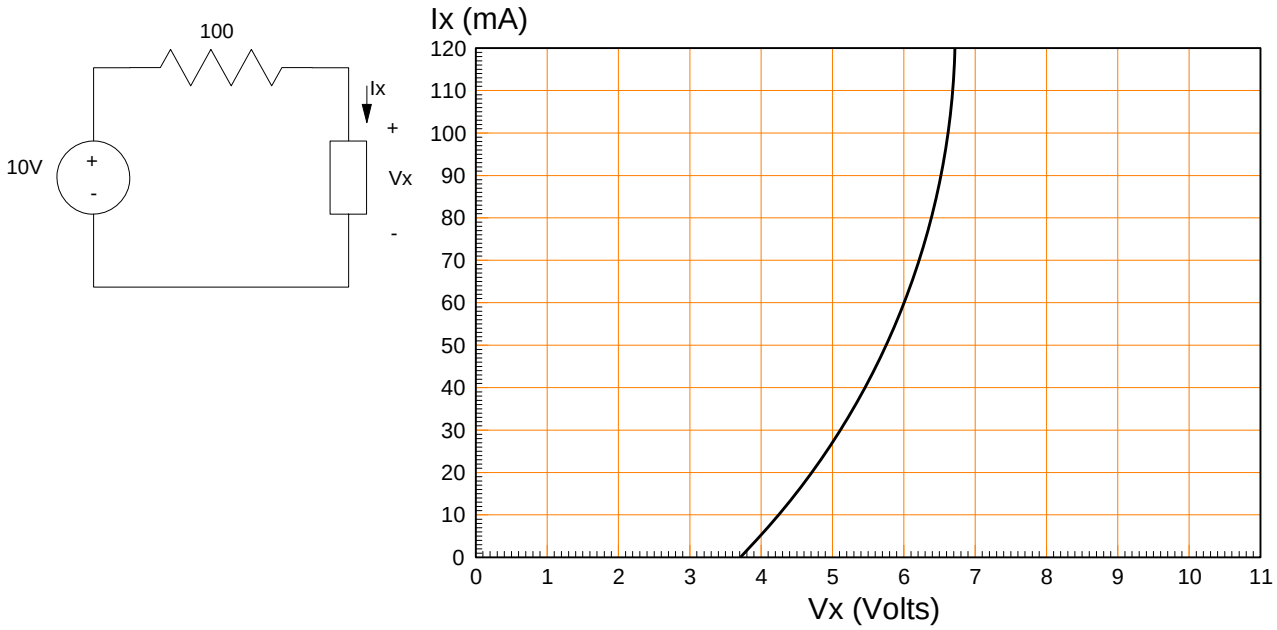
ECE 321 - Qualifier Exam Sample Problems

Semiconductor Physics:

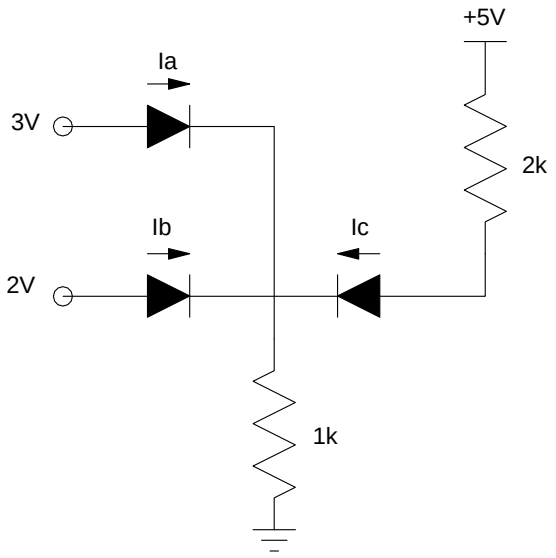
- What is meant by n-type and p-type Silicon?
- For metals, resistance goes up with temperature. For semiconductors, resistance goes down with temperature. Why?

