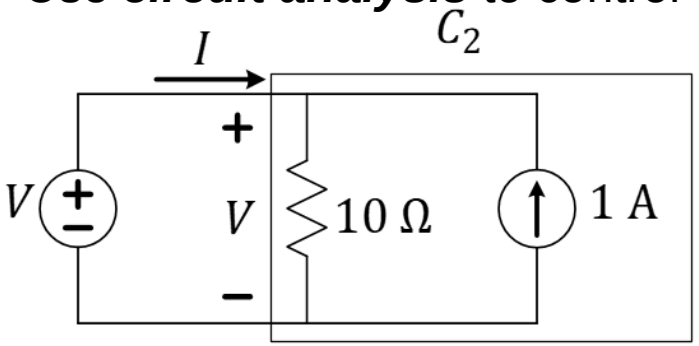
Lecture 13: Thevenin Equivalents

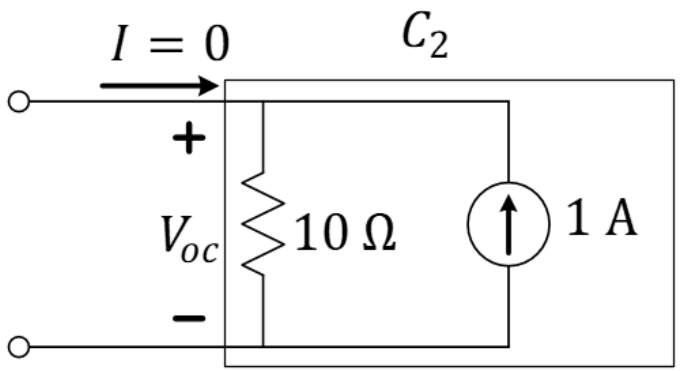
- Review of I-V Linear Equation
- Thevenin Equivalent Circuit
- Effective Resistance in Linear network
- Calculating R_{eff} by Removing Sources
- Problem Strategy and Practice

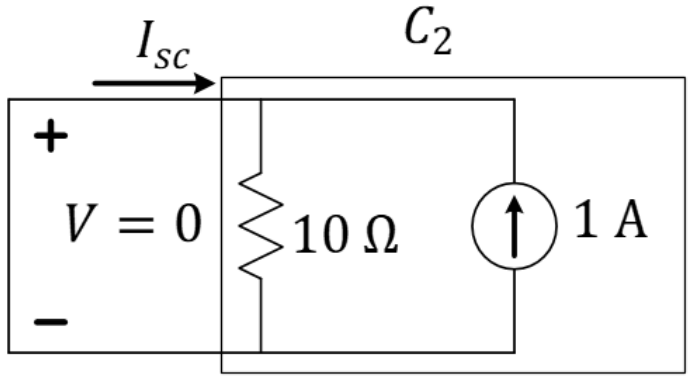
Methods to find IV

Use ***circuit analysis*** to control V



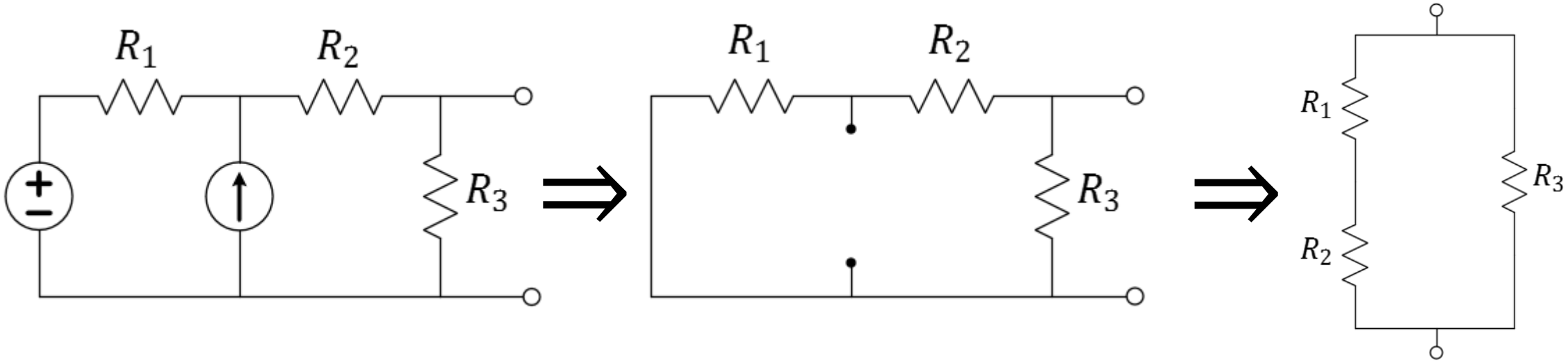
Find two points (usually ***open*** and ***short***)





