ECE 201, Section 3
Lecture 15

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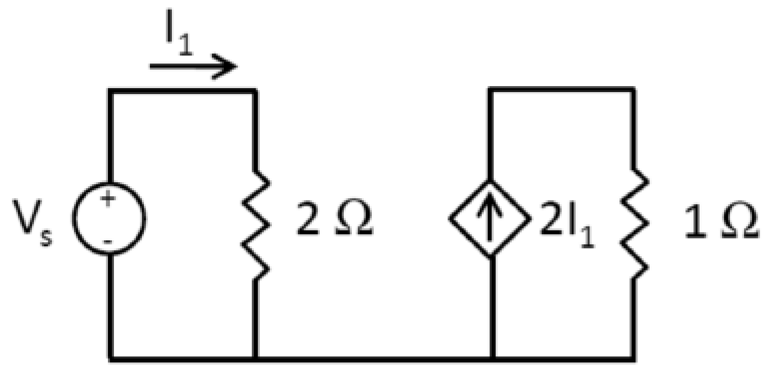
September 24, 2012

Solutions for Exam #1

- Posted answer key for now
- Will post more comprehensive solutions soon
- Will review the following today:
  - Eight hard & medium difficulty problems: 3, 6, 8, 10-13, 15
- Will not review seven problems in class: 1, 2, 4, 5, 7, 9, 14

Exam 1, Problem 3

3. If an independent voltage source of 6V drives current I_1 through a 2 Ω resistor, and a dependent current source generates a current of $2I_1$ connected to a resistor of 1 Ω, what total power is dissipated by both resistors combined?

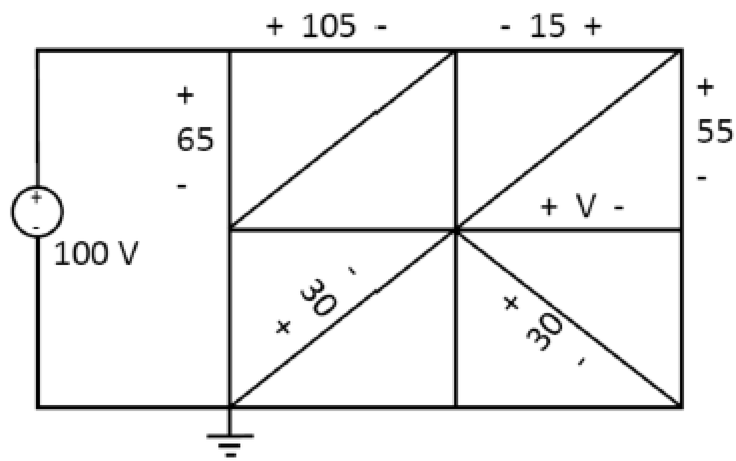


Answers:

(1) 6
(2) 12
(3) 18
(4) 36
(5) 54
(6) 72
(7) 108
(8) None of the above

Exam 1, Problem 6

6. What is the voltage *V* in the indicated location of the diagram below?

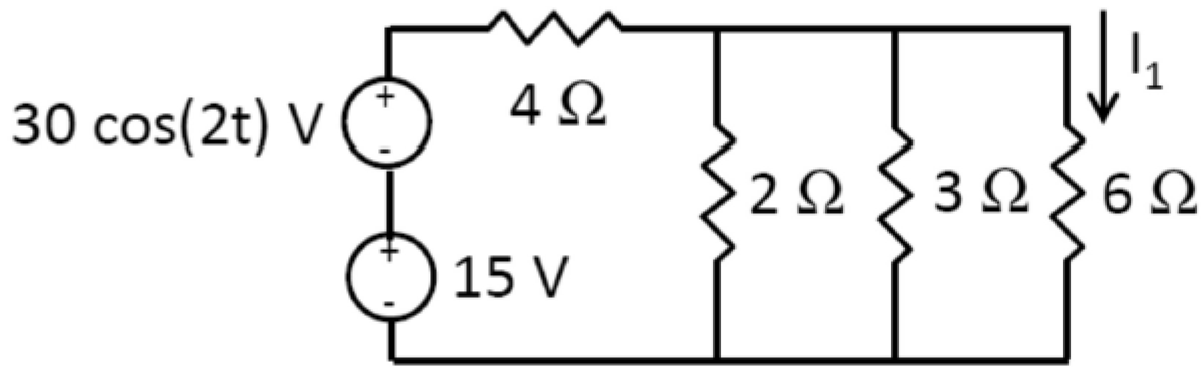


Answers:

