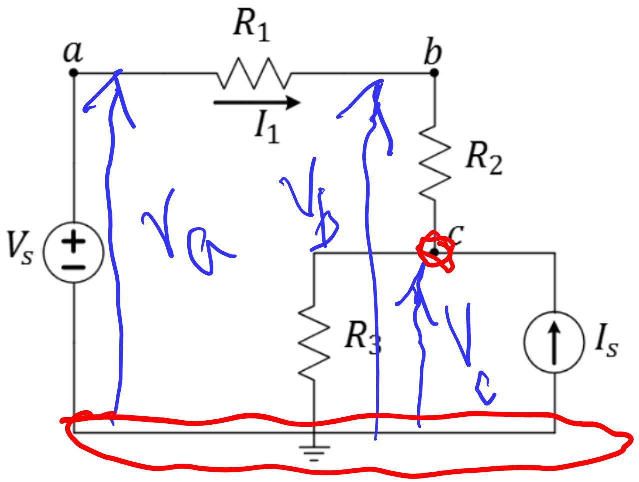


$R_1 = 5\ \text{k}\Omega$

$R_2 = 5\ \text{k}\Omega$

$R_3 = 7\ \text{k}\Omega$

The measured nodal voltages are:

$V_a = 19\ V$

$V_b = 14.441176470588236\ V$

$V_c = 9.882352941176471\ V$

Find voltage V_{ab} and the current I_1.

$V_{ab} =$ ______ V

$I_1 =$ ______ mA

(within three significant digits)

What is the power for the voltage and current source in watts?

$$V_{ab} = V_a - V_b \approx 4.559 \ \checkmark$$

$$I_1 = \frac{V_{ab}}{5K} \approx \frac{4.559}{5}\ mA$$

$$P_{V_s} = -(19 \cdot I)$$

$$I_s = I - V_c / 7K$$

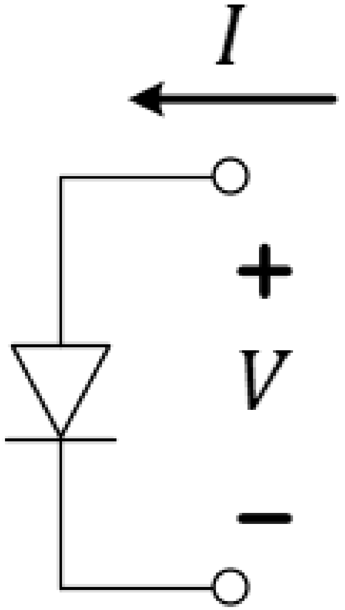
$$\therefore P_{I_s} = -(V_c \cdot I_s)$$

