ECE 201, Section 3
Lecture 4

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August 27, 2012

Definitions

- **Node** – a connecting point between two or more circuit elements
- **Branch** – part of a circuit; one or more circuit elements with two terminals
- **Gaussian surface** – enclosed surface where charge & electromagnetic flux is calculated
- **Parallel circuit** – two or more branches linked by two nodes
- **Series circuit** – two or more branches linked by one node

Definitions

- **Closed path** – series of connected nodes with the same beginning & end
- **Closed node sequence** – series of nodes where the same beginning & end
- **Connected circuit** – a circuit in which all nodes are connected to each other via a path of circuit elements

Kirchoff's Current Law

- Sum of all currents entering a node or Gaussian surface is zero at all times
- From the conservation of charge:

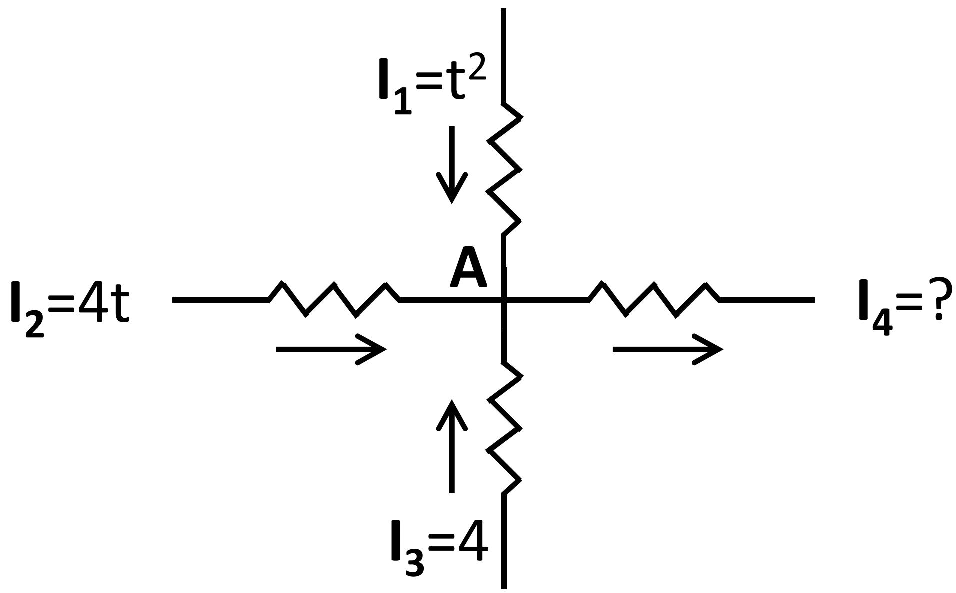
$$Q(t) = \int_0^t \sum_{k=1}^{N} dQ_k = 0, \text{ for all t}$$

$$Q(t) = \int_0^t dt \sum_{k=1}^{N} I_k(t) = 0, \text{ for all t}$$

$$\sum_{k=1}^{N} I_k(t) = 0\,, \text{for all t}$$

Example 1

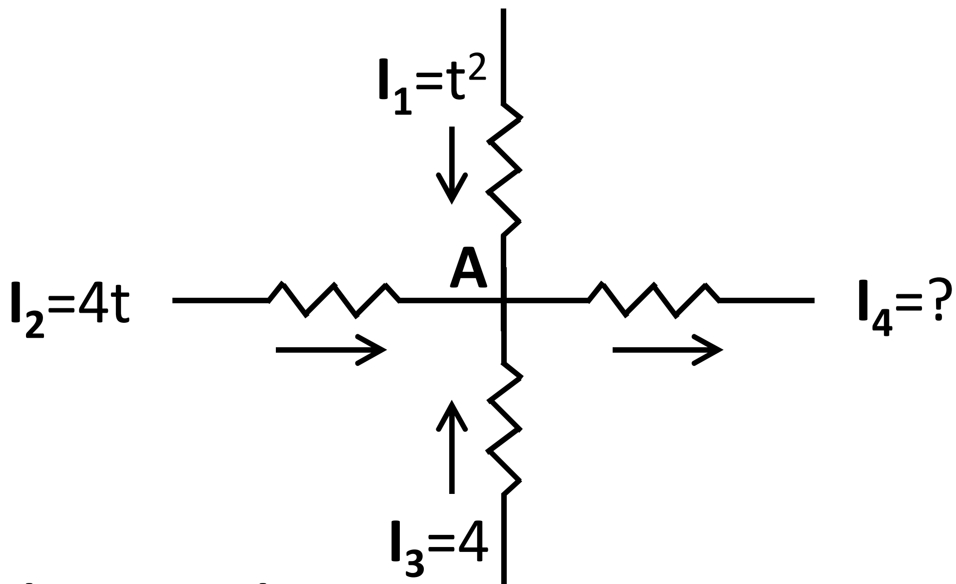
- At node A, input currents look like this:



What is the output current I_4?

Example 1: Solution

- At node A, input currents look like this:

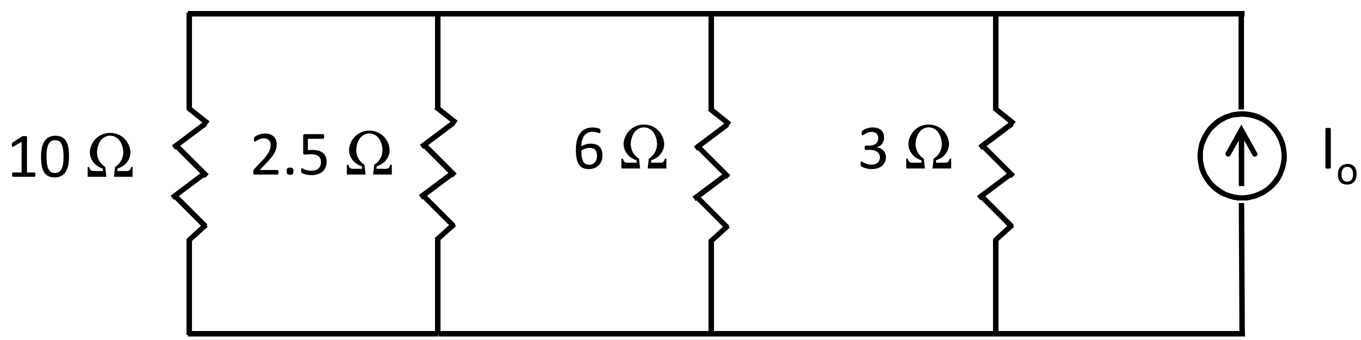


What is the output current I_4?

$I_4 = t^2 + 4t + 4 = (t+2)^2$

Example 2

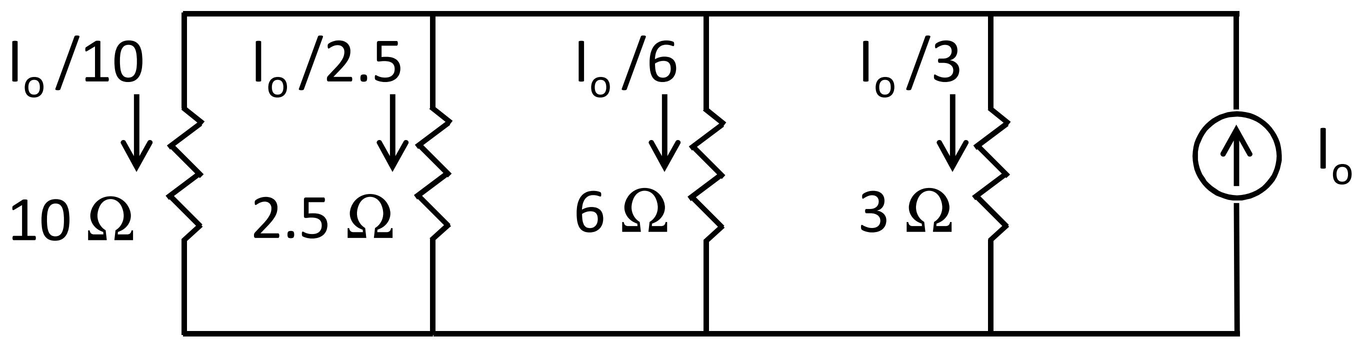
- Given an ideal current source I_o connected to 4 parallel resistors, how is the current divided?



- What if 2 identical ICS's are connected in parallel? In series? What if only one has its current doubled?