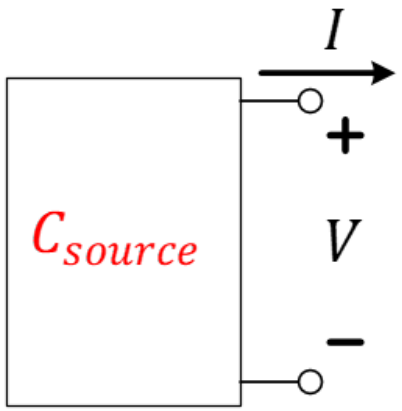
Effective Resistance: R_{eff} is R_{eq} with sources "zeroed"

1. Short-circuit all voltage sources (i.e. set them to zero)
2. Open-circuit all current sources (i.e. set them to zero)
3. Find resulting R_{eq} using parallel and series relationships

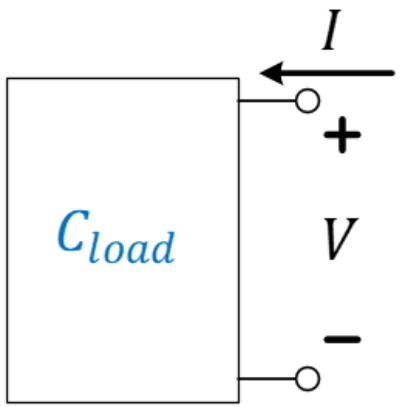


Q: How is R_{eff} related to the slope of the I-V line?