Diodes & the pn junction

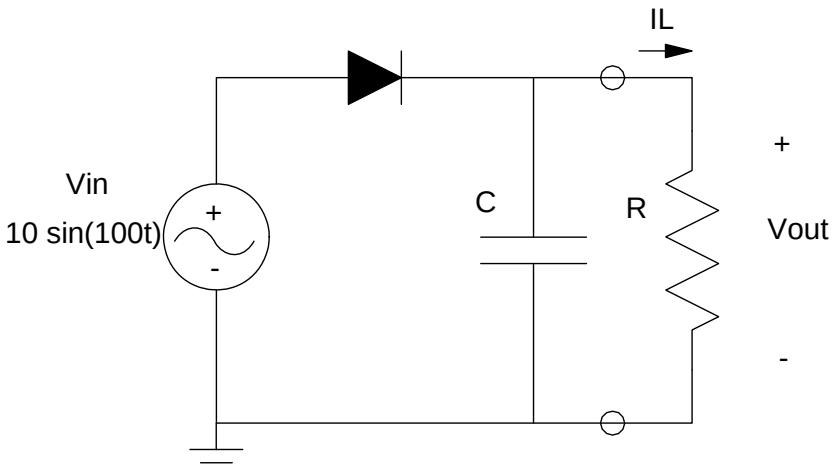
- Diodes act like a valve, allowing current to flow from p to n but not the other way. Why?
- Actually, a small amount of current can flow backwards, from n to p. Why?
- A nonlinear device has the following V/I characteristic. It is driven by a 10V source through a 100 Ohm resistor. Sketch the load-line for this circuit and determine Vx and Ix.
- At this operating point, determine a piecewise linear model for Rx



- Assume ideal silicon diodes (Vf = 0.7V). Determine the currents Ia, Ib, and Ic for the following circuit:



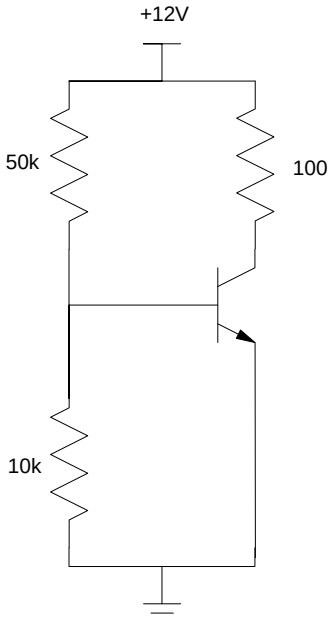
- For the following half-wave rectifier, sketch Vout for
  - R = 1k and C = 0
  - R = 1k and C = 1000uF

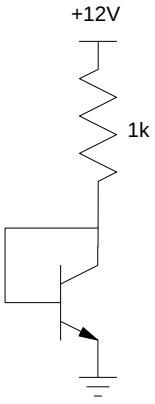


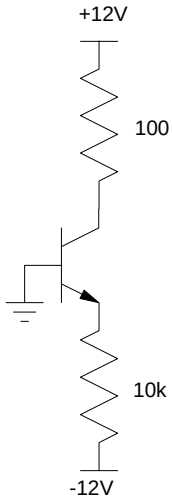
Transistors:

Assume ideal silicon transistors with a gain of 100 for all problems.

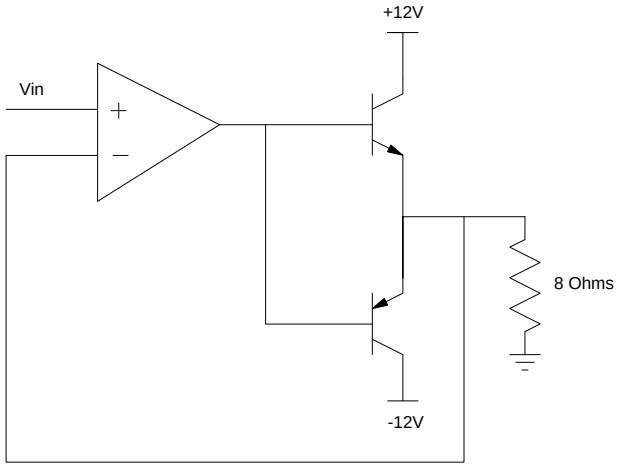
- Transistor Switch: Design a circuit with a transistor to meet the following design requirements:
  - Input: 0V or 6V DC signal, capable of driving up to 10mA
  - Output: An 8 Ohm speaker
  - When the input is 0V, no current flows through the speaker
  - When the input is 6V, 6V is applied to the speaker (+/- 0.5V)
- Determine the curents and voltages for the following circuits







- Push-Pull Amplifier: Determine the currents and voltages for
  - Vin = +5V
  - Vin = -5V



