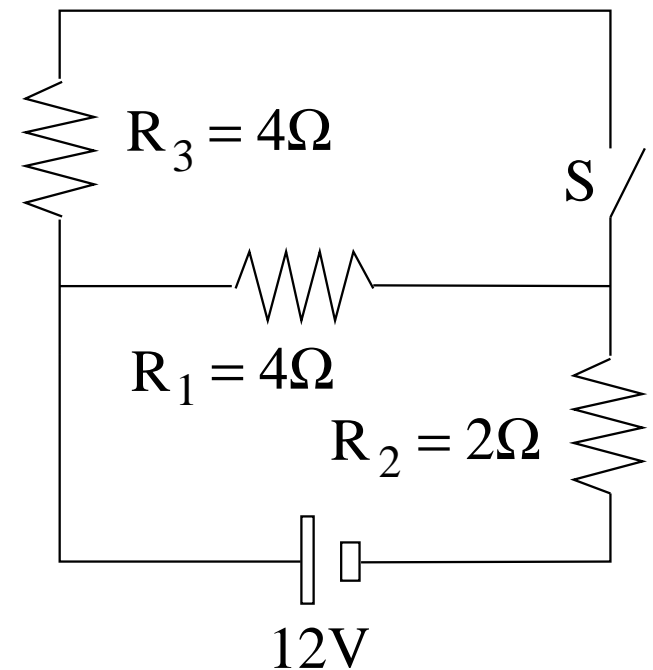
**Solution:**

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

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

$$(c) \quad R_{eq} = \left( \frac{1}{4\Omega} + \frac{1}{4\Omega} \right)^{-1} + 2\Omega = 4\Omega,$$

$$P = \frac{(12V)^2}{4\Omega} = 36W.$$

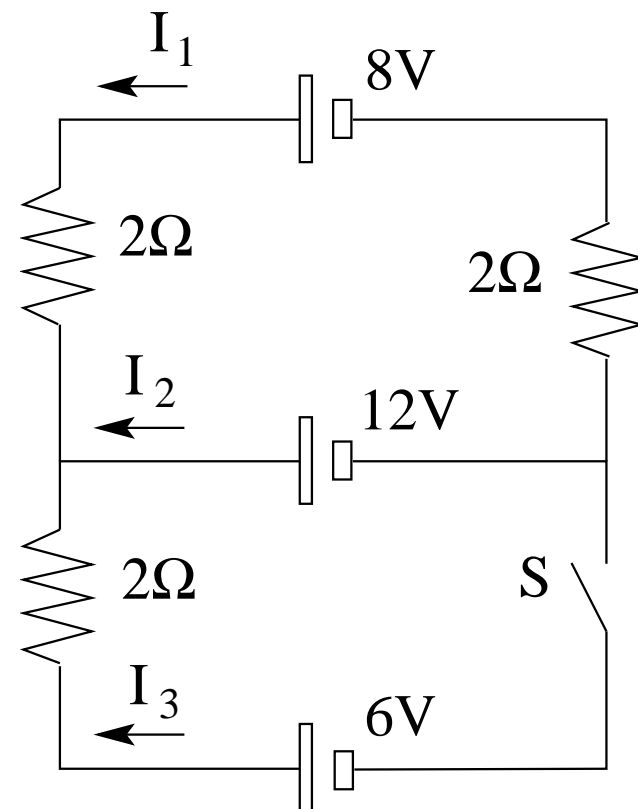


## Unit Exam II: Problem #3 (Spring '08)



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.



# Unit Exam II: Problem #3 (Spring '08)



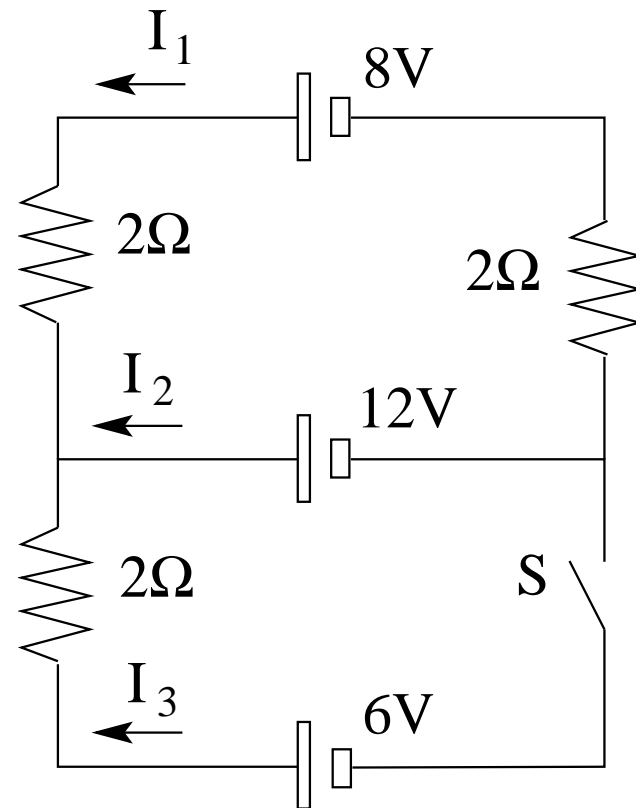
Consider the electric circuit shown. Find the currents  $I_1$ ,  $I_2$ , and  $I_3$

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



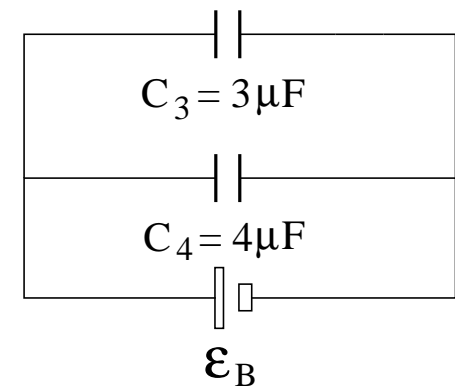
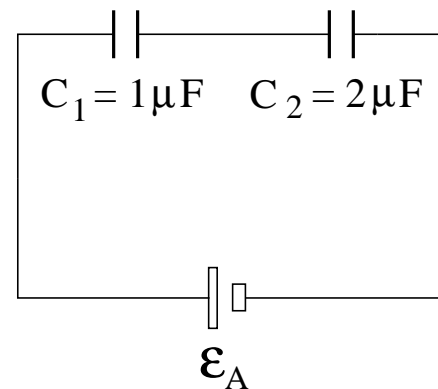
# Unit Exam II: Problem #1 (Spring '09)



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.



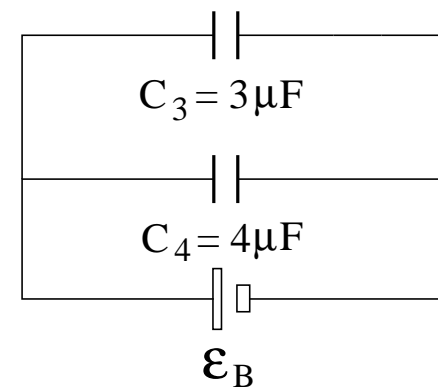
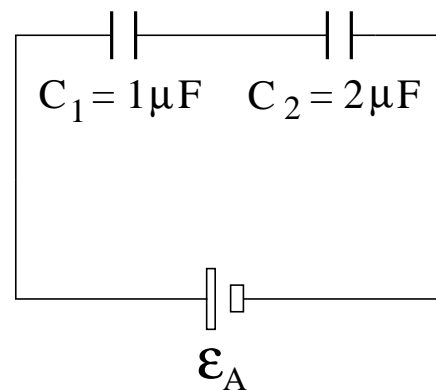
## Unit Exam II: Problem #1 (Spring '09)



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:**

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

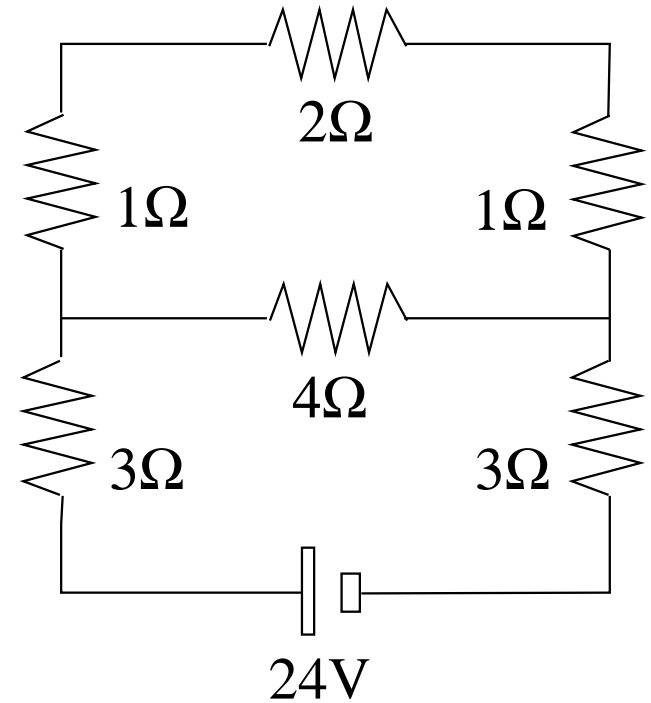
$$(b) \quad V_3 = \frac{6\mu C}{3\mu F} = 2V, \quad V_4 = V_3 = 2V, \\ Q_4 = (2V)(4\mu F) = 8\mu C, \quad \mathcal{E}_B = V_3 = V_4 = 2V.$$

## Unit Exam II: Problem #2 (Spring '09)



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.





## Unit Exam II: Problem #2 (Spring '09)

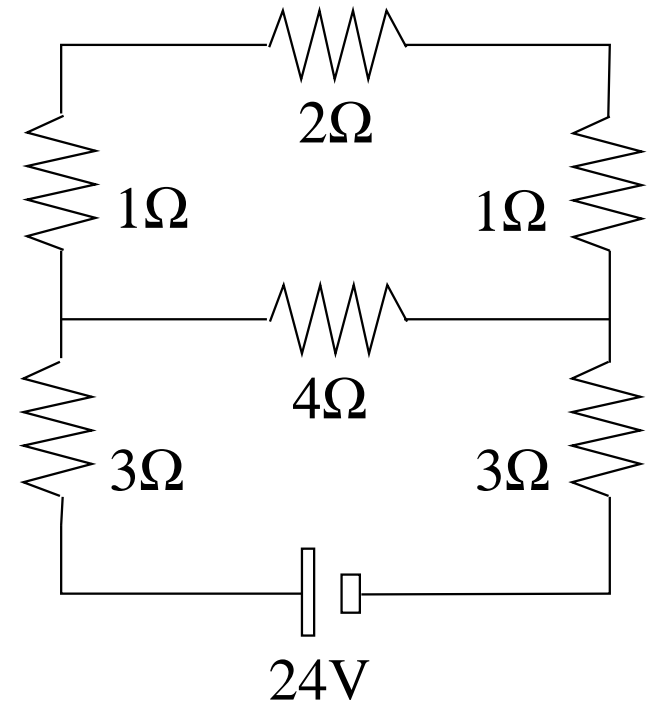


Consider the resistor circuit shown.

- (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:**

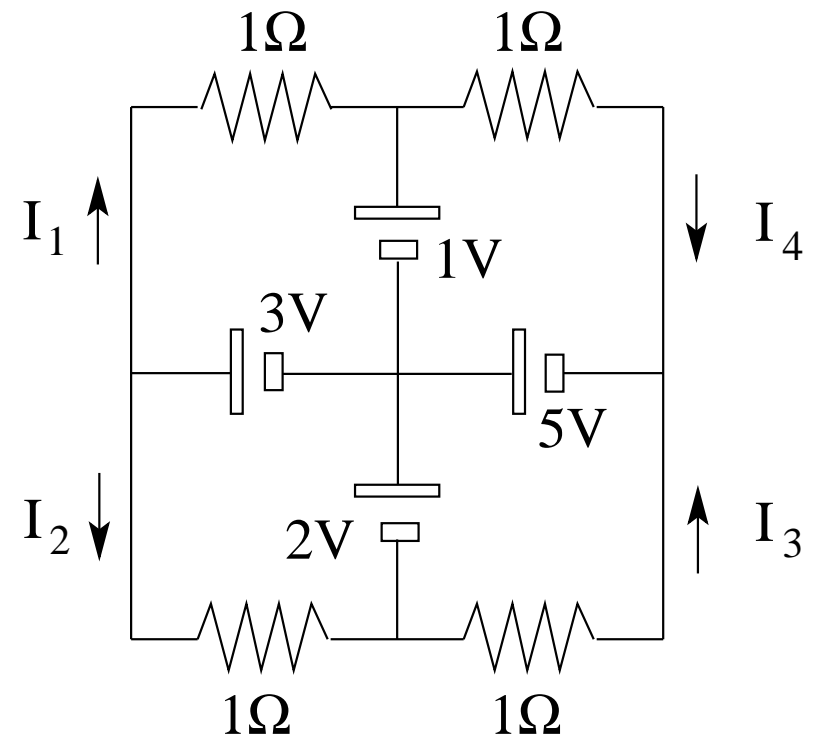
- (a)  $R_{eq} = 8\Omega$ .
- (b)  $P = \frac{(24V)^2}{8\Omega} = 72W$ .
- (c)  $I_4 = \frac{1}{2} \frac{24V}{8\Omega} = 1.5A$ .
- (d)  $V_2 = (1.5A)(2\Omega) = 3V$ .



# Unit Exam II: Problem #3 (Spring '09)



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



# Unit Exam II: Problem #3 (Spring '09)



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

**Solution:**

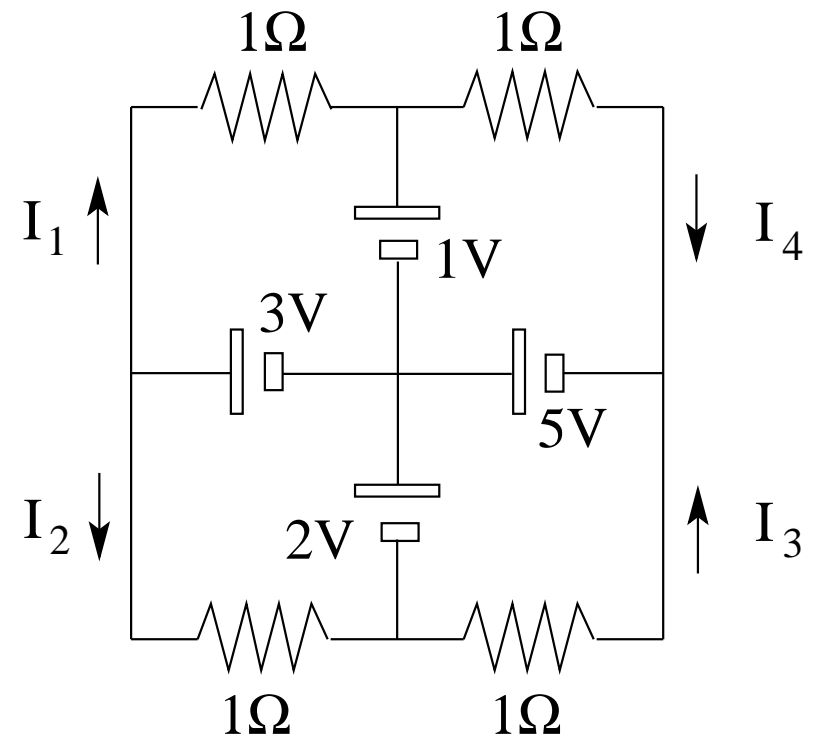
Use loops along quadrants in assumed current directions.  
Start at center.

$$+3V - I_1(1\Omega) - 1V = 0 \Rightarrow I_1 = 2A.$$

$$+3V - I_2(1\Omega) + 2V = 0 \Rightarrow I_2 = 5A.$$

$$-2V - I_3(1\Omega) + 5V = 0 \Rightarrow I_3 = 3A.$$

$$+1V - I_4(1\Omega) + 5V = 0 \Rightarrow I_4 = 6A.$$

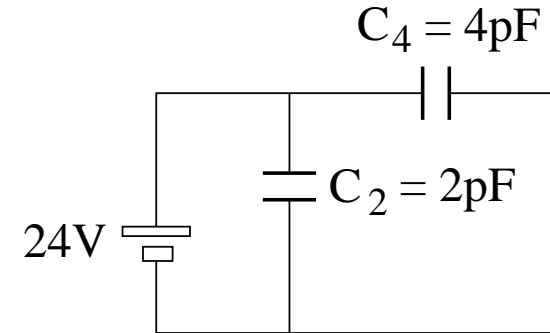
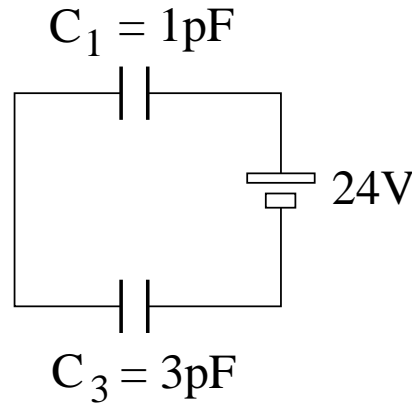


# Unit Exam II: Problem #1 (Spring '11)



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.