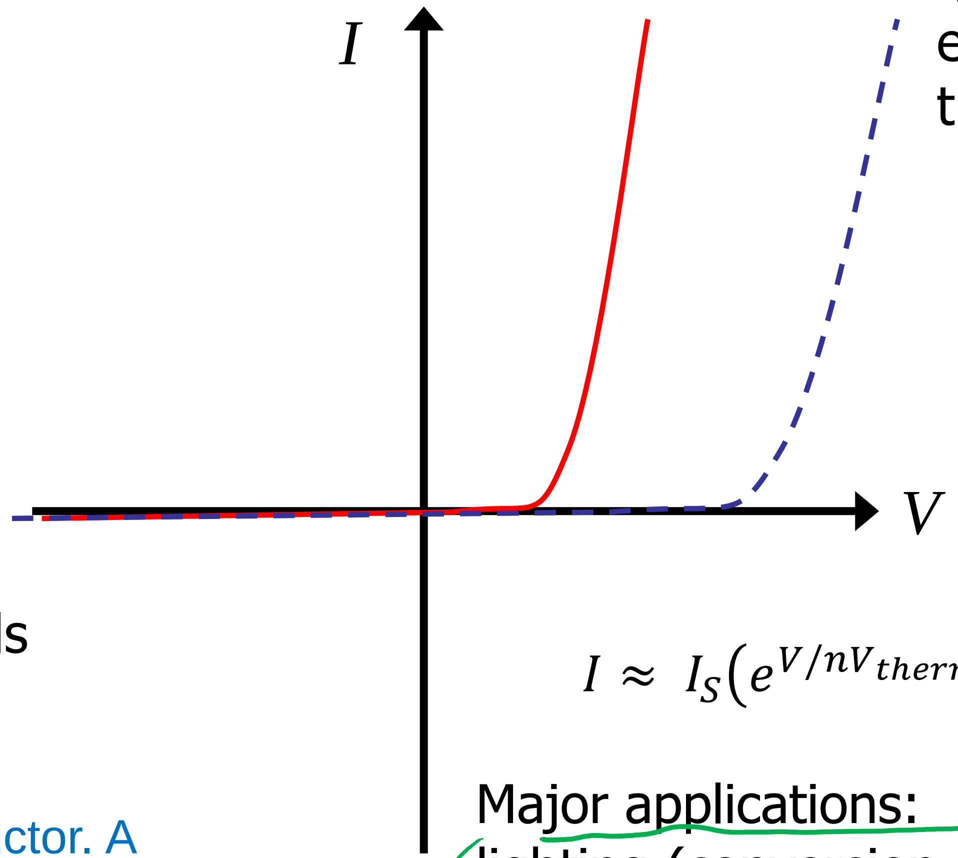
Lecture 16: Introduction to Diodes

- Diode IV characteristics
- Connecting diode to a linear circuit
- Piecewise linear models of diodes

Recommended: https://learn.sparkfun.com/tutorials/diodes

Diode as a two-terminal device





Q: Based on the exponential equation for IV as shown, can the diode supply power?

A. Yes
B. No

Made out of *semiconductor* materials like Si, Ge, GaAs, AlGaAs, GaN with some additives called *dopants.*

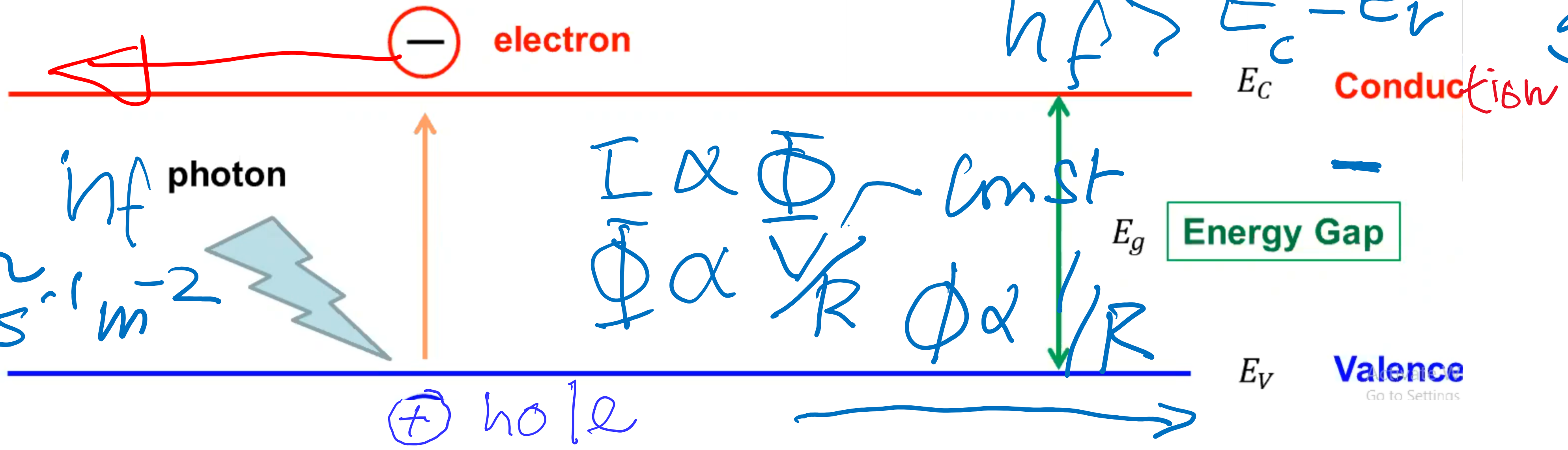
$$I \approx I_S\left(e^{V/nV_{therm}} - 1\right)$$

Refer to L15 introduction to a semiconductor. A diode is formed by bringing two semiconductor regions together. One has excess mobile electrons (n-type) and the other excess mobile holes (p-type) due to different *dopants (e.g. As, B in Si)*

Major applications:
lighting (conversion of I to photons), electronics

But when exposed to light ***I*** can reverse **(-*I*)** with **+*V*** to supply power: Which is how a solar power cell works! Will discuss in later lectures.