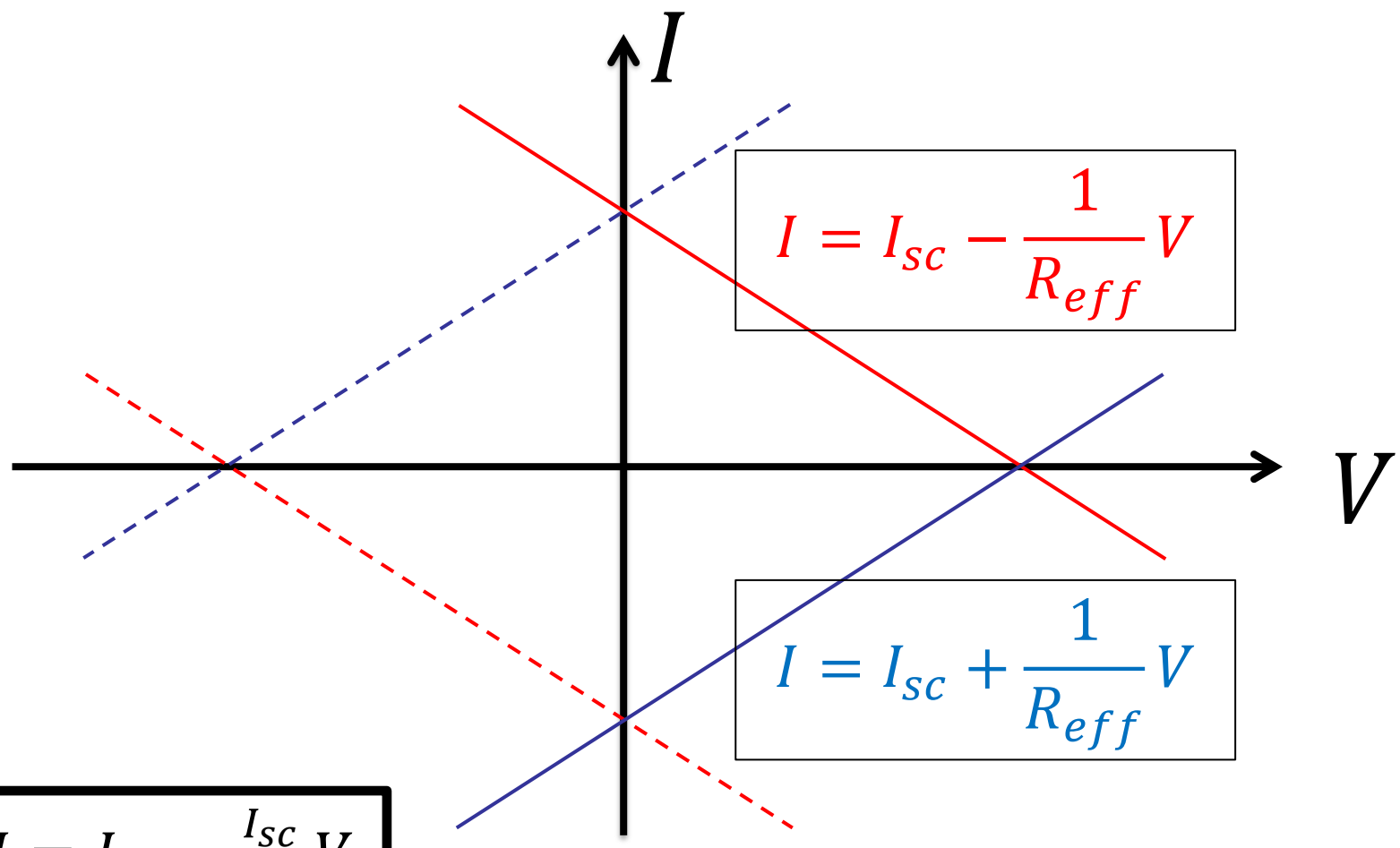
Relating I-V Line to Equation



$$R_{eff} = \frac{V_{oc}}{I_{sc}}$$



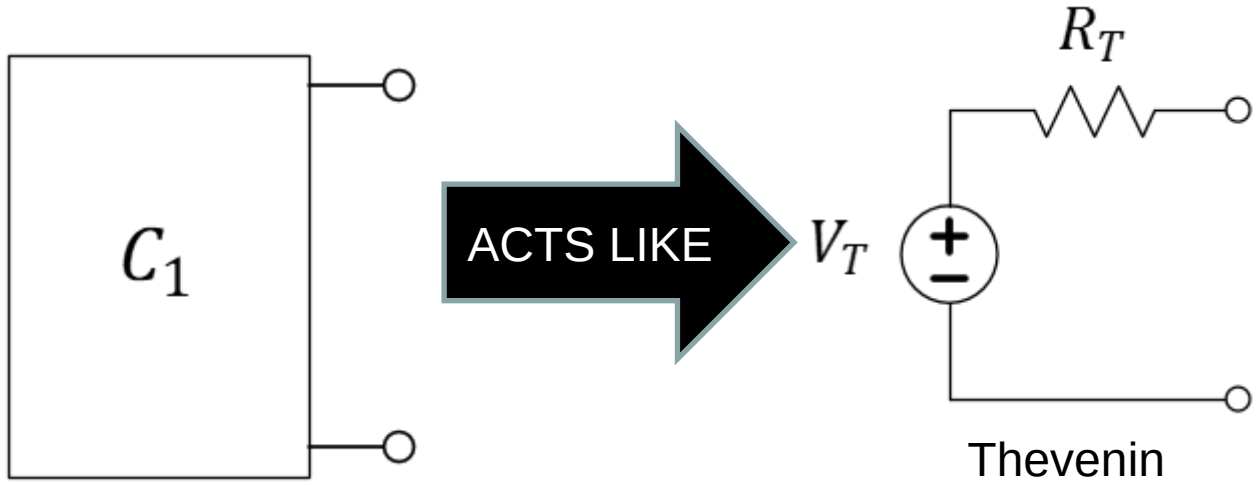
$$R_{eff} = -\frac{V_{oc}}{I_{sc}}$$



Universal: $I = I_{sc} - \frac{I_{sc}}{V_{oc}} V$

Thevenin Equivalent

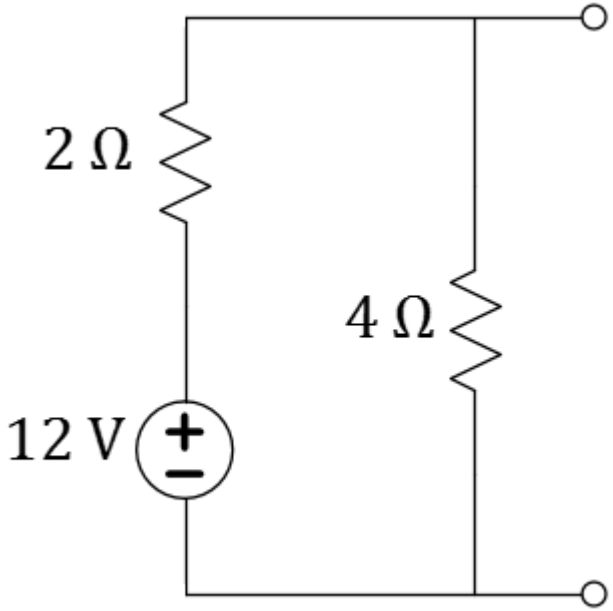
Any linear IV $I = mV + b$ can be matched by the circuit on the right with proper selection of V_T and R_T.