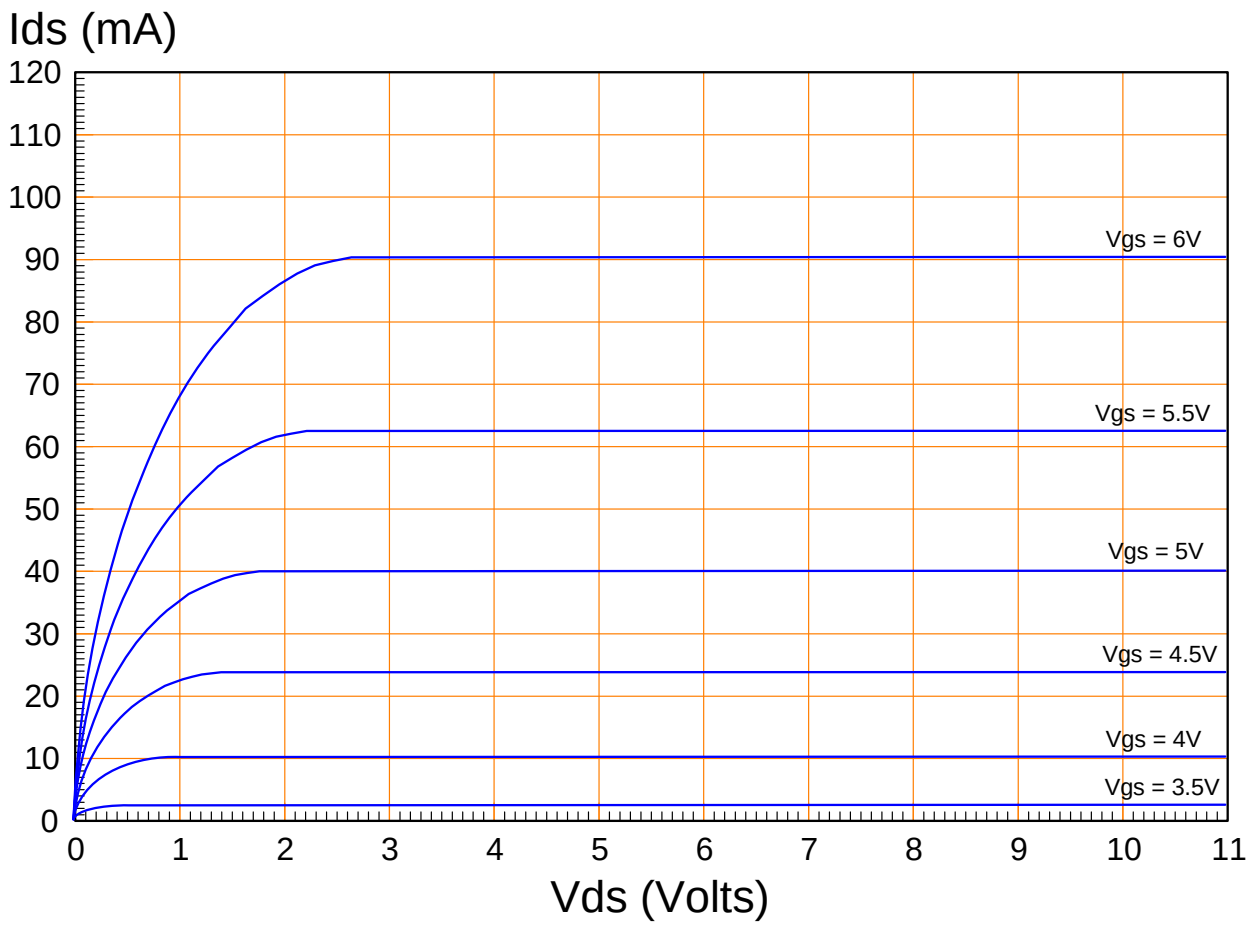
MOSFET

A MOSFET has the following V/I characteristics. The model for a MOSFET in the active and saturated regions are:

