Physics 261
Exam 2

70 points possible.

Remember to show your work.

Name: Solution

10:04 – 10:08

1. (*18 points*) For each schematic, complete the sketch of the diode. You may assume $V_T = 0.6\,\text{V}$. Label the following items:

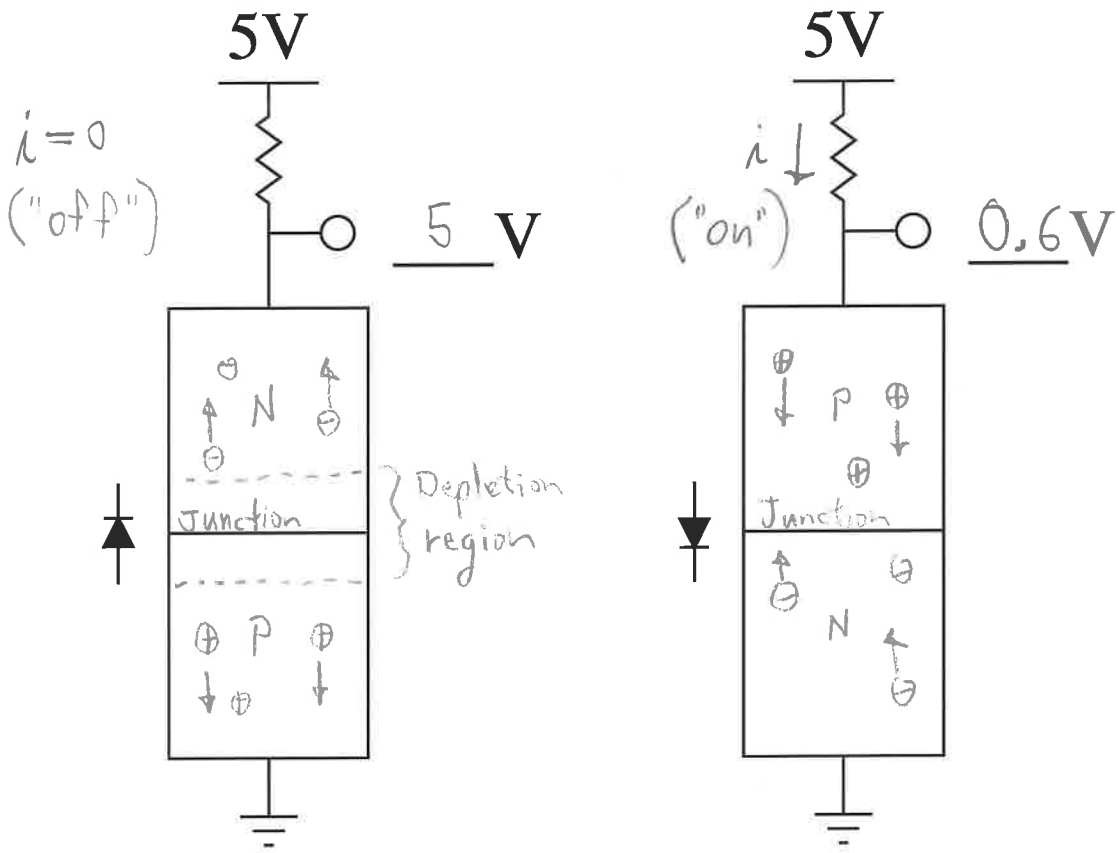
3+3 (a) Type **P** and **N** semiconductors, and the **junction** between them.

2+2 (b) A few **charge carriers** in each region, indicated by $\ominus$ or $\oplus$ as appropriate.

2+2 (c) Indicate with arrows the **direction that the charge carriers would move** (or the direction the supply voltage would attempt to move them, if the diode is "off").

1+1 (d) The **depletion region** (if applicable).

1+1 (e) Write the **potential** at the labeled terminal ($-\circ$).



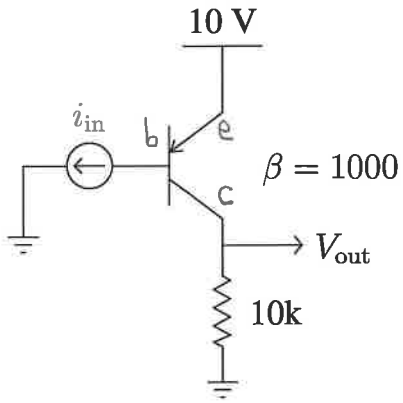
10:09 – 10:14

1 (c) $i_b = i_{in}$

2 $i_c = \beta i_b = 1000\, i_{in}$

2 $V_{out} = (10k\Omega)\, i_c$

1 $V_{out} = 10^7\,\Omega\, i_{in}$



2. (*18 points*) A bipolar junction transistor can be used as a crude substitute for a transimpedance amplifier (current to voltage converter).[1]

3 (a) Label the base, collector, and emitter (b, c, e).