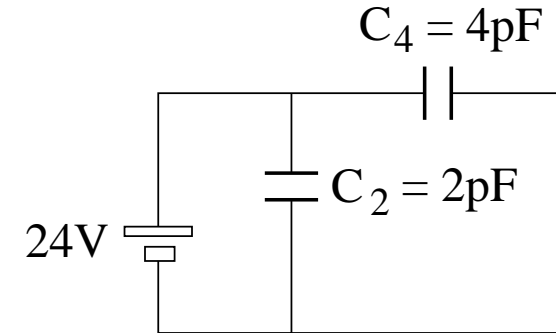
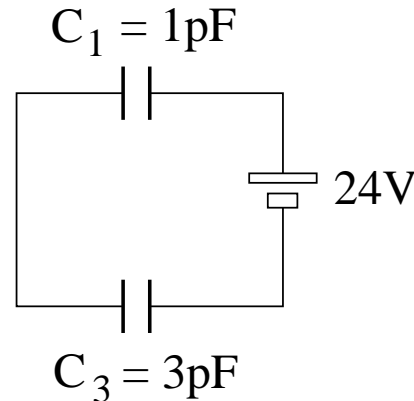


## Unit Exam II: Problem #1 (Spring '11)



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:**

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

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

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

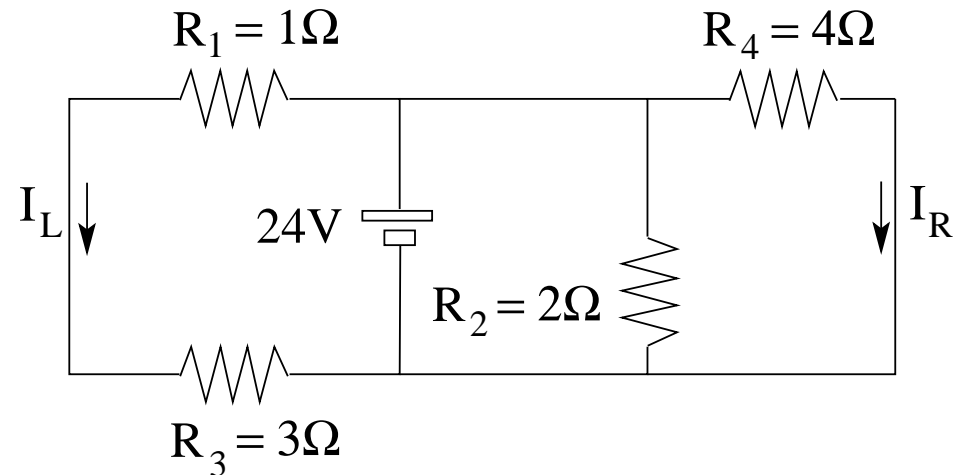
$$(d) \quad U_4 = \frac{1}{2}C_4V_4^2 = \frac{1}{2}(4\text{pF})(24\text{V})^2 = 1152\text{pJ}.$$

## Unit Exam II: Problem #2 (Spring '11)



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.



## Unit Exam II: Problem #2 (Spring '11)



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.

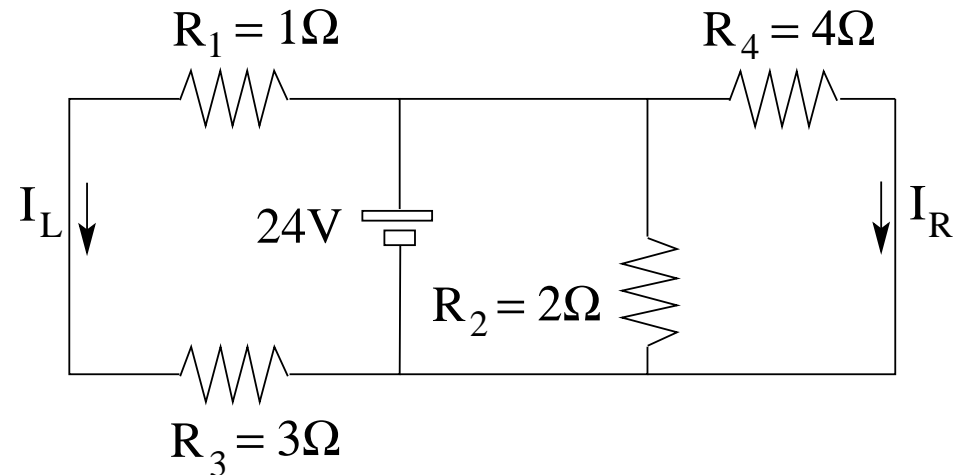
**Solution:**

$$(a) \quad I_L = \frac{24V}{1\Omega + 3\Omega} = 6A.$$

$$(b) \quad I_R = \frac{24V}{4\Omega} = 6A.$$

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

$$(d) \quad P_2 = \frac{(24V)^2}{2\Omega} = 288W.$$

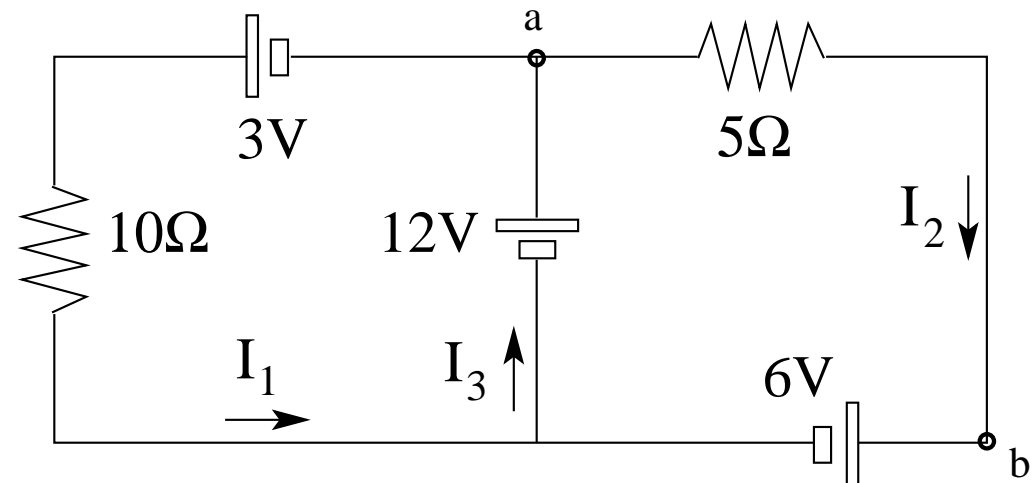


## Unit Exam II: Problem #3 (Spring '11)



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  $V_a - V_b$ .



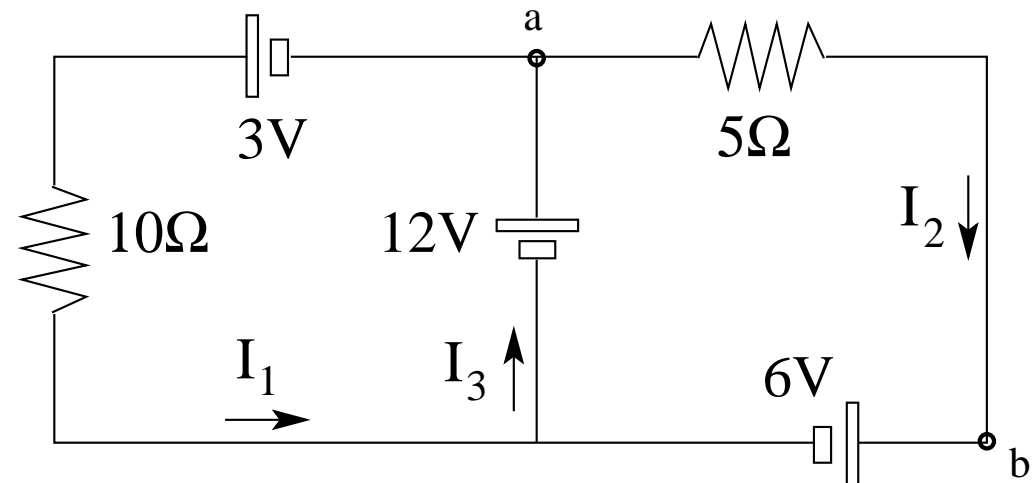


## Unit Exam II: Problem #3 (Spring '11)



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:**

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

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

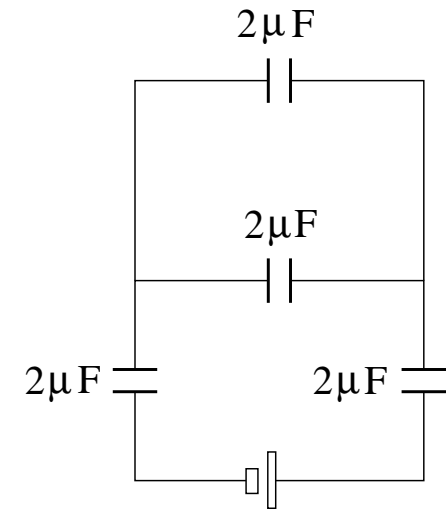
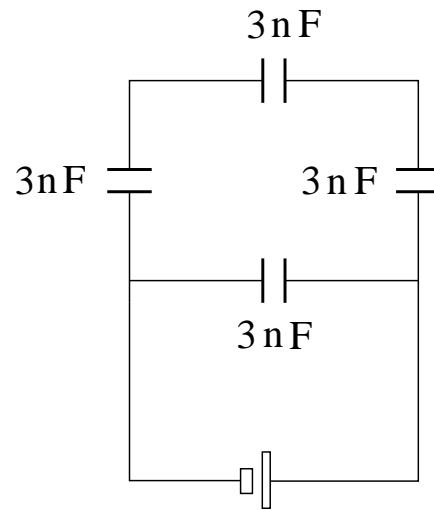
$$(c) \quad I_3 = I_1 + I_2 = 2.7A.$$

$$(d) \quad V_a - V_b = -6V + 12V = 6V.$$

# Unit Exam II: Problem #1 (Spring '12)



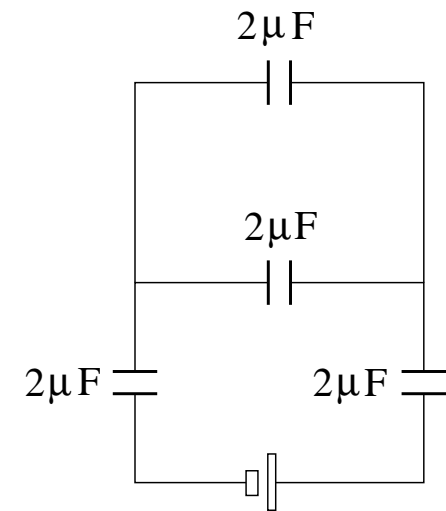
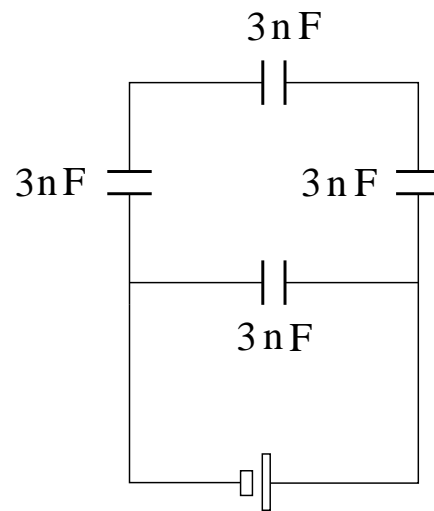
Find the equivalent capacitances  $C_{eq}$  of the two capacitor circuits.



# Unit Exam II: Problem #1 (Spring '12)



Find the equivalent capacitances  $C_{eq}$  of the two capacitor circuits.



**Solution:**

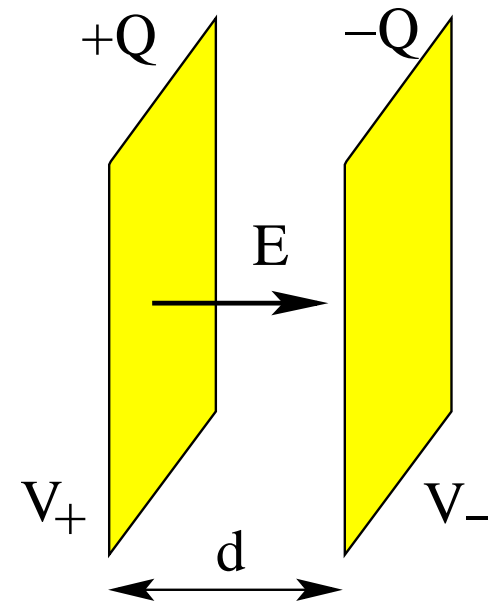
- $C_{eq} = 3\text{nF} + \left( \frac{1}{3\text{nF}} + \frac{1}{3\text{nF}} + \frac{1}{3\text{nF}} \right)^{-1} = 4\text{nF}.$
- $C_{eq} = \left( \frac{1}{2\mu\text{F}} + \frac{1}{2\mu\text{F} + 2\mu\text{F}} + \frac{1}{2\mu\text{F}} \right)^{-1} = \frac{4}{5}\mu\text{F}.$

## Unit Exam II: Problem #2 (Spring '12)



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.

- Find the magnitude  $E$  of the electric field between the plates.
- Find the amount  $Q$  of charge on each plate.
- Find the energy  $U$  stored on the capacitor.
- Find the area  $A$  of each plate.



## Unit Exam II: Problem #2 (Spring '12)



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.

- Find the magnitude  $E$  of the electric field between the plates.
- Find the amount  $Q$  of charge on each plate.
- Find the energy  $U$  stored on the capacitor.
- Find the area  $A$  of each plate.

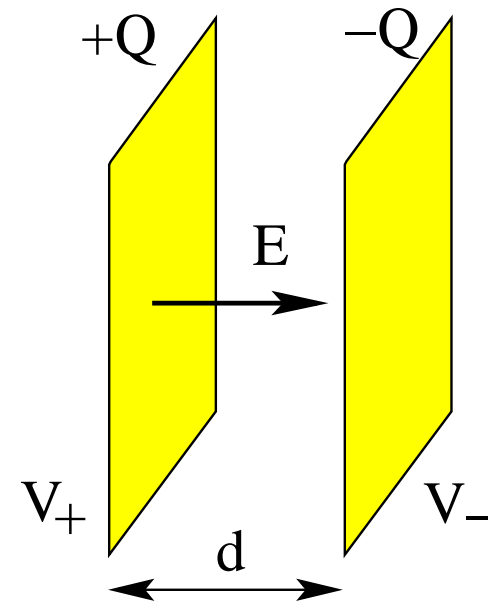
**Solution:**

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

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

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

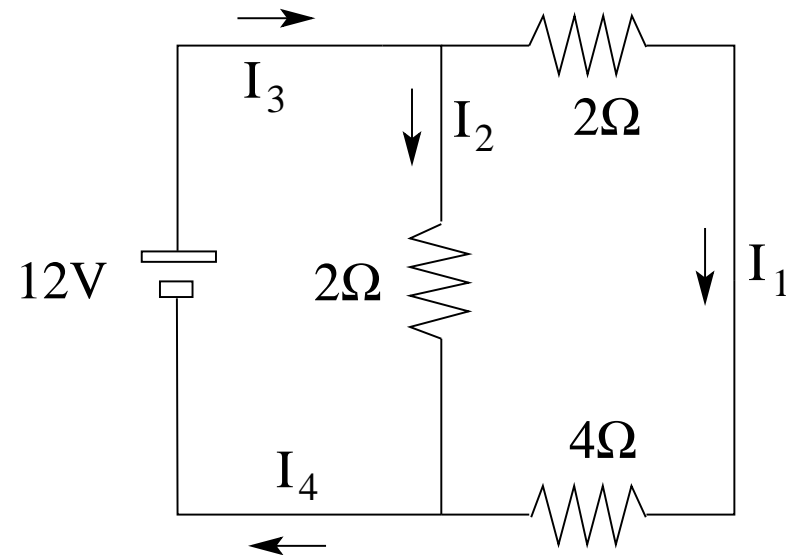
$$(d) \quad A = \frac{Cd}{\epsilon_0} = \frac{(6\text{pF})(1\text{mm})}{8.85 \times 10^{-12}\text{C}^2\text{N}^{-1}\text{m}^{-2}} = 6.78 \times 10^{-4}\text{m}^2.$$



## Unit Exam II: Problem #3 (Spring '12)



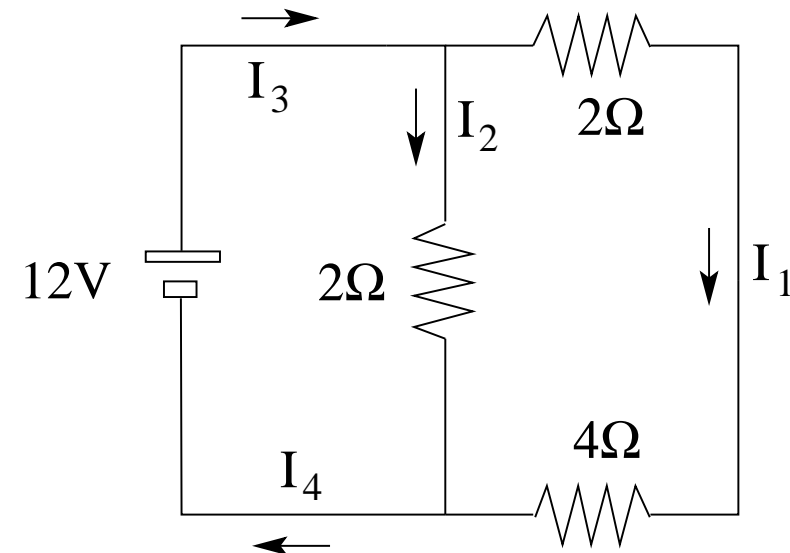
Consider the electric circuit shown. Find the currents  $I_1$ ,  $I_2$ ,  $I_3$ , and  $I_4$



## Unit Exam II: Problem #3 (Spring '12)



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



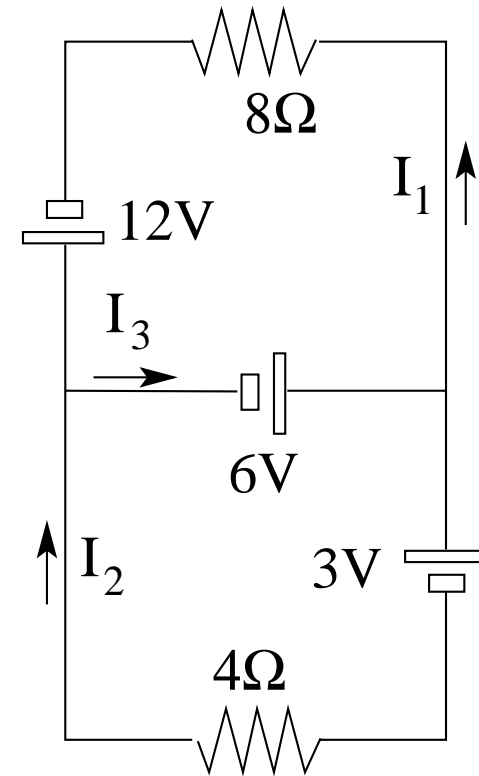
**Solution:**

- $I_1 = \frac{12V}{2\Omega + 4\Omega} = 2A.$
- $I_2 = \frac{12V}{2\Omega} = 6A.$
- $I_3 = I_4 = I_1 + I_2 = 8A.$

