

EE3002/EE5310: Analog Circuits
Tutorial 6

For the transistors, assume that

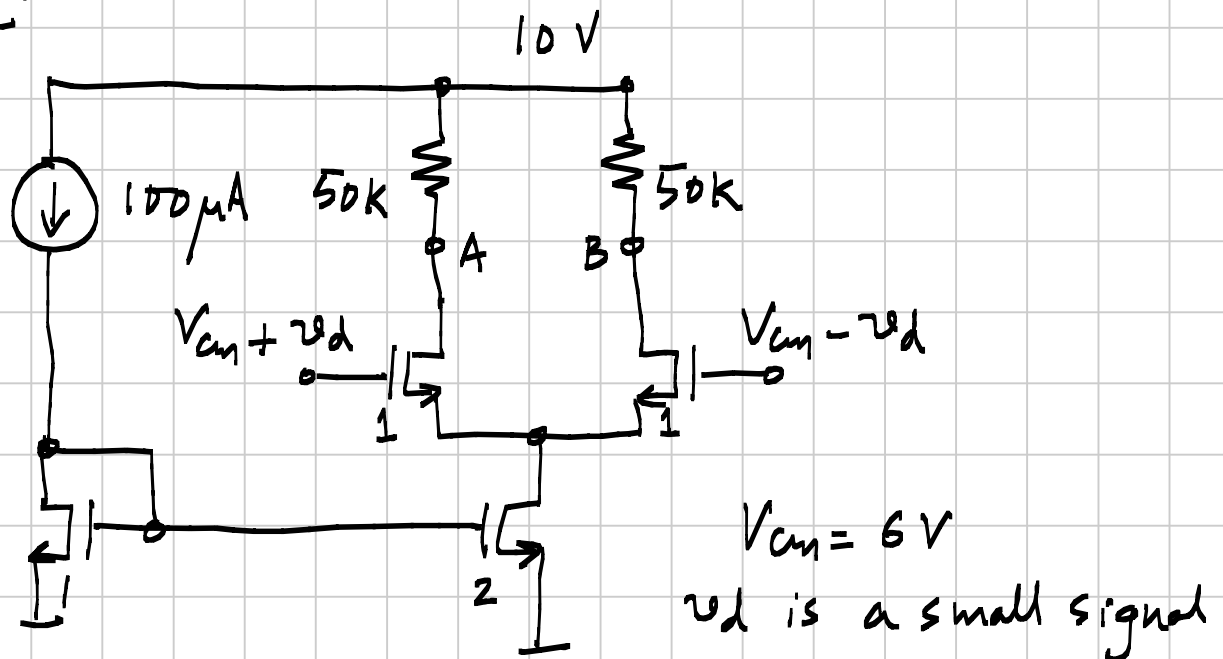
$$\mu_n C_{ox} = 200 \mu\text{A}/\text{V}^2 \quad V_{Tn} = 1\text{V}$$

$$\mu_p C_{ox} = 50 \mu\text{A}/\text{V}^2 \quad V_{Tp} = 1\text{V}$$

The W/L is marked beside each device.

$\lambda_n = \lambda_p = 0$, unless otherwise mentioned.

Problem 1:



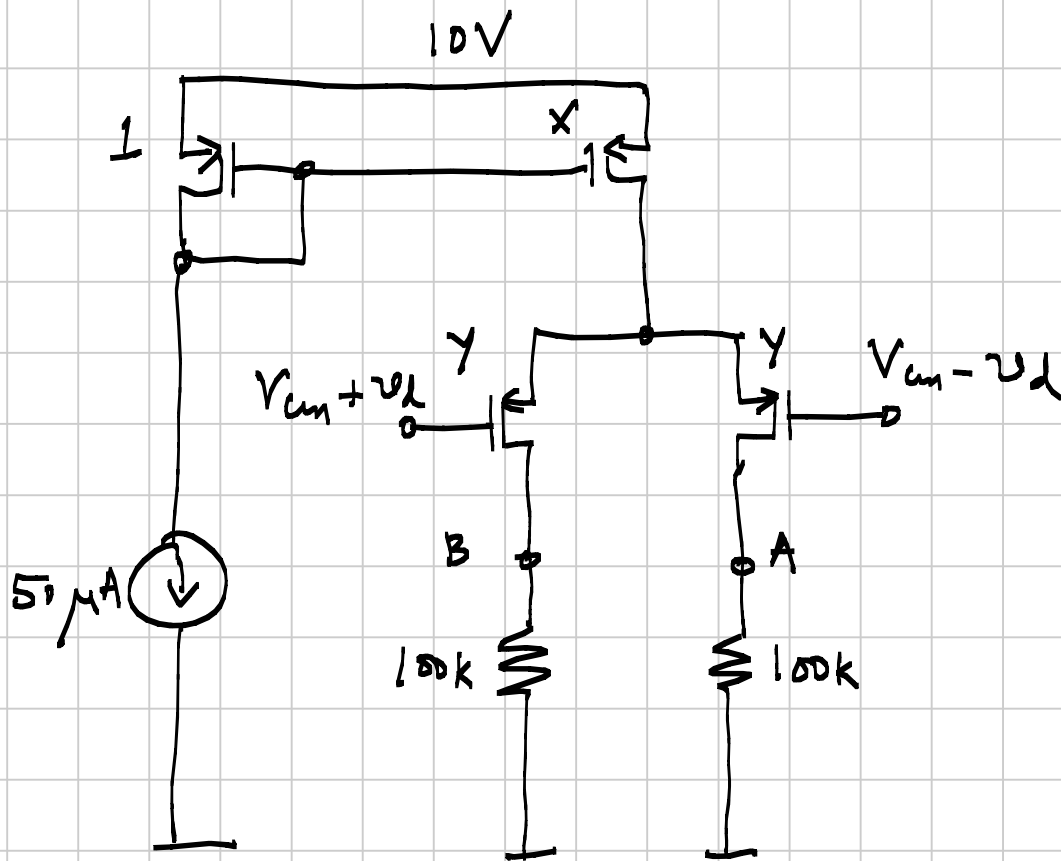
(i) Determine the quiescent voltages at A & B.

(ii) Determine the incremental voltages at A & B.

(iii) Over what range can V_{cm} vary, while still keeping all devices in saturation?

(iv) With $V_{cm} = 6V$, it is desired to increase the incremental gain by increasing the value of the load resistors. What is the maximum value of the gain thus obtainable?

Problem 2:

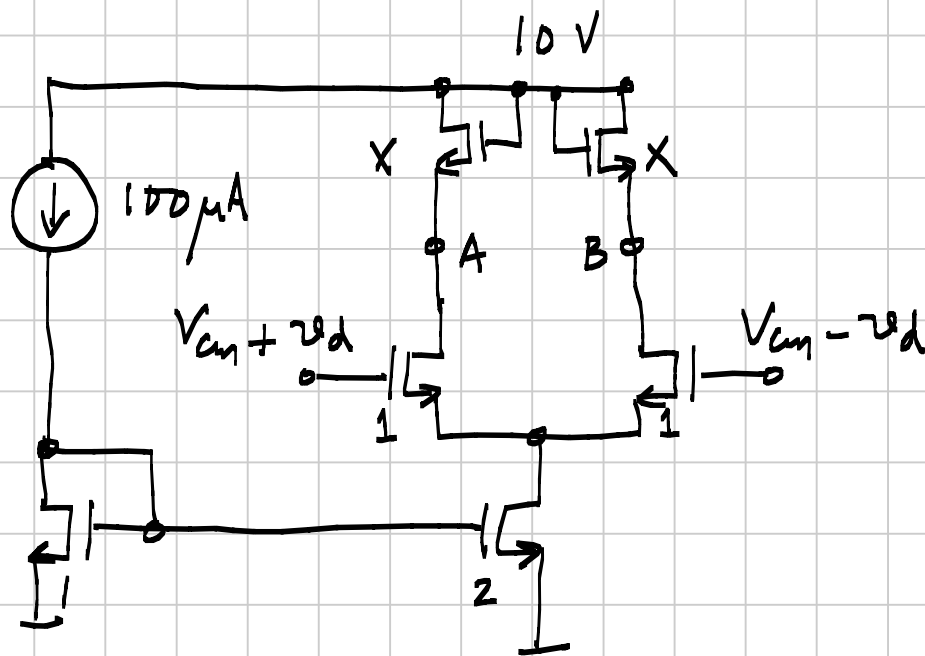


Determine the aspect ratios x & y so that

- The quiescent potentials at A & B are the same as in problem 1
- The incremental gain is the same as in problem 1 (assuming all devices are in saturation)

(c) What is the common mode range?

