Full resolution photo on my Instagram @feenafoto

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ECOR1043: Circuits

Course Introduction
&
Basic Concepts

Basic Quantities & Circuit Elements

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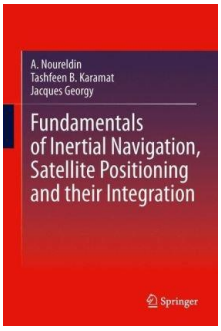
Tashfeen Karamat

- Teaching Experience
  - Carleton University
  - Royal Military College of Canada (RMC)
  - Queen's University
- Research
  - Navigation, GPS & INS
- Education
  - PhD Queen's 2014
  - MASc RMC 2008
  - M.Eng Queen's 2006
- Publications
  - Book on GPS/INS- Oct 2012
  - Several papers on GPS/INS
- Interests
  - Photography
    Instagram: @feenafoto
  - Etymology
  - Astronomy
  - Juggling
  - Watch Enthusiast
  - Music
  - Sketching /Painting
  - …



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Introduction

- Read "Course Outline" on Brightspace and
- Read "Pre-Lab & Lab Instructions" on Brightspace for details
- Grading Scheme
  - Pre-labs Quizzes 10% No Pre-lab report
  - Lab reports 25%
  - Final Exam 65%
- To pass the course
  - Must pass final exam (≥ 50%) to pass the course
  - Must achieve a combined average grade of >40% in Pre-labs and Lab reports
- The minimum passing grade for this course is C-. Any grade below this will be recorded as an F in the final grade

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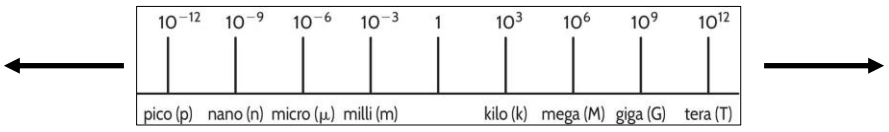
Admin

- Prof. Tashfeen, Room 4526 EDC
- tashfeen.karamat@carleton.ca
- Office hour: Thu: 09:00 PM – 10:00 PM (Email to book slot)
- Emails should be sent from your university account
- Emails should follow the guidelines provided on Brightspace, otherwise they will not receive a response.
- Labs
  - Lab #0 (Part-I and Part-II)
  - Lab #0 is not graded but vital to do well in subsequent graded labs
- Head TA:
  - Name: Name: Masood Nekoei
  - Email: masoodnekoei@cmail.carleton.ca

Basic Quantities

- Circuits … they are everywhere!
  - Computers, cellphones, TV, airplanes, cars, spacecraft, robots … all contain electrical circuits
- An Electric circuit
  - An interconnection of electrical components the allow electrons to flow to perform useful function
  - It can be described with a mathematical model to predict its behavior
- Standard SI prefixes



Basic Quantities

- Electric charge (q)
  - Charge is an electrical property of the atomic particles
  - It is measured in coulombs (C)

$$1 \text{ COULOMB} = 6.241 \times 10^{18} \text{ (e)}$$

- Electric current (i)
  - The time rate of change of charge (or flow of charge over time)
  - The basic unit of current is the ampere (A)

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Basic Quantities

- Voltage (electromotive force, potential, or potential difference v)
  - The difference in energy (w) level required to move a unit charge between two points
  - It is a kind of a 'push' or 'pressure' to move electrons resulting in current
  - Basic unit of voltage is volt (V)
  - Voltage is always measured in a relative form as the voltage difference between two points

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Basic Quantities

- Power (p)
  - Time rate of change of energy (delivered or absorbed)
  - It is measured in Watts(W)
  - Power is related to current and voltage through

$$p = v \times i$$

  - Derivation of the above formula can be found in Appendix A to this lecture

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Basic Quantities

- Circuits elements
  - Devices that are completely characterized by the current through the element and/or the voltage across it.
- Types
  - Active: Generate power
    - Voltage sources (batteries)
    - Current sources
    - Generators
  - Passive: Cannot generate power (but absorb/dissipate power)
    - Resistors  
    - Capacitors  
    - Inductors  