Lecture 15 – Photoresistor: Photon flux converted to charge flux (current *I*)



$hf > E_c - E_v$ Energy gap

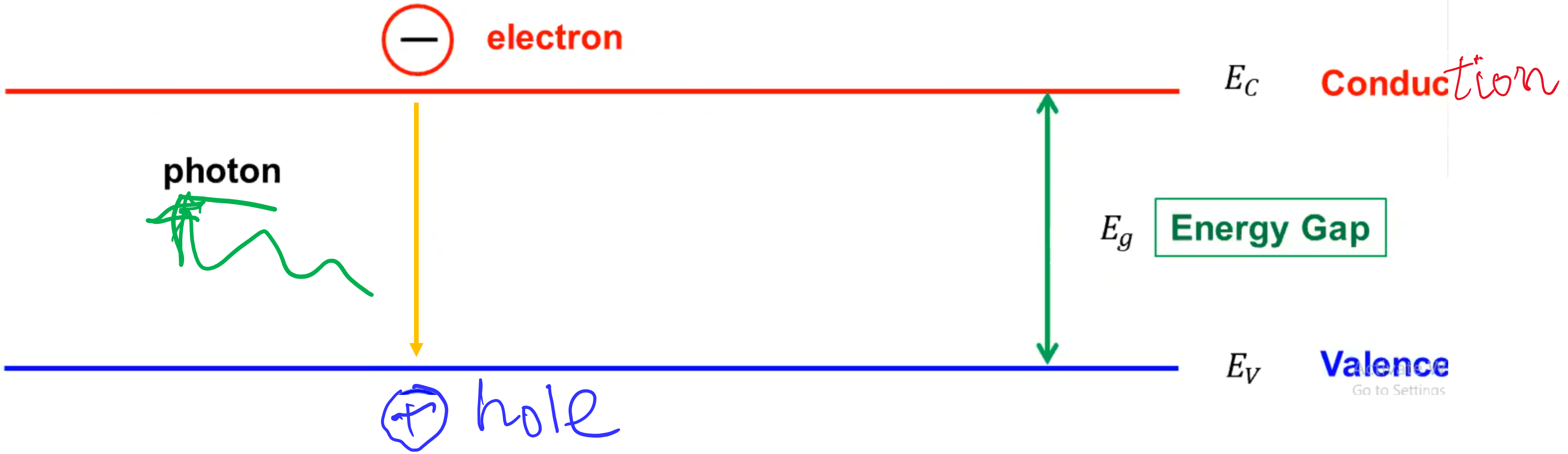
$I = I_e + I_h$

$\Phi = ph.s^{-1}m^{-2}$

$I \propto \Phi$ ~ const

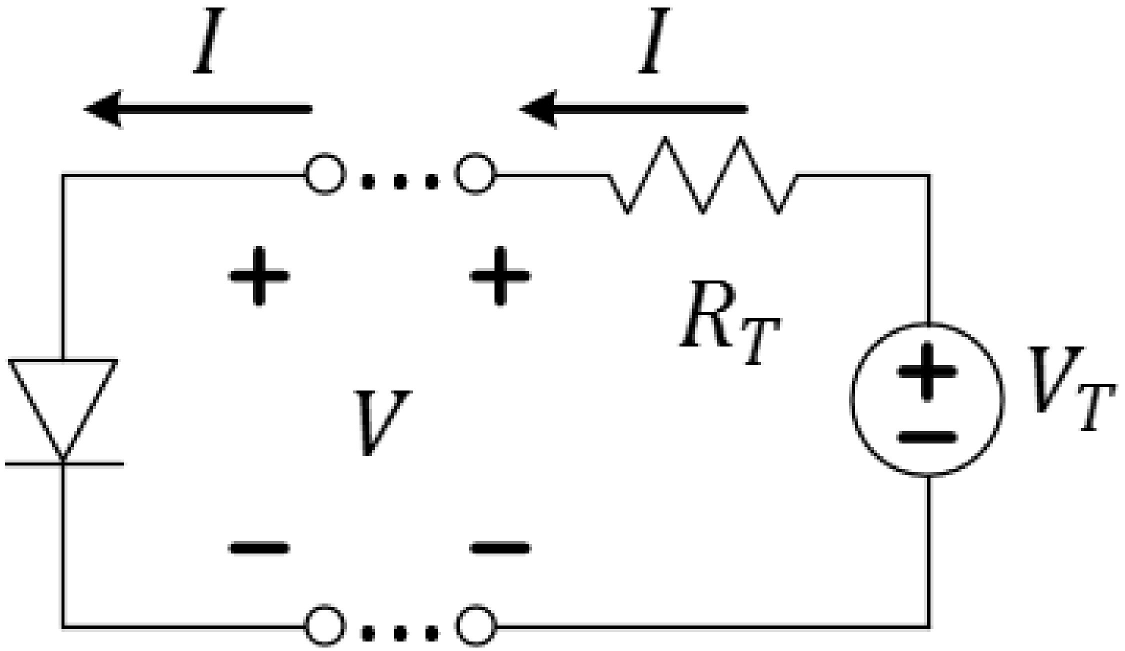