(1) 5
(2) 10
(3) 15
(4) 20
(5) 25
(6) 30
(7) 35
(8) None of the above

Exam 1, Problem 8

8. What is the current I_1 (in Amperes) flowing through the 6 Ω resistor on the right-hand side of the diagram below?

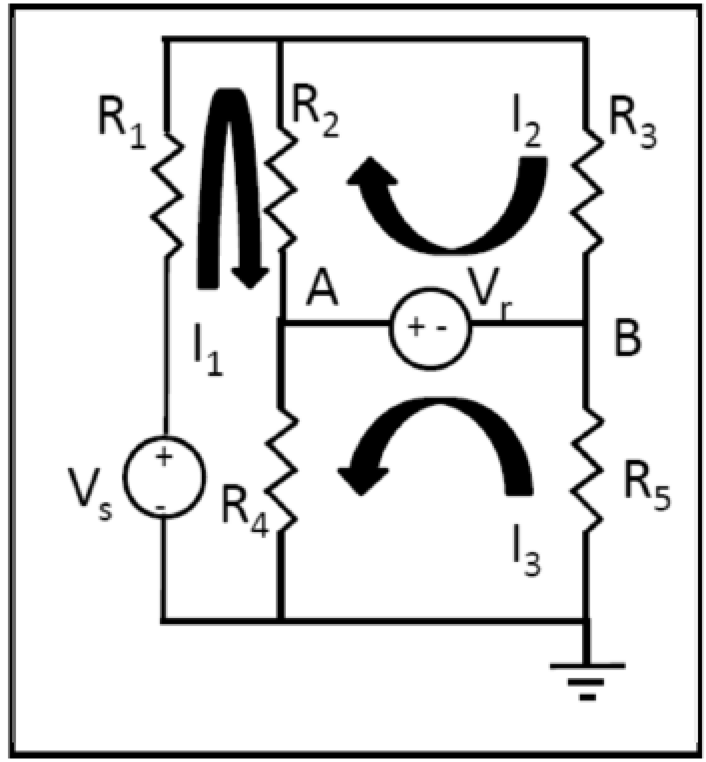


Answers:

(1) 0.5+cos(2t)
(2) 1+cos(2t)
(3) 1+2cos(2t)
(4) 1.5+1.5cos(2t)
(5) 1.5+3cos(2t)
(6) 2.5
(7) 5 cos(2t)
(8) None of the above

Exam 1, Problem 10

10. Write down the matrix equation for the currents in the circuit below using loop analysis, in terms of the given resistances and voltages (Note: $R_{124}=R_1+R_2+R_4$).



Answers:

(1) $$\begin{bmatrix} R_4 & 0 & R_4+R_5 \\ -R_2 & R_2+R_3 & 0 \\ R_{124} & -R_2 & R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_s \\ V_r \\ V_s \end{bmatrix}$$

(2) $$\begin{bmatrix} R_4 & 0 & R_4+R_5 \\ -R_2 & R_3 & 0 \\ R_{124} & R_2 & -R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_r \\ V_s \end{bmatrix}$$

(3) $$\begin{bmatrix} R_1 & R_2+R_3 & R_4+R_5 \\ -R_2 & R_1+R_4 & 0 \\ R_{124} & -R_2 & R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_s \\ V_r \end{bmatrix}$$

(4) $$\begin{bmatrix} R_1 & 0 & R_4+R_5 \\ -R_2 & R_2 & 0 \\ R_{124} & -R_2 & R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_r \\ V_s \end{bmatrix}$$

(5) $$\begin{bmatrix} R_4 & 0 & R_4+R_5 \\ R_2 & R_2-R_3 & R_1 \\ R_{124} & -R_2 & R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_r \\ V_s \end{bmatrix}$$

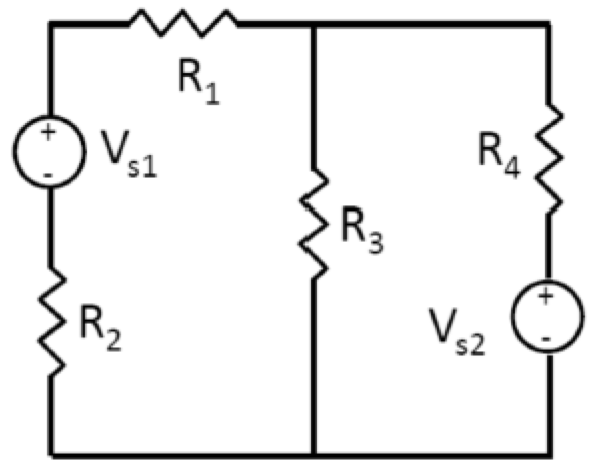
(6) $$\begin{bmatrix} R_4+R_5 & 0 & 0 \\ 0 & R_2+R_3 & 0 \\ 0 & 0 & R_{124} \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_r \\ V_s \end{bmatrix}$$