# Unit Exam II: Problem #4 (Spring '12)



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

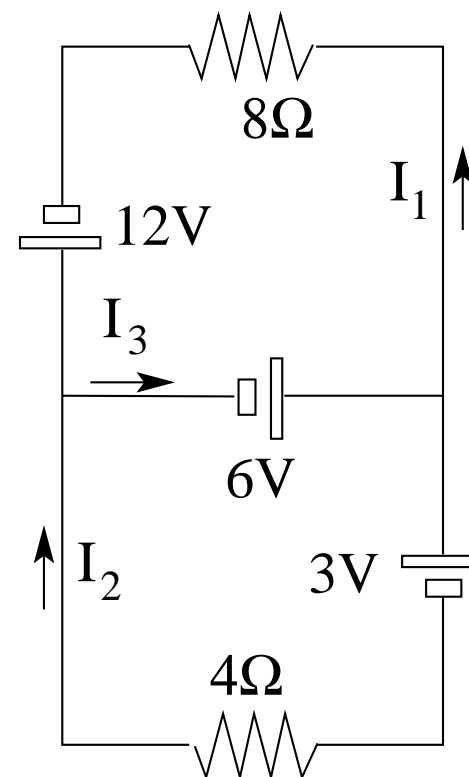




## Unit Exam II: Problem #4 (Spring '12)



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



**Solution:**

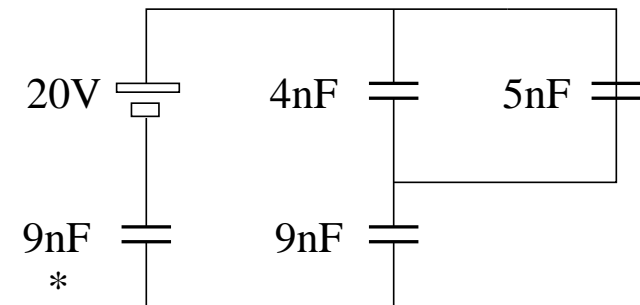
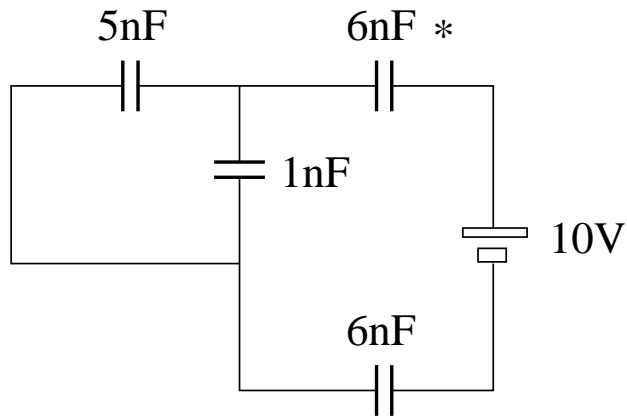
- $12V + 6V - (8\Omega)I_1 = 0 \Rightarrow I_1 = \frac{9}{4}A = 2.25A.$
- $6V - 3V - (4\Omega)I_2 = 0 \Rightarrow I_2 = \frac{3}{4}A = 0.75A.$
- $I_3 = I_1 + I_2 = 3.00A.$

# Unit Exam II: Problem #1 (Spring '13)



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.

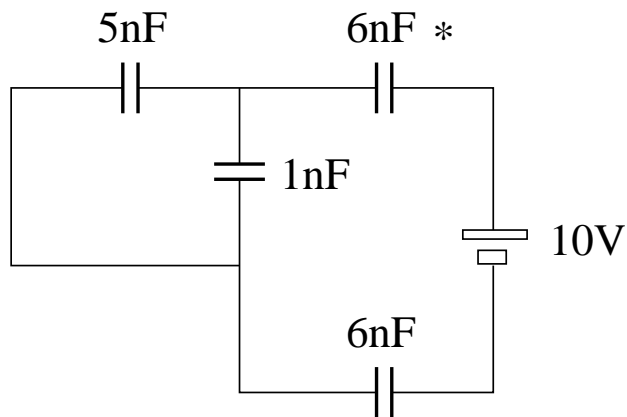


# Unit Exam II: Problem #1 (Spring '13)



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.

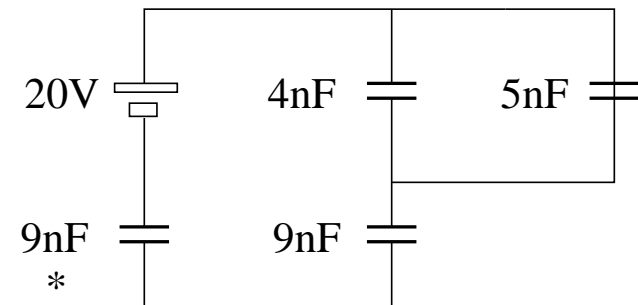


**Solution:**

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

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

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



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

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

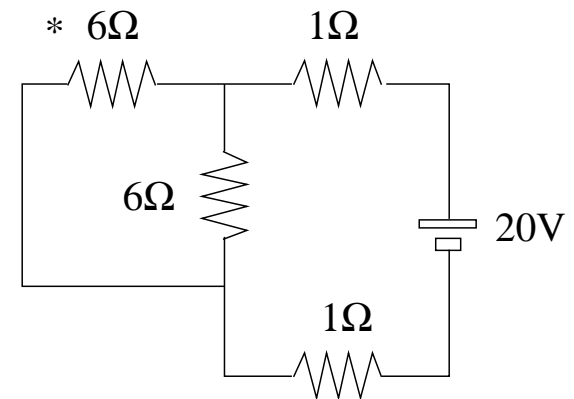
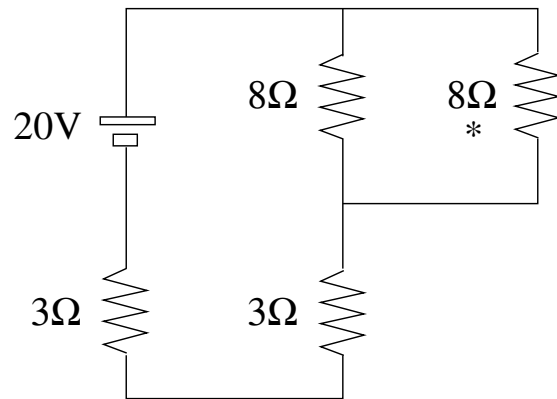
$$V_* = \frac{20}{3}\text{V} = 6.67\text{V}$$

## Unit Exam II: Problem #2 (Spring '13)



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.

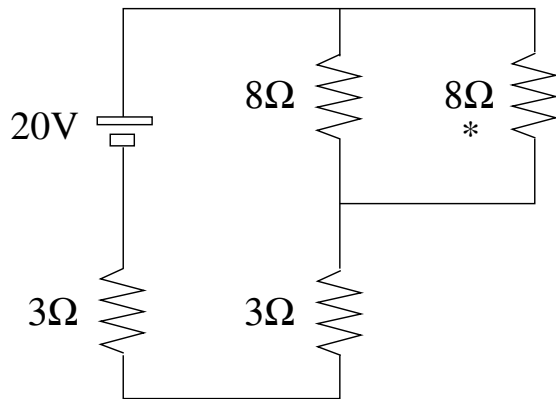


# Unit Exam II: Problem #2 (Spring '13)



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.

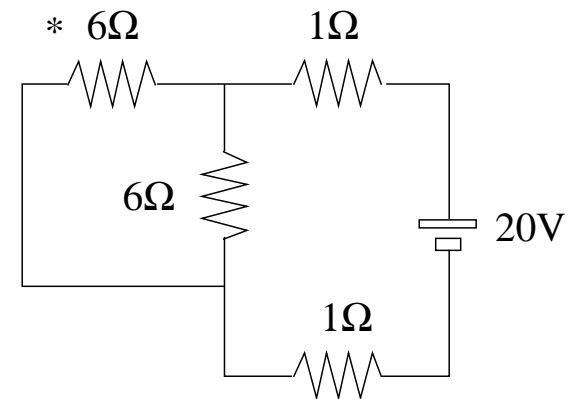


**Solution:**

$$R_{eq} = \left( \frac{1}{8\Omega} + \frac{1}{8\Omega} \right)^{-1} + 3\Omega + 3\Omega = 10\Omega$$

$$I = \frac{20V}{10\Omega} = 2A$$

$$V_* = (2A)(8\Omega) = 16V$$



$$R_{eq} = \left( \frac{1}{6\Omega} + \frac{1}{6\Omega} \right)^{-1} + 1\Omega + 1\Omega = 5\Omega$$

$$I = \frac{20V}{5\Omega} = 4A$$

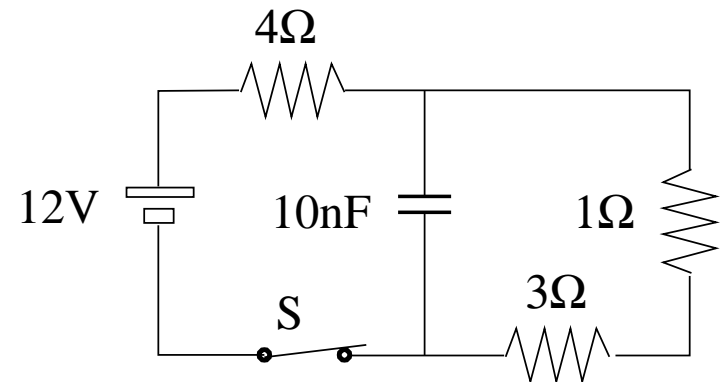
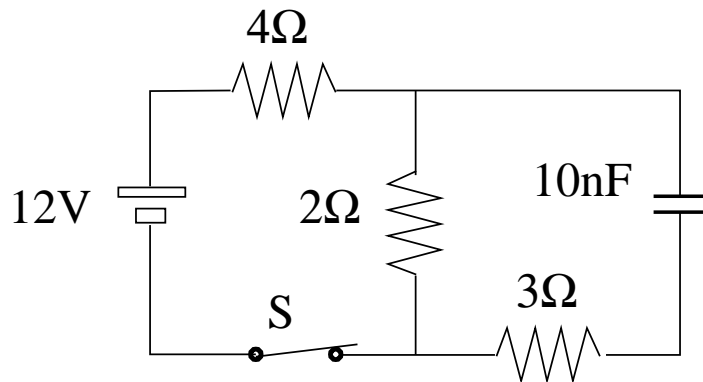
$$V_* = (4A)(6\Omega) = 24V$$

# Unit Exam II: Problem #3 (Spring '13)



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.

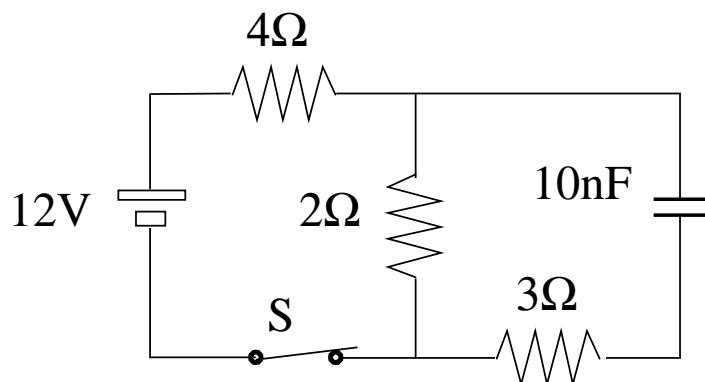


## Unit Exam II: Problem #3 (Spring '13)



Consider the  $RC$  circuit shown. The switch has been closed for a long time.

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



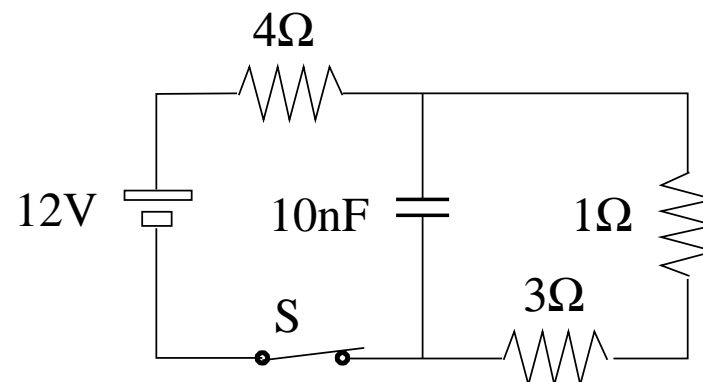
**Solution:**

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

$$V_C = (2\text{A})(2\Omega) = 4\text{V}$$

$$Q = (4\text{V})(10\text{nF}) = 40\text{nC}$$

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



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

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

$$Q = (6\text{V})(10\text{nF}) = 60\text{nC}$$

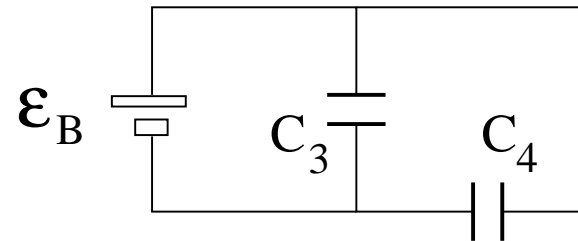
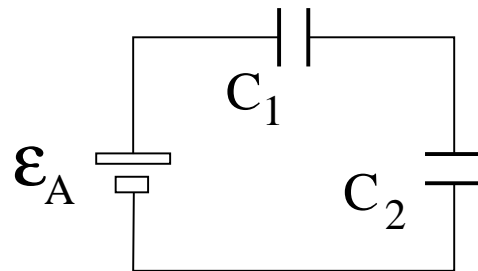
$$I_3 = \frac{6\text{V}}{3\Omega + 1\Omega} = 1.5\text{A}$$

# Unit Exam II: Problem #1 (Spring '14)



Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. The charge on capacitor  $C_1 = 6\text{pF}$  [8pF] is  $Q_1 = 18\text{pC}$  [16pF] and charge on capacitor  $C_4 = 8\text{pF}$  [4pF] is  $Q_4 = 16\text{pC}$  [12pF].

- (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.



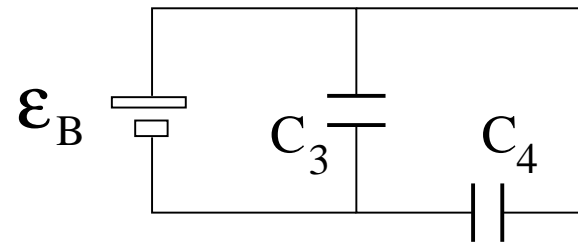
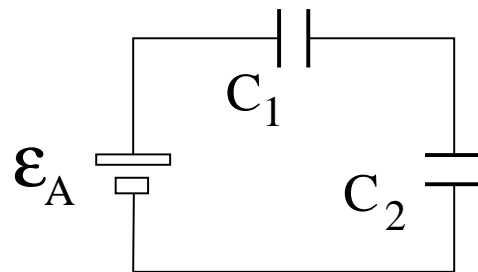


## Unit Exam II: Problem #1 (Spring '14)



Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. The charge on capacitor  $C_1 = 6\text{pF}$  [8pF] is  $Q_1 = 18\text{pC}$  [16pF] and charge on capacitor  $C_4 = 8\text{pF}$  [4pF] is  $Q_4 = 16\text{pC}$  [12pF].

- Find the voltage  $V_2$  across capacitor  $C_2 = 4\text{pF}$ .
- Find the emf  $\mathcal{E}_A$  supplied by the battery.
- Find the charge  $Q_3$  on capacitor  $C_3 = 3\text{pF}$ .
- Find the emf  $\mathcal{E}_B$  supplied by the battery.



**Solution:**

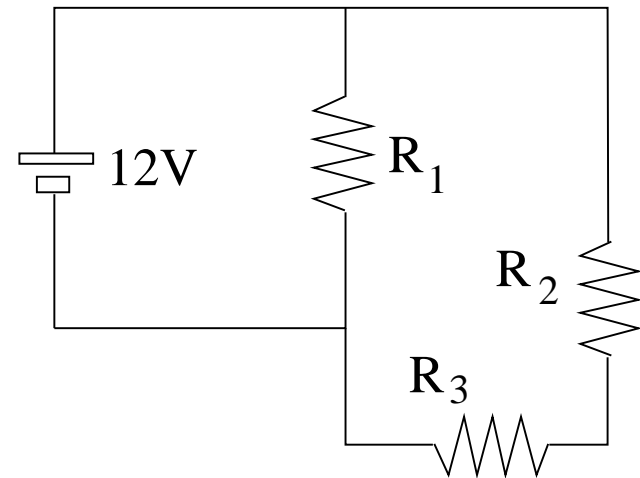
- $Q_2 = Q_1 = 18\text{pC}$ , [16pC],  $V_2 = \frac{Q_2}{C_2} = 4.5\text{V}$  [4V].
- $\mathcal{E}_A = V_1 + V_2 = 3\text{V} + 4.5\text{V} = 7.5\text{V}$  [2V + 4V = 6V].
- $V_3 = V_4 = \frac{Q_4}{C_4} = 2\text{V}$  [3V],  $Q_3 = V_3 C_3 = 6\text{pC}$  [9pC].
- $\mathcal{E}_B = V_3 = V_4 = 2\text{V}$  [3V].

## Unit Exam II: Problem #2 (Spring '14)



Consider the resistor circuit shown with  $R_1 = 2\Omega$  [ $3\Omega$ ],  $R_2 = 3\Omega$  [ $2\Omega$ ], 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  $R_{eq}$ .