Ohmic: $I_{ds} = k_n\left(V_{gs} - V_{tn} - \frac{V_{ds}}{2}\right)V_{ds}$

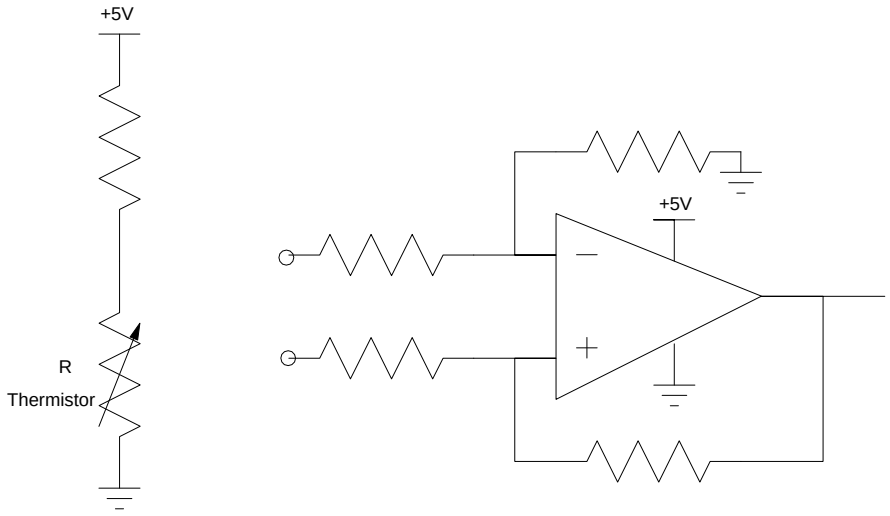
Saturated: $I_{ds} = k_n(V_{gs} - V_{tn})^2$

- Show on this graph the Ohmic, Saturated, and Off regions
- Determine kn for this MOSFET

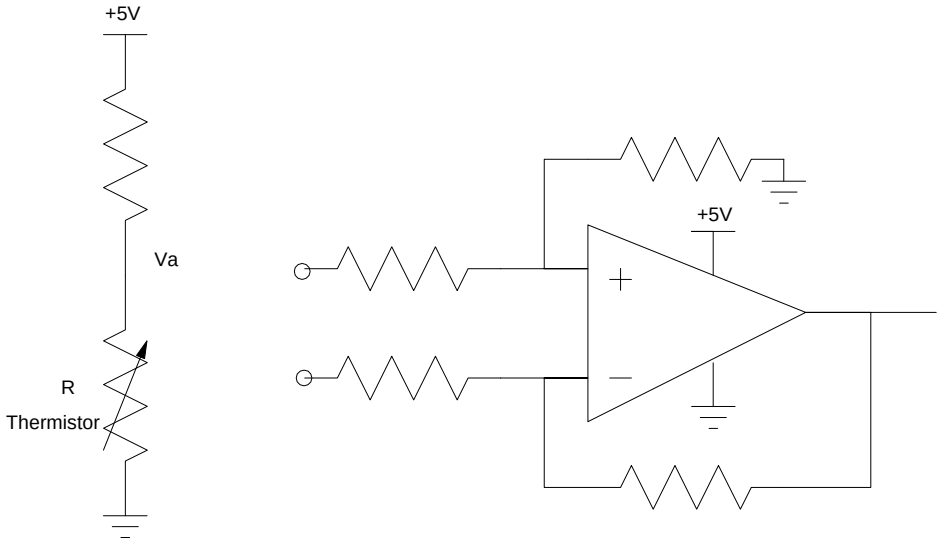


Operational Amplifiers

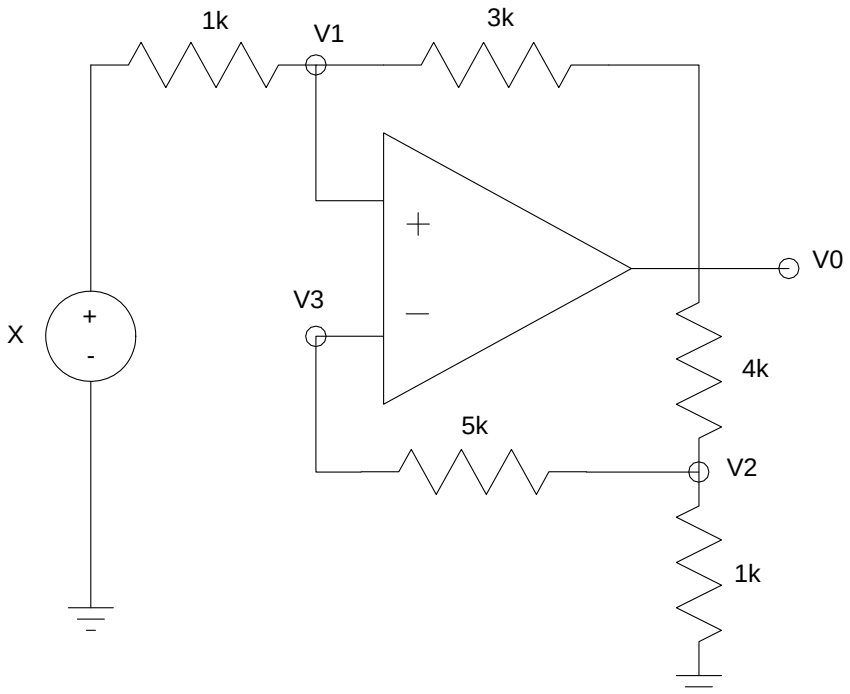
- Schmitt Trigger: Find the voltages and resistors so that the output
  - Switches to +5V for R > 1000 Ohms, and
  - Switches to 0V for R < 900 Ohms