(7) $$\begin{bmatrix} R_4 & 0 & R_4+R_5 \\ -R_2 & R_2+R_3 & 0 \\ R_{124} & -R_2 & R_4 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}=\begin{bmatrix} V_r \\ V_r \\ V_s \end{bmatrix}$$

(8) None of the above

Exam 1, Problem 11

11. Find the voltage drop across R_3, if $R_1=R_2=R_3=R_4=1\ \Omega$ and $V_{s1}=V_{s2}=1$ V:

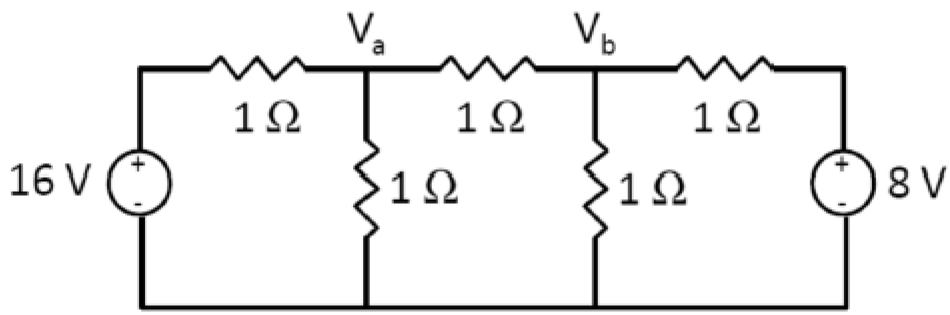


Answers:

(1) 0.1 V
(2) 0.2 V
(3) 0.3 V
(4) 0.4 V
(5) 0.5 V
(6) 0.6 V
(7) 0.7 V
(8) None of the above

Exam 1, Problem 12

12. Find V_a and V_b for the circuit below, assuming that the bottom plane is grounded:

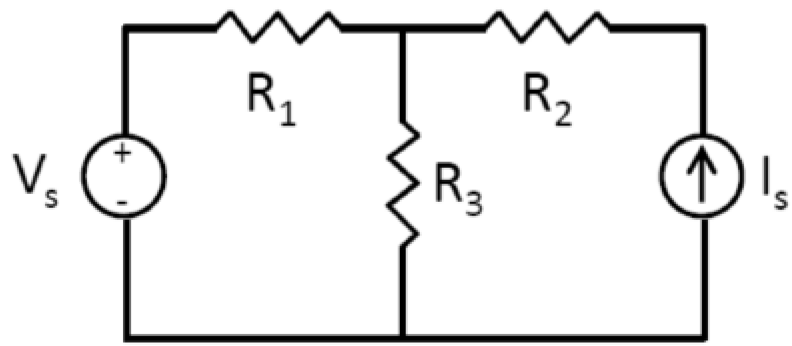


Answers:

(1) $V_a = 2$ V; $V_b = 1$ V
(2) $V_a = 5$ V; $V_b = 5$ V
(3) $V_a = 7$ V; $V_b = 4$ V
(4) $V_a = 7$ V; $V_b = 5$ V
(5) $V_a = 9$ V; $V_b = 7$ V
(6) $V_a = 16$ V; $V_b = 8$ V
(7) $V_a = 16$ V; $V_b = 16$ V
(8) None of the above

Exam 1, Problem 13

13. Find the voltage across R_3 as a function of the independent sources V_s and I_s for the circuit below, if R_1=R_2=3 Ω and R_3=6 Ω (Hint – try simplifying the diagram and using superposition):