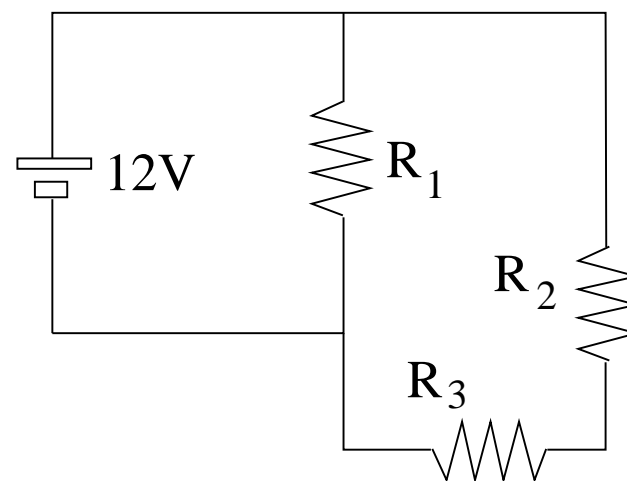


## Unit Exam II: Problem #2 (Spring '14)



Consider the resistor circuit shown with  $R_1 = 2\Omega$  [ $3\Omega$ ],  $R_2 = 3\Omega$  [ $2\Omega$ ], 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:**

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

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

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

$$(d) R_{eq} = \left( \frac{1}{2\Omega} + \frac{1}{3\Omega + 1\Omega} \right)^{-1} = \frac{4}{3} \Omega \quad \left[ \left( \frac{1}{3\Omega} + \frac{1}{2\Omega + 1\Omega} \right)^{-1} = \frac{3}{2} \Omega \right].$$

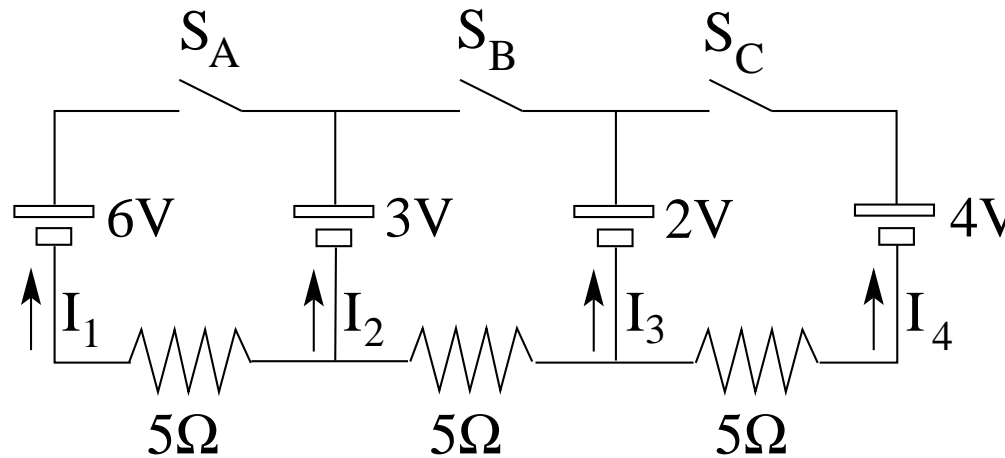
# Unit Exam II: Problem #3 (Spring '14)



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.



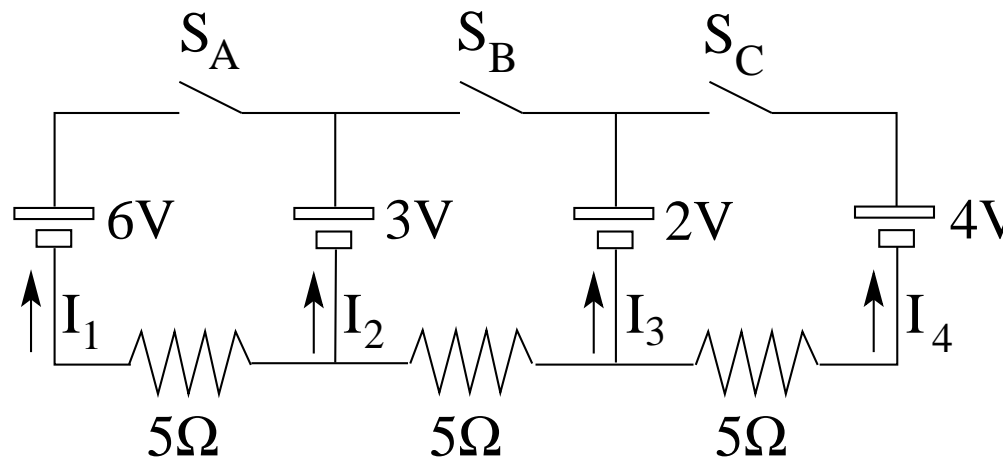
# Unit Exam II: Problem #3 (Spring '14)



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:**

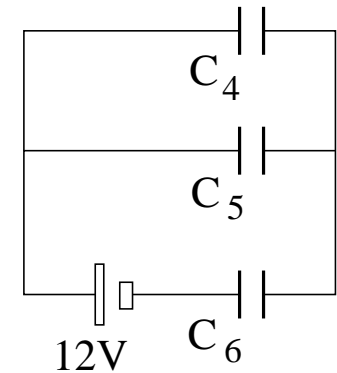
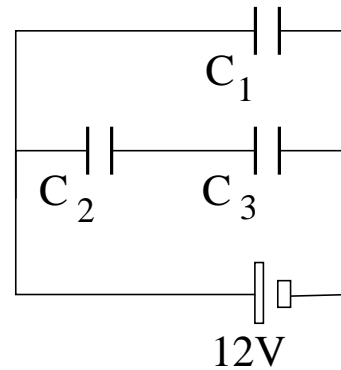
- |                                                                                |                                                                               |
|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| (a) $I_1 = 0.6\text{A}, I_2 = -0.6\text{A}, I_3 = 0, I_4 = 0.$                 | (a) $I_1 = 0, I_2 = 0, I_3 = -0.4\text{A}, I_4 = 0.4\text{A}.$                |
| (b) $I_1 = 0, I_2 = 0.2\text{A}, I_3 = -0.2\text{A}, I_4 = 0.$                 | (b) $I_1 = 0, I_2 = 0.2\text{A}, I_3 = -0.2\text{A}, I_4 = 0.$                |
| (c) $I_1 = 0.6\text{A}, I_2 = -0.4\text{A},$<br>$I_3 = -0.2\text{A}, I_4 = 0.$ | (c) $I_1 = 0, I_2 = 0.2\text{A},$<br>$I_3 = -0.6\text{A}, I_4 = 0.4\text{A}.$ |

## Unit Exam II: Problem #1 (Fall '14)



Both capacitor circuits, charged up by batteries as shown, are now at equilibrium. Each of the six capacitors has a  $2\text{pF}$  capacitance.

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

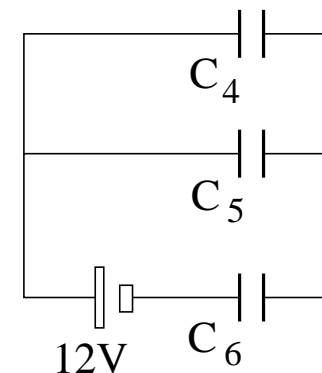
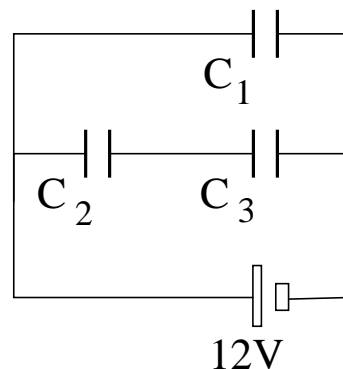


# Unit Exam II: Problem #1 (Fall '14)



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:**

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

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

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

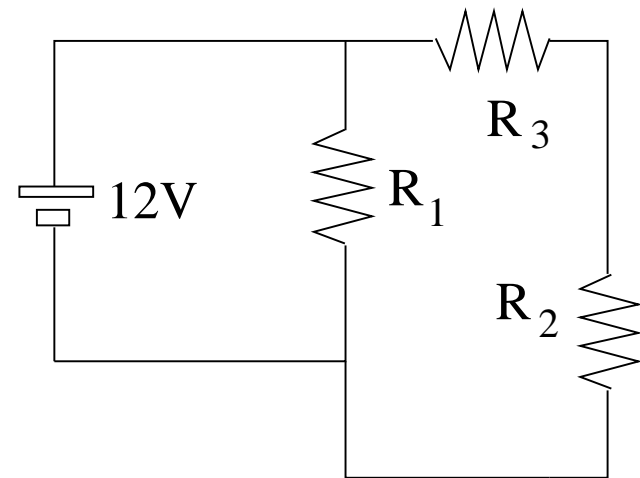
$$(d) Q_{45} = Q_6 = C_{eq}(12\text{V}) = 16\text{pC} \quad \Rightarrow \quad Q_4 = Q_5 = 8\text{pC}.$$

## Unit Exam II: Problem #2 (Fall '14)



Consider the resistor circuit shown with  $R_1 = 5\Omega$ ,  $R_2 = 1\Omega$ , and  $R_3 = 3\Omega$ .

- Find the equivalent resistance  $R_{eq}$ .
- Find the currents  $I_1$ ,  $I_2$ ,  $I_3$  through resistors  $R_1$ ,  $R_2$ ,  $R_3$ , respectively.
- Find the voltages  $V_1$ ,  $V_2$ ,  $V_3$  across resistors  $R_1$ ,  $R_2$ ,  $R_3$ , respectively.



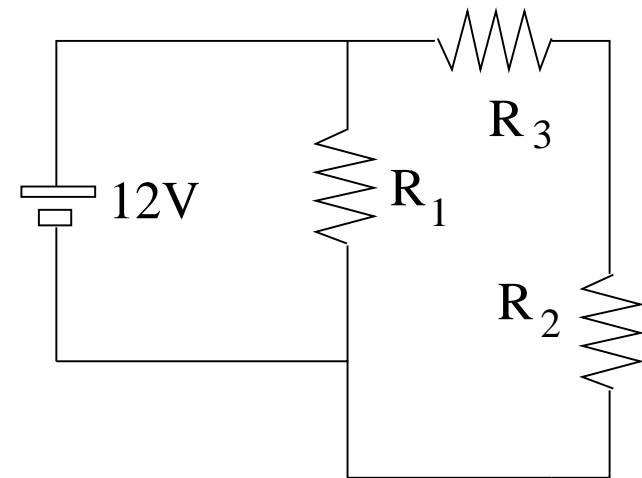


## Unit Exam II: Problem #2 (Fall '14)



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.



**Solution:**

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

$$(b) I_1 = \frac{12V}{5\Omega} = 2.4A, \quad I_2 = I_3 = \frac{12V}{1\Omega + 3\Omega} = 3A.$$

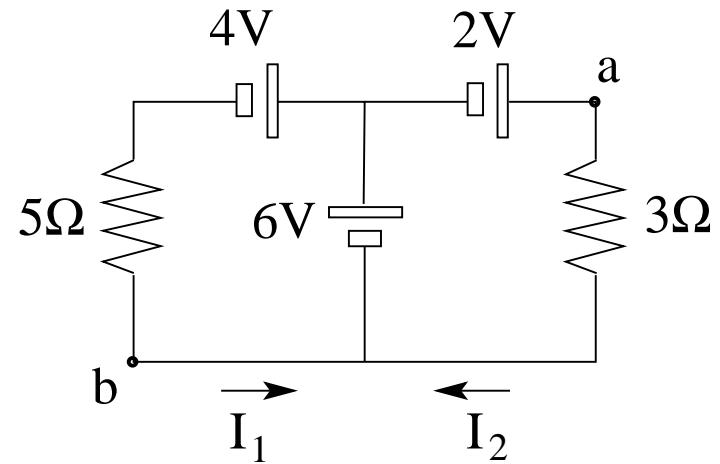
$$(c) V_1 = R_1 I_1 = 12V, \quad V_2 = R_2 I_2 = 3V, \quad V_3 = R_3 I_3 = 9V.$$

## Unit Exam II: Problem #3 (Fall '14)



Consider the two-loop circuit shown.

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

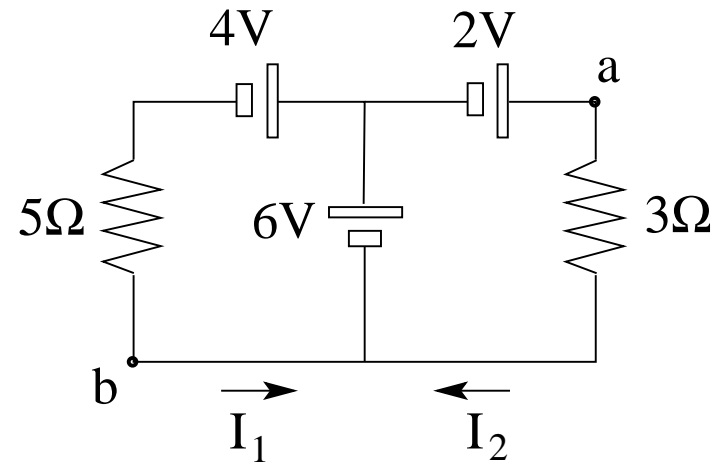


## Unit Exam II: Problem #3 (Fall '14)



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:**

$$(a) \quad I_1 = \frac{6V - 4V}{5\Omega} = 0.4A.$$

$$(b) \quad I_2 = \frac{6V + 2V}{3\Omega} = 2.67A.$$

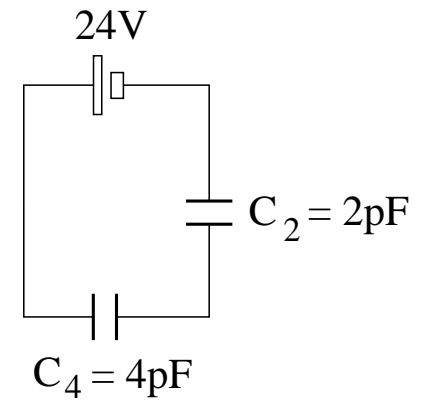
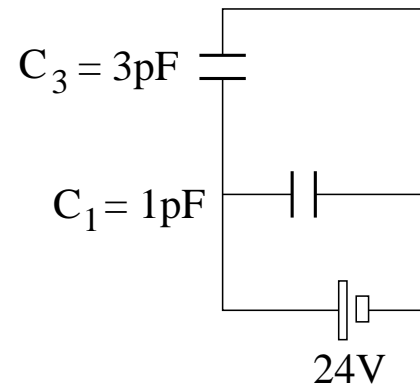
$$(c) \quad V_a - V_b = 6V + 2V = 8V.$$

# Unit Exam II: Problem #1 (Spring '15)



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.



# Unit Exam II: Problem #1 (Spring '15)



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:**

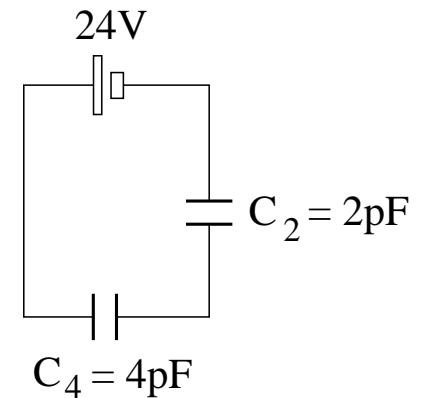
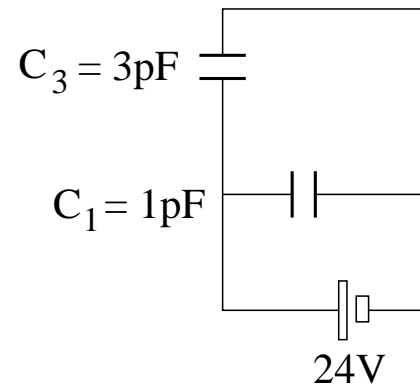
(a)  $Q_1 = C_1 V_1 = (1\text{pF})(24\text{V}) = 24\text{pC}.$

(b)  $U_3 = \frac{1}{2} C_3 V_3^2 = \frac{1}{2} (3\text{pF})(24\text{V})^2 = 864\text{pJ}.$

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

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

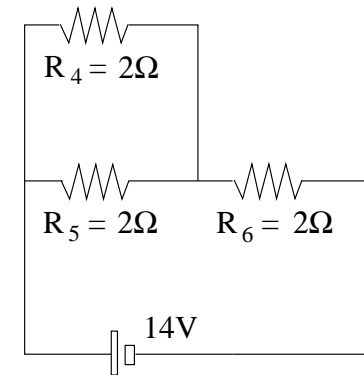
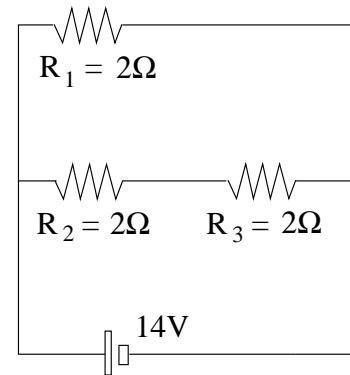
(d)  $V_4 = \frac{Q_4}{C_4} = \frac{32\text{pC}}{4\text{pF}} = 8\text{V}.$



## Unit Exam II: Problem #2 (Spring '15)



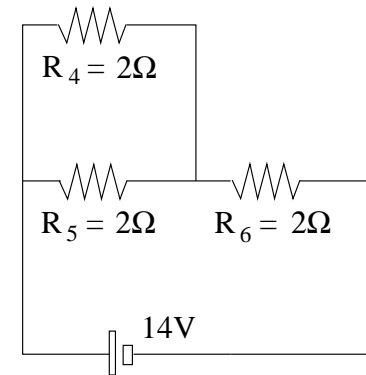
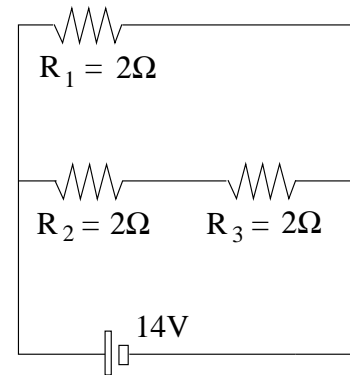
In the two resistor circuits shown find the equivalent resistances  $R_{123}$  (left) and  $R_{456}$  (right). Then find the currents  $I_1, I_2, I_3$  through the individual resistors on the left. and the currents  $I_4, I_5, I_6$  through the individual resistors on the right.



## Unit Exam II: Problem #2 (Spring '15)



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.



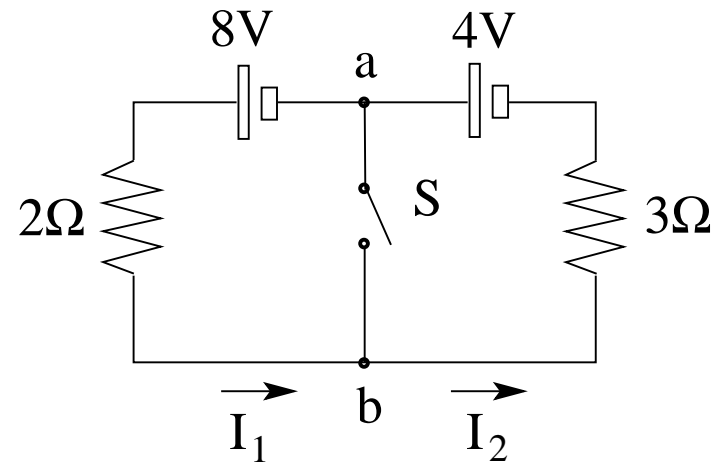
**Solution:**

- $R_{23} = 2\Omega + 2\Omega = 4\Omega$ ,  $R_{123} = \left(\frac{1}{2\Omega} + \frac{1}{4\Omega}\right)^{-1} = \frac{4}{3}\Omega$
- $R_{45} = \left(\frac{1}{2\Omega} + \frac{1}{2\Omega}\right)^{-1} = 1\Omega$ ,  $R_{456} = R_{45} + R_6 = 3\Omega$
- $I_1 = \frac{14V}{2\Omega} = 7A$ ,  $I_2 = I_3 = \frac{14V}{4\Omega} = 3.5A$
- $I_6 = I_{45} = \frac{14V}{3\Omega} = 4.67A$ ,  $I_4 = I_5 = \frac{1}{2}I_6 = 2.33A$

## Unit Exam II: Problem #3 (Spring '15)



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.