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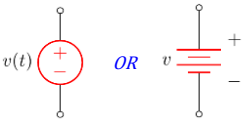
Power Supplies & Conventional Current

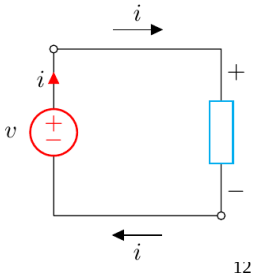
- Power supplies provide a source of electrical power
  - Voltage source



AC

  - Current source

  - Conventional Current assumes that current flows out of the positive terminal, through the circuit and into the negative terminal of the source.



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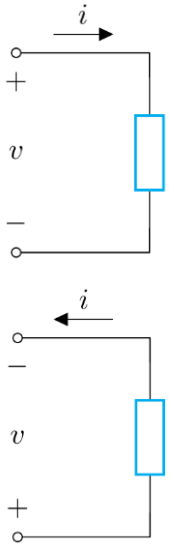
Passive Sign Convention (PSC)

- We want to establish the sign of the current relative to the voltage for passive circuit elements (or vice versa)
  - We assume that the current enters the node at the higher voltage (the positive '+' side)
- Sign must be known for active circuit elements
  - Current directions are given for current sources and
  - Voltage polarities are given for voltage sources



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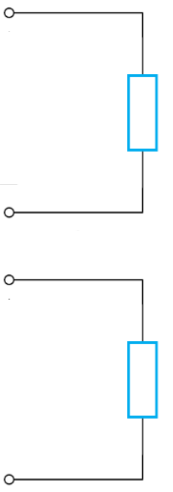
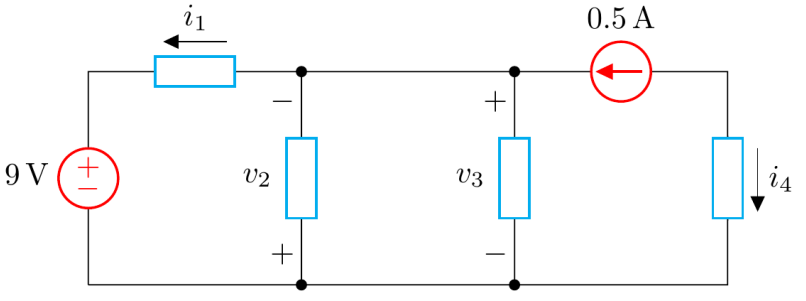
Passive Sign Convention (PSC)

- We can assume (arbitrarily) either the voltage polarity or current direction if neither are given.
- Once we assume either the voltage polarity or current direction, this will dictate the assumed direction of the other parameter (due to the fact we are also assuming current is entering the +ve side)
- Subsequent analysis is performed on this assumption and a negative result simply means that the assumed value, whether voltage polarity or current direction, was incorrect
- It is generally counter-productive to attempt to determine the "correct" voltage polarities and current directions before analyzing the circuit



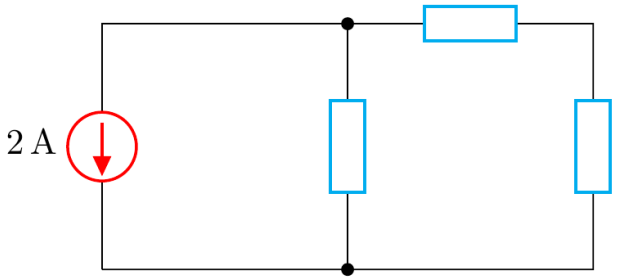
Passive Sign Convention (PSC)

- Ex. 1: Provide the appropriate sign convention for the missing parameter (current direction or voltage polarity) on the four passive elements represented by blue outline.