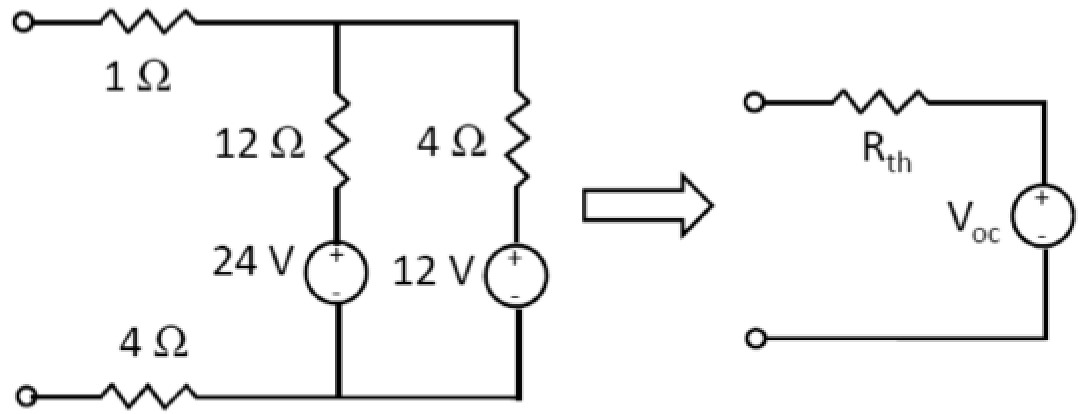


Answers:

(1) $V_s/3 + I_s$
(2) $2V_s/3 + I_s$
(3) $2V_s/3 + 6I_s$
(4) $V_s/2 + 6I_s$
(5) $V_s + 6I_s$
(6) $4V_s/3 + 4I_s$
(7) $2V_s/3 + 2I_s$
(8) None of the above

Exam 1, Problem 15

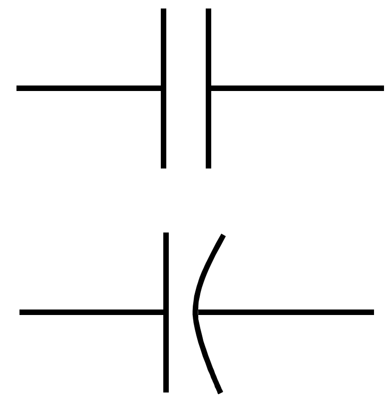
15. Using source transformation, find the voltage source voltage and resistance for the circuit on the right-hand side needed to make it equivalent to the circuit on the left-hand side:



Answers:

(1) $R_{th} = 5\ \Omega$; $V_{oc} = 12$ V
(2) $R_{th} = 5\ \Omega$; $V_{oc} = 24$ V
(3) $R_{th} = 8\ \Omega$; $V_{oc} = 8$ V
(4) $R_{th} = 8\ \Omega$; $V_{oc} = 15$ V
(5) $R_{th} = 9\ \Omega$; $V_{oc} = 15$ V
(6) $R_{th} = 9\ \Omega$; $V_{oc} = 24$ V
(7) $R_{th} = 21\ \Omega$; $V_{oc} = 36$ V
(8) None of the above

Introduction to Capacitors



- Capacitors are circuit elements capable of storing charge
- Voltage drop proportional to stored charge: V=Q/C, or Q=CV
- Capacitance C in units of C/V or F
- Current flow given by:

$$I = \frac{dQ}{dt} = C\frac{dV}{dt}$$

Calculating Capacitance

- Capacitance determined by geometry and materials present
- Calculated using Gauss' Law:

$$Q_{\text{enc}} = \epsilon \Phi_E = \epsilon \oint_S E \cdot dA$$

- For parallel plate capacitor, E=Q/εA=V/d, thus:

$$Q = \left(\frac{\epsilon A}{d}\right) V = CV$$

- In vacuum, $\epsilon = \epsilon_o = 8.854 \cdot 10^{-12}$ F/m

Calculating Capacitance

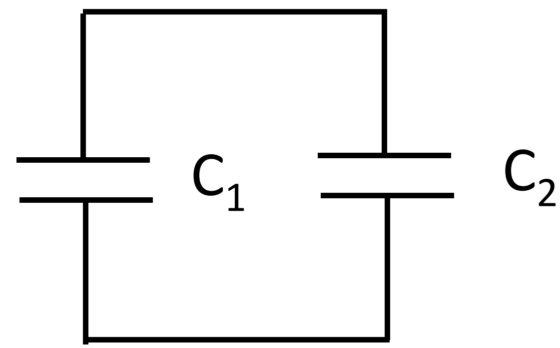
- For two capacitors ***in parallel***:

$$V = \frac{Q_1}{C_1} = \frac{Q_2}{C_2} = \frac{Q_{\text{tot}}}{C_{eq}}$$

$$C_{eq}V = Q_{\text{tot}} \;\; = Q_1 + Q_2$$

$$= C_1V + C_2V$$

$$C_{eq} = C_1 + C_2$$



- For *N* capacitors in parallel:

$$C_{eq} = \sum_{k=1}^{N} C_k$$

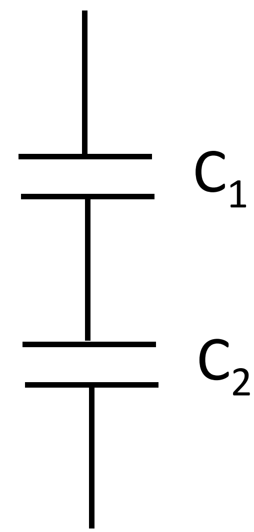
Calculating Capacitance

- For two capacitors ***in series***:

$$I = C_1 \frac{dV_1}{dt} = C_2 \frac{dV_2}{dt} = C_{eq} \frac{dV_{\text{tot}}}{dt}$$

$$\frac{I}{C_{eq}} = \frac{dV_1}{dt} + \frac{dV_2}{dt} = \frac{I}{C_1} + \frac{I}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

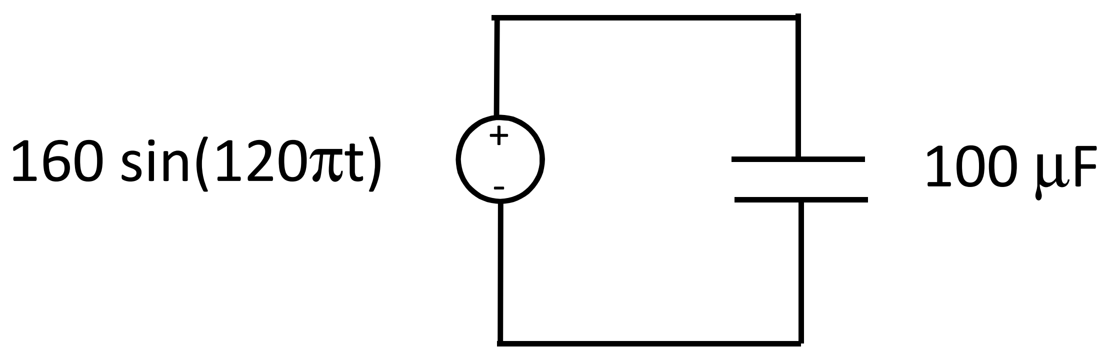


- For N capacitors in parallel:

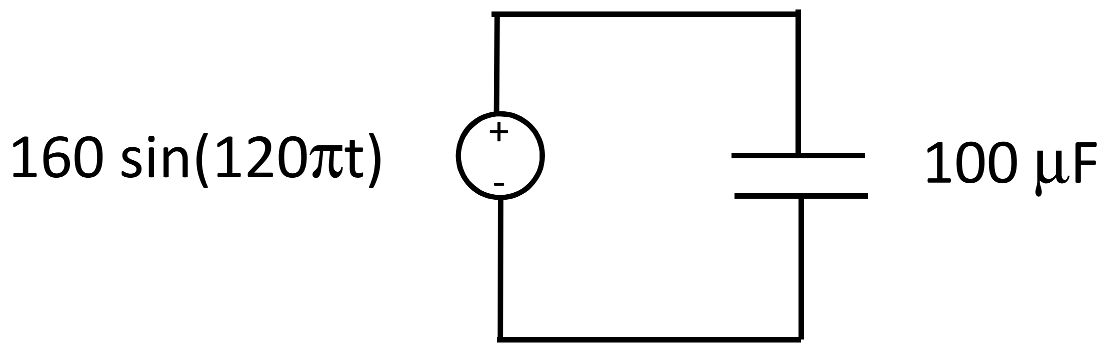
$$\frac{1}{C_{eq}} = \sum_{k=1}^{N} \frac{1}{C_k}$$

Example 1

- What is the current produced by plugging a 100 μF capacitor into the wall? How much power is dissipated by it?



Solution



$$I = C\frac{dV}{dt} = (100\ \mu F) \cdot 160 \cdot 120\pi \cos(120\pi t)$$
$$I = 1.92 \cos(120\pi t)$$

$$P = IV = 1.92 \cos(120\pi t) \cdot 160 \sin(120\pi t)$$
$$P = 153.6 \sin(240\pi t)$$

Homework

- HW #13 due today by 4:30 pm in EE 326B
- HW #14 due Wed.: DeCarlo & Lin, Chapter 6:
  – Problem 38
  – Problem 50
  – Problem 53 [Correction: The independent source on the left side of Figure P6.53 is a current source. Change this symbol to an upward arrow.]