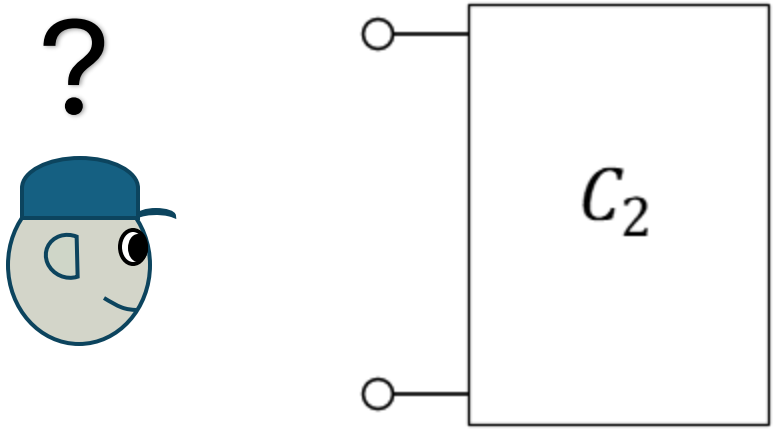
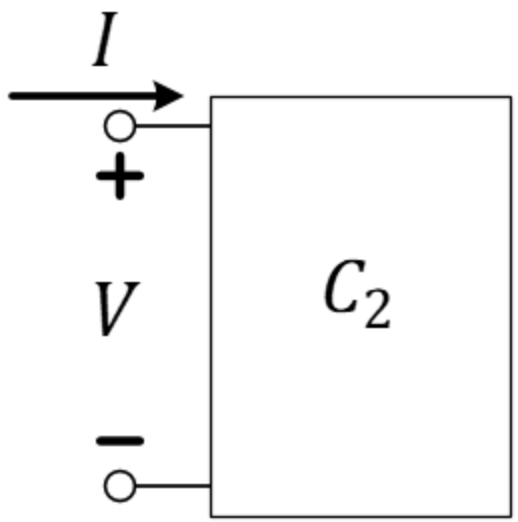
Lecture 11: IV Characteristics

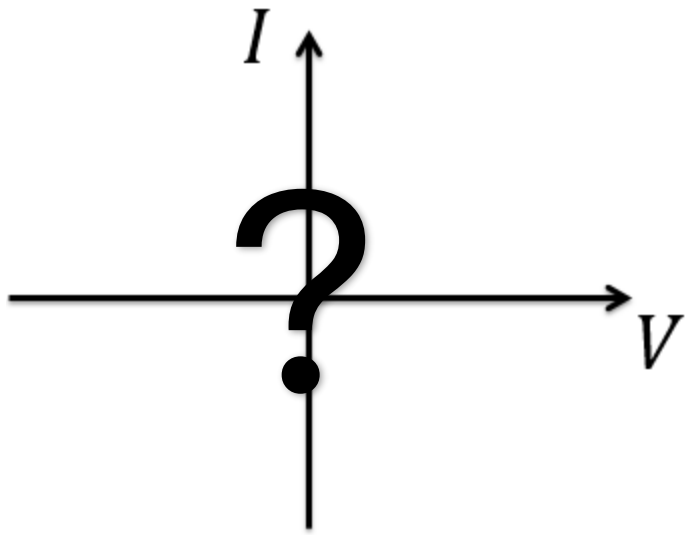
- Measuring I-V Characteristics of Circuits
- Calculating I-V Characteristics of Linear Circuits
- Operating (I,V) point when Sub-circuits are Connected
- Power and the I-V Characteristics

What's in the Box?



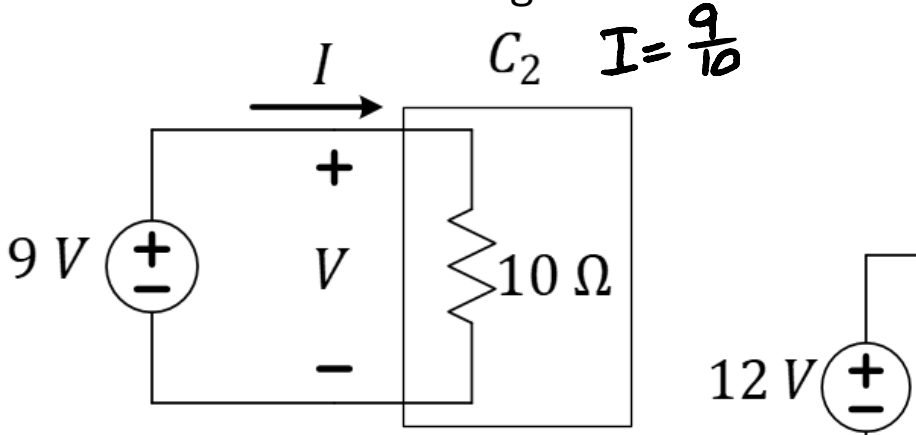
Can We Uncover the IV Behavior?