Example 2: Solution

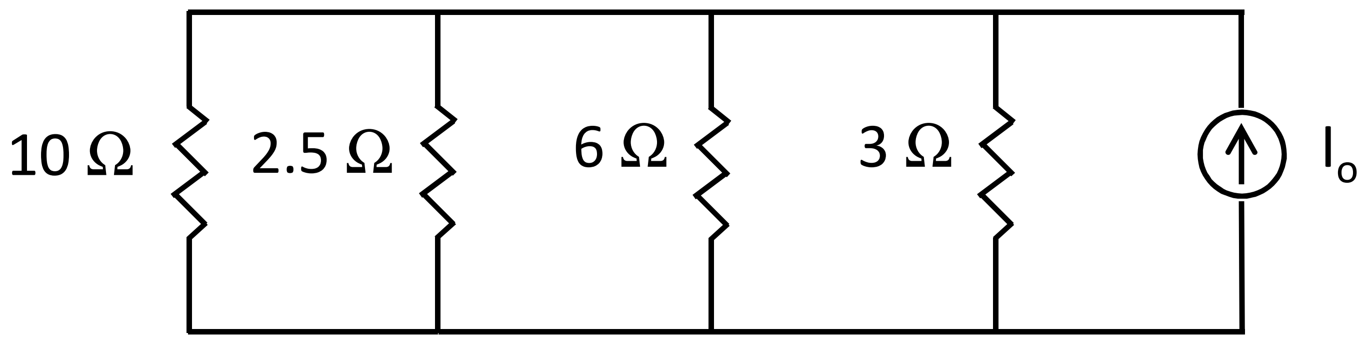
- Given an ideal current source I_o connected to 4 parallel resistors, how is the current divided?



- Equal voltage drop across every resistor implies:

$$I_k = \frac{V}{R_k} = \frac{I_o}{R_k} \sum_{l=1}^{N} \frac{1}{R_l}$$

Example 2: Solution, Cont'd



- What if 2 identical ICS's are connected in parallel?
  - All currents in resistors double
- In series?
  - No change
- What if only one has its current doubled?
  - Currents triple in parallel; unphysical in series