1 (b) Is the transistor PNP or NPN?

6 (c) Find V_{out} as a function of i_{in}.

4 (d) What is the maximum possible value of the collector current?

4 (e) For what values of i_{in} is the transistor in saturation?

2 (d) $V_{out} = 10V$ in saturation

2 $10V/10k\Omega = 1mA$ Max current

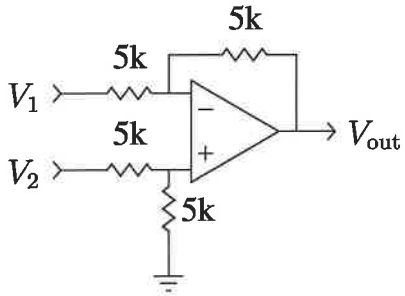
2 (e) $V_{out} = 10V = 10^7\,\Omega\, i_{in} \Rightarrow i_{in} = 10^{-6}\,A$

2 Saturate for $i_{in} > 1\,\mu A$

[1]The input current source could be a photodiode, for example.

10:16 - 10:19

3. (*14 points*) Assuming an ideal op amp, find the transfer function (V_{out} as a function of V_1 and V_2).



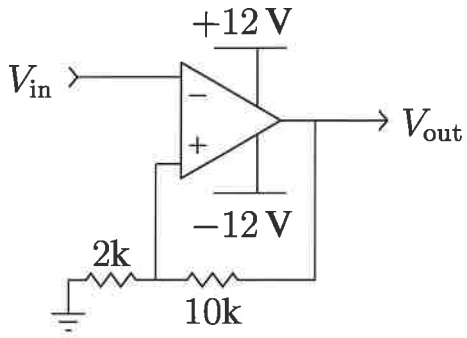
NVA: $\frac{V_1 - V_-}{5k} + \frac{V_{out} - V_-}{5k} = 0 \Rightarrow V_- = \frac{1}{2}(V_1 + V_{out})$

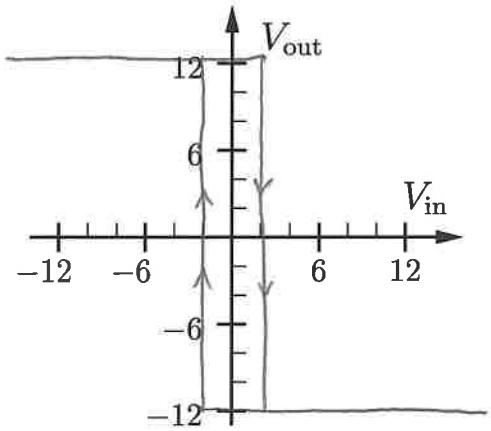
$\frac{V_2 - V_+}{5k} + \frac{0 - V_+}{5k} = 0 \Rightarrow V_+ = \frac{1}{2}V_2$

$V_+ = V_- \Rightarrow V_2 = V_1 + V_{out}$

$$\boxed{V_{out} = V_2 - V_1}$$

10:21 – 10:27





4. (*20 points*) Analyze this Schmitt trigger.

3 (a) Express V_+ in terms of V_{out}.

6 (b) Suppose $V_+ > V_-$. What is V_{out}? What range of V_{in} is possible?

6 (c) Suppose $V_+ < V_-$. What is V_{out}? What range of V_{in} is possible?

4 (d) Carefully sketch the hysteresis curve on the given axes.

(+1)

(a) $V_+ = \frac{2k\Omega}{2k\Omega + 10k\Omega} V_{out}$ ² $= \frac{V_{out}}{6}$ ¹ (Voltage divider)

(b) $V_+ > V_- \Rightarrow \boxed{V_{out} = +12V}$ ²

$\Rightarrow V_+ = 2V$ ² ($V_{in} = V_-$)

$\therefore \boxed{V_{in} < 2V}$ ²

(c) $V_+ < V_- \Rightarrow \boxed{V_{out} = -12V}$ ²

$\Rightarrow V_+ = -2V$ ² ($V_{in} = V_-$)

$\therefore \boxed{V_{in} > -2V}$ ²

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