Passive Sign Convention (PSC)

- Ex. 2: Assign reference voltage and current directions for the three passive elements represented by blue outline in the circuit below:



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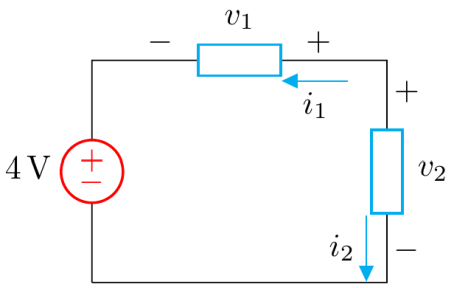
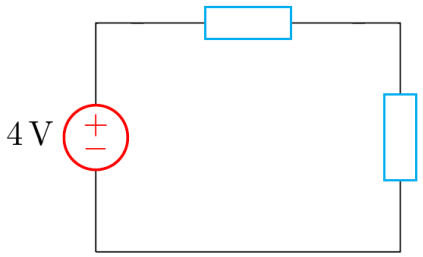
Passive Sign Convention (PSC)

- Ex. 3: For the circuit below, the sign convention shown is chosen





- After analyzing the circuit, it is determined that $i_1 = -3\text{mA}$, $i_2 = 3\text{mA}$, $v_1 = -1.5\text{V}$, and $v_2 = 2.5\text{V}$. Re-draw the circuit showing the actual voltages and currents and their directions

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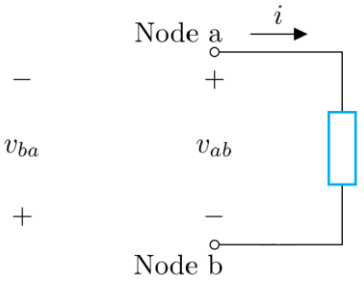
Voltage Notation

- Voltage polarity is sometimes indicated by subscript notation
- The order of the subscripts indicates the polarity
  - The first subscript indicates assumed higher-voltage node
  - The second subscript is the assumed lower-voltage node



Note:

$v_{ba} = -v_{ab}$

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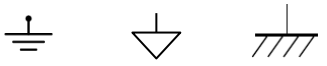
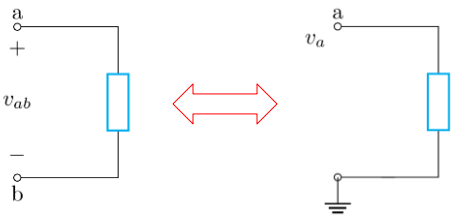
Voltage Notation

- Voltages are often represented as relative to "ground"
- Ground is a reference voltage; typically, 0V.



- Voltages relative to ground generally **not** called a voltage difference; they are a difference relative to zero volts
- Voltages relative to ground often represented with a single subscript



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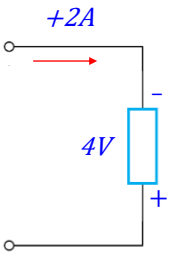
Power Supplied and Absorbed

- Power = voltage × current

$$p = vi$$

- Circuit elements can either dissipate or generate power
- Power is absorbed if the power is positive
- Power is generated if the power is negative
- You can always reverse either the voltage or current and multiply the value by "− 1" (if this makes your life easier)



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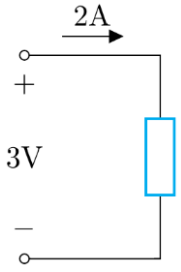
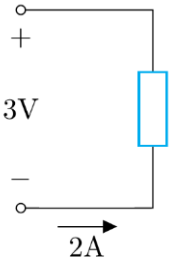
Power Supplied and Absorbed

- Ex 4: Determine the power associated with the circuit element below.



- Ex 5: Determine the power associated with the circuit element below.



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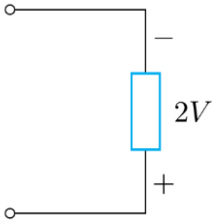
Power Supplied and Absorbed

- Ex 6: The circuit element absorbs 10W. Determine the current in the element.