$\Phi \propto V/R$

$\Phi \propto 1/R$



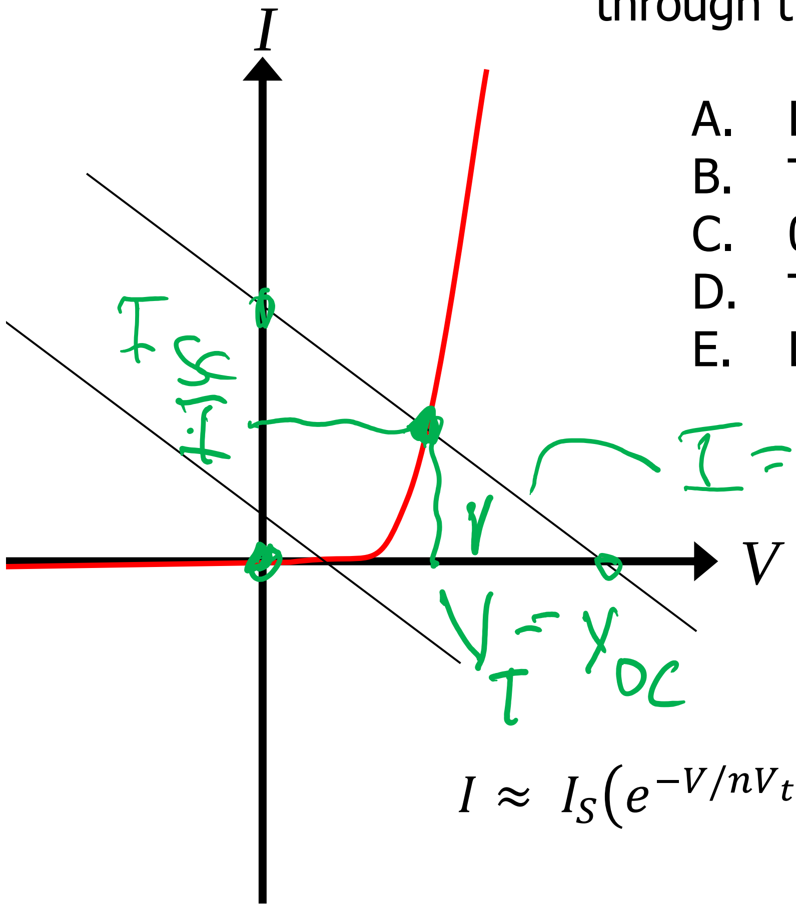
Reverse process to convert current *I* to a photon flux also possible - LED

Connecting diode to a linear circuit



Q: What is the current flowing through the diode if $V_T < 0$?

