

NAME:

ID #:

# 1	# 2	# 3	# 4	# 5	# 6	TOTAL
8	8	14	15	15	30	90

**Instructions:**

- 1 Write your name and student ID number.
- 2 Read the questions carefully.
- 3 Write your solution clearly.
- 4 This exam has 6 questions worth 90 points, so you should proceed at approximately 1 point per minute.

**Problem # 1** (4 \* 2 = 8 points)

Circle the most appropriate answers. **Incorrect answers receive -2 points.** No explanations are necessary.

The internal resistance of a current source is in  with the source. For a well-designed circuit with a current source, this internal resistance should be much  than the load resistance.

A circuit element that requires an external power supply is called .

We  find the Thevenin equivalent of a circuit containing diodes.

**Problem # 2** (4 + 4 = 8 points)

- (a) You have two resistors  $R_1$  and  $R_2$ . Using these in various combinations you can make resistances of 4, 6, 12, and 18 $\Omega$ . Find  $R_1, R_2$ .

- (b) Draw the  $i - v$  characteristic of a Zener diode. What is a Zener diode useful for?

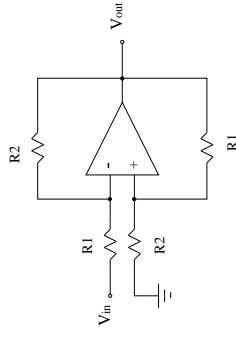
**Problem # 3** (5 + 5 + 2 + 2 = 14 points)

A 10 volt battery with internal resistance  $R_1$  is connected to a resistive load  $R_L$ . The voltage across the load is measured with a voltmeter whose internal resistance is  $R_2$ .

- Draw a circuit diagram for this problem.
- Find an expression for the voltage recorded by the voltmeter in terms of  $R_1$ ,  $R_2$ ,  $R_L$ .
- Ideally, what are the values of  $R_1$  and  $R_2$ ?
- In the ideal case, what would the voltmeter read?


**Problem # 4** (5 + 5 + 5 = 15 points)

Consider the op-amp circuit shown below. Use the ideal op-amp method to find the output voltage  $V_{out}$  in terms of the input voltage  $V_{in}$  and the resistances  $R_1$ ,  $R_2$ .



**Problem # 5** (5+5+5 = 15 points)

Consider the op-amp circuit shown below. Both diodes have current-voltage characteristic

$$i = c \cdot \exp(dv)$$


where  $c$  and  $d$  are some constants. The sign convention for this  $i = v$  characteristic is shown above. Find an expression for the output voltage  $V_{out}$ . You may use the ideal op-amp method.

**Hint:** Consider the two diodes together as a single nonlinear circuit element. Your final algebra will simplify if you recognize that

$$\sinh(x) = \frac{\exp(x) - \exp(-x)}{2}$$