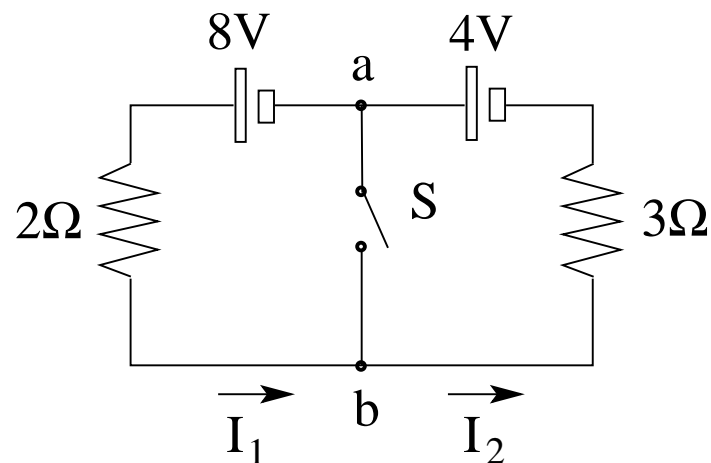


## Unit Exam II: Problem #3 (Spring '15)



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:**

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

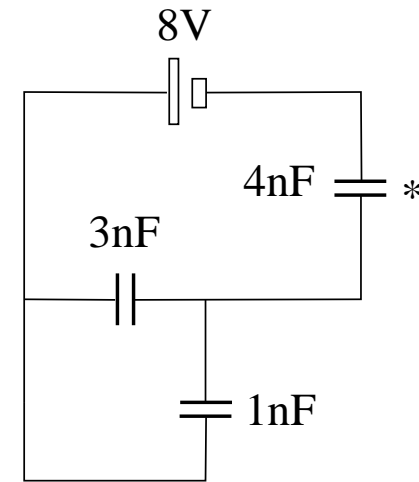
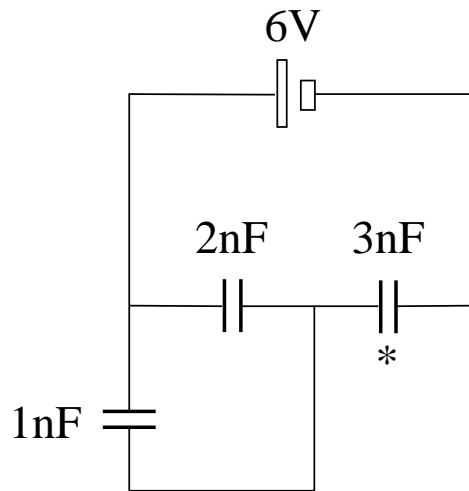
$$V_b - V_a = 8V - (2.4A)(2\Omega) = -4V + (2.4A)(3\Omega) = 3.2V.$$

$$(b) \quad I_1 = \frac{8V}{2\Omega} = 4A, \quad I_2 = \frac{4V}{3\Omega} = 1.33A, \quad V_b - V_a = 0.$$

# Unit Exam II: Problem #1 (Fall '15)



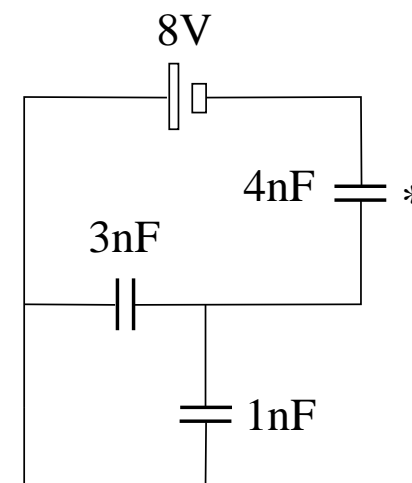
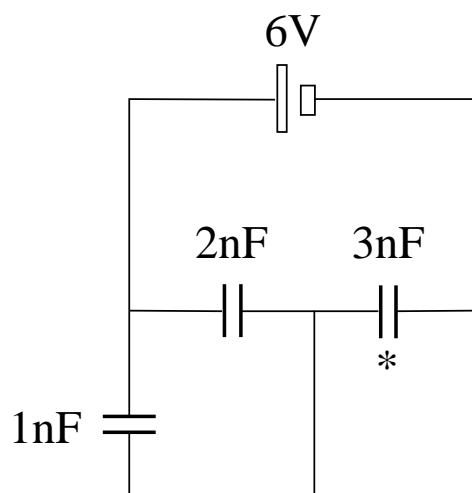
Consider the capacitor circuit shown at equilibrium. (a) Find the equivalent capacitance  $C_{eq}$ . (b) Find the total energy  $U$  stored in the three capacitors. (c) Find the voltage  $V_*$  across the capacitor marked by an asterisk. (d) Find the voltage  $V_1$  across the 1nF-capacitor.



# Unit Exam II: Problem #1 (Fall '15)



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:**

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

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

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

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

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

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

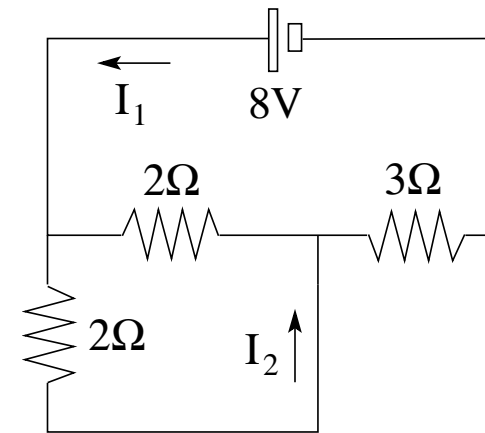
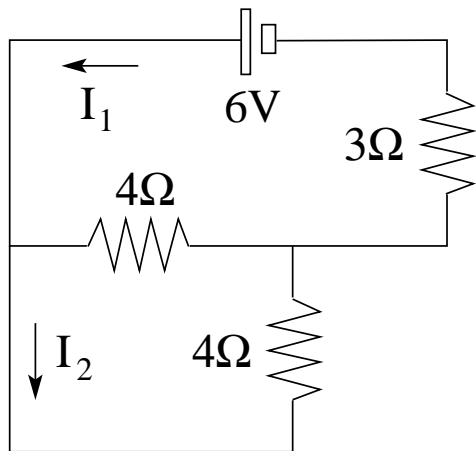
$$(c) V_* = \frac{1}{2} 8\text{V} = 4\text{V}$$

$$(d) V_1 = 8\text{V} - 4\text{V} = 4\text{V}$$

## Unit Exam II: Problem #2 (Fall '15)



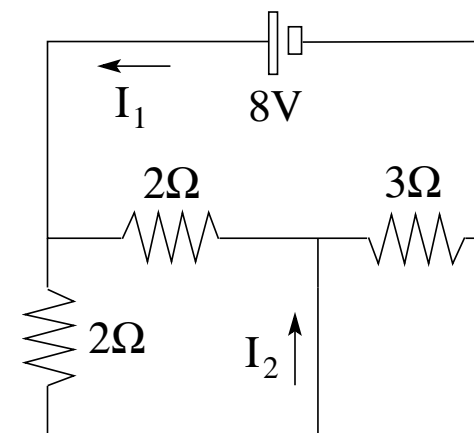
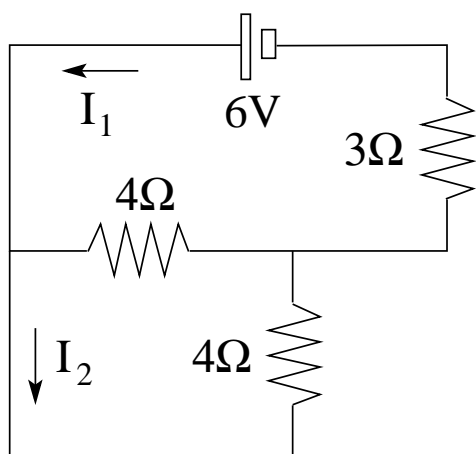
Consider the resistor circuit shown. (a) Find the equivalent resistance  $R_{eq}$ . (b) Find the currents  $I_1$  and  $I_2$ . (c) Find the power  $P$  supplied by the battery.



## Unit Exam II: Problem #2 (Fall '15)



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:**

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

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

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

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

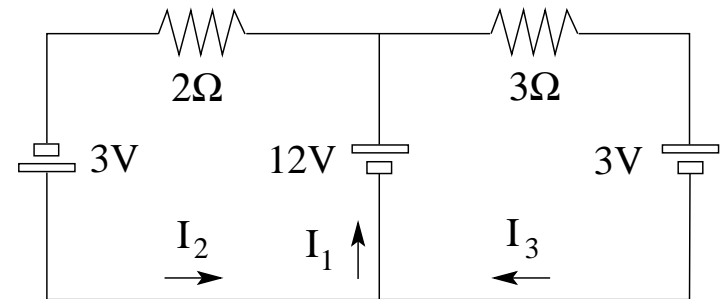
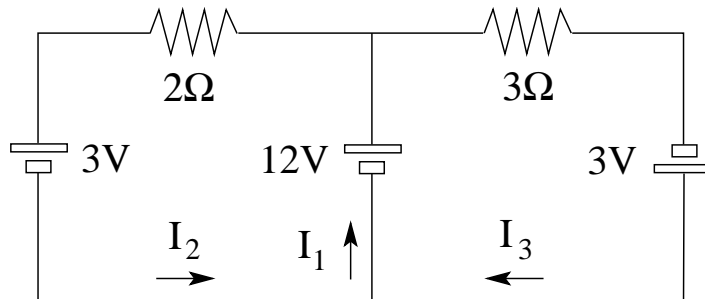
$$(b) I_1 = \frac{8V}{4\Omega} = 2A, \quad I_2 = \frac{1}{2}I_1 = 1A$$

$$(c) P = (2A)(8V) = 16W$$

# Unit Exam II: Problem #3 (Fall '15)



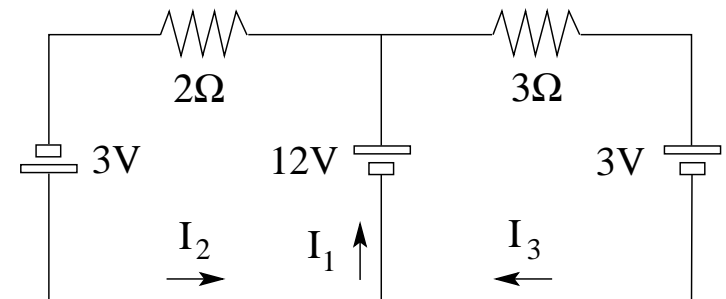
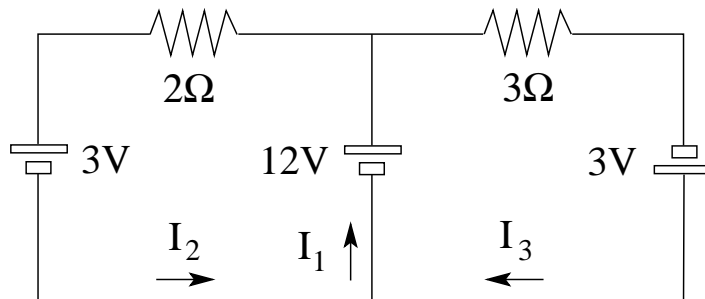
Consider the electric circuit shown.  
Find the currents  $I_1$ ,  $I_2$ ,  $I_3$ .



# Unit Exam II: Problem #3 (Fall '15)



Consider the electric circuit shown.  
Find the currents  $I_1$ ,  $I_2$ ,  $I_3$ .



**Solution:**

$$12V - I_2(2\Omega) - 3V = 0$$

$$\Rightarrow I_2 = \frac{9V}{2\Omega} = 4.5A$$

$$12V - I_3(3\Omega) + 3V = 0$$

$$\Rightarrow I_3 = \frac{15V}{3\Omega} = 5A.$$

$$I_1 = I_2 + I_3 = 9.5A$$

$$12V - I_2(2\Omega) + 3V = 0$$

$$\Rightarrow I_2 = \frac{15V}{2\Omega} = 7.5A.$$

$$12V - I_3(3\Omega) - 3V = 0$$

$$\Rightarrow I_3 = \frac{9V}{3\Omega} = 3A.$$

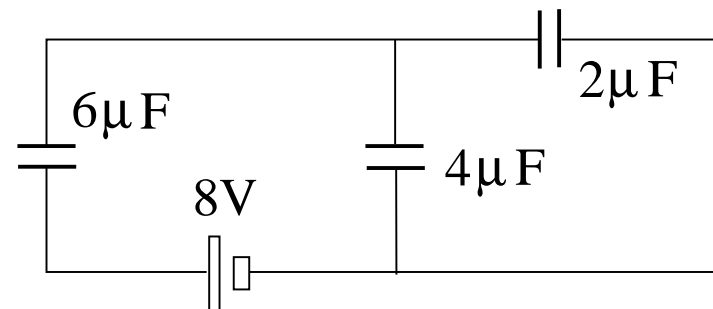
$$I_1 = I_2 + I_3 = 10.5A$$

## Unit Exam II: Problem #1 (Spring '16)



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.





## Unit Exam II: Problem #1 (Spring '16)



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.

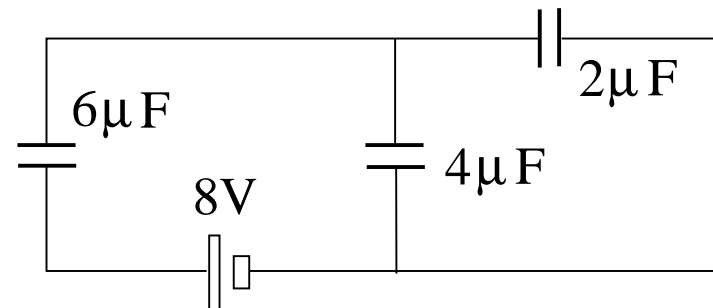
**Solution:**

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

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

$$(c) \quad Q_6 = (8\text{V})(3\mu\text{F}) = 24\mu\text{C}.$$

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

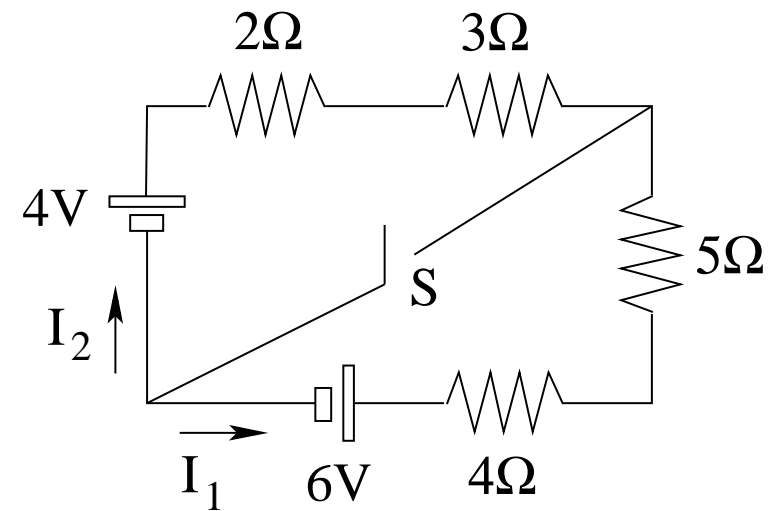


## Unit Exam II: Problem #2 (Spring '16)



Consider the electrical circuit shown.

- Find the current  $I_1$  when the switch  $S$  is open.
- Find the currents  $I_1$  and  $I_2$  when the switch  $S$  is closed.

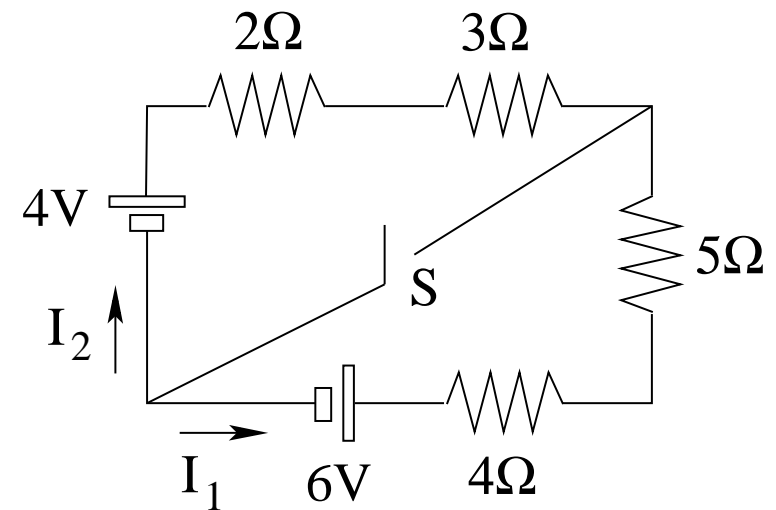


## Unit Exam II: Problem #2 (Spring '16)



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:**

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

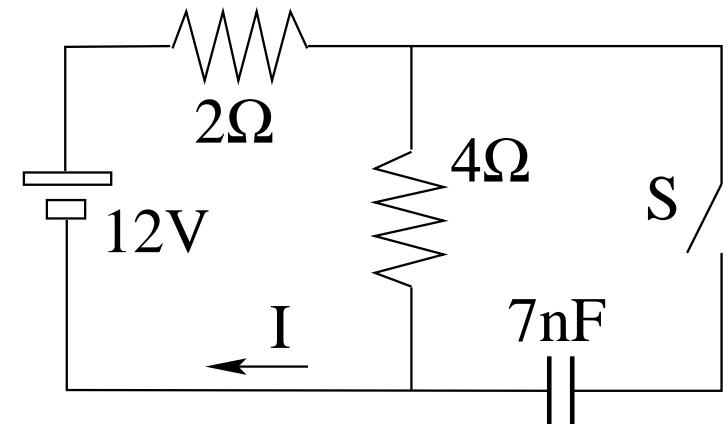
$$(b) \quad I_1 = \frac{6V}{4\Omega + 5\Omega} = 0.667A, \quad I_2 = \frac{4V}{3\Omega + 2\Omega} = 0.8A.$$

## Unit Exam II: Problem #3 (Spring '15)



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.