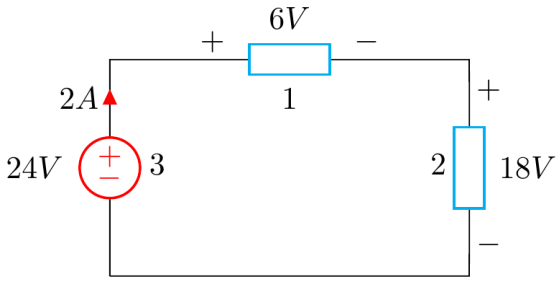


I=5A (upwards

Practice Problems

Basic Quantities

- Prob 1a: Compute power supplied/absorbed by each element
  - P_1 = ?
  - P_2 = ?
  - P_3 = ?



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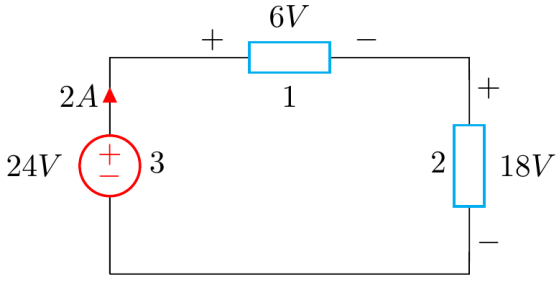
Basic Quantities

- Prob 1a (cont.):
  - P_1 = +V×I=6× 2
    = 12W (absorbed)
  - P_2 = +V×I=18 × 2
    = 36W (absorbed)
  - P_3 = −(V×I)= − 24× 2
    = − 48W (supplied)
  - Note that the total power absorbed is equal to total supplied



- Conservation of Power
  - the sum of the powers absorbed by all elements in an electrical network is zero

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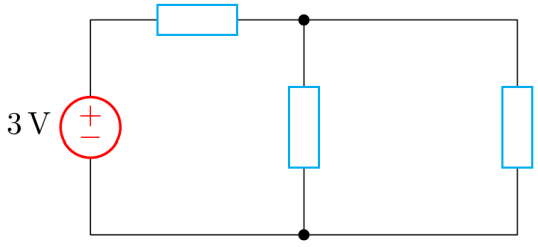
Passive sign convention (PSC)

- Prob 1: Assign reference voltage and current directions for the passive elements represented by shaded boxes in the circuit below:



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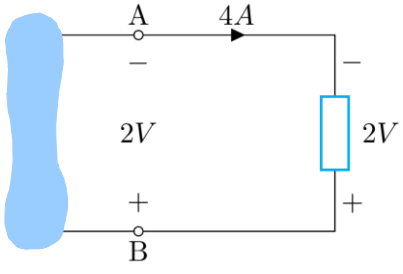
Power Supplied and Absorbed

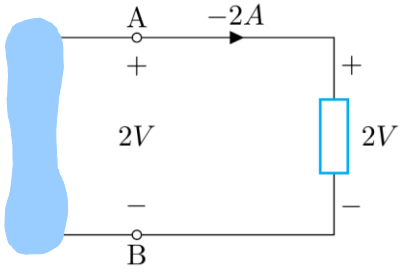
- Prob 2: Determine the power associated with the circuit element



  - The current direction (or voltage polarity) should be reversed to agree with PSC

$P = -8W$ So power is being supplied

- Prob 3: : Determine the power associated with the circuit element



  - The current direction and voltage polarity are OK and agree with PSC

$P = -4W$ So power is being supplied

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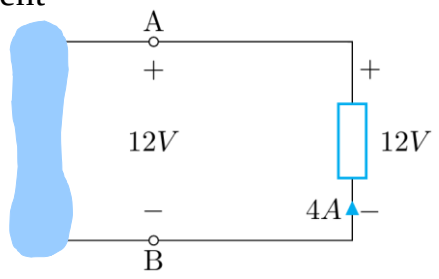
Basic Quantities

