MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.002 – Electronic Circuits
Fall 2002

Problem Set 5

Issued: October 2, 2002 **Due: October 9, 2002**

Reading Assignment:

- A&L Section 7.7 and Chapter 8 for Thursday, October 3.
- A&L Chapter 8 for Tuesday, October 8.

Problem 5.1: Figures 3 and 4, at the end of this problem set, show three amplifier configurations with the MOSFET characteristics.

(A) Determine K and V_T for the MOSFETs used in these circuits.

(B) In each case, sketch the load line directly on the characteristics clearly indicating the slope and intercepts.

(C) For each amplifier, determine $v_O(v_I)$ assuming the MOSFET operates in its saturation region.

(D) For the amplifiers in (b) and (c), find the small-signal gain in the limit $v_I - V_T >> 1/2KR_2$.

(E) For each of the amplifiers, determine the range of v_I and v_O for which the MOSFET operates in saturation, i.e., $V_T < v_{GS} < v_{DS} + V_T$.

Problem 5.2: The MOSFETs M1 and M2 in the circuit of Figure 1 are characterized by $K = 2mA/V^2$ and $V_T = 2V$, while MOSFET M3 has $K = 1mA/V^2$ and $V_T = 2V$.

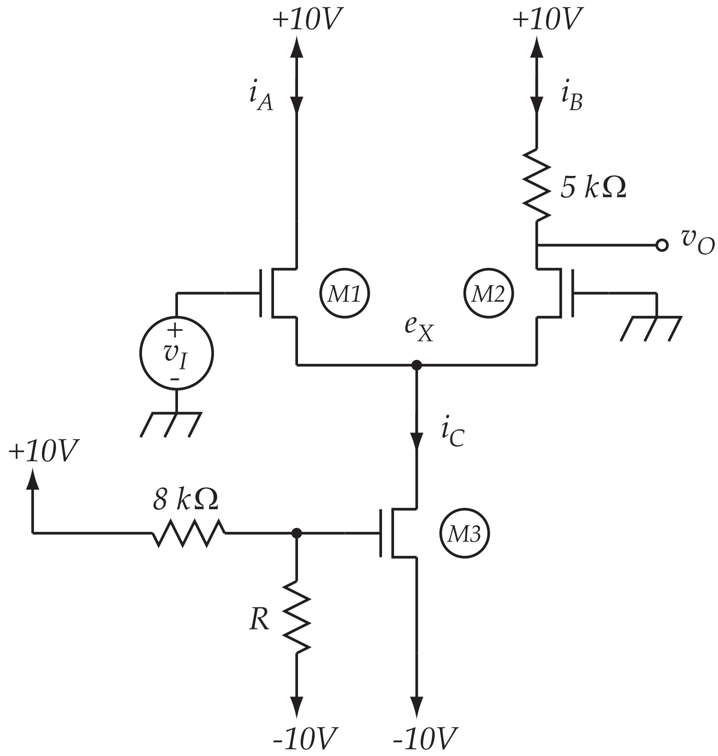

Figure 1: Circuit for Problem 5.2

(A) For the circuit shown in Figure 1, determine R so that $I_C = 2mA$ with $v_I = 0$.

(B) For the bias condition determined in part (A), what are the currents I_A and I_B, and the node voltage E_X?

(C) Now let $v_I = v_i$, a small-signal input voltage. Determine e_x, the small-signal component of the node voltage e_X, and from that determine the small-signal gain v_o/v_i.

(D) Assume now that the above amplifier operates in the large-signal, nonlinear regime. At what value of v_I will the output MOSFET M2 cutoff, i.e., its current decrease to 0?

Problem 5.3: The two MOSFETs in the circuit shown in Figure 2(a) are identical and characterized by the i_{DS}-v_{DS} relationship shown in Figure 2(b). Note that in the triode region the characteristics are approximated by a single i_{DS}-v_{DS} relationship that is independent of v_{GS} and that M1 and M2 are characterized by the same values of K and V_T as for the MOSFETs in Problem 5.1.