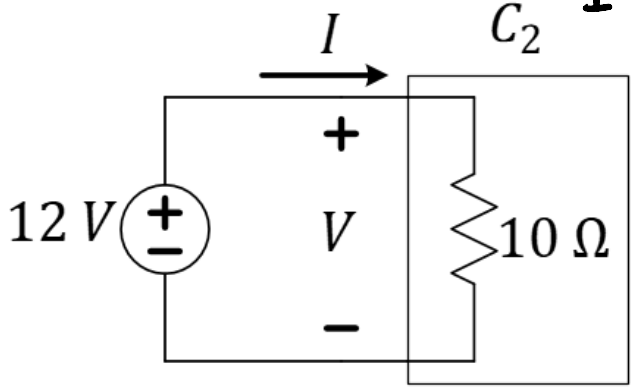


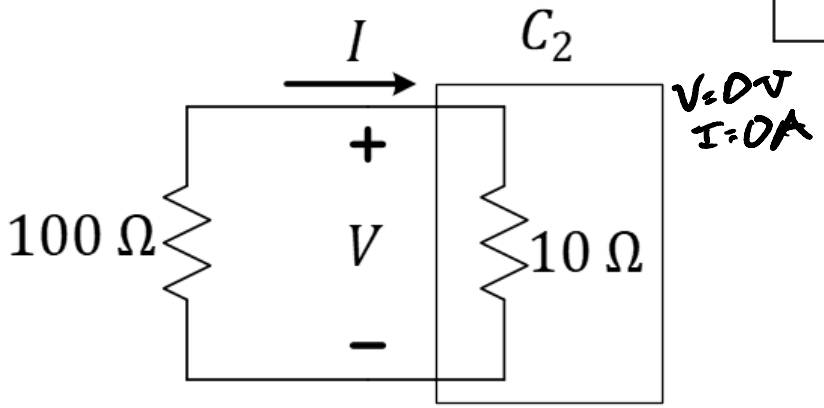


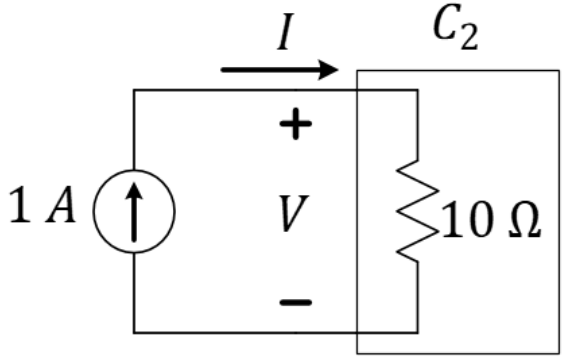
Example: C2 is a $\mathbf{10\ \Omega}$ Resistor

Attach a bunch of things to the 10 Ω and take current-voltage data points!

