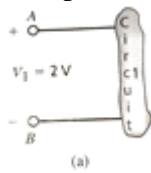


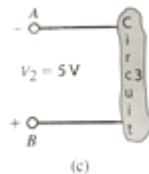
- 1 Volt = 1 Joule per coulomb = 1 newton meter per coulomb
- Example 1:



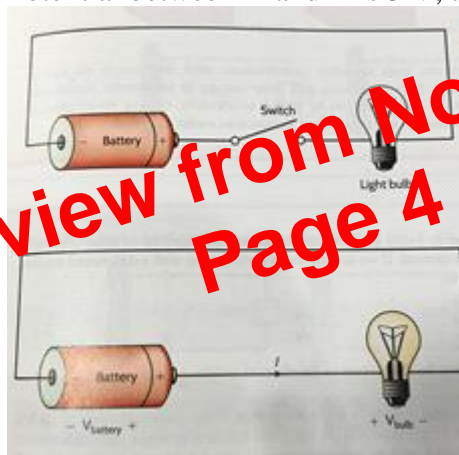
- A is at a higher potential than B
- 2 J less at B than A



- Potential difference between A and B is -5 V
- Potential between A and B is 5 V, but B is the higher potential



- Potential difference between A and B is 5 V
- Potential between A and B is 5 V, and B is the higher potential



- Figure 1
  - Current/charges flow out of positive end of the battery, through the switch and lightbulb, and back into the negative end of the battery.
- Figure 2
  - Bulb uses energy = charges leaving the bulb have less energy than those entering
  - Charges expend energy as they move through the bulb
  - Charges gain energy as they pass through the battery
  - Current enters positive end of bulb = absorbing energy
  - Current leaving positive end of battery = supplying energy

# 1.3 Circuit Elements

Tuesday, January 26, 2016 9:20 PM

## Terminal Devices (Elements):

- Characterized by the current through the element or voltage across it
- Passive or Active
  - Whether they supply or absorb energy
- Active
  - Supply energy (generate)
  - Ex:
    - Batteries, generators
- Passive
  - Absorb energy (cannot generate)
  - Ex:
    - Resistors, capacitors, and inductors

## Active Elements:

- Independent Sources:
  - Supply power to the remainder of the circuit
  - May also be connected into a circuit in which they absorb power (car battery example)
  - The symbol for an independent source is a *circle*
  - Models have limits, and are valid representations under certain conditions
    - Theoretically...
      - ◻ In the Independent Voltage Source, we assume the voltage source delivers  $v$  volts regardless of what is connected to the terminals.
      - ◻ If the external circuit is adjusted to allow an infinite amount of current to flow, the voltage source would deliver an infinite amount of power.
      - ◻ Physically impossible
      - ◻ Can also be done to the Independent Current Source, but with infinite voltage
  - Independent Voltage Source
    - Two-terminal element that maintains a specified voltage between its terminals *regardless of the current through it* shown by the graph
    - Terminal A is  $v(t)$  volts positive with respect to B
  - Independent Current Source
    - Two-terminal element that maintains a specified current *regardless of the voltage across its terminals* shown by the graph
    - $i(t)$  is the specified current and the arrow indicates the positive direction of current flow
- Dependent Sources:
  - Generate a voltage or current that is determined by a voltage or current at a specified location in the circuit
  - Important to calculate/describe behavior of many electronic circuit elements
  - Metal-oxide-semiconductor field-effect transistors (**MOSFETs**) and bipolar transistors
    - Used in lots of electronic equipment
    - Modeled with dependent sources
    - Analysis of electronic circuits involve the use of these controlled elements
  - The symbol for a dependent (or controlled) source is a *diamond*
    - Four types of dependent sources
    - In A and D, we are transforming voltage to voltage, and current to current,

respectively.

- Therefore,  $\mu$  and  $\beta$  are dimensionless constants.
- In B and C, we must describe the units of factors  $r$  and  $g$ .