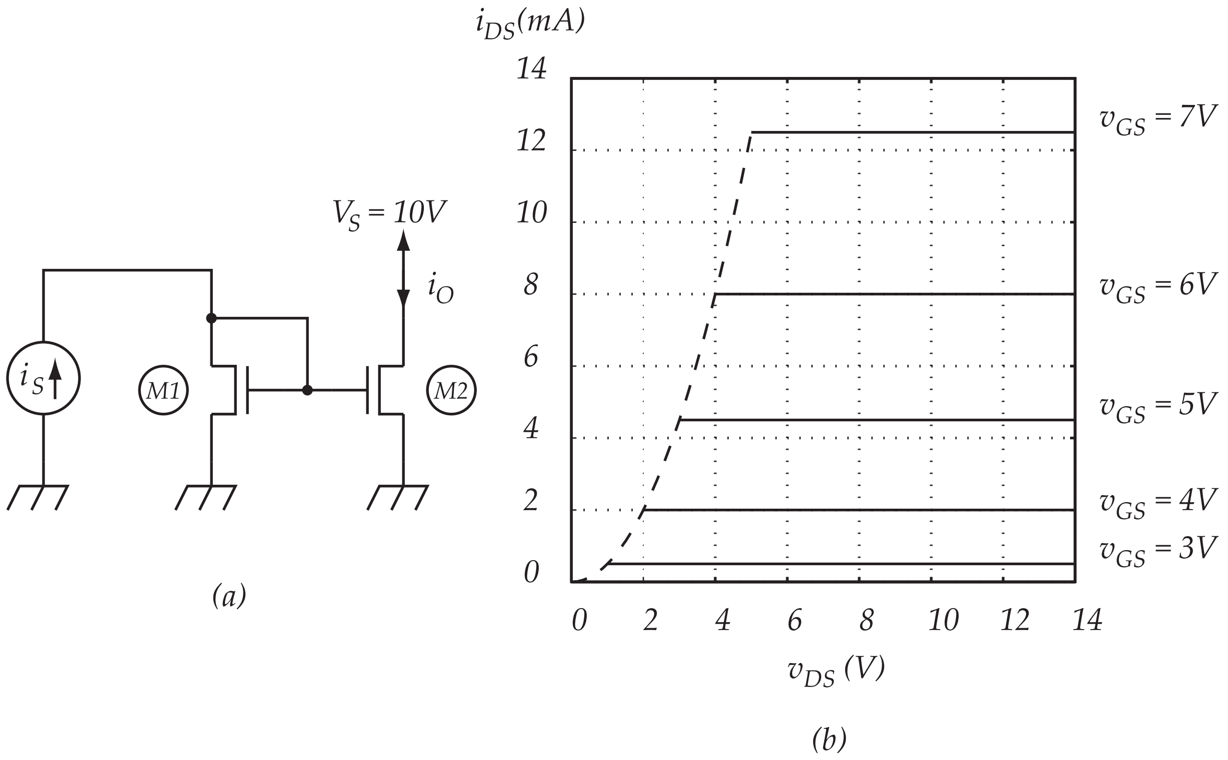

Figure 2: Circuit for Problem 5.3

(A) Determine and graph i_O vs. i_S for $i_S > 0$. Explain why this circuit is called a "current mirror".

(B) Repeat part (A) with a $1k\Omega$ load resistor between the drain of M2 and the V_S rail.

