Resistors and Ohm's Law

Today we will review fundamentals like voltage, current, power, Ohm's Law and Kirchhoff's Laws. The way we think about these concepts will be a little different from the way you thought about them in E&M.

Outline

1 Welcome and Introductions

- Your name
- Year
- What are you excited to learn in this class?

2 Course format

- Pre-lab reading and questions, due on Gradescope before each class meeting
  - Pre-lab questions: graded on completion
  - Post-lab questions: graded on correctness
- Class meetings
  - Lecture: about 1 hr
  - Lab activities: main component of course!
- Three midterms
  - In-class, written and hands-on components
  - No final
- Three written reports
  - Two labs (I think 4 and 11) with revision opportunities
  - Digital electronics project write-up
- Open Lab/Office Hours
  - Monday 3:15-4:30pm in SENG 306
- Additional Office Hours by appointment

3 Electronics in the Lab: Information and Energy

sending information
as voltage signals

physical quantities → voltages

operations on voltages

low power applications

Sensor → signal

power

control:
- motor
- laser
- etc.

GOALS:

① learn how voltages behave in circuits

② use circuits to send signals + control equipment

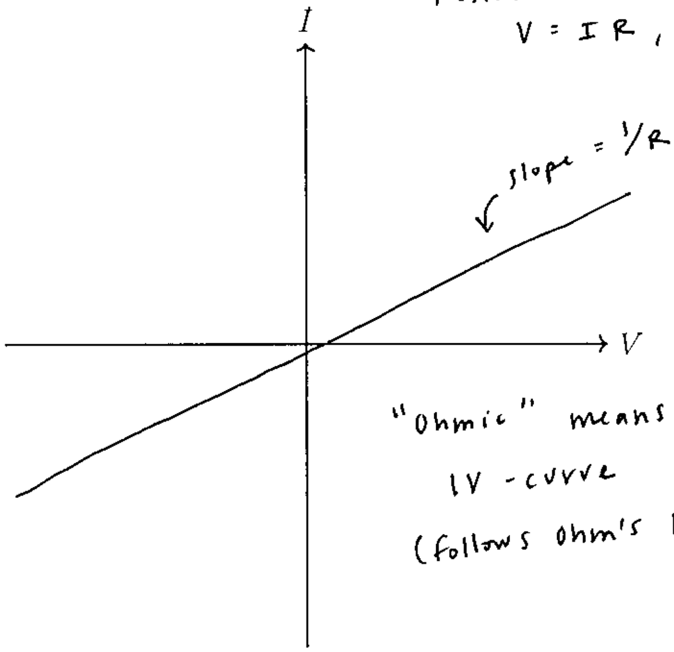
4 DC Voltage, Current, and Power

Quantity	Physical meaning	Units
Voltage "across"	Electric potential ↳ difference between points ↳ relative to some ground (reference pt) related to work required to move charge $V_{12} = -\int_1^2 \vec{E} \cdot d\vec{l}$	Volts (V) $V = J/C$ 0.1 - 30 V in this class
Current "through"	Flow of charges (rate) Through some component	Amp $A = C/s$ μA - mA in this class
delivered converted Power dissapated	Energy per time (rate) $P = IV$ energy conversion between different forms (chemical, electrical, thermal, etc)	Watts $W = J/s$ typically mW

5 I-V Relationships and Ohm's Law

Resistor —/\/\/— R

$V = IR$, $I = V/R$

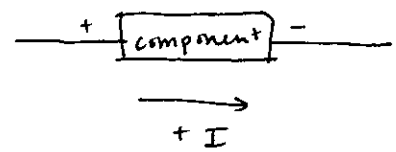


"Ohmic" means linear IV-curve (follows Ohm's law $V = IR$)

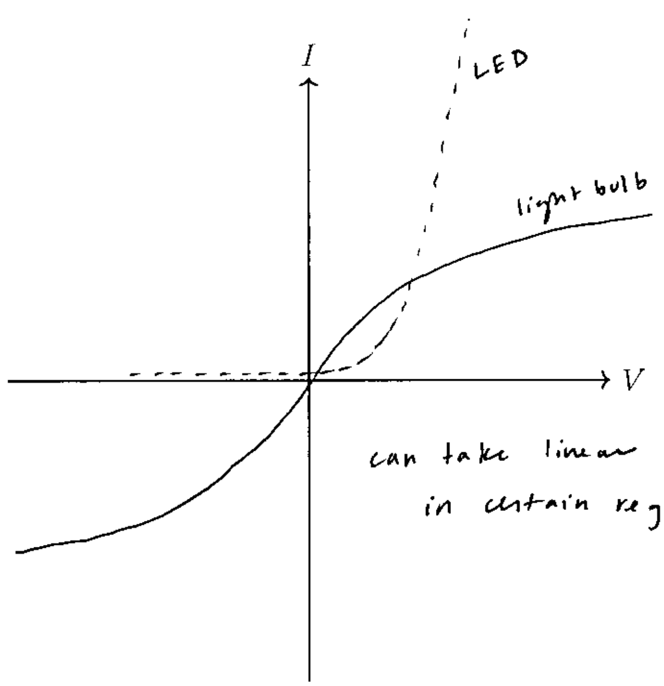
current flow convention:

positive current from

$+V \longrightarrow -V$



$\Delta V = V_+ - V_-$



can take linear approx. in certain regions

Nonlinear components do not have well defined R.