**Preview from Notesale.co.uk**  
**Page 8 of 61**

## 2.2 Kirchhoff's Laws

Sunday, January 31, 2016 1:54 PM

### Kirchhoff's Law

- Lumped-Parameter Circuit
  - Wires in circuits are assumed perfect conductor
  - Interconnections in circuits have zero resistance
  - Wire doesn't consume energy
    - Energy in circuits is lumped in each circuit element
- Node
  - A point of connection of two or more circuit elements
- Loop
  - Any closed path through the circuit in which no node is encountered more than once
- Branch
  - Portion of a circuit containing only a single element and the nodes at each end of the element.

### Kirchhoff's Current Law (KCL)

- KCL
  - Algebraic sum of the currents **entering** any node is zero

$$\sum_{j=1}^N i_j(t) = 0$$

- If current is '+', then entering node
- If current is '-', then leaving node

▪ Example 2.5

### Kirchhoff's Voltage Law (KVL)

- KVL
  - Algebraic sum of the voltages **around** any loop is zero

$$\sum_{j=1}^N v_j(t) = 0$$

- If sign '-' first, then voltage is negative
- If sign '+' first, then voltage is positive

- Example 2.9
- Example 2.11

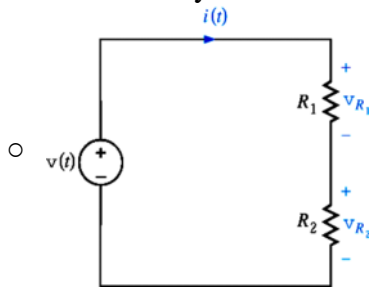
Preview from Notesale.co.uk  
Page 10 of 61

## 2.3 Single Loop & Single Node-Pair

Sunday, January 31, 2016 1:54 PM

### Single Loop Circuits

- Elements are connected in **series**
- All elements carry same current

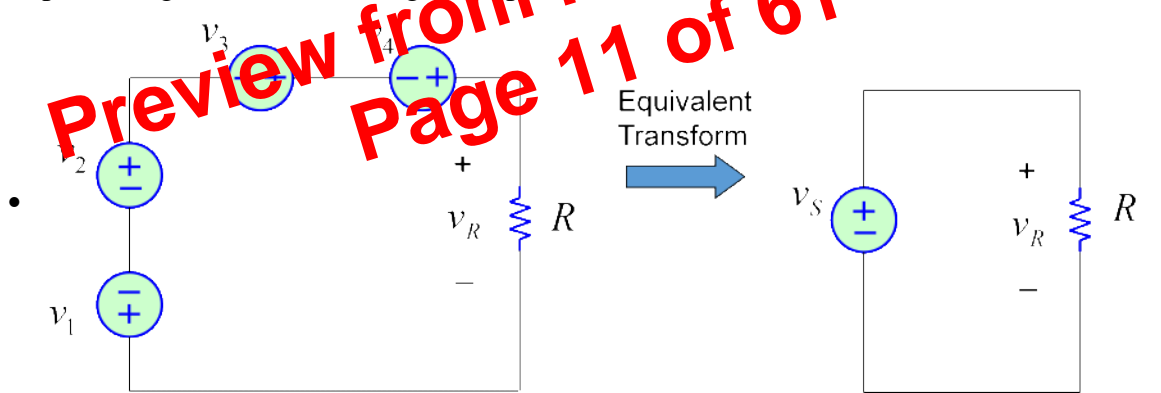


### Voltage Divider

- Source  $v(t)$  is divided between two resistors in proportion to the resistance

$$\left. \begin{array}{l} -v(t) + v_{R_1} + v_{R_2} = 0 \\ v_{R_1} = i(t)R_1 \\ v_{R_2} = i(t)R_2 \end{array} \right\} \Rightarrow i(t) = \frac{v(t)}{R_1 + R_2} \Rightarrow \begin{cases} v_{R_1} = \frac{R_1}{R_1 + R_2} v(t) \\ v_{R_2} = \frac{R_2}{R_1 + R_2} v(t) \end{cases}$$