## Unit Exam II: Problem #3 (Spring '15)



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.

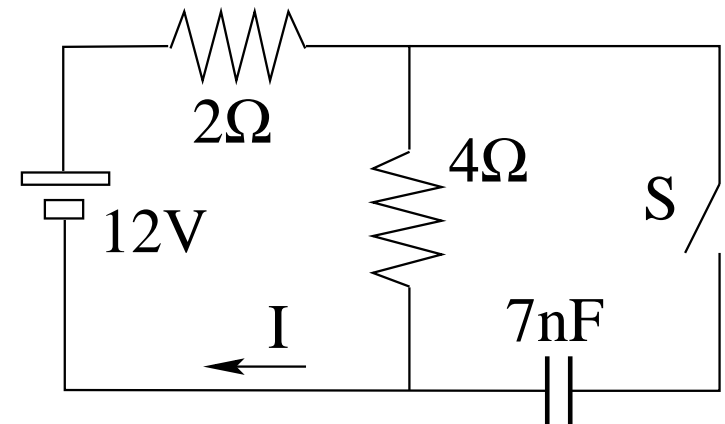
**Solution:**

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

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

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

$$(d) \quad Q = (8\text{V})(7\text{nF}) = 56\text{nC}.$$

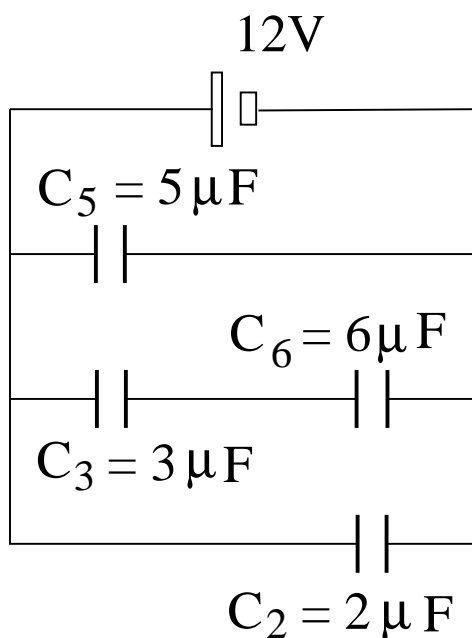


# Unit Exam II: Problem #1 (Fall '16)

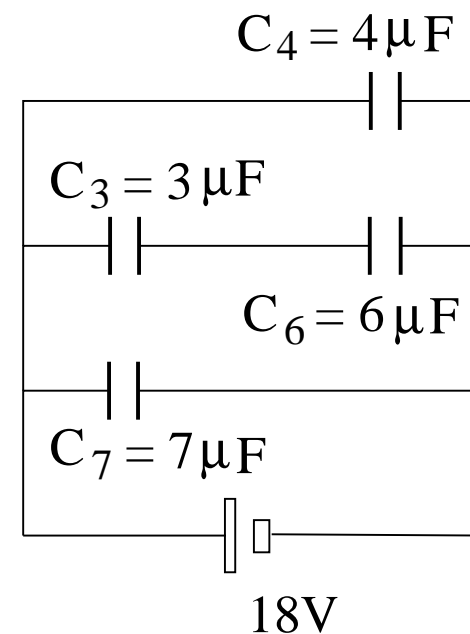


The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

- (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  $C_{eq}$ .



## Unit Exam II: Problem #1 (Fall '16)



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)  $V_2 = 12\text{V}$ .
- (b)  $U_5 = \frac{1}{2}(5\mu\text{F})(12\text{V})^2 = 360\mu\text{J}$ .
- (c)  $C_{36} = 2\mu\text{F}$   
 $\Rightarrow Q_3 = Q_{36} = (12\text{V})(2\mu\text{F}) = 24\mu\text{C}$ .
- (d)  $C_{eq} = C_5 + C_{36} + C_2 = 9\mu\text{F}$ .

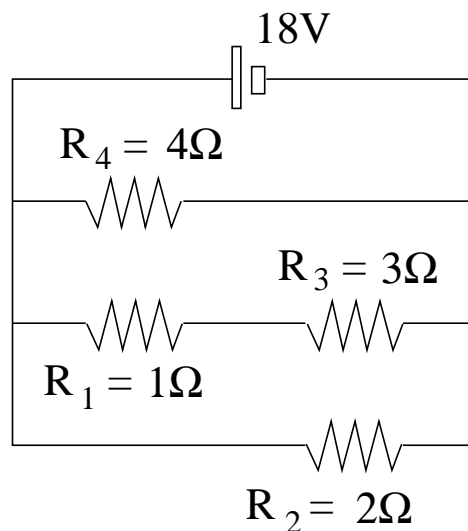
- (a)  $V_4 = 18\text{V}$ .
- (b)  $U_7 = \frac{1}{2}(7\mu\text{F})(18\text{V})^2 = 1134\mu\text{J}$ .
- (c)  $C_{36} = 2\mu\text{F}$   
 $\Rightarrow Q_6 = Q_{36} = (18\text{V})(2\mu\text{F}) = 36\mu\text{C}$ .
- (d)  $C_{eq} = C_4 + C_{36} + C_7 = 13\mu\text{F}$ .

# Unit Exam II: Problem #2 (Fall '16)

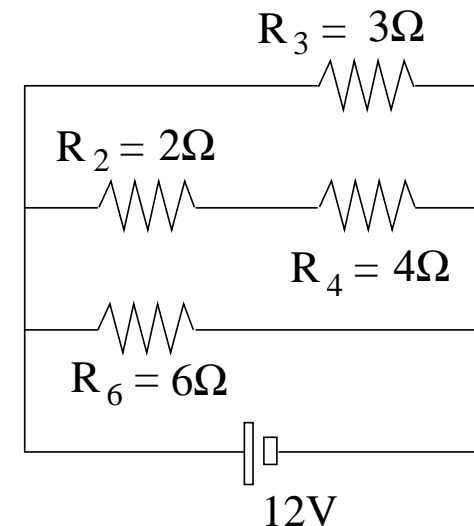


This resistor circuit is in a state of steady currents. Find ...

- (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  $R_{eq}$ .





## Unit Exam II: Problem #2 (Fall '16)



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)  $V_2 = 18\text{V}$ .

(b)  $P_4 = \frac{18\text{V}^2}{4\Omega} = 81\text{W}$ .

(c)  $I_3 = \frac{18\text{V}}{3\Omega + 1\Omega} = 4.5\text{A}$ .

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

(a)  $V_3 = 12\text{V}$

(b)  $P_6 = \frac{12\text{V}^2}{6\Omega} = 24\text{W}$ .

(c)  $I_4 = \frac{12\text{V}}{2\Omega + 4\Omega} = 2\text{A}$ .

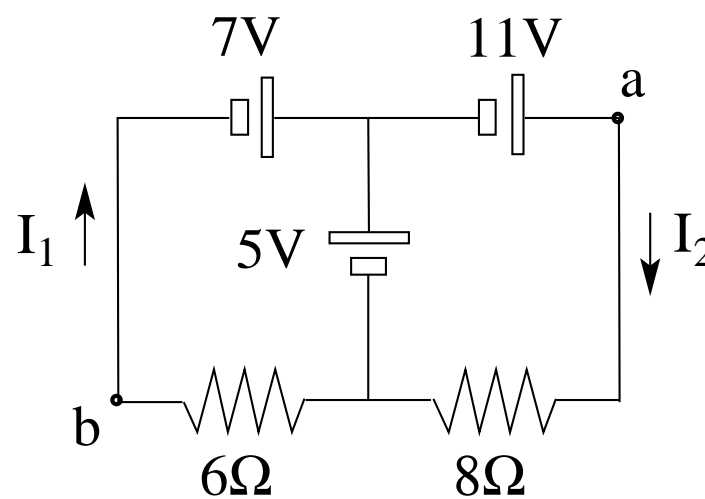
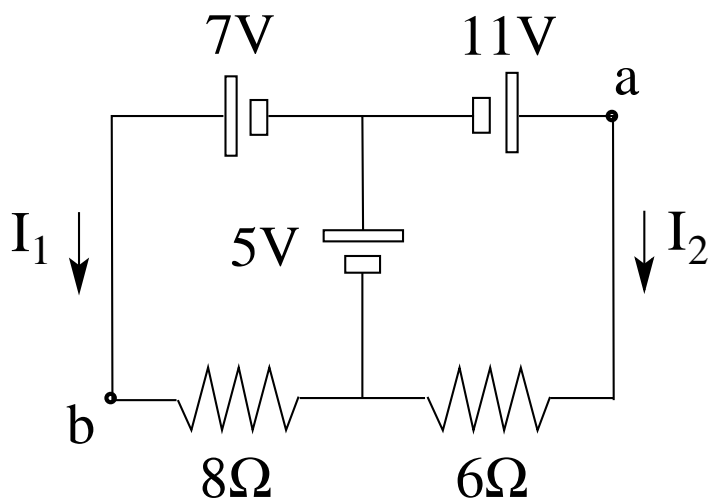
(d)  $R_{eq} = \left( \frac{1}{3\Omega} + \frac{1}{2\Omega + 4\Omega} + \frac{1}{6\Omega} \right)^{-1} = 1.5\Omega$

# Unit Exam II: Problem #3 (Fall '16)



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  $V_a - V_b$ .

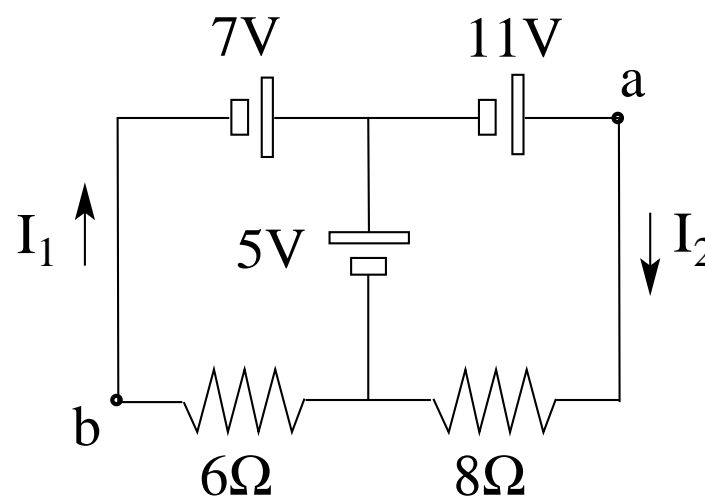
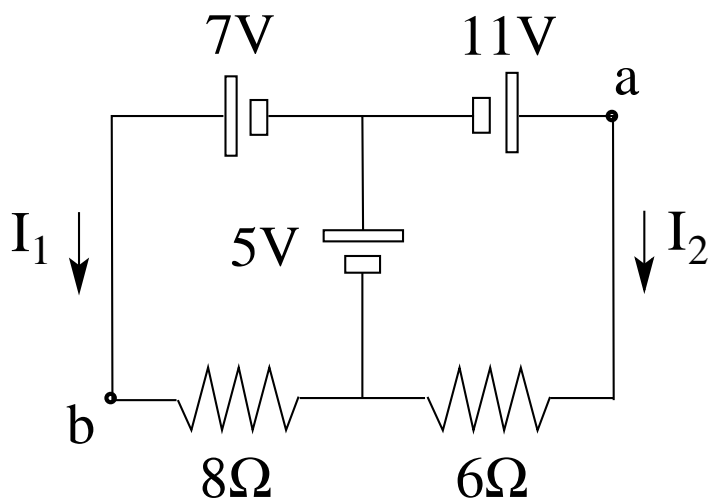


# Unit Exam II: Problem #3 (Fall '16)



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)  $I_2 = \frac{5V + 11V}{8\Omega} = +2A.$

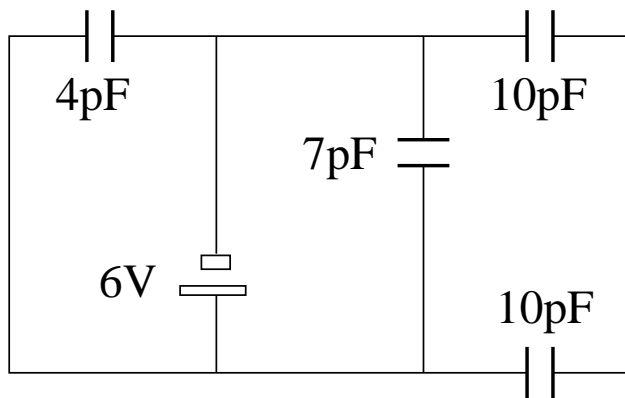
(c)  $V_a - V_b = 7V + 11V = +18V.$

# Unit Exam II: Problem #1 (Spring '17)

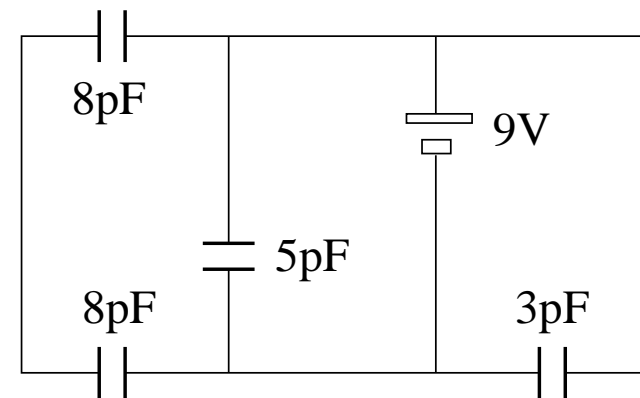


The capacitors (initially discharged) have been connected to the battery. The circuit is now at equilibrium. Find ...

- (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  $C_{eq}$ .



## Unit Exam II: Problem #1 (Spring '17)



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)  $C_{eq} = 3pF + 5pF + 4pF = 12pF.$

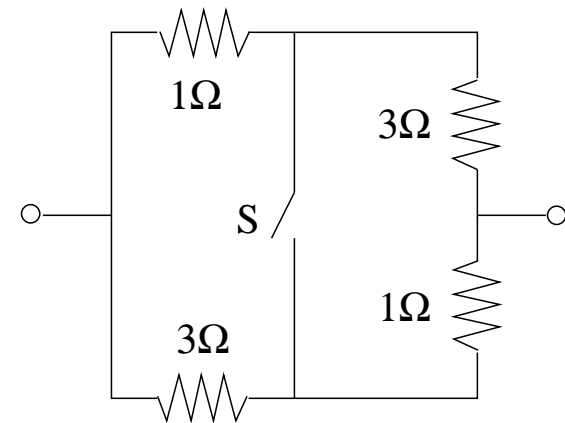
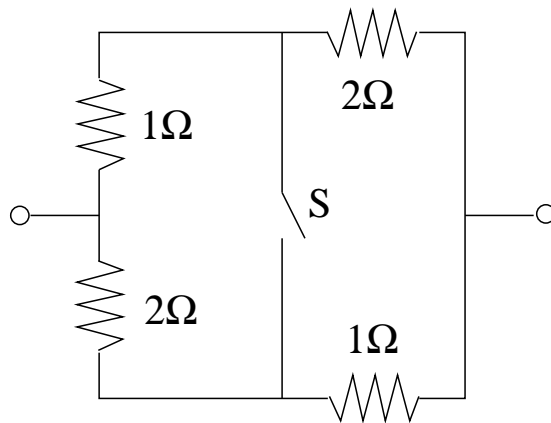
## Unit Exam II: Problem #2 (Spring '17)



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.



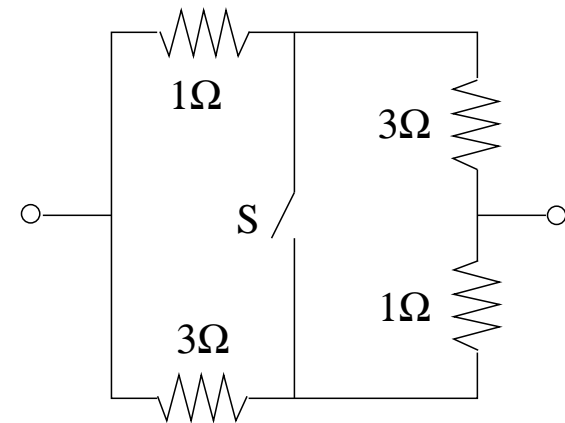
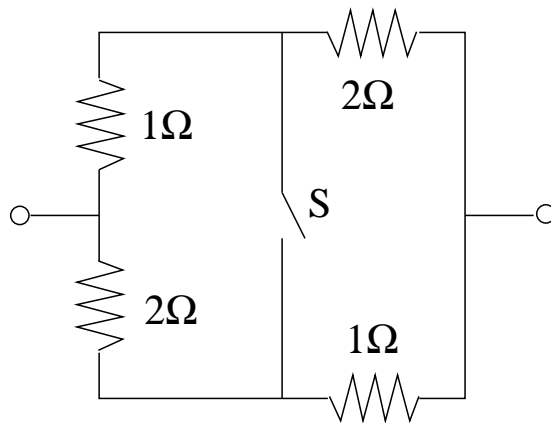
## Unit Exam II: Problem #2 (Spring '17)



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:**

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

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

$$\begin{aligned} R_{\text{eq}}^{(\text{closed})} &= \left( \frac{1}{1\Omega} + \frac{1}{2\Omega} \right)^{-1} + \left( \frac{1}{1\Omega} + \frac{1}{2\Omega} \right)^{-1} \\ &= \frac{4}{3}\Omega. \end{aligned}$$

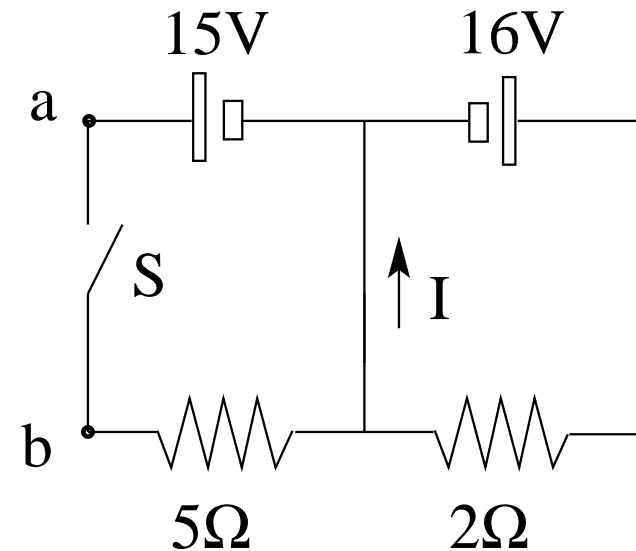
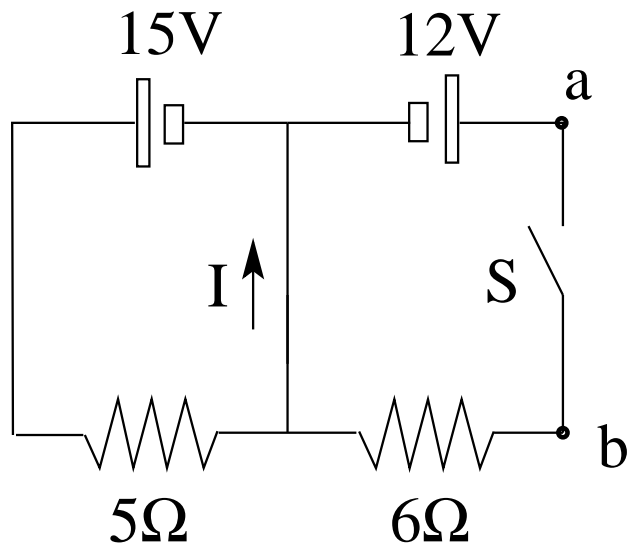
$$\begin{aligned} R_{\text{eq}}^{(\text{closed})} &= \left( \frac{1}{1\Omega} + \frac{1}{3\Omega} \right)^{-1} + \left( \frac{1}{1\Omega} + \frac{1}{3\Omega} \right)^{-1} \\ &= \frac{3}{2}\Omega. \end{aligned}$$

## Unit Exam II: Problem #3 (Spring '17)



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.