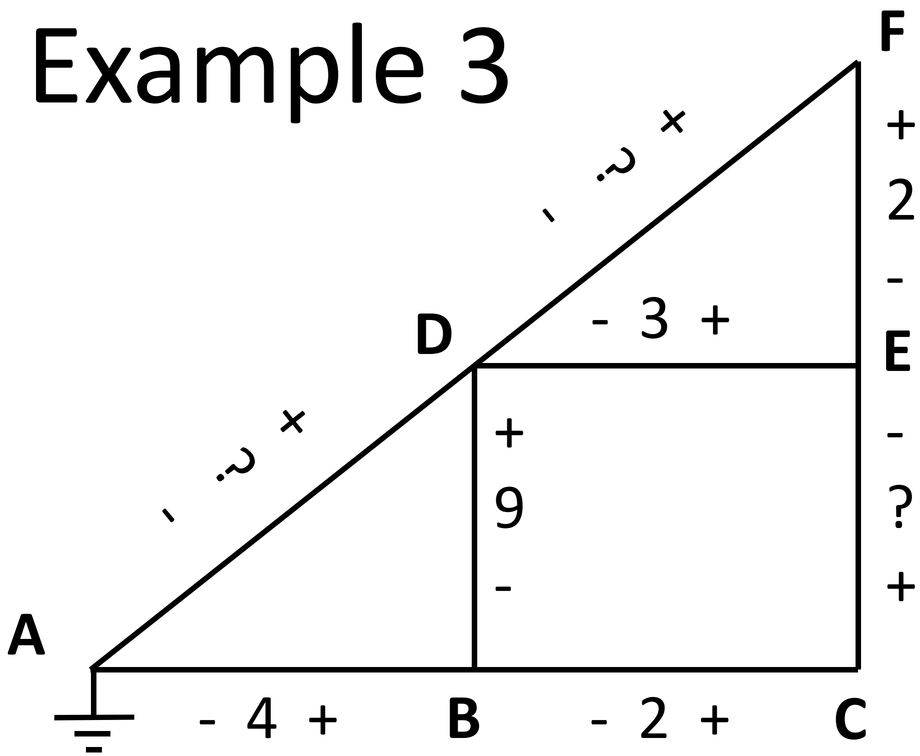
Kirchoff's Voltage Law

- Since voltage is a unique quantity at a given place and time (see Lecture 2):
  - Voltage drop between any two nodes is given by the difference of their voltages, independent of path (i.e., $V_{AB} = V_A - V_B$)
  - It is directionally dependent (e.g., $V_{AB} = -V_{BA}$, since $V_A - V_B = -(V_B - V_A)$)
  - Sum of voltage drops over any closed loop is zero (otherwise, voltage would be non-unique)

Kirchoff's Voltage Law

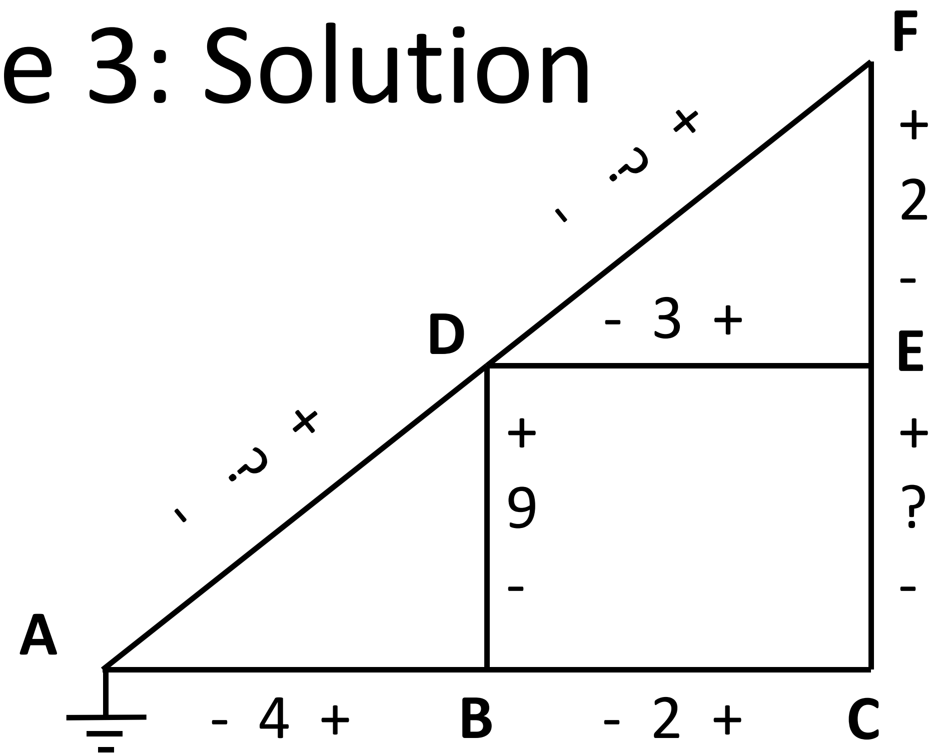
- Alternative statements:
  - For connected circuits and any node sequence, the voltage difference between the end points equals the sum of the voltage drops across each element: e.g., $V_{AD} = V_{AB} + V_{BC} + V_{CD}$, since $V_{AB} + V_{BC} + V_{CD} = V_A - V_B + V_B - V_C + V_C - V_D = V_A - V_D$
  - For connected circuits, the sum of node-to-node voltages over any closed node sequence is always zero (a special case of the last rule)

Example 3



- What are V_{DA}, V_{FD}, and V_{EC}?

Example 3: Solution



- What are V_{DA}, V_{FD}, and V_{EC}?
  - $V_{DA}=V_{DB}+V_{BA}=9\ V + 4\ V = 13\ V$
  - $V_{FD}=V_{FE}+V_{ED}=2\ V + 3\ V = 5\ V$
  - $V_{EC}=V_{ED}+V_{DB}+V_{BC}=3\ V + 9\ V – 2\ V = 10\ V$

Homework

- HW #2 solution posting this morning
- HW #3 due today by 4:30 pm in EE 325B
- HW #4 due Wed. – DeCarlo & Lin, **Chapter 2**:
  - Problem 2(a)
  - Problem 3
  - Problem 6
  - Problem 12