### Multiple Voltage Sources in a Single-Loop Circuit



KVL:

$$v_1 - v_2 - v_3 - v_4 + v_R = 0$$

$$-v_S = v_1 - v_2 - v_3 - v_4$$

KVL:

$$-v_S + v_R = 0$$

### Multiple Resistors in Single-Loop Circuit

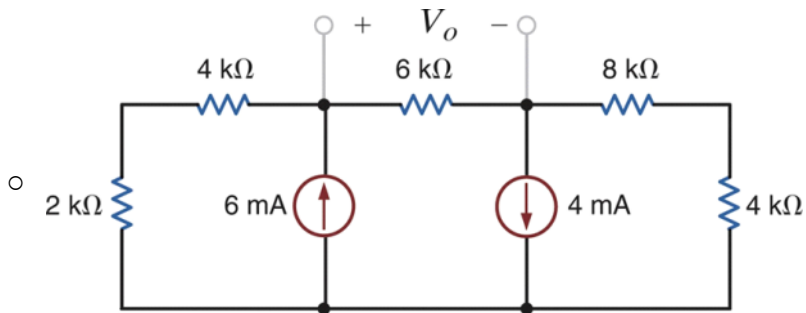
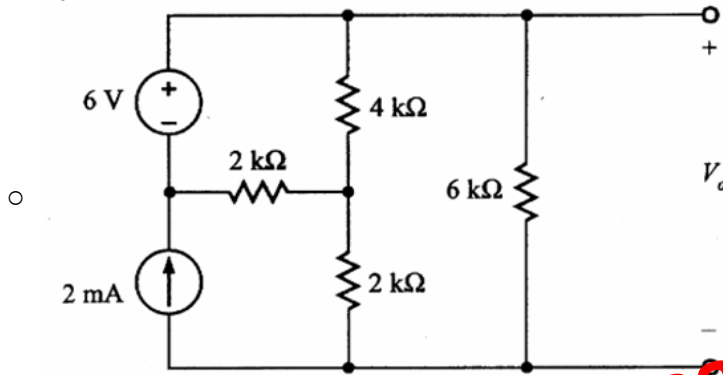


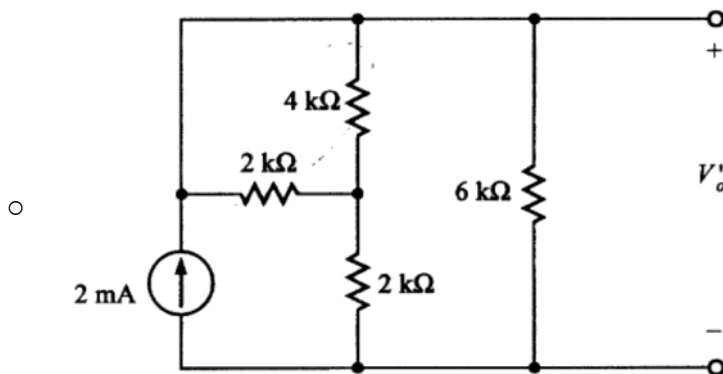
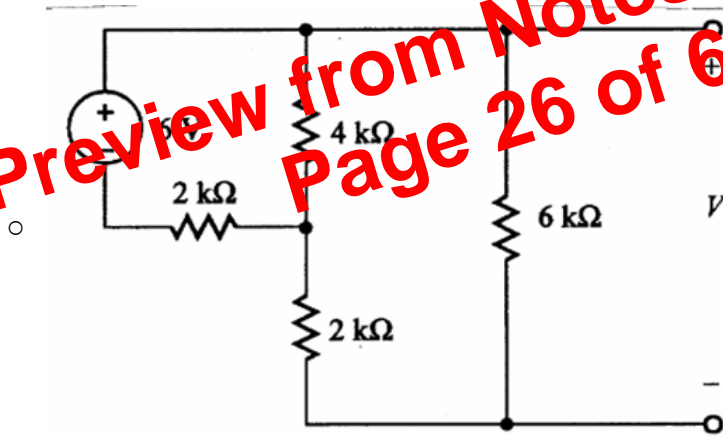
Figure PS.9  
© John Wiley & Sons, Inc. All rights reserved.