## Unit Exam II: Problem #3 (Spring '17)



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:**

$$(a) \quad I = \frac{15\text{V}}{5\Omega} = 3\text{A}.$$

$$(b) \quad I = \frac{15\text{V}}{5\Omega} + \frac{12\text{V}}{6\Omega} = 3\text{A} + 2\text{A} = 5\text{A}.$$

$$(c) \quad V_a - V_b = 12\text{V}.$$

$$(d) \quad V_a - V_b = 0.$$

$$(a) \quad I = \frac{16\text{V}}{2\Omega} = 8\text{A}.$$

$$(b) \quad I = \frac{16\text{V}}{2\Omega} + \frac{15\text{V}}{5\Omega} = 8\text{A} + 3\text{A} = 11\text{A}.$$

$$(c) \quad V_a - V_b = 15\text{V}.$$

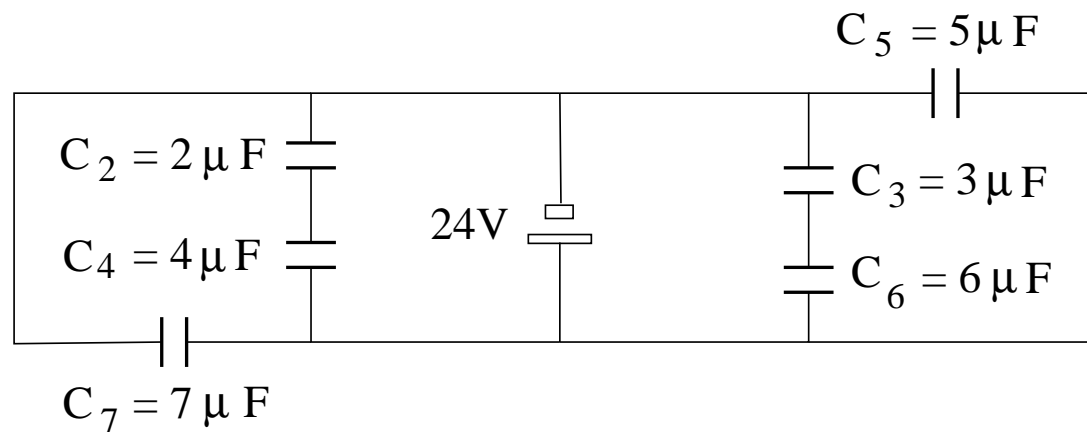
$$(d) \quad V_a - V_b = 0.$$

# Unit Exam II: Problem #1 (Fall '17)



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  $C_3, C_6$ ].

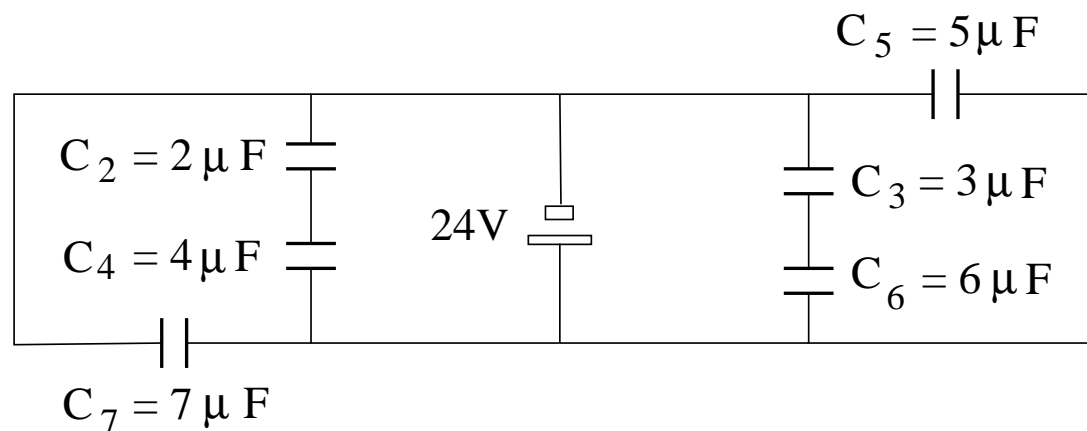


# Unit Exam II: Problem #1 (Fall '17)



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:**

- $Q_7 = (24\text{V})(7\mu\text{F}) = 168\mu\text{C}$  [ $Q_5 = (24\text{V})(5\mu\text{F}) = 120\mu\text{C}$ ]
- $U_5 = \frac{1}{2}(5\mu\text{F})(24\text{V})^2 = 1440\mu\text{J}$  [ $U_7 = \frac{1}{2}(7\mu\text{F})(24\text{V})^2 = 2016\mu\text{J}$ ]
- $V_2 + V_4 = 24\text{V}, \quad V_2C_2 = V_4C_4 \Rightarrow V_2 = 16\text{V}, \quad V_4 = 8\text{V}$   
 $[V_3 + V_6 = 24\text{V}, \quad V_3C_3 = V_6C_6 \Rightarrow V_3 = 16\text{V}, \quad V_6 = 8\text{V}]$

## Unit Exam II: Problem #2 (Fall '17)

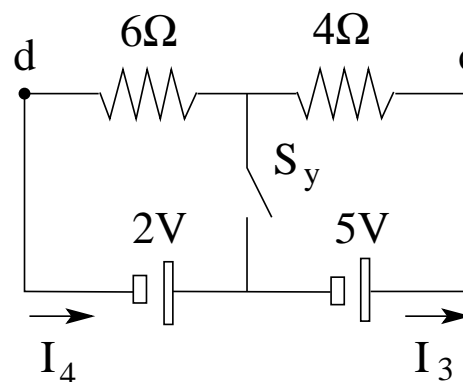
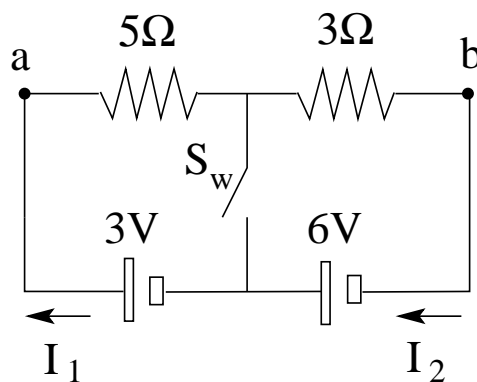


Consider the resistor circuit on the left [right].

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



## Unit Exam II: Problem #2 (Fall '17)

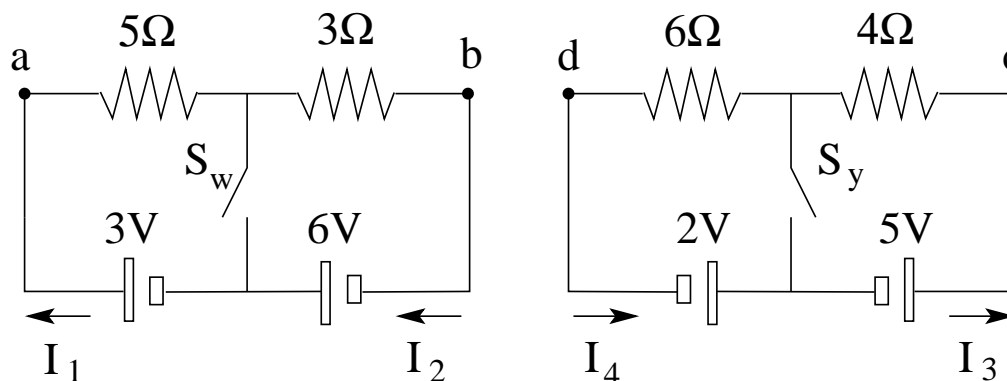


Consider the resistor circuit on the left [right].

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



**Solution:**

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

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

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

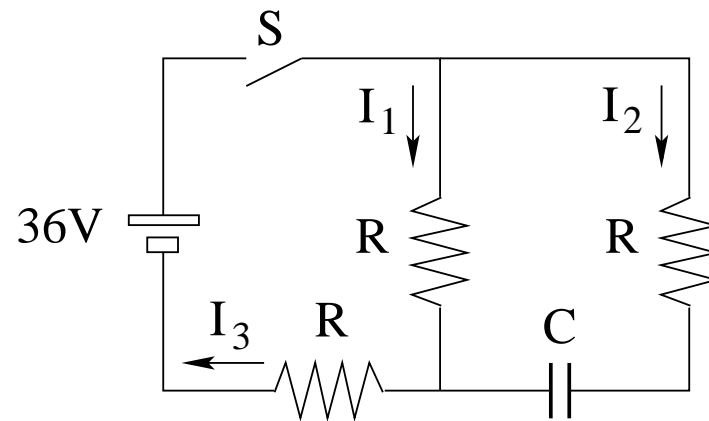
$$\left[ I_3 = \frac{5V}{4\Omega} = 1.25A, \quad I_4 = \frac{2V}{6\Omega} = 0.333A, \quad V_c - V_d = 7V. \right]$$

## Unit Exam II: Problem #3 (Fall '17)



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

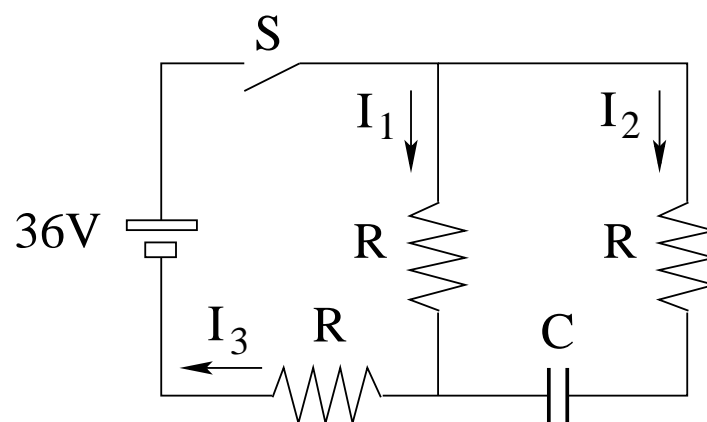


## Unit Exam II: Problem #3 (Fall '17)



The switch  $S$  of this circuit has been open for a long time. The capacitor has capacitance  $C = 6\mu\text{F}$  [ $C = 4\mu\text{F}$ ]. 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:  $R_{eq} = 9\Omega$  [ $R_{eq} = 6\Omega$ ]

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

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

$$I_1 = I_3 = \frac{36\text{V}}{12\Omega} = 3\text{A}, \quad I_2 = 0, \quad \left[ I_1 = I_3 = \frac{36\text{V}}{8\Omega} = 4.5\text{A}, \quad I_2 = 0 \right].$$

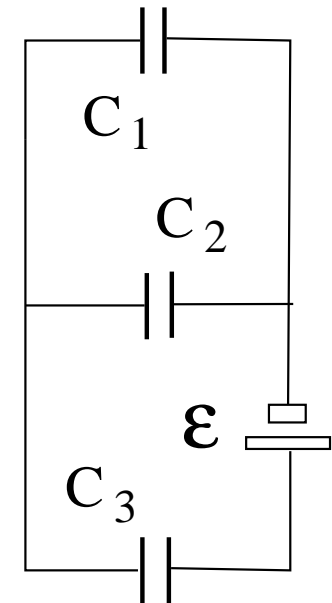
## Unit Exam II: Problem #1 (Spring '18)



The circuit shown has reached equilibrium.

The specifications are  $\mathcal{E} = 12\text{V}$  [18V],  $C_1 = C_2 = C_3 = 5\text{nF}$  [4nF]

- Find the equivalent capacitance  $C_{eq}$ .
- Find the charge  $Q_2$  on capacitor  $C_2$ .
- Find the voltage  $V_3$  across capacitor  $C_3$ .
- Find the total energy  $U$  stored in the capacitors.





## Unit Exam II: Problem #1 (Spring '18)



The circuit shown has reached equilibrium.

The specifications are  $\mathcal{E} = 12\text{V}$  [18V],  $C_1 = C_2 = C_3 = 5\text{nF}$  [4nF]

- Find the equivalent capacitance  $C_{eq}$ .
- Find the charge  $Q_2$  on capacitor  $C_2$ .
- Find the voltage  $V_3$  across capacitor  $C_3$ .
- Find the total energy  $U$  stored in the capacitors.

**Solution:**

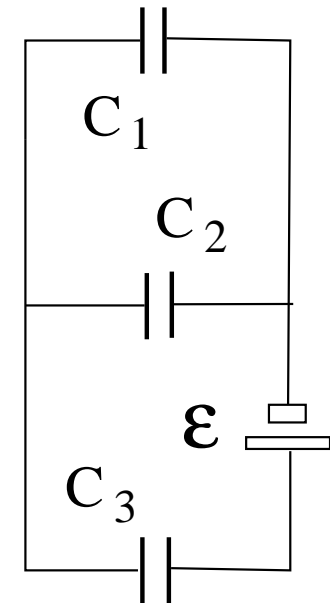
(a)  $C_{12} = C_1 + C_2 = 10\text{nF}$  [8nF].

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

(b)  $Q_3 = Q_{12} = \mathcal{E}C_{eq} = 40\text{nC}$  [48nC],  $Q_1 = Q_2 = \frac{1}{2}Q_{12} = 20\text{nC}$  [24nC].

(c)  $V_3 = \frac{Q_3}{C_3} = 8\text{V}$  [12V],  $V_1 = V_2 = \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = 4\text{V}$  [6V].

(d)  $U = \frac{1}{2}C_{eq}\mathcal{E}^2 = 240\text{nJ}$  [432nJ].



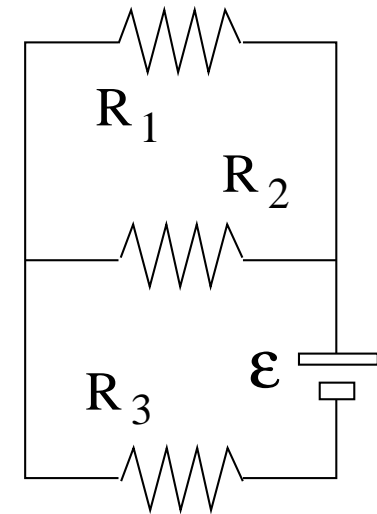
## Unit Exam II: Problem #2 (Spring '18)



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.



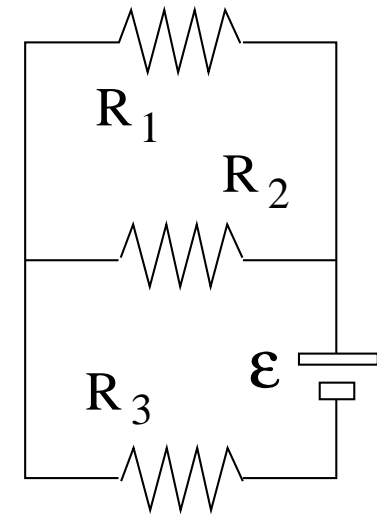
## Unit Exam II: Problem #2 (Spring '18)



The circuit shown is in a steady state.

The specifications are  $\mathcal{E} = 12\text{V}$  [18V],  $R_1 = R_2 = R_3 = 5\Omega$  [4Ω].

- Find the equivalent resistance  $R_{eq}$ .
- Find the currents  $I_1$  through resistor  $R_1$ .
- Find the voltage  $V_3$  across resistor  $R_3$ .
- Find the power  $P$  produced by the battery.



**Solution:**

$$(a) R_{12} = \left( \frac{1}{R_1} + \frac{1}{R_2} \right)^{-1} = 2.5\Omega \text{ [2.0}\Omega], \quad R_{eq} = R_{12} + R_3 = 7.5\Omega \text{ [6.0}\Omega].$$

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

$$(c) V_3 = R_3 I_3 = 8\text{V} \text{ [12V]}, \quad V_1 = V_2 = R_1 I_1 = R_2 I_2 = 4\text{V} \text{ [6V]}.$$

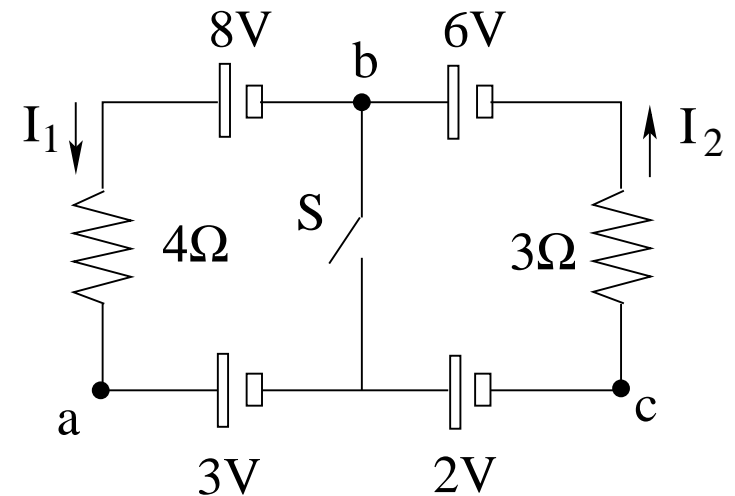
$$(d) P = \frac{\mathcal{E}^2}{R_{eq}} = R_{eq} I_3^2 = 19.2\text{W} \text{ [54.0W]}.$$

## Unit Exam II: Problem #3 (Spring '18)



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.