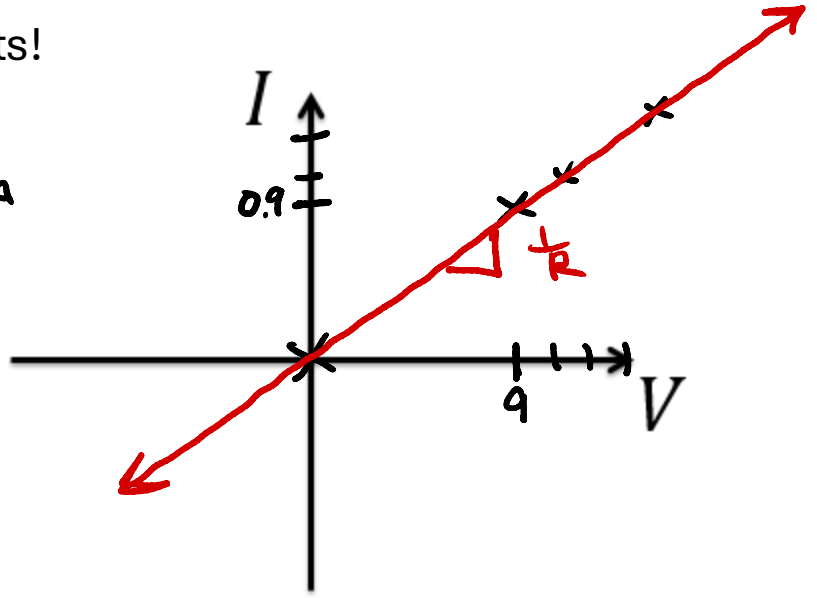




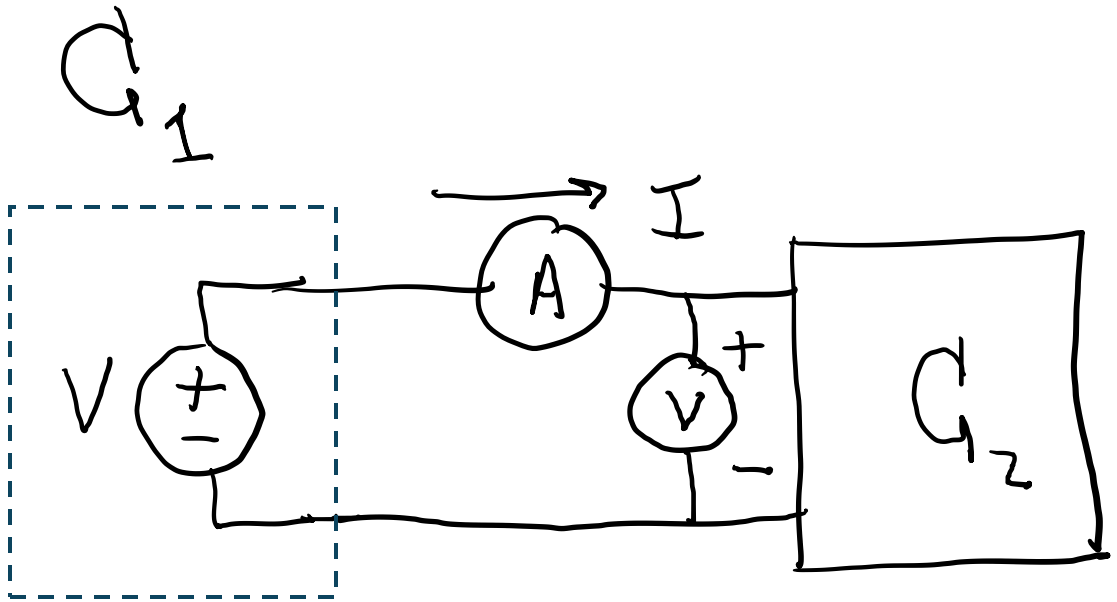


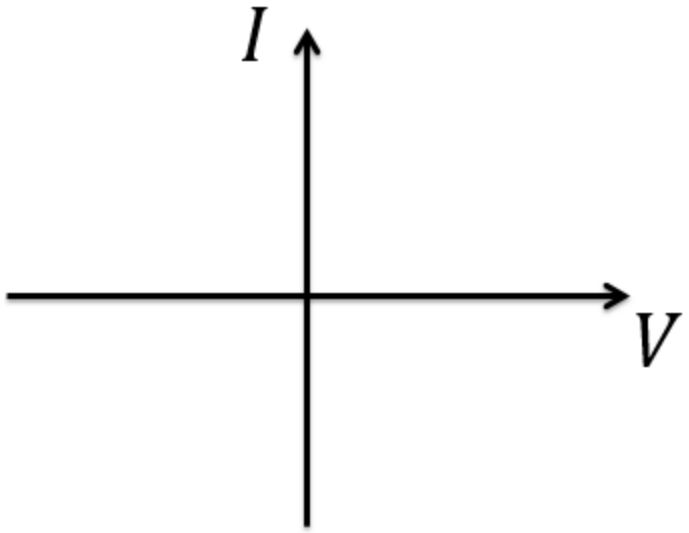


I=1A
V=1(10)
V=10V



Measuring IV Data in the Lab

