EE140 **Midterm** **Oct. 25, 2001**

- You may use one sheet (8.5" x 11") of your own notes. No other materials can be used.
- There are two problems.

Name _____ SID# _____

1	
2	
total	

1. (60 pts)

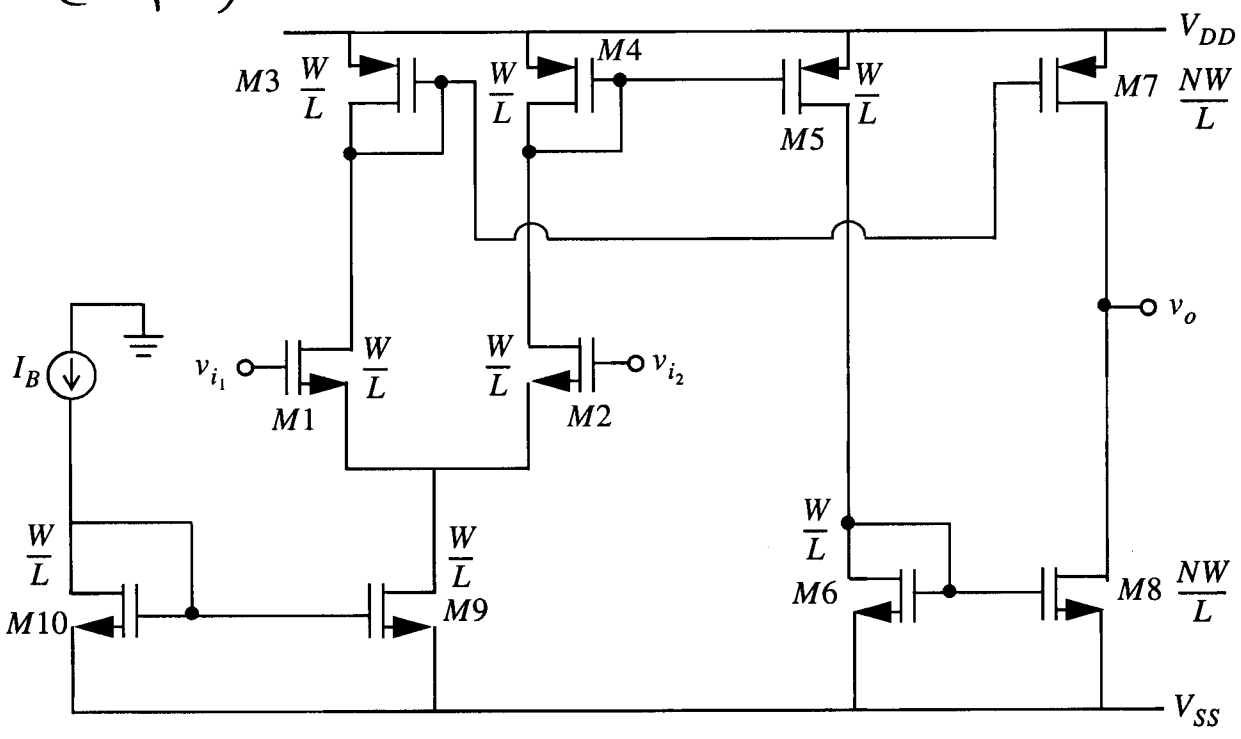

Fig. 1: Current Mirror Op-Amp

(10)

a) Suppose inputs v_{i_1} and v_{i_2} are grounded, i.e. $v_{i_1} = v_{i_2} = 0$.
Determine the dc bias values for the following variables: (see next page)
(You may neglect the r_o of all transistors for this.)
Leave your results in symbolic form involving I_B, k'_p, k'_n, etc.

I_{D_1}	
I_{D_2}	
I_{D_6}	
I_{D_8}	
ΔV_1	
ΔV_2	
ΔV_3	
ΔV_4	
ΔV_5	
ΔV_6	
ΔV_7	
ΔV_8	
ΔV_9	

(10) **b)** Determine the common mode input range for the circuit, that is consistent with all transistors remaining active.

(10) **c)** Determine the output voltage range, that is consistent with all transistors remaining active.

(10) **d)** Determine R_{out}.

(10) **e)** Determine the differential mode circuit G_m, i.e.

$$G_{m_{dm}} = \left.\frac{i_{out}}{v_{i_d}}\right|_{v_{out}=0} \quad ; v_{i_d} = v_{i_1} - v_{i_2}$$

(10) **f)** Determine the common mode voltage gain:

$$A_{v-cm} = \frac{v_o}{v_{i_{cm}}}$$

2) (40 pts)

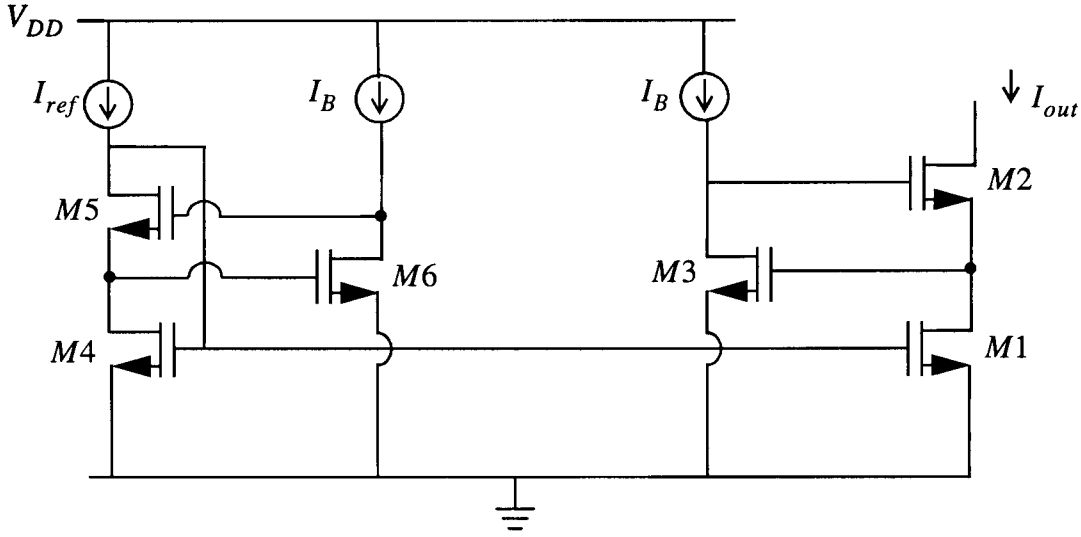

Fig. 2: Current Mirror

In the current mirror of Fig. 2, all devices M1-M6 have identical $\frac{W}{L}$'s.

(10) **a)** Assuming all devices are biased in the active region, determine the nominal bias values for the following.

Leave your answers as expressions involving V_T's, k', I_B, I_{ref}, $\frac{W}{L}$ etc.:

I_{out}	
V_{GS1}	
V_{GS2}	
V_{GS3}	
V_{GS4}	
V_{GS5}	
V_{GS6}	

(10) **b)** Determine the minimum output voltage that keeps all devices in the active region.

(10) **c)** Determine R_{out} for this circuit assuming all devices are active. Express your answer as a formula involving transistor small signal parameters like $g_{m_{1-6}}$, $r_{o_{1-6}}$, etc.

(10) **d)** Briefly explain the purpose of $M5$ and $M6$ in this circuit.