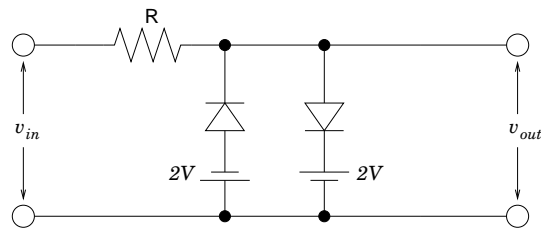# Physics 536 - Second Exam
## March 28, 2007

1. Consider the circuit shown below:

Assume that the voltage drop across the diodes is 0.7 volts when they are forward biased.
(a) What is v_{out} when $v_{in} = 1$ V?
(b) What is v_{out} when $v_{in} = -1$ V?
(c) What is v_{out} when $v_{in} = 5$ V?
(d) What is v_{out} when $v_{in} = -5$ V?

2. Draw the following operational amplifier circuits and give an expression for the gain in terms of any resistors that may be present in each circuit:
(**a**) An voltage follower,
(**b**) An inverting amplifier,
(**c**) An non-inverting amplifier.

3. Consider the FET amplifier circuit:
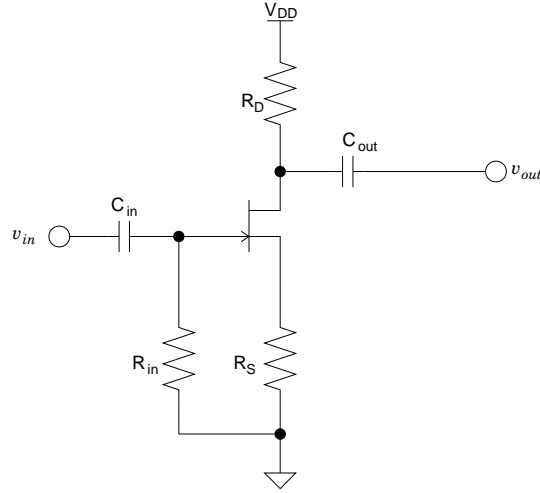
Assume that the drain current is described by the formula

$$I_D = I_{DSS} \left(1 + \frac{V_{GS}}{|V_P|} \right)^2 \tag{1}$$

in which $I_{DSS} = 10$ mA and $V_P = -2$ V.

(a) Calculate the value of V_{GS} that will produce a quiescent current of $I_D = 2.5$ mA.

(b) What is the transconductance at this operating point? Recall that

$$g_m = \frac{\partial I_D}{\partial V_{GS}}. \tag{2}$$

(c) Assuming that R_{in} is very large but maintains the gate at a potential of 0 volts, what value of R_S will yield the value of V_{GS} determined in part (a)?

(d) The voltage gain of the amplifier is given by

$$G = \frac{-R_D}{1/g_m + R_S}. \tag{3}$$

What value of R_D will give a small signal voltage gain of -6?

(e) What is the output impedance of this amplifier circuit?

4. For an NPN transistor that is correctly biased, the emittor will be at a potential that is V_{be} lower than the base: $V_e = V_b - V_{be}$.

(a) If the base of a PNP transistor is at a potential V_b, what is the potential of its emittor?

(b) Consider the following circuit:
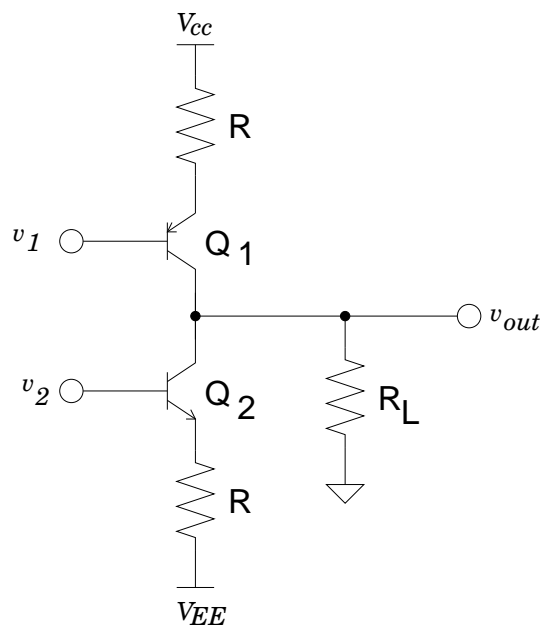
Assuming that V_{be} is the same for both transistors, calculate the current, I_1, that flows through Q_1 in terms of v_1 and the current, I_2, that flows through Q_2 in terms of v_2. Assume that the voltages v_1 and v_2 allow both transistors to operate in the active region.

(c) By considering the current conservation rule, what current will flow through the resistor, R_L?