↓

"dynamic resistance"

$= \frac{dI}{dV}$ at some point

ex: diodes
light bulbs
transistors

5.1 Resistors

last band gives power

3 Band		1.2MΩ ±20%
4 Band		1KΩ ±5%
5 Band		12.5KΩ ±10%
6 Band		12MΩ ±4% 50ppm/k

$\underbrace{10}\ \underbrace{2} = 10 \times 10^2 = 1\,k\Omega$

$\underbrace{125}\ \underbrace{2} = 125 \times 10^2 = 12{,}500$
$= 12.5\ k\Omega$

	1st Digit	2nd Digit	3rd Digit	Multiplier	Tolerance	Temp. Coeff.
Black	0	0	0	$\times 10^0$		250 (U)
Brown	1	1	1	$\times 10^1$	±1%	100 (S)
Red	2	2	2	$\times 10^2$	±2%	50 (R)
Orange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Yellow	4	4	4	$\times 10^4$	±4%	25 (Q)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grey	8	8	8	$\times 10^8$	±0.05%	1 (K)
White	9	9	9	$\times 10^9$		
Gold	-	-	-	$\times 10^{-1}$	±5%	
Silver	-	-	-	$\times 10^{-2}$	±10%	

better be right or your great big venture goes wrong

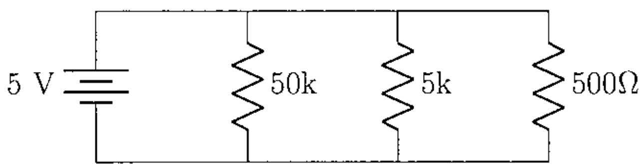
helpful? not sure.

power rating typically 250 mW

6 Power

$$P = IV$$

resistors: $V = IR \longrightarrow P = I^2 R = V^2/R$



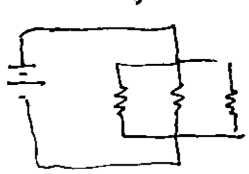
- How much current flows through each resistor?
- How much power is dissipated in each resistor?
- Which resistor gets the hottest?
- How much current flows through the battery?

$I = V/R \longrightarrow$

$P = IV \longrightarrow$

50 k	5 k	500
10^{-4} A = 0.1 mA	1 mA	10 mA
0.5 mW	5 mW	50 mW
		hottest!

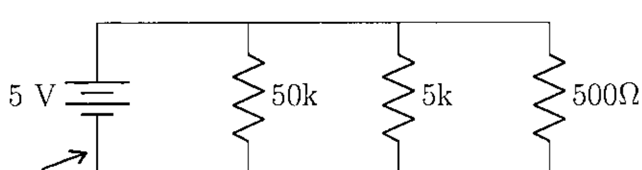
$\Sigma I = 0$ in each junction / node



$\longrightarrow I = 0.1 + 1 + 10 = 11.1$ mA

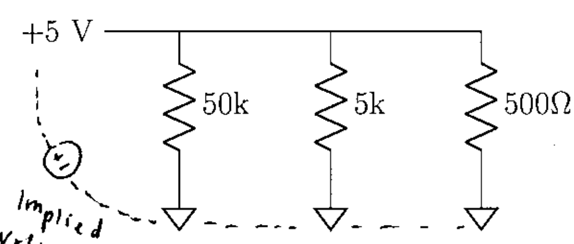
7 Circuit Diagrams

equivalent!



0V point of circuit

"ground"



Implied Voltage Source

all grounds connected + shared w/ implied V-source

earth signal chassis

V = 0

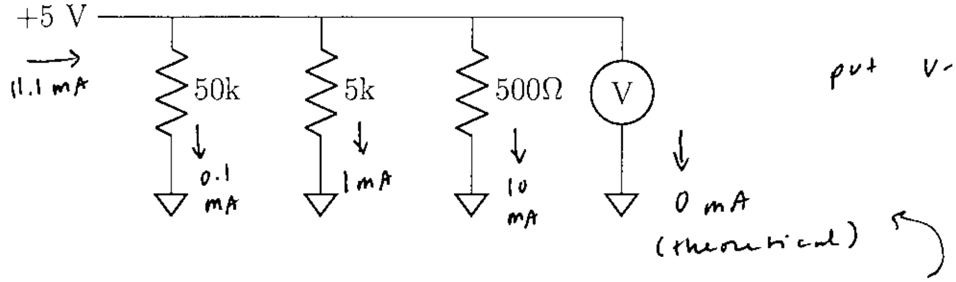
common ground

8 Measurement Devices

8.1 Voltage Across

Same V across all parallel components.

put V-meter in parallel to measure across component.



- We want our voltmeter to affect the circuit as little as possible. How much current ideally flows through the meter? How much voltage is ideally across it?

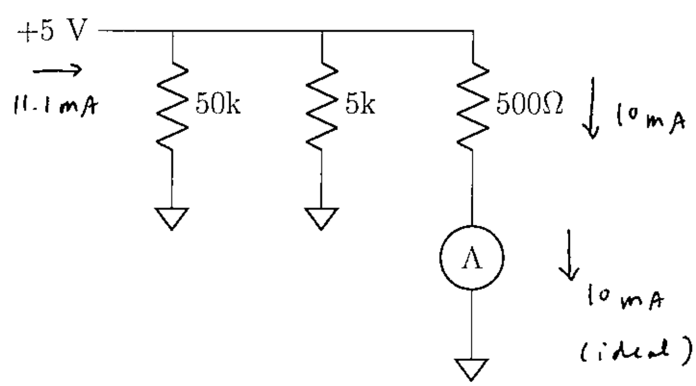
Ideally: 0 A current

otherwise it will affect the total current draw of the circuit

5V measures full voltage

ideal V-meter has $R = \infty$!

8.2 Current Through



components in series share the same current.

Put the ammeter in series.

- We want our ammeter to affect the circuit as little as possible. How much current ideally flows through the meter? How much voltage is ideally across it?

all current, 0 V

otherwise we would change the component voltage drop!

ideal $R = 0$