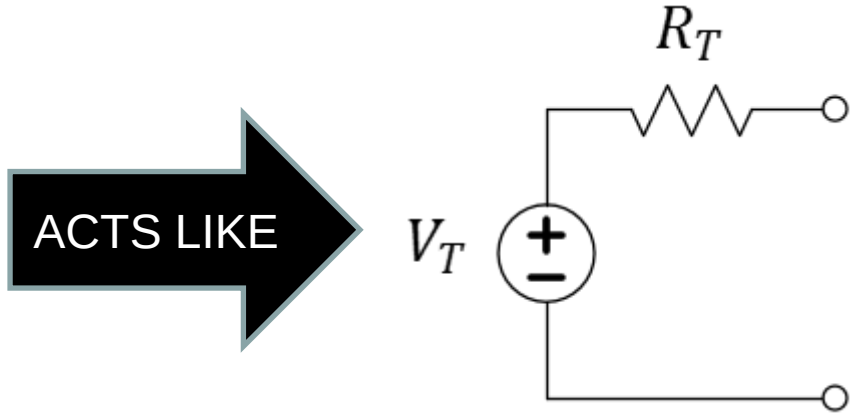


- The Thevenin will have the same universal formula $I = I_{sc} - \frac{I_{sc}}{V_{oc}} V$
- It will contain all information on how original circuit interact with others
- However, it loses information on power dissipation WITHIN the circuit

Example

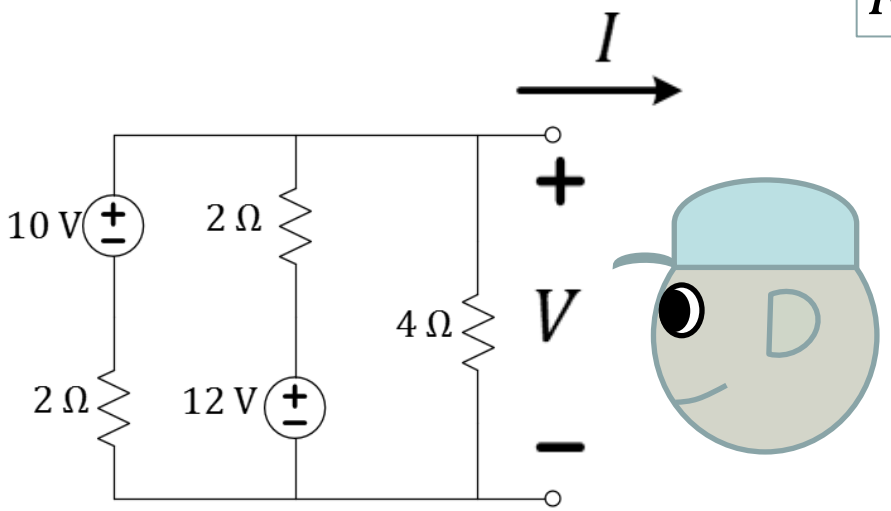
Q: What is the Thevenin equivalent of the circuit?





