

**Massachusetts Institute of Technology**  
**Department of Electrical Engineering and Computer Science**

**6.002 - Electronic Circuits**  
**Fall 2000**

**Homework #4**  
**Handout F00-024**

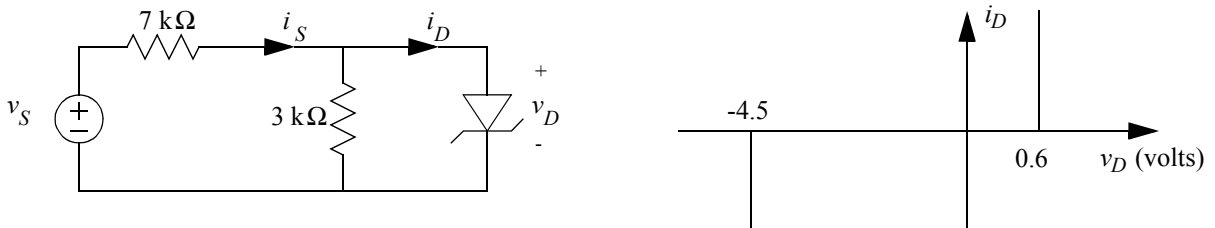
**Issued 9/28/2000 - Due 10/5/2000**

**Read Chapter 5 except Section 5.4.**

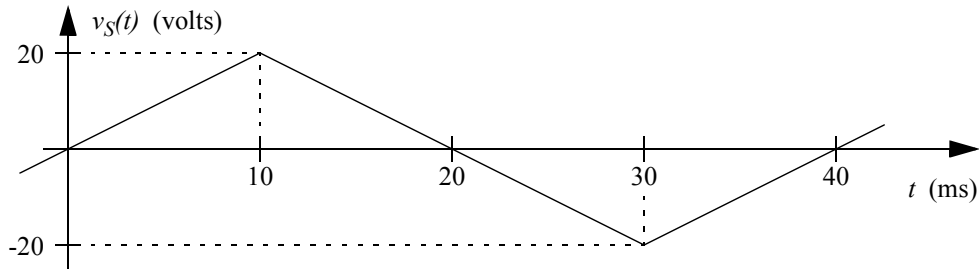
**Exercise 4-1:** Exercise 3, Chapter 5.

**Exercise 4-2:** Exercise 5, Chapter 7.

**Problem 4.1:** The zener diode in the circuit below has the  $v$ - $i$  characteristic shown at the right.



- a) For the input voltage  $v_S$  shown below, indicate the time regions where the diode is ON (conducting a current) and OFF (open circuit). Label the boundaries with numerical values.



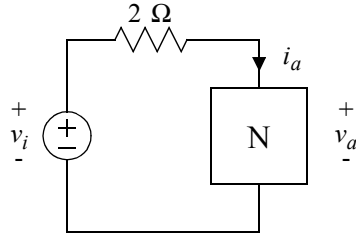
- b) For the input voltage  $v_S$  shown above, sketch the diode voltage waveform,  $v_D(t)$ . Label all breakpoint coordinates with values and units.
- c) Find the value of the current  $i_S$  for  $v_S = -25.5$  volts.

**Problem 4.2:** Problem 3, Chapter 5. Replace the words “piecewise-linear” with “incremental” in parts c) and d), and use as the operating point  $v = 3$ ,  $i = 0$ .

**(over)**

**Problem 4.3:** Consider the circuit containing a nonlinear element N as shown in Figure 4.3. The  $i$ - $v$  relation for

the element N is given by  $i_a = (10A) \cdot \left(1 - e^{\frac{-v_a}{5V}}\right)$ .



- Write an equation relating the voltage  $v_a$  to the input voltage  $v_i$ .
- Solve for the voltage  $v_a$  for  $v_i = 10$  volts. Note: This requires that you solve the equation in part a. iteratively for  $v_a$ . Hint: Use the exponential term to solve for  $v_a$  as a function of  $v_a$  and iterate.
- Find the incremental change in  $v_a$  for a 2% increase in  $v_i$  and calculate the ratio  $\frac{\Delta v_a}{\Delta v_i}$ .
- Find the value for the incremental resistance of the nonlinear element N by linearizing the expression for  $i_a$  about the operating point when  $v_i = 10$  volts.
- Draw the incremental circuit for the circuit in Figure 4.3.
- Find the ratio  $\frac{\Delta v_a}{\Delta v_i}$  from the incremental circuit and compare with your exact value from part c.