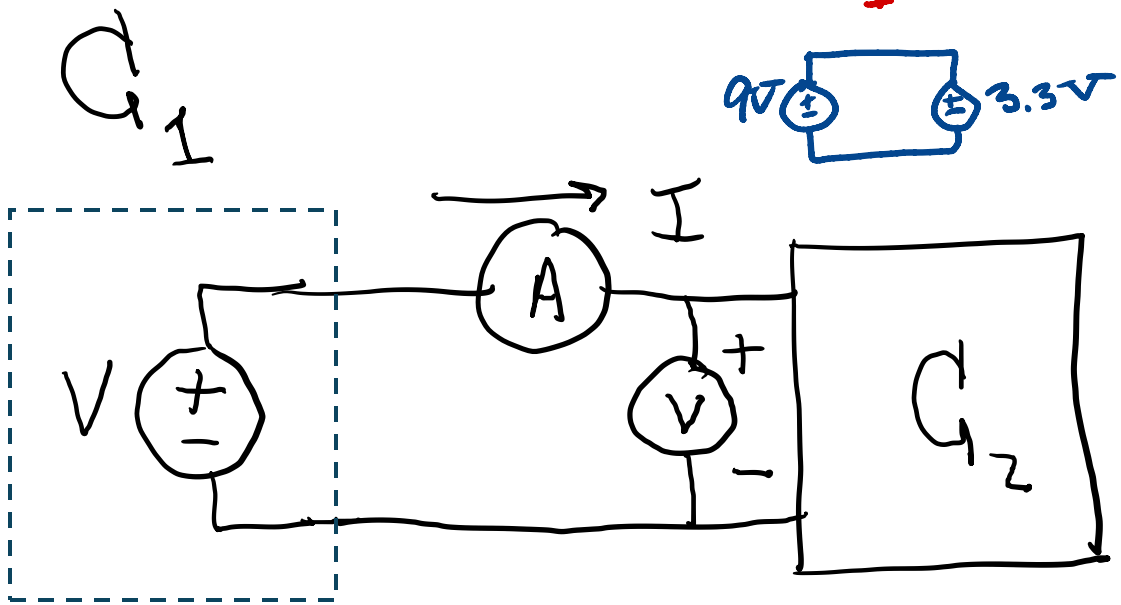


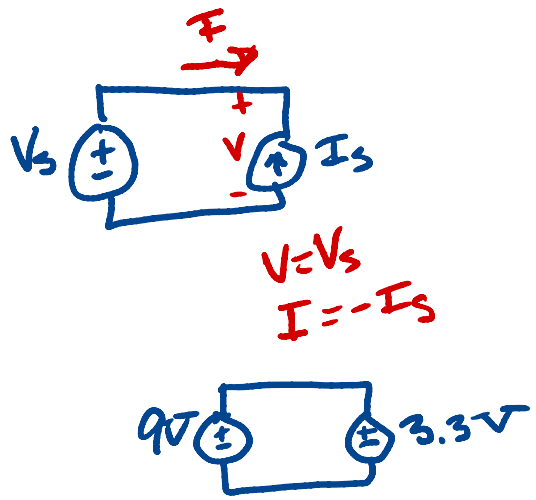


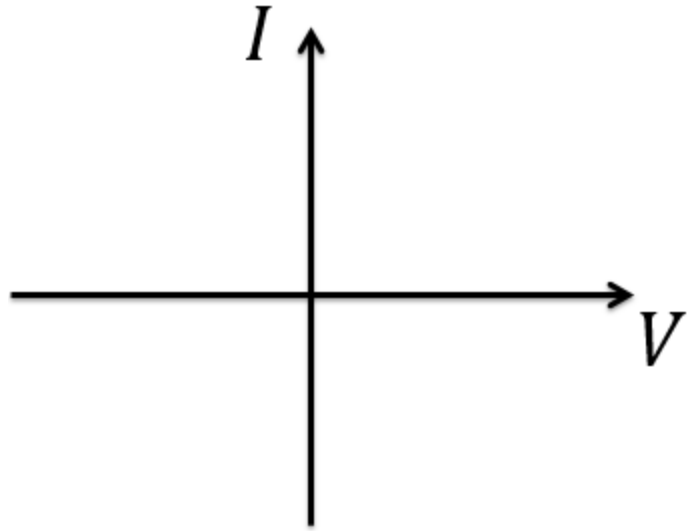
Q: What is the voltage drop across an ideal current-meter (ammeter)?