Finding R_{eff} is easy in multi-source circuits

$$R_{eff} = R_T!$$



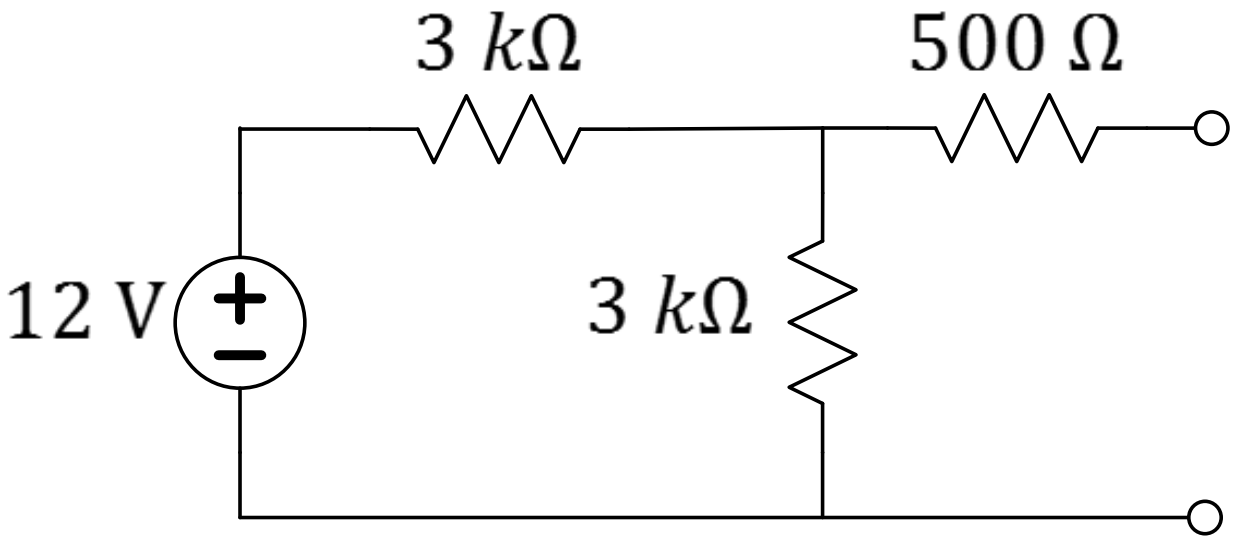
Q: What is R_{eff}, for the circuit?

$A.\ 8\ \Omega$
$B.\ 5\ \Omega$
$C.\ 4\ \Omega$
$D.\ 2\ \Omega$
$E.\ 0.8\ \Omega$

Q: Find the value of I_{SC}.

Q: Find $I = mV + b$.

Practice!



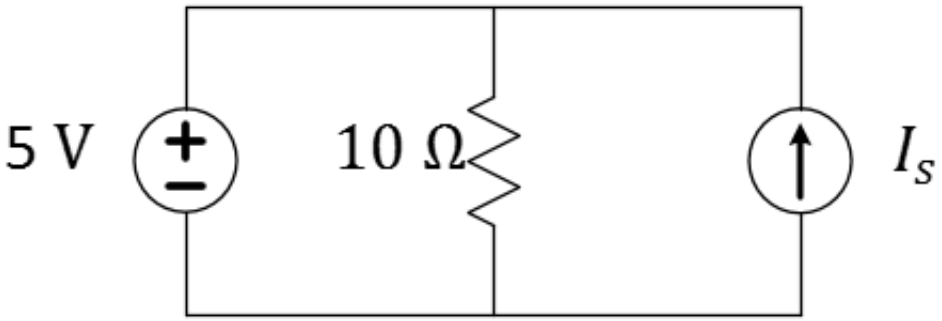
Q: What is the Thevenin equivalent for the circuit above?

In History…

Leon Charles Thevenin was a telegraph engineer. In 1883, his theorem expanded modelling of circuits and simplified circuit analysis based on Ohm's Law and Kirchhoff's Laws.

The dual "Norton's theorem" didn't arrive until 1926 with the efforts of Bell Labs engineer, **Edward Lawry Norton**.