A. Large and negative
B. Tiny and negative
C. 0
D. Tiny and positive
E. Large and positive



$I = mV + I_{sc}$

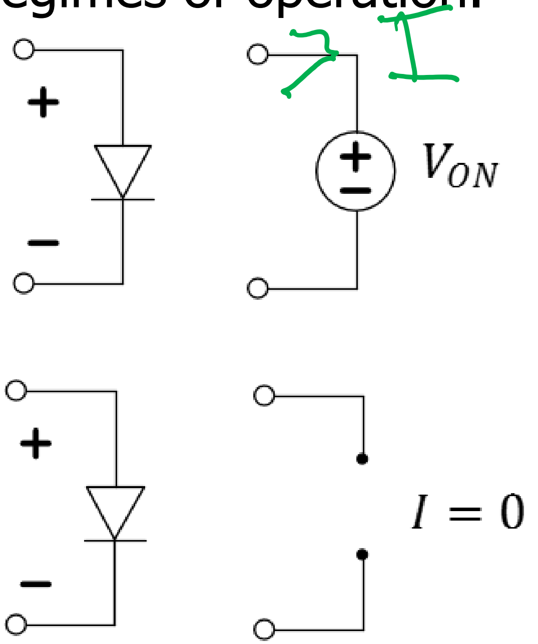
$m = -1/R_T$

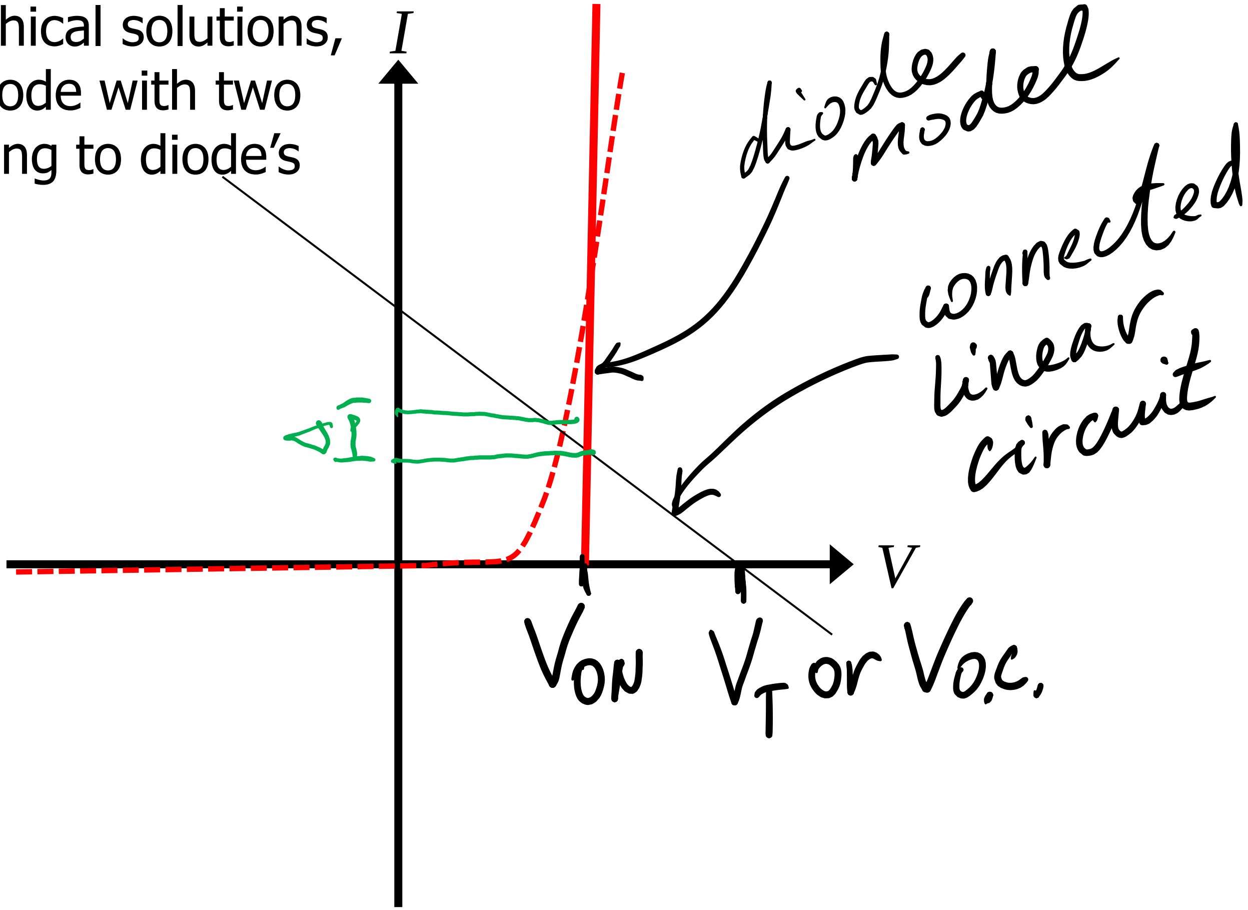
$$I \approx I_S\left(e^{-V/nV_{therm}} - 1\right) \sim -I_S$$

We can solve graphically for an operating point.
For an LED more current means more light.