A. 0 V
B. 1 V
C. Depends on the ammeter's internal resistance

Measuring IV Data



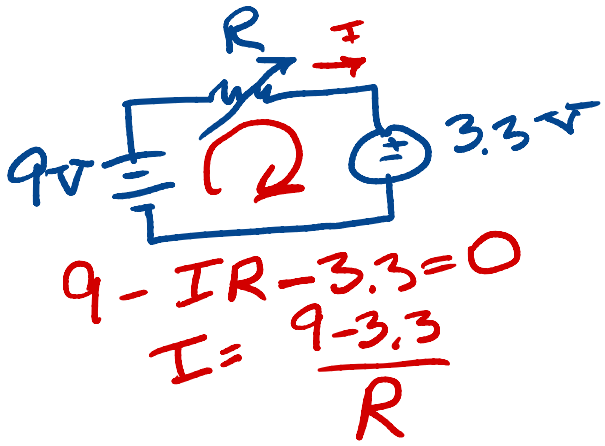


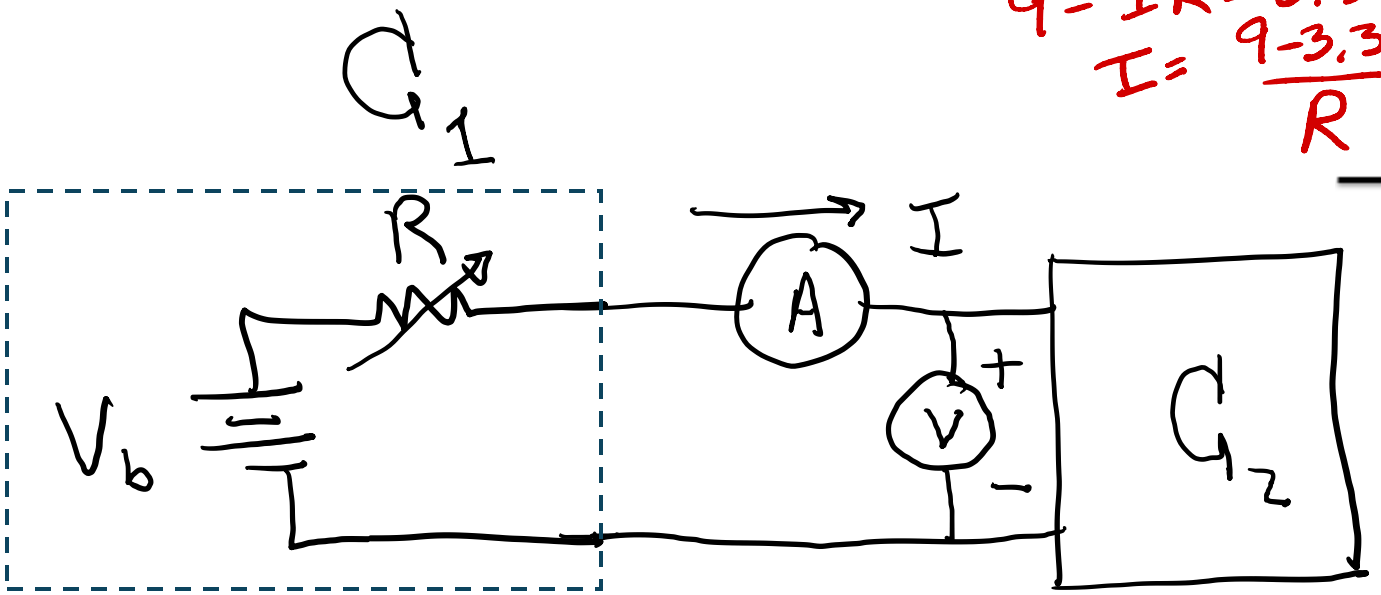


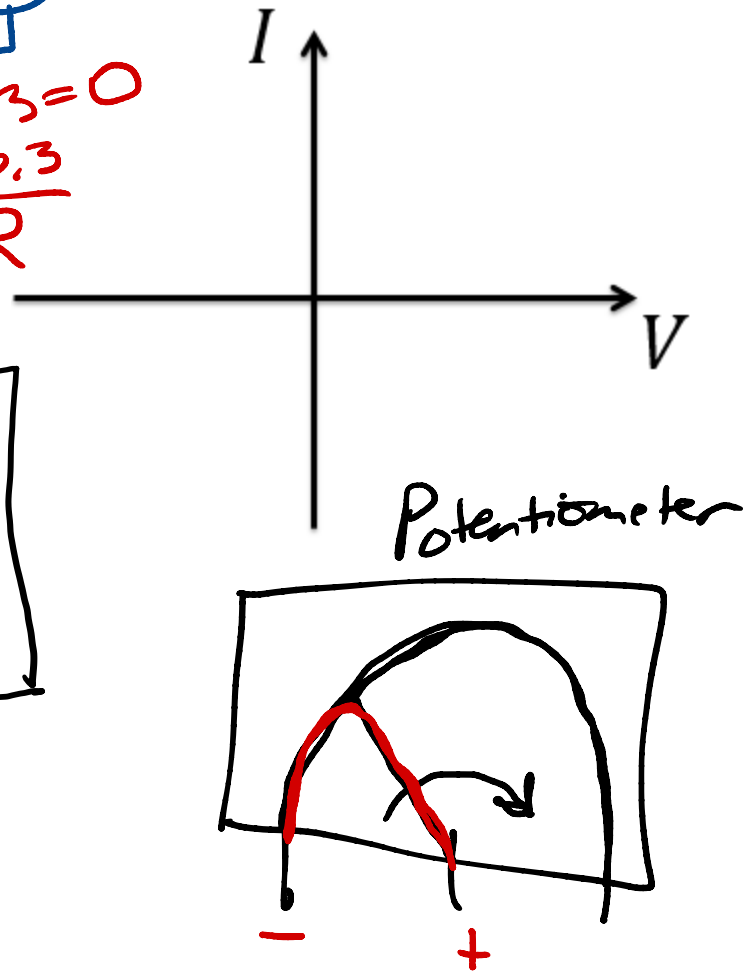
Q: When would this technique be a bad idea?

A. When C_2 is another voltage source
B. When C_2 is a current source
C. When C_2 is a resistor

Measuring IV Data





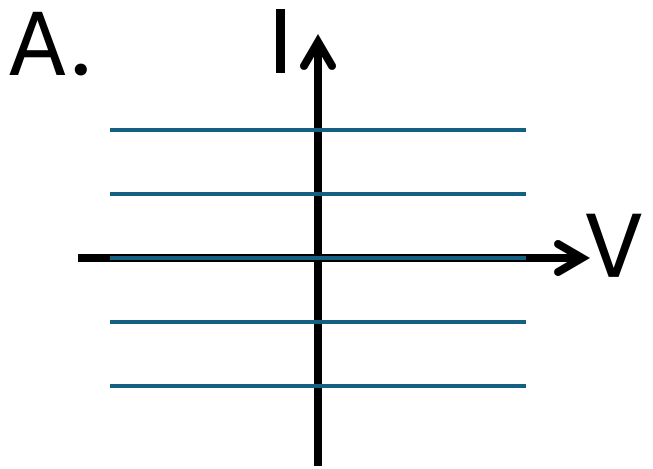


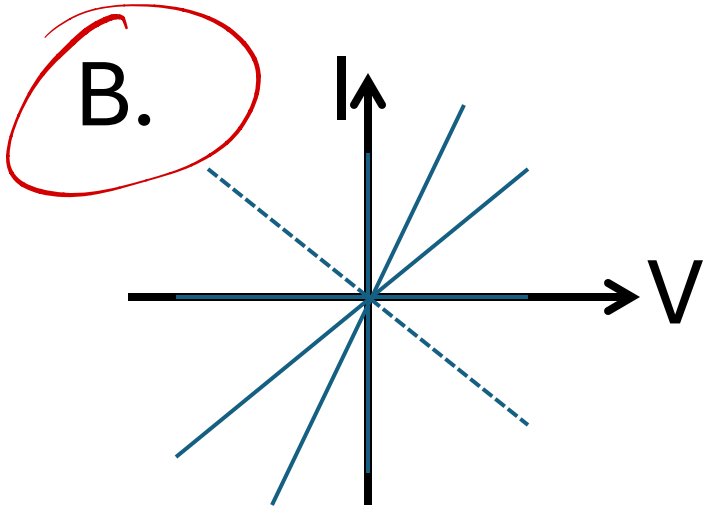
Q: Should this work to fix V_b and allow $0 < R < \infty\ \Omega$?