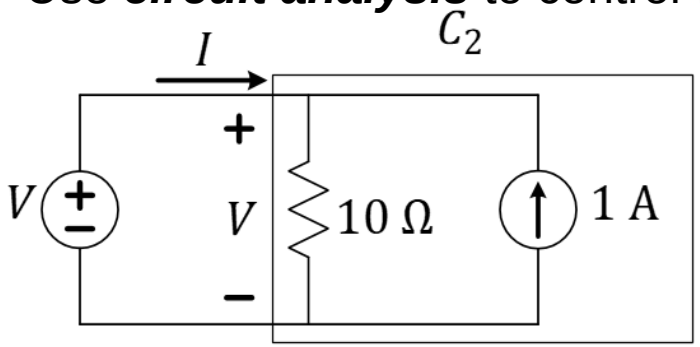
Flashback! Use Thevenin to solve.



Q: For what values of I_s does the voltage source supply power?

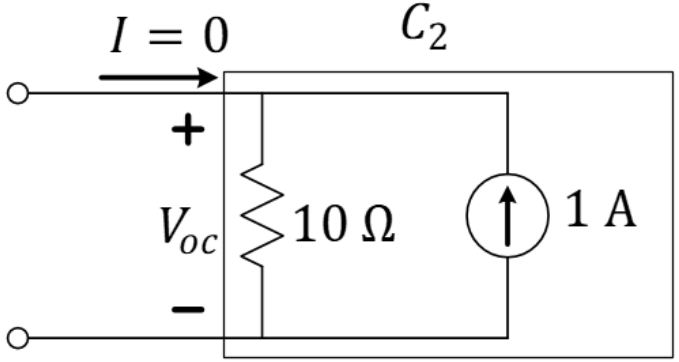
Common Methods to find IV

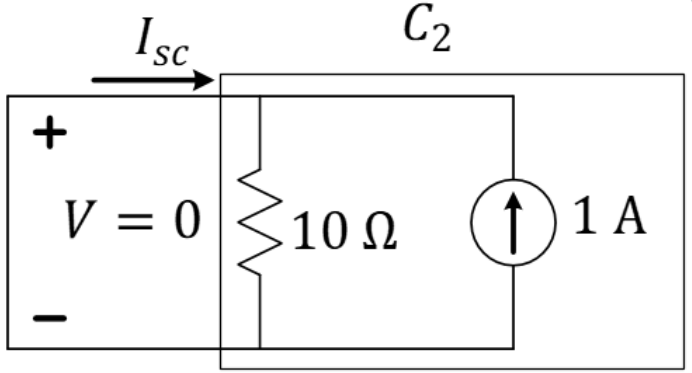
Use ***circuit analysis*** to control V



$$I = mV + b$$

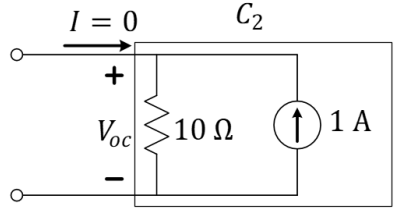
Find two points (usually ***open*** and ***short***)

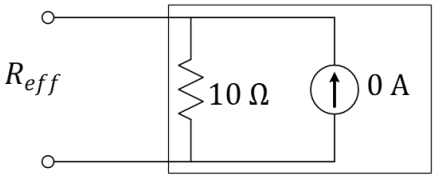




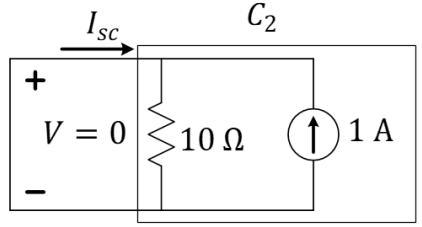
$$I = I_{sc} - \frac{I_{sc}}{V_{oc}} V$$

Use R_{eff} and either ***open*** or ***short***





or



load

$$I = I_{sc} \pm \frac{1}{R_{eff}} V$$

source

L13 Learning Objectives

a. Represent *any* (non-horizontal) linear IV characteristic by a series combination of a voltage source and a resistor (Thévenin equivalent circuit).

b. Use multiple methods to find IV characteristics.