Modeling diode with linear IV segments

Instead of looking for graphical solutions, we can approximate the diode with two line segments, corresponding to diode's regimes of operation.





Q: What is the minimum V_T of the connected linear circuit which causes current to flow through the diode assuming the IV model?

A. $0\ V$
B. V_T
C. V_{oc}
D. V_{ON}
E. None of these.

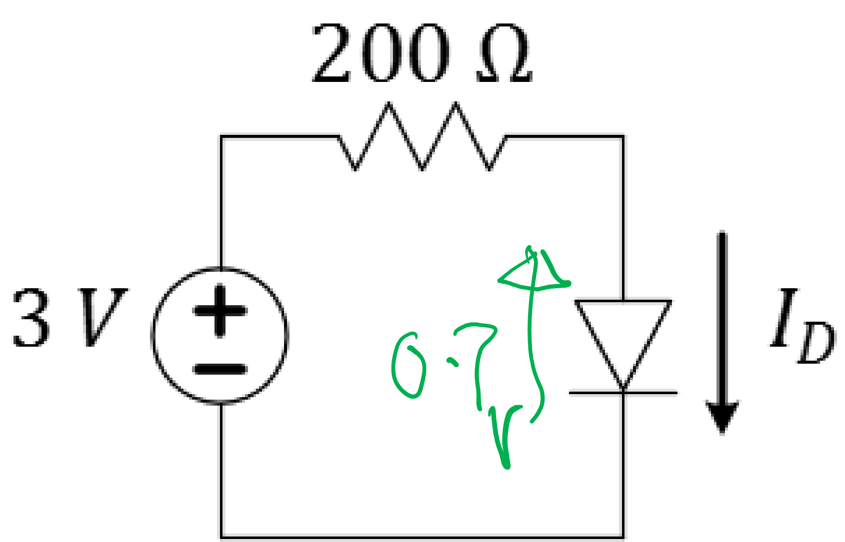
Different diode types have different V_{ON}

Diode Type	V_{ON}(V)	Applications
Silicon	0.6-0.7	General; integrated circuits; switching, circuit protection, logic, rectification, etc.
Germanium	~0.3	Low-power, RF signal detectors
Schottky	0.15-0.4	Power-sensitive, high-speed switching, RF
Red LED (GaAs)	~2	Indicators, signs, color-changing lighting
Blue LED (GaN)	~3	Lighting, flashlights, indicators
"Ideal"	0	Can neglect V_{ON} for high voltage applications

Q: What is the power dissipated by a Ge diode if 30 mA is flowing through it?

A. $3\ mW$
B. $9\ mW$
C. $30\ mW$
D. $90\ mW$
E. $900\ mW$

Diode circuit examples (offset ideal model)



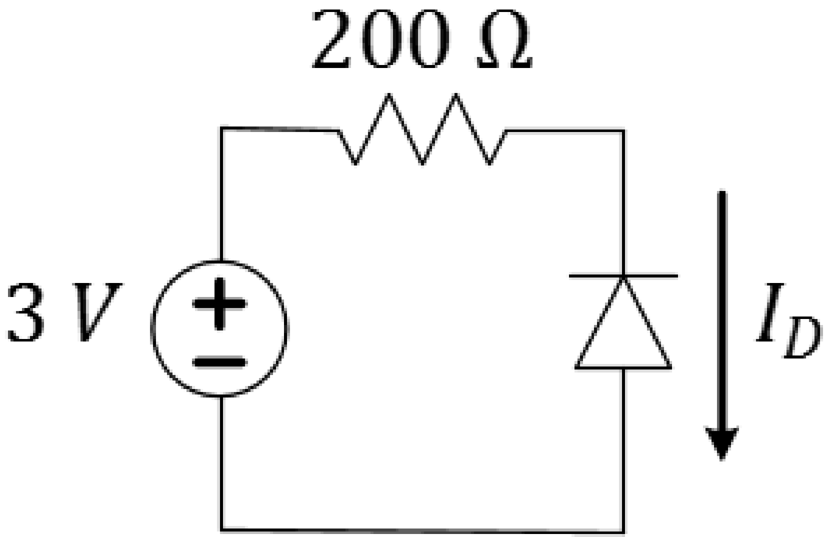
Assume offset-ideal model with V_{ON} = 0.7 (common Si diodes)

Q: What is the current through the diode?