- Prob 4: Determine the power associated with the circuit element

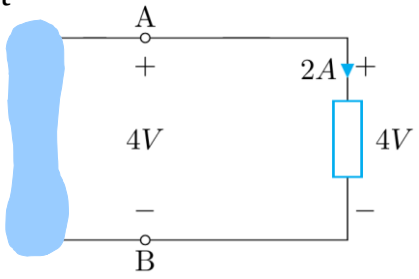


  - The current direction (or voltage polarity) should be reversed to agree with PSC

    $P = -48W$

    So power is being supplied

- Prob 5: Determine the power associated with the circuit element



  - The current direction and voltage polarity are OK and agree with PSC

    $P = 8W$

    So power is being absorbed

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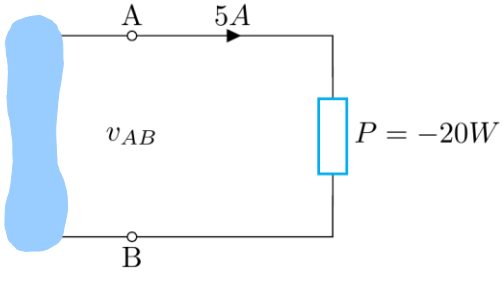
Basic Quantities

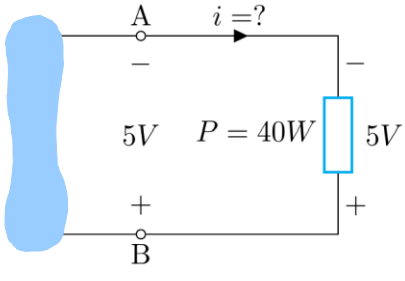
- Prob 6: Determine voltage



  - Label A is + and B – (according to current directions)

    $v_{AB} = -4$ V (A is + and B is -)
    We can also say $v_{BA} = 4$

- Prob 7: Determine current



  - Current direction (or voltage polarity) should be reversed to conform to PSC

    $I = -8\ A$

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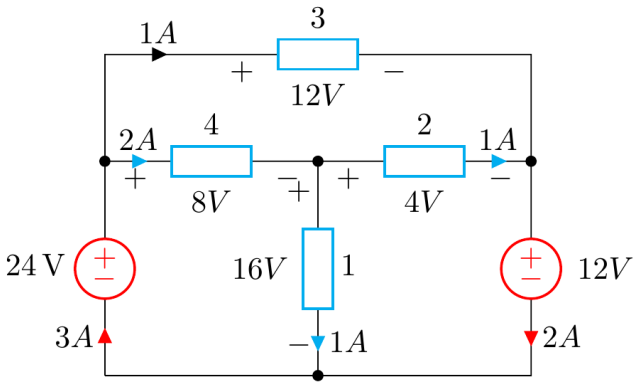
Basic Quantities

- Prob 8: Calculate the power associated with each element in the network



$P_1 = (16V)(1A) = 16[W]$

$P_2 = (4V)(1A) = 4[W]$

$P_3 = (12V)(1A) = 12[W]$

$P_4 = (8V)(2A) = 16[W]$

$P_{12V} = (12V)(2A) = 24[W]$

$P_{24V} = (-24V)(3A) = -72[W]$

NOTICE THE POWER BALANCE

$16 + 4 + 12 + 16 + 24 - 72 = 0$

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Appendix A: Derivation of Power Formula

- Power is defined as time rate of change of energy (delivered or absorbed)

$$p = \frac{dw}{dt}$$

- Using chain rule

$$p = \frac{dw}{dq} \times \frac{dq}{dt} \qquad \textit{Eq. 1}$$

- Current is the time rate of change of charge (or flow charge over time)

$$i = dq/dt$$

- Voltage is the difference in energy (w) level required to move a unit charge between two points

$$v = dw/dq$$

- Substituting i and v back into eq. 1, we get

$$\boxed{p = v \times i}$$

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White Board

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