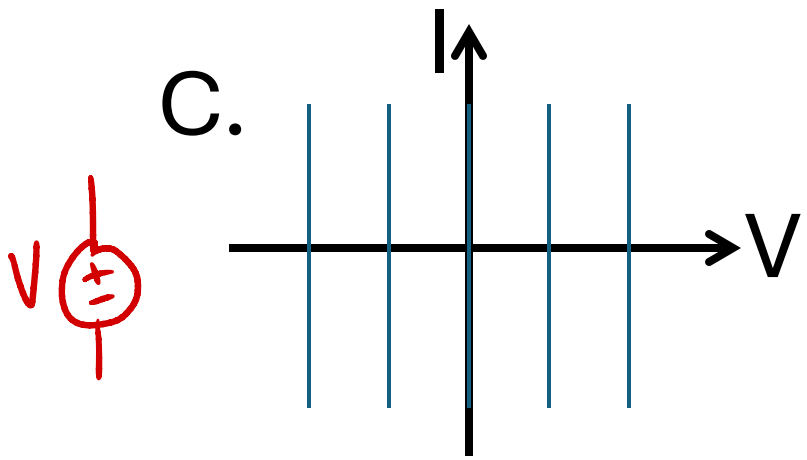
A. Yes
B. No

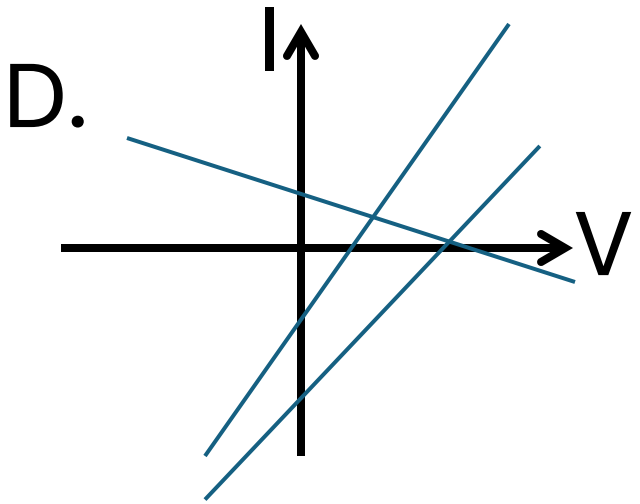
Linear I-V curves

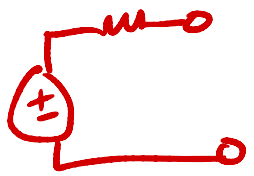
Q: Which set of graphs corresponds to pure resistances?

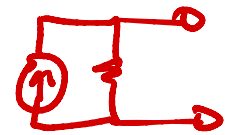






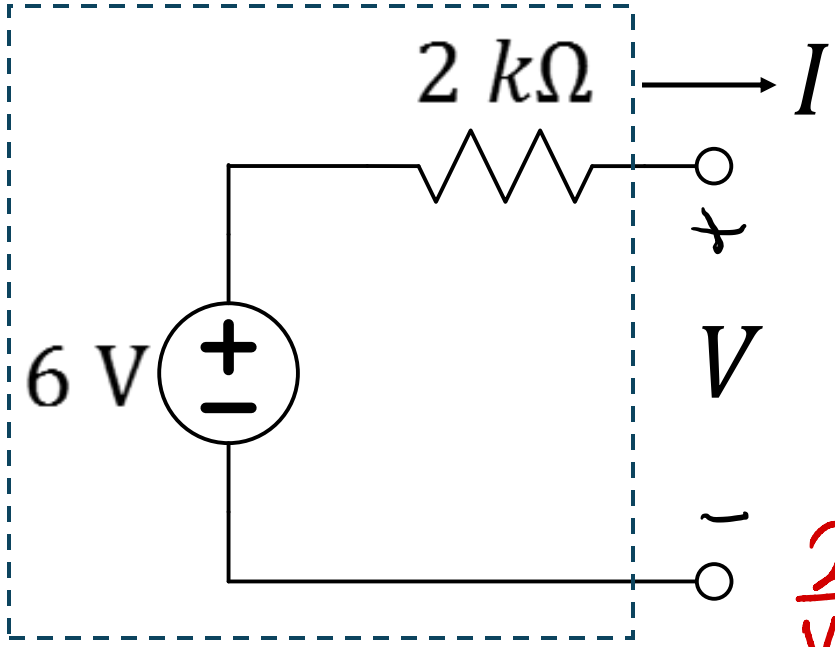




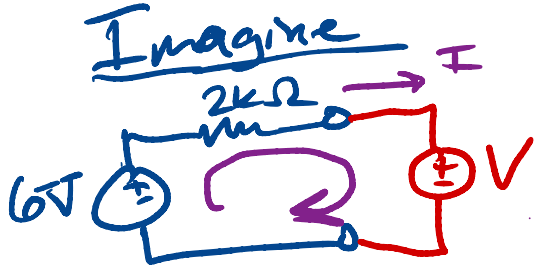


Simple Series Circuit

Show that the circuit has a linear IV characteristic by attaching a voltage source and analyzing it using your circuit-analysis toolbox.