A. 15 mA
B. 11.5 mA
C. 5 mA
D. 1.15 mA
E. 0 mA

$$\frac{3-0.7}{200} = \frac{2.3}{200} = 11.5\,mA$$

Diode circuit examples (offset ideal model)



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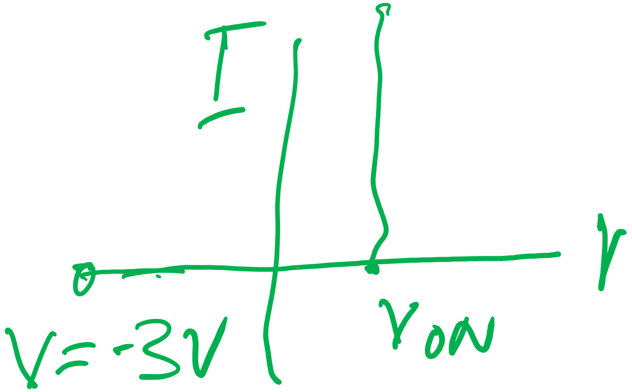
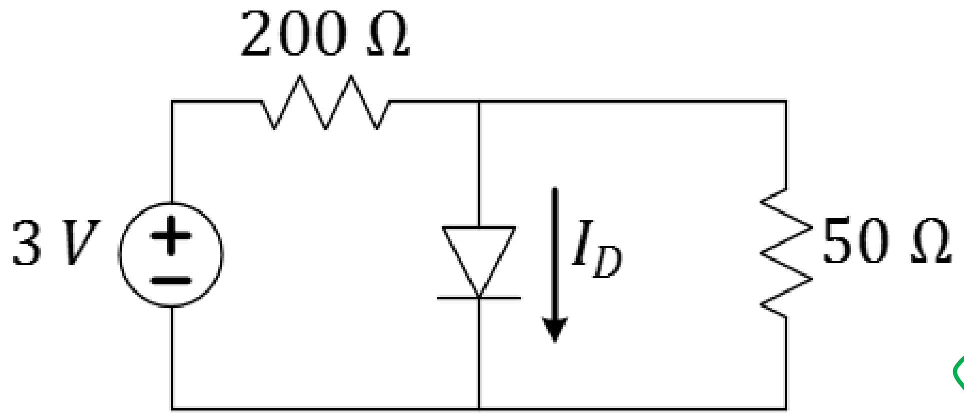


Diode circuit examples (offset ideal model)

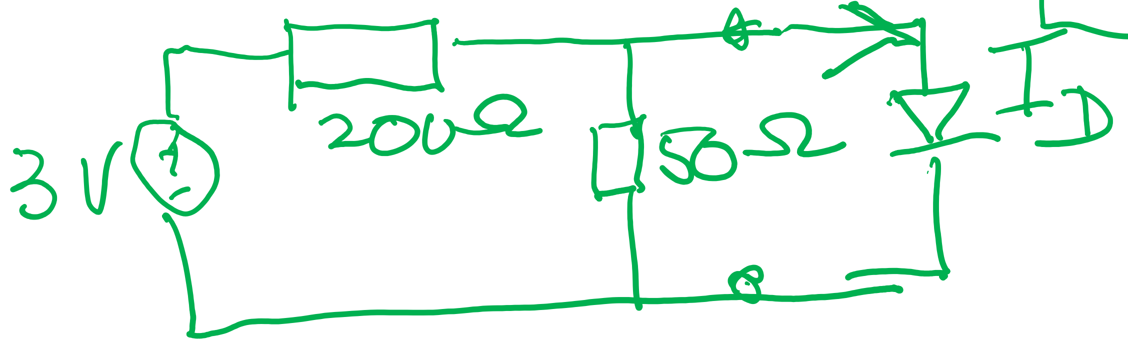


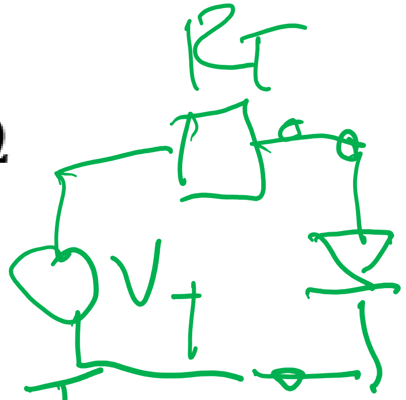
Assume offset-ideal model with V_{ON} = 0.7 (common Si diodes)

Q: What is the current through the diode in the circuit?