Example 5.4

- Find  $V_o$

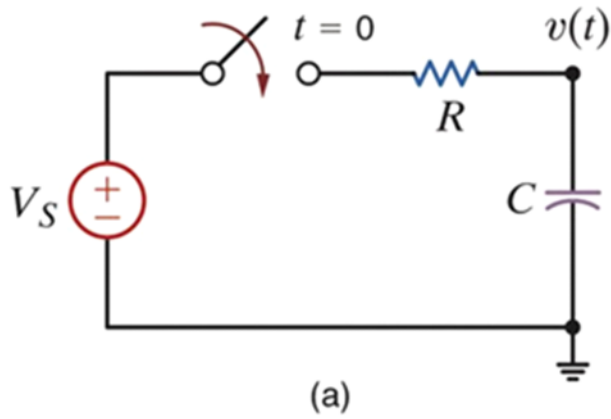


Preview from Notesale.co.uk  
Page 26 of 61



Applying Superposition

-

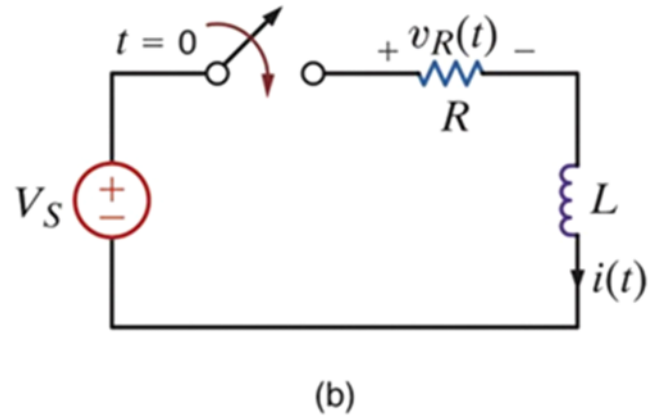


KCL@a:

$$C \frac{dv_c(t)}{dt} + \frac{v_c(t) - v_s}{R} = 0$$



$$v_c(t) = V_s - V_s e^{-t/RC}$$



KVL@b:

$$V_S = v_R + v_L = Ri(t) + L \frac{di(t)}{dt}$$

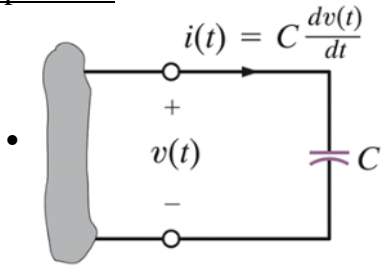


$$i(t) = \frac{V_s}{R} - \frac{V_s}{R} e^{-\frac{R}{L}t}$$

Preview from Notesale.co.uk  
Page 43 of 61

- $V = j\omega LI$

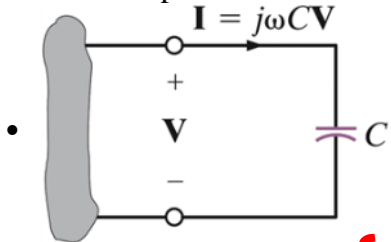
Capacitors:



- $I_M e^{j(\omega t + \phi)} = C \frac{d}{dt} (V_M e^{j(\omega t + \theta)})$

$$I_M e^{j\phi} = j\omega C V_M e^{j\theta}$$

- Phasor representation for a capacitor



- $I = j\omega CV$

Example 8.5:

$$L = 0.05H, I = 4\angle -30^\circ(A), f = 60Hz$$

Find the voltage across the inductor

$$\omega = 2\pi f = 120\pi$$

- $V = j\omega LI$

$$V = 120\pi \times 0.05 \times 1\angle 90^\circ \times 4\angle -30^\circ$$

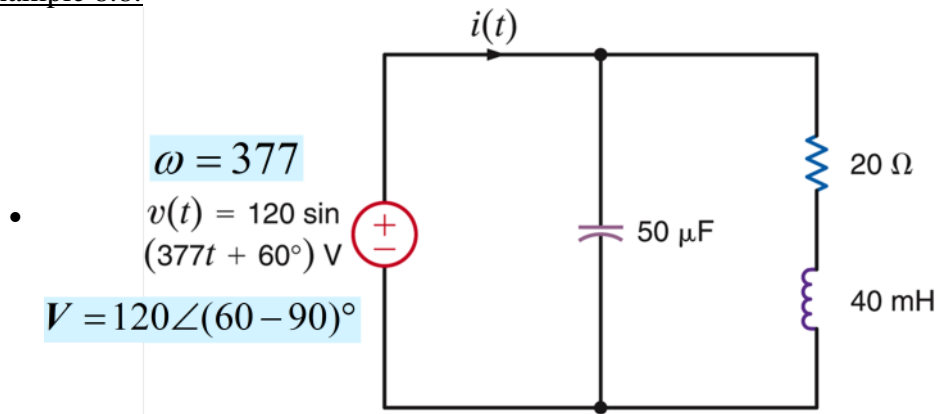
$$V = 24\pi\angle 60^\circ$$

$$v(t) = 24\pi \cos(120\pi t + 60^\circ)$$

Example 8.6:

Preview from Notesale.co.uk  
Page 53 of 61

Example 8.8:



- $\omega = 377$   
 $v(t) = 120 \sin(377t + 60^\circ) \text{ V}$   
 $V = 120 \angle (60 - 90)^\circ$

- Find  $i(t)$

$$Z_L = j377 \times 40 \times 10^{-3} = j15.08 \Omega$$

$$Z_{eq} = Z_C \parallel (Z_R + Z_L)$$

$$Z_C = \frac{-j}{377 \times 50 \times 10^{-6}} = -j53.05$$

$$Z_{eq} = 30.5616 + j4.9714 = 30.963 \angle 9.239^\circ$$

- $$I = \frac{V}{Z_{eq}} = \frac{120 \angle -30^\circ}{30.963 \angle 9.239^\circ} = 3.876 \angle -39.924^\circ (\text{A})$$

$$i(t) = 3.876 \cos(377t - 39.924^\circ) (\text{A})$$

Preview from Notesale.co.uk  
Page 57 of 61

## 8.8: Analysis Techniques

Thursday, May 05, 2016 12:47 AM

### Problem Solving Strategy:

For relatively simple circuits use

Ohm's law for AC analysis; i.e.,  $V = IZ$

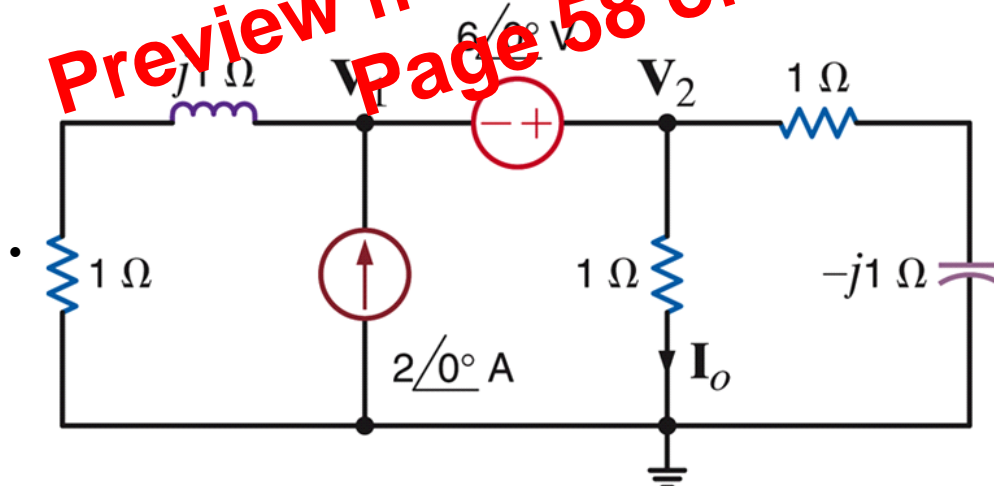
- The rules for combining  $Z$   
KCL and KVL  
Current and voltage divider

For more complex circuits use

Node analysis

- Loop analysis  
Superposition  
Thevenin's and Norton's theorems

### Example 8.15:



- Determine the current  $I_o$  in the network below using nodal analysis, loop analysis, superposition, Thévenin's theorem, and Norton's theorem
- **Nodal Analysis**