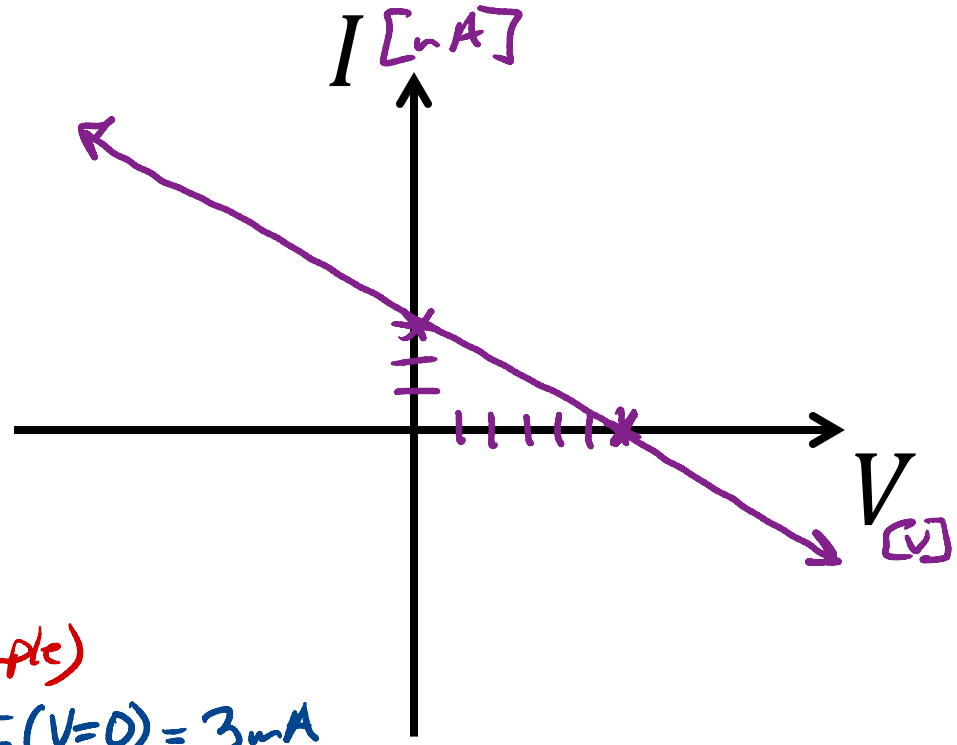
Imagine I



$6 - 2000I - V = 0$

$6 - V = 2000\,I$

$I = -\frac{V}{2000} + 3\text{mA}$



2 Points

$V_{oc} = V(I=0) = 6\text{V}$ (in this example)

Open circuit voltage

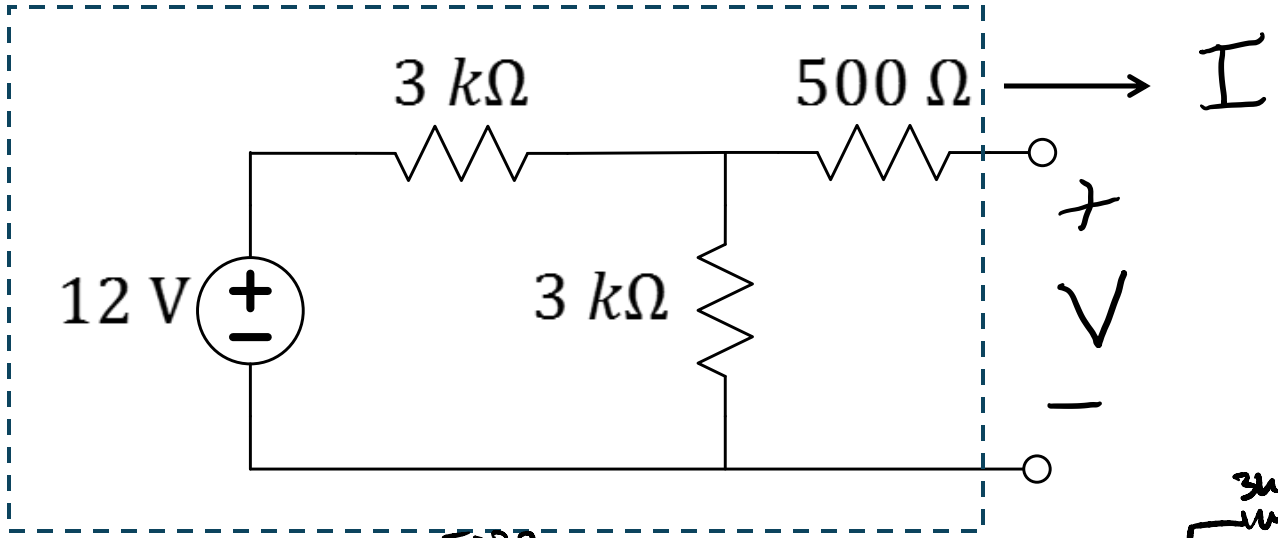
$I_{sc} = I(V=0) = 3\text{mA}$

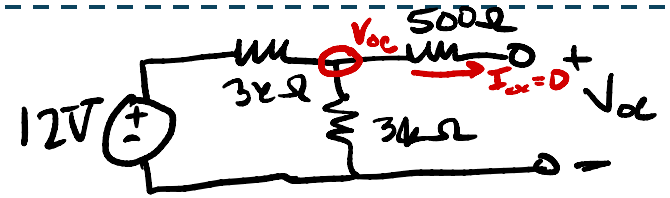
Short circuit current

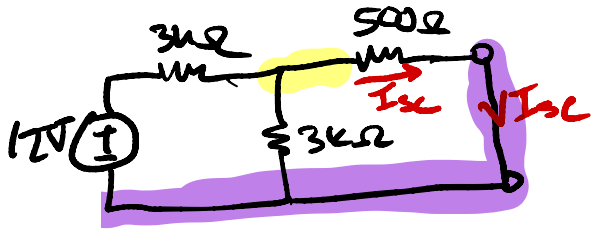
Q: Find m and b such that $I = mV + b$ and then graph it.