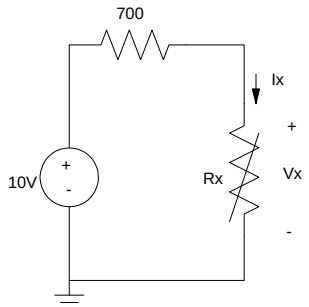


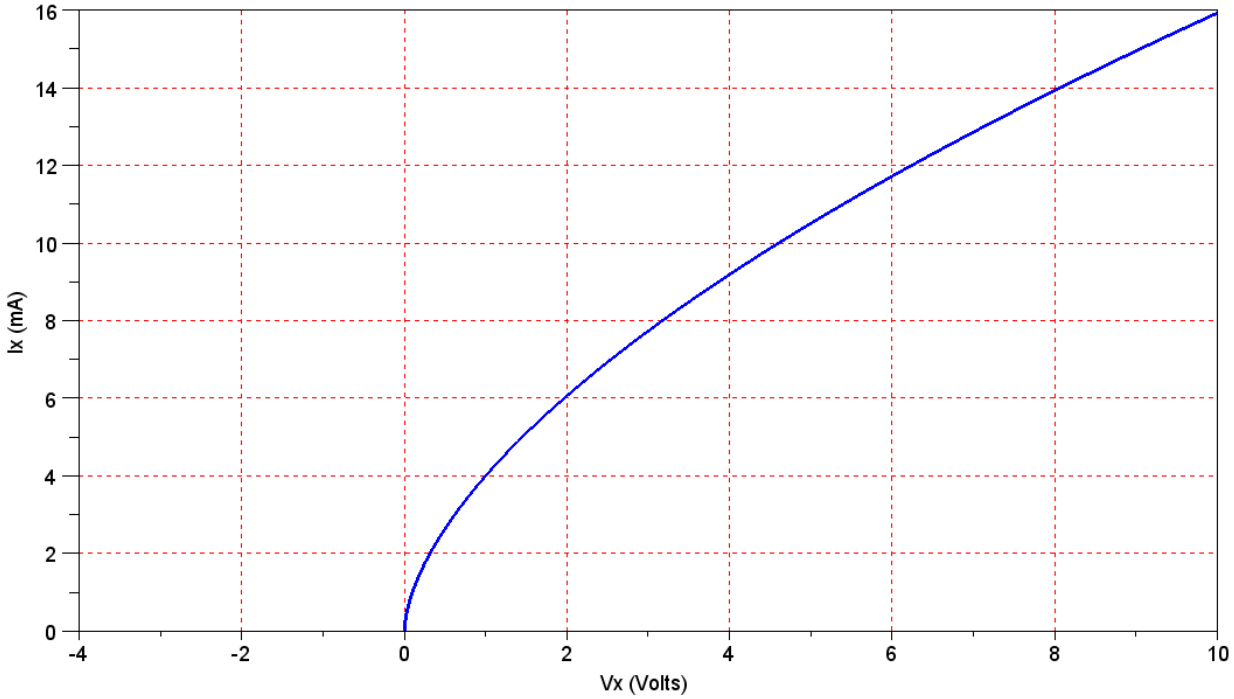
- Instrumentation Amplfier: Find the voltages and resistors so that the ouput is
  - 0V at R = 900 Ohms
  - 5V at R = 1000 Ohms, and
  - Proportaional to R for 900 < R < 1000 Ohms



- Give N equations to solve for the voltages at the N nodes.




700
Ix
+
Vx
-
10V
+
-
Rx


16
14
12
10
8
6
4
2
0
Ix (mA)
-4
-2
0
2
4
6
8
10
Vx (Volts)