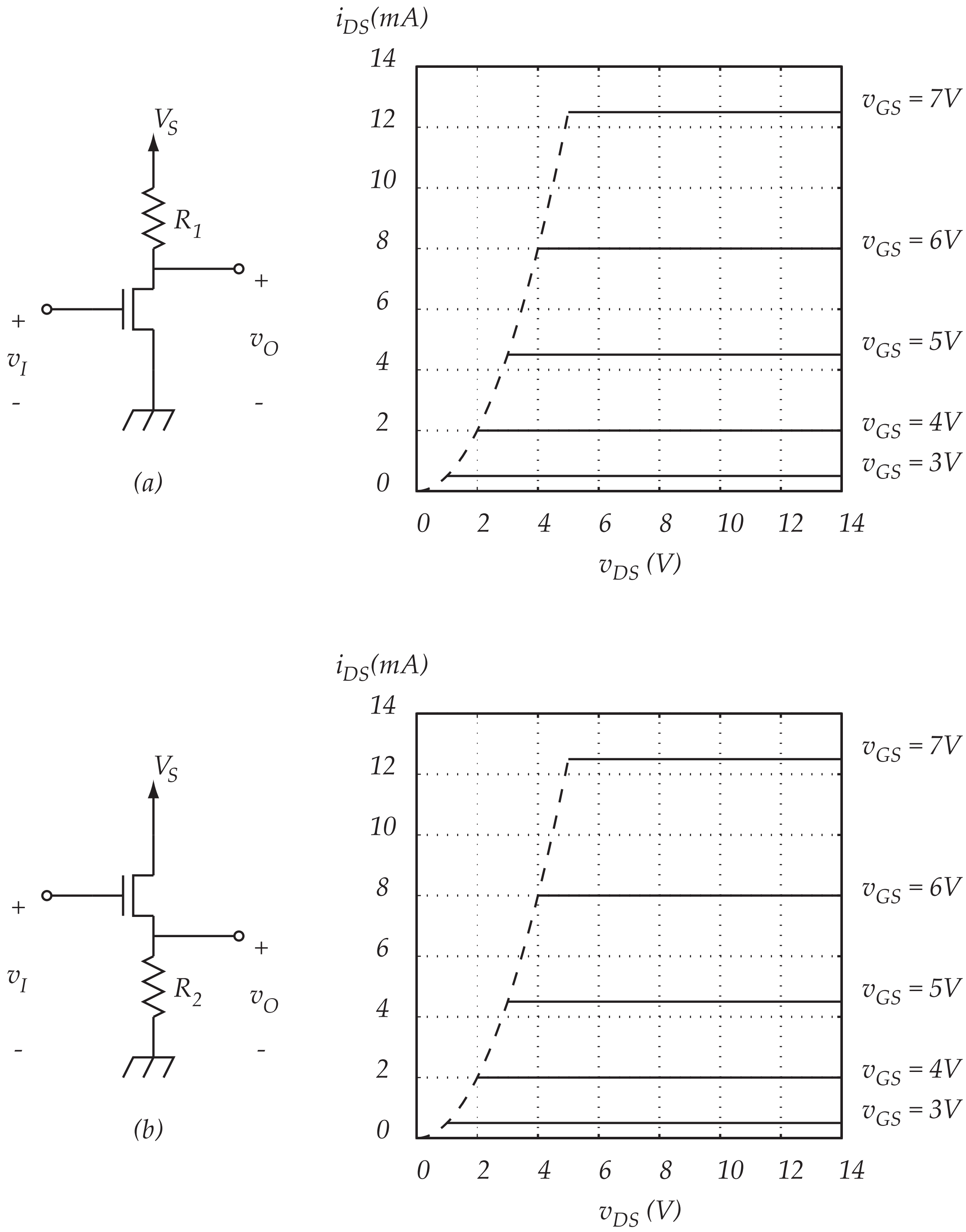

Figure 3: Circuits (a) and (b) for Problem 5.1

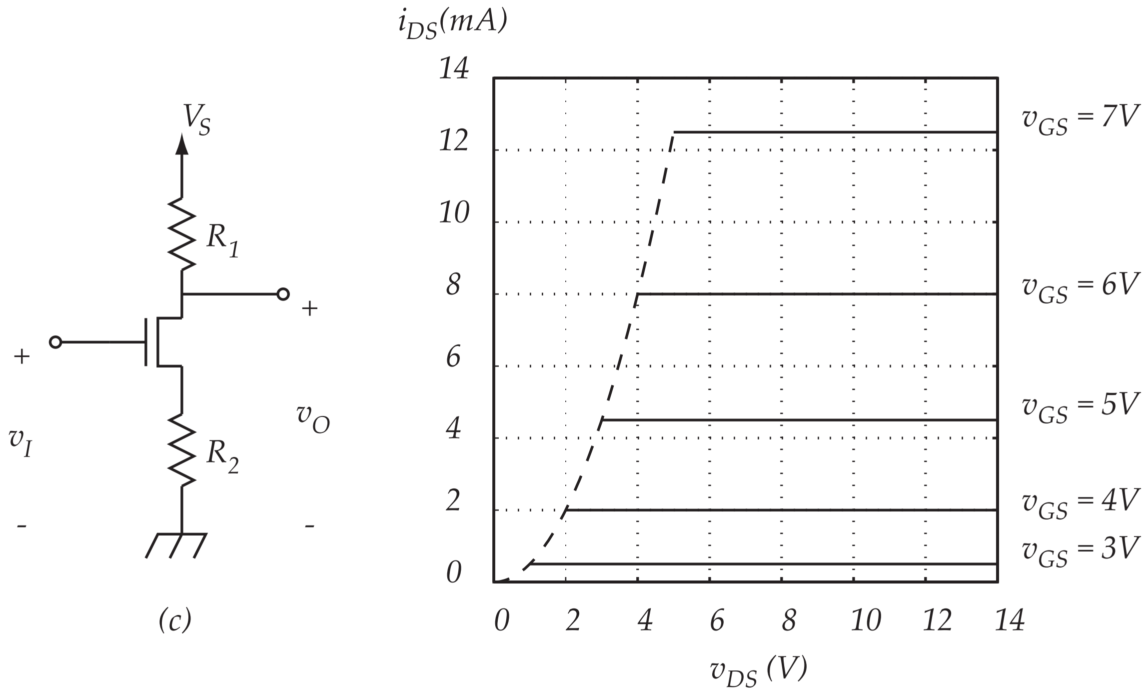

Figure 4: Circuit (c) for Problem 5.1