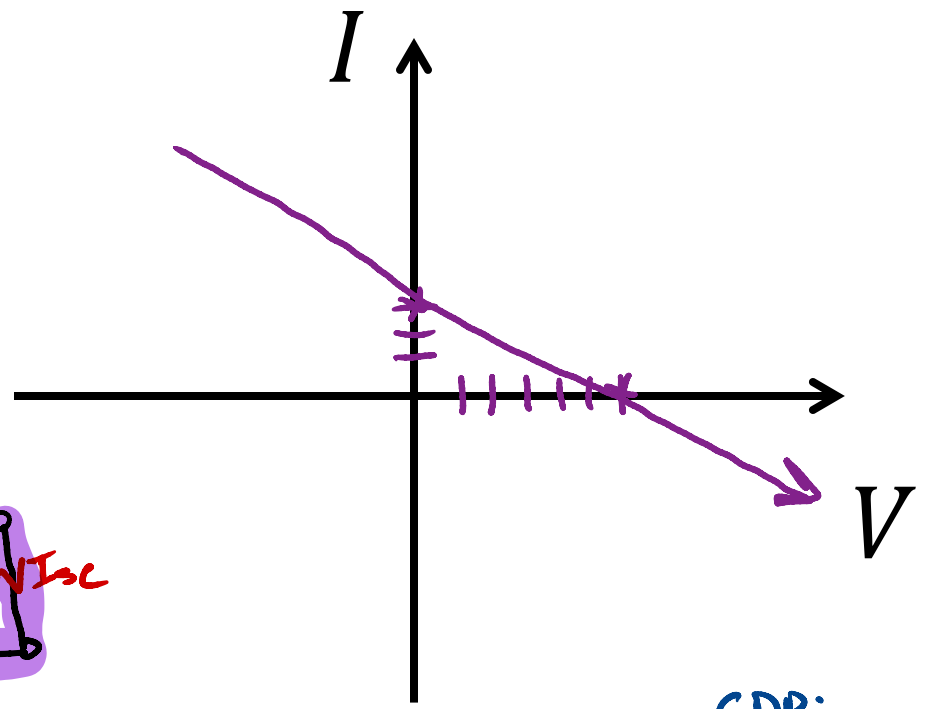
Embedded Voltage Source

Show that this circuit also has a linear IV characteristic.









Q: Find m and b such that $I = mV + b$ and then graph it.

$V_{500} = 0$

$V_{3k\Omega} = \left(\frac{3k}{6k}\right)(12)$

$= 6\,V = V_{oc}$

$R_{eq} = \left(\frac{1}{500} + \frac{1}{3000}\right)^{-1}$

$= \left(\frac{6+1}{3000}\right)^{-1}$

$= \frac{3}{7}\,k\Omega$

$I_+ = \frac{12}{3000 + \frac{3000}{7}}$

$I_+ = 3.5\,mA$

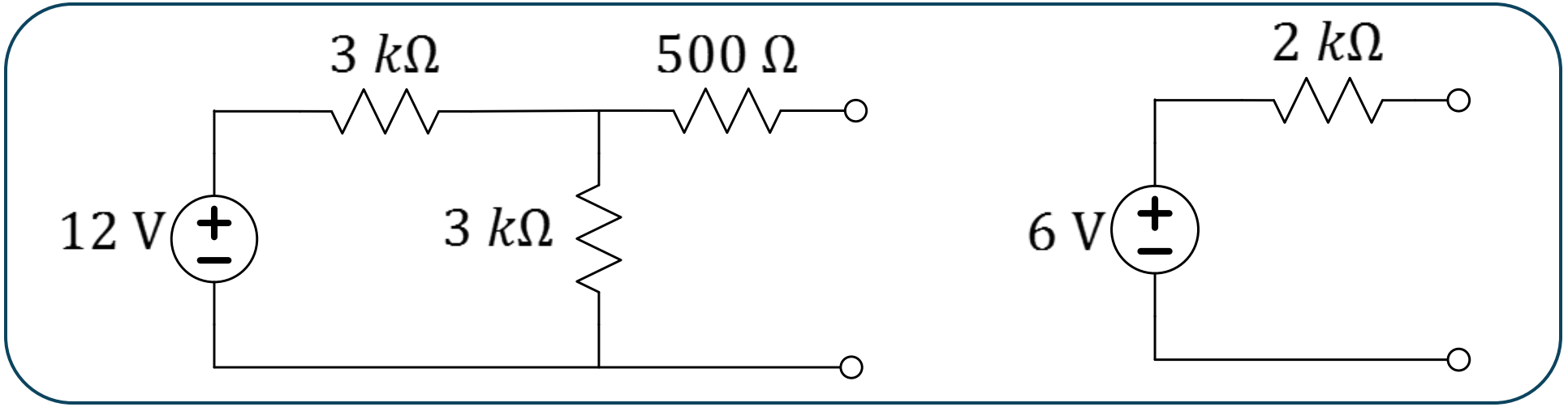
CDR:

$I_{3k\Omega} = \left(\frac{\frac{3}{7}k\Omega}{500}\right)(3.5\,mA)$

$I_{3k\Omega} = 3\,mA$

Embedded Voltage Source

Both these circuits have the SAME linear IV characteristic!



Q: If both circuits produce the same $I = mV + b$ plot, can the IV data be used to tell which of the two circuits is "in the box"?

A. Yes
B. No
C. Other

L11 Learning Objectives

a. Given one of the three sub-circuit descriptions (IV equation, IV line, diagram), find the other two

    Note that more than one circuit diagram fits an IV description

b. Quickly identify the IV representations of voltage and current sources, resistors, and combinations