$I_D =$

A. $-11.5\ mA$
B. $-2.5\ mA$
C. $0\ mA$
D. $+2.5\ mA$
E. $+11.5\ mA$

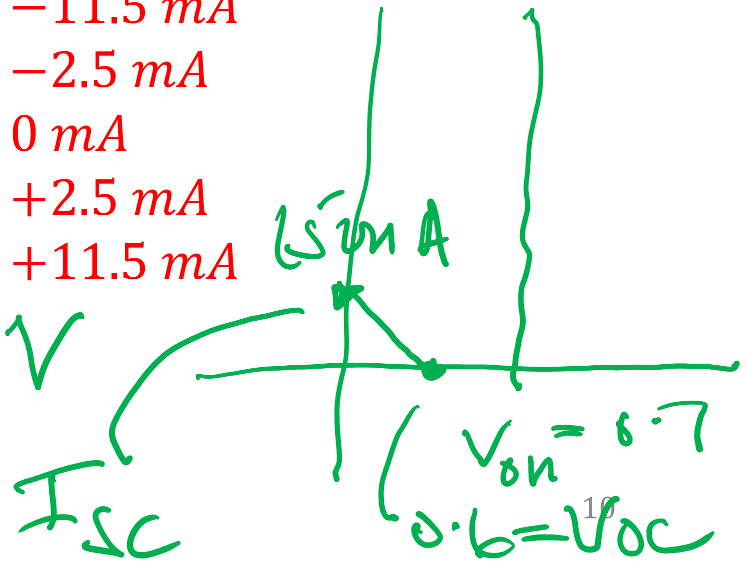




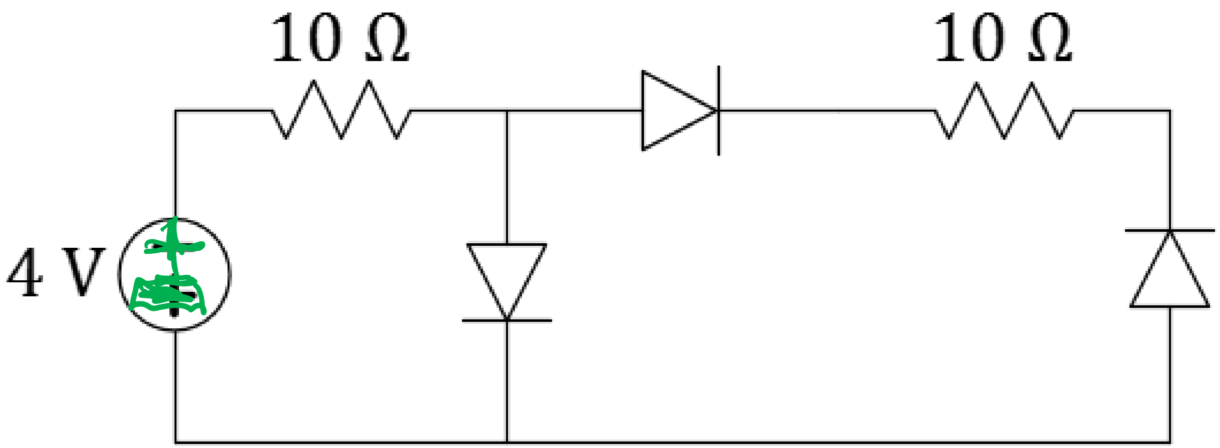
$R_T = \frac{10000}{250} = 40\Omega$

$V_{OC} = V_T = \frac{50}{250} \cdot 3 = 0.6V$

V



Back-to-back diodes in series are modeled by OIM as an open circuit



Q: Assume OIM with V_{ON} = 0.7 V (Si)
What is the current through the left-most diode?

A. 0 *Amps*
B. 0.2 *Amps*
C. 0.33 *Amps*
D. 0.4 *Amps*
E. 3.3 *Amps*

L16 Learning Objectives

a. Draw a “typical” diode IV curve and describe its shape

b. Explain how to use graphical analysis to find the operating point of a non-linear diode connected to a linear circuit

c. Describe the offset ideal diode model (open, V-source)

d. Solve simple circuit problems with one diode, given V_{ON}