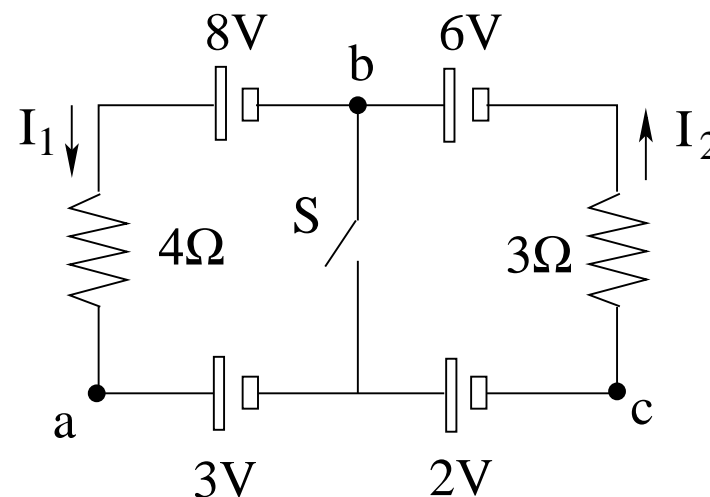


## Unit Exam II: Problem #3 (Spring '18)



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:**

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

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

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

$$(d) \quad V_a - V_b = 3V, \quad V_b - V_c = 2V.$$

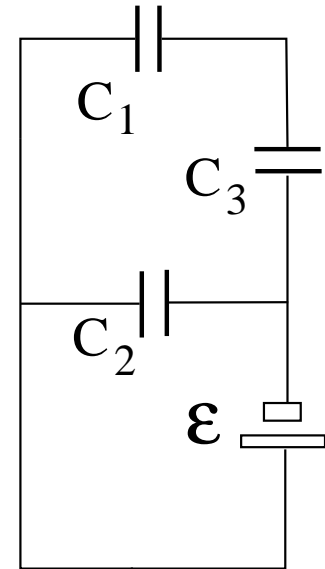
## Unit Exam II: Problem #1 (Fall '18)



The circuit shown has reached equilibrium.

The specifications are  $\mathcal{E} = 12\text{V}$  [14V],  $C_1 = C_2 = C_3 = 7\text{nF}$  [5nF]

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



## Unit Exam II: Problem #1 (Fall '18)



The circuit shown has reached equilibrium.

The specifications are  $\mathcal{E} = 12\text{V}$  [14V],  $C_1 = C_2 = C_3 = 7\text{nF}$  [5nF]

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

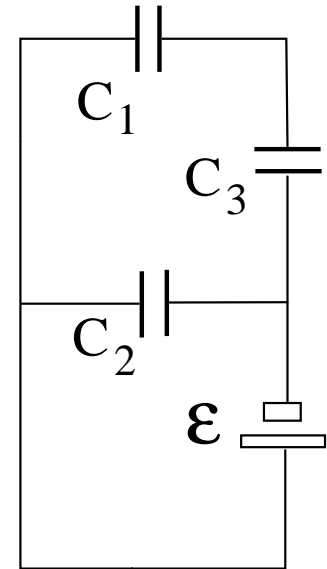
**Solution:**

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

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

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

$$(c) \quad V_1 = \frac{Q_1}{C_1} = 6\text{V} [7\text{V}], \quad V_2 = \frac{Q_2}{C_2} = 12\text{V} [14\text{V}], \quad V_3 = \frac{Q_3}{C_3} = 6\text{V} [7\text{V}].$$



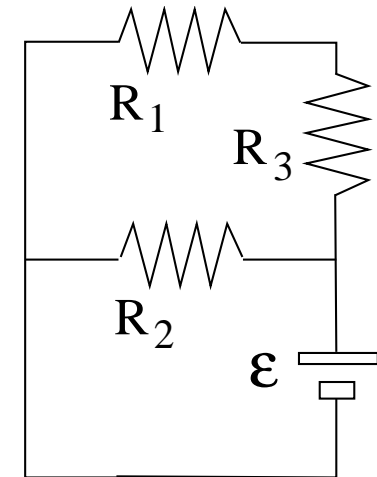
## Unit Exam II: Problem #2 (Fall '18)



The circuit shown is in a steady state.

The specifications are  $\mathcal{E} = 12\text{V}$  [14V],  $R_1 = R_2 = R_3 = 7\Omega$  [5 $\Omega$ ].

- Find the equivalent resistance  $R_{eq}$ .
- Find the currents  $I_1, I_2, I_3$  through resistors 1, 2, 3, respectively.
- Find the voltages  $V_1, V_2, V_3$  across resistors 1, 2, 3, respectively.





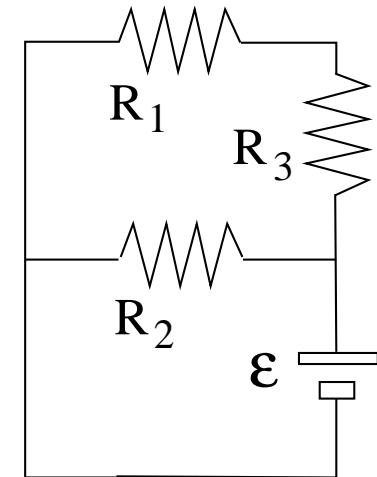
## Unit Exam II: Problem #2 (Fall '18)



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].

- Find the equivalent resistance  $R_{eq}$ .
- Find the currents  $I_1, I_2, I_3$  through resistors 1, 2, 3, respectively.
- 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)  $I_1 = I_3 = \frac{\mathcal{E}}{R_{13}} = 0.857\text{A}$  [1.40A],  $I_2 = \frac{\mathcal{E}}{R_2} = 1.71\text{A}$  [2.80A].

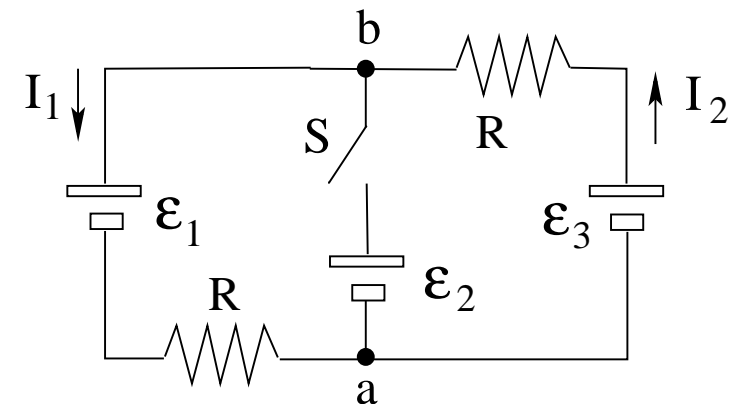
(c)  $V_1 = R_1 I_1 = 6\text{V}$  [7V],  $V_2 = R_2 I_2 = 12\text{V}$  [14V],  $V_3 = R_3 I_3 = 6\text{V}$  [7V].

## Unit Exam II: Problem #3 (Fall '18)



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

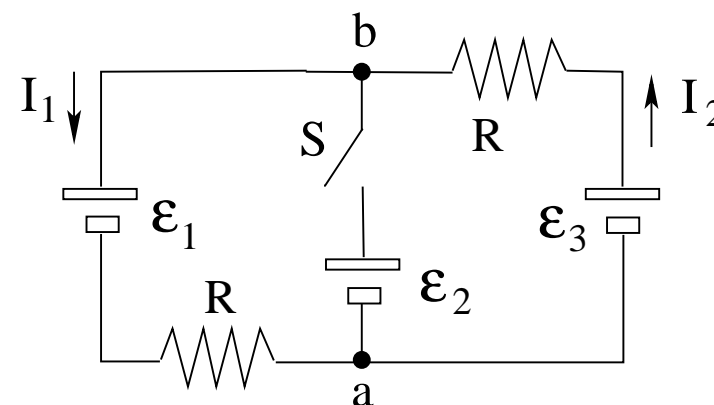


## Unit Exam II: Problem #3 (Fall '18)



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

- Find the currents  $I_1$  and  $I_2$  when the switch is open.
- Find the currents  $I_1$  and  $I_2$  when the switch is closed.
- Find the voltages  $V_b - V_a$  when the switch is open.
- Find the voltages  $V_b - V_a$  when the switch is closed.



**Solution:**

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

$$\left[ I_1 = I_2 = \frac{9V - 3V}{11\Omega + 11\Omega} = 0.273A \right]$$

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

$$\left[ I_1 = \frac{7V - 3V}{11\Omega} = 0.364A, \quad I_2 = \frac{9V - 7V}{11\Omega} = 0.182A \right]$$

$$(c) \quad V_b - V_a = (0.429A)(7\Omega) + 4V = 10V - (0.429A)(7\Omega) = 7V$$
$$[V_b - V_a = (0.273A)(11\Omega) + 3V = 9V - (0.273A)(11\Omega) = 6V]$$

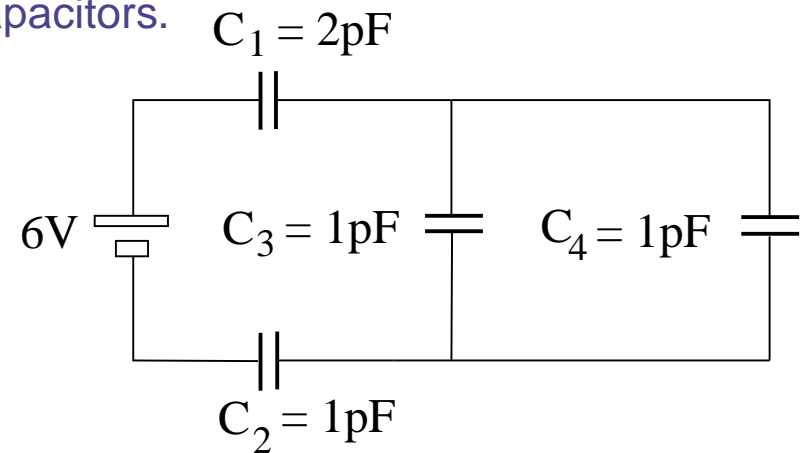
$$(d) \quad V_b - V_a = 6V \quad [V_b - V_a = 7V]$$

## Unit Exam II: Problem #1 (Spring '19)



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.

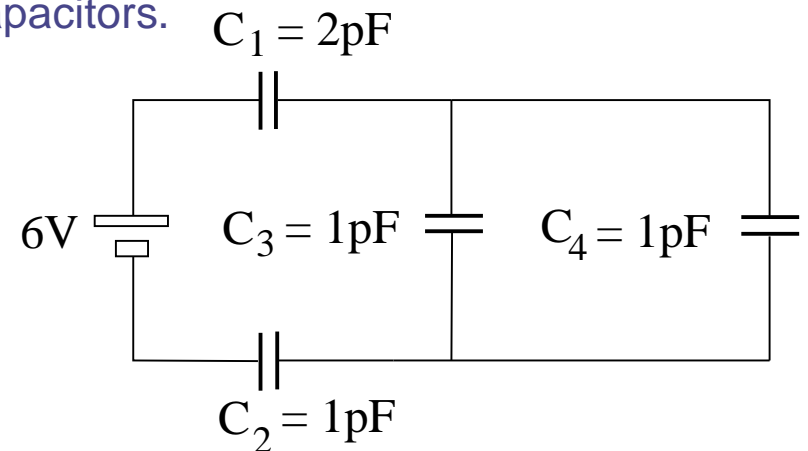


# Unit Exam II: Problem #1 (Spring '19)



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:**

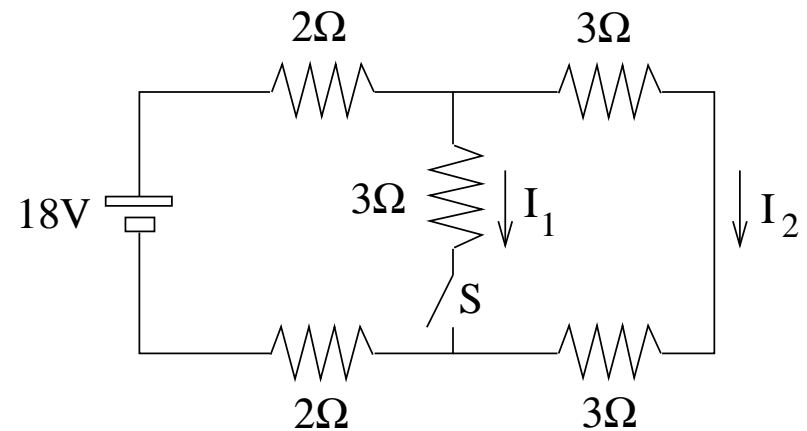
- (a)  $C_{34} = C_3 + C_4 = 2\text{pF}$ ,  $C_{eq} = \left( \frac{1}{C_1} + \frac{1}{C_{34}} + \frac{1}{C_2} \right)^{-1} = \frac{1}{2}\text{pF}$ .
- (b)  $Q_1 = Q_2 = Q_{34} = C_{eq}(6\text{V}) = 3\text{pC}$ ,  $Q_3 = Q_4 = \frac{1}{2}Q_{34} = 1.5\text{pC}$ .
- (c)  $V_1 = \frac{Q_1}{C_1} = 1.5\text{V}$ ,  $V_2 = \frac{Q_2}{C_2} = 3\text{V}$ ,  $V_3 = \frac{Q_3}{C_3} = 1.5\text{V}$ ,  $V_4 = \frac{Q_4}{C_4} = 1.5\text{V}$ .

## Unit Exam II: Problem #2 (Spring '19)



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.



## Unit Exam II: Problem #2 (Spring '19)



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.

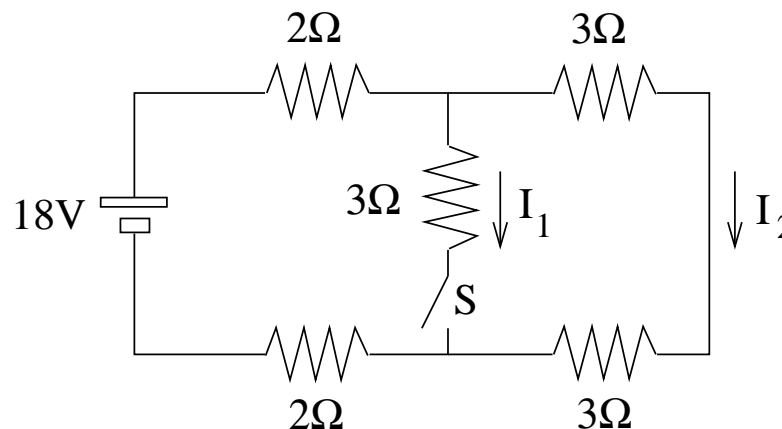
**Solution:**

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

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

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

(d)  $I_1 = \frac{6V}{3\Omega} = 2A, \quad I_2 = \frac{6V}{3\Omega + 3\Omega} = 1A.$

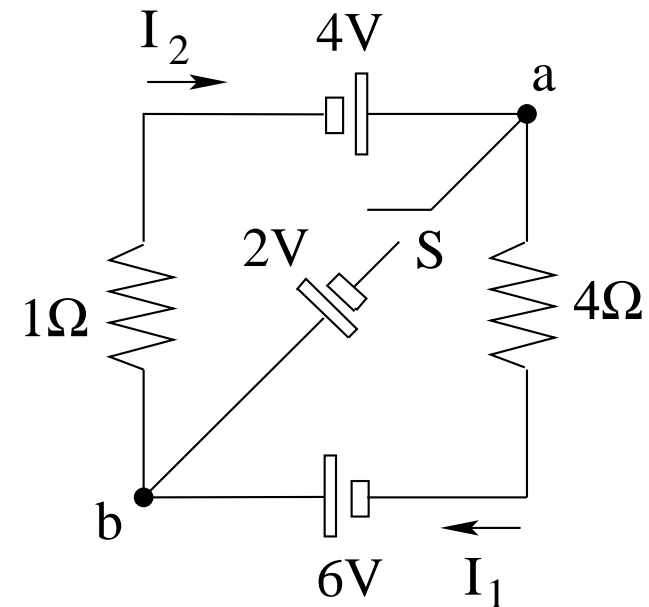


## Unit Exam II: Problem #3 (Spring '19)



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.



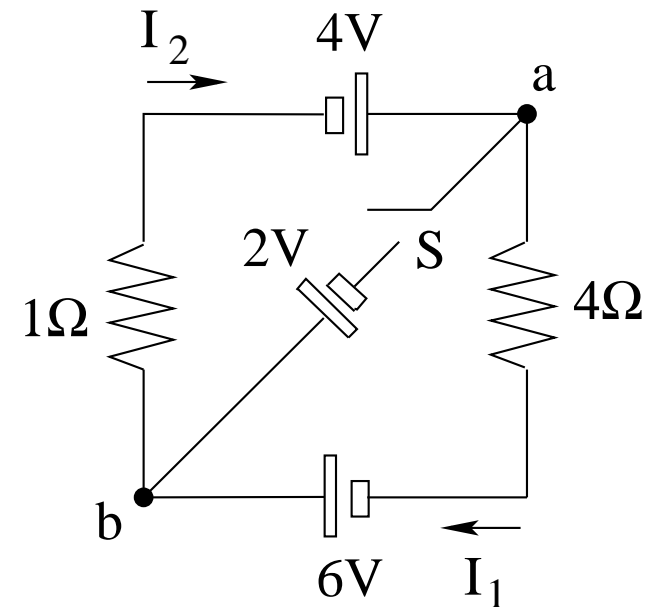


## Unit Exam II: Problem #3 (Spring '19)



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)  $V_a - V_b = -2V.$