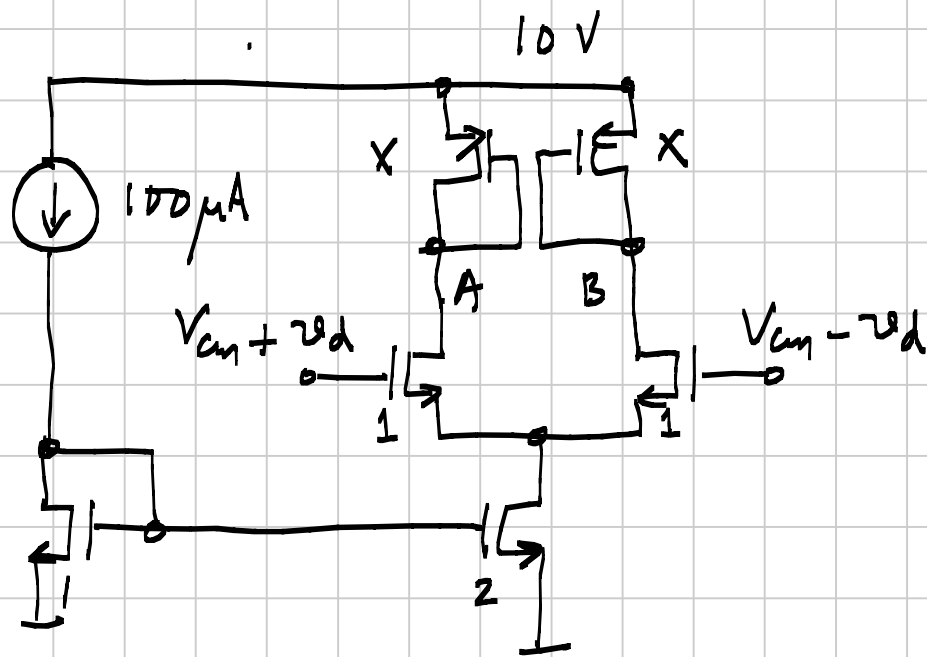
Problem 3:



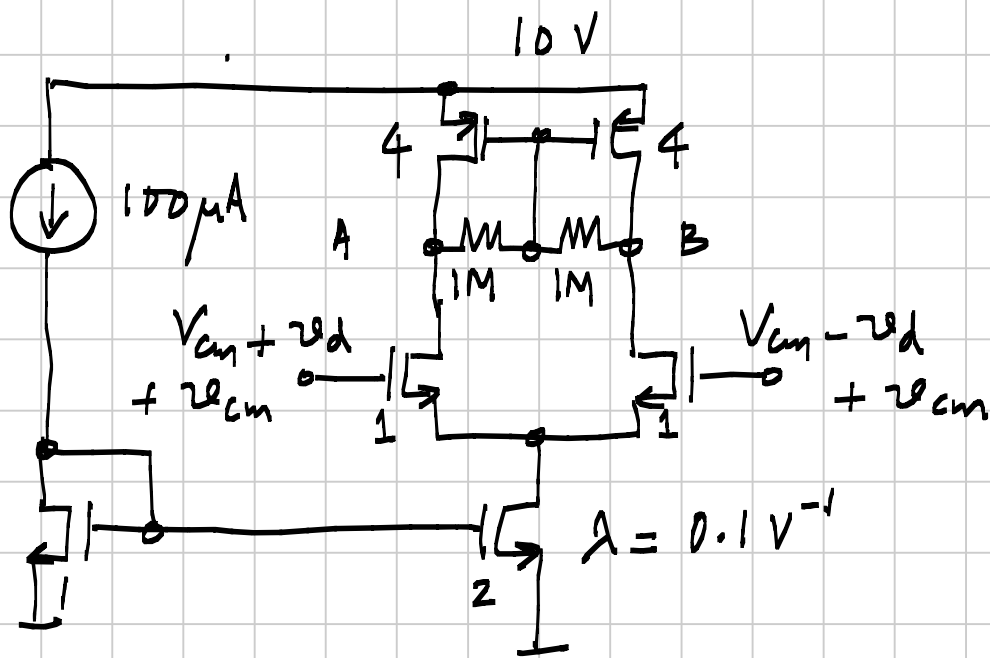
Determine the aspect ratio X , so that the incremental voltage between B & A is $4r_{od}$. What is the quiescent voltage at A ?

Problem 4:

Repeat problem 3 if the load devices were PMOS transistors as shown below.



Problem 5:



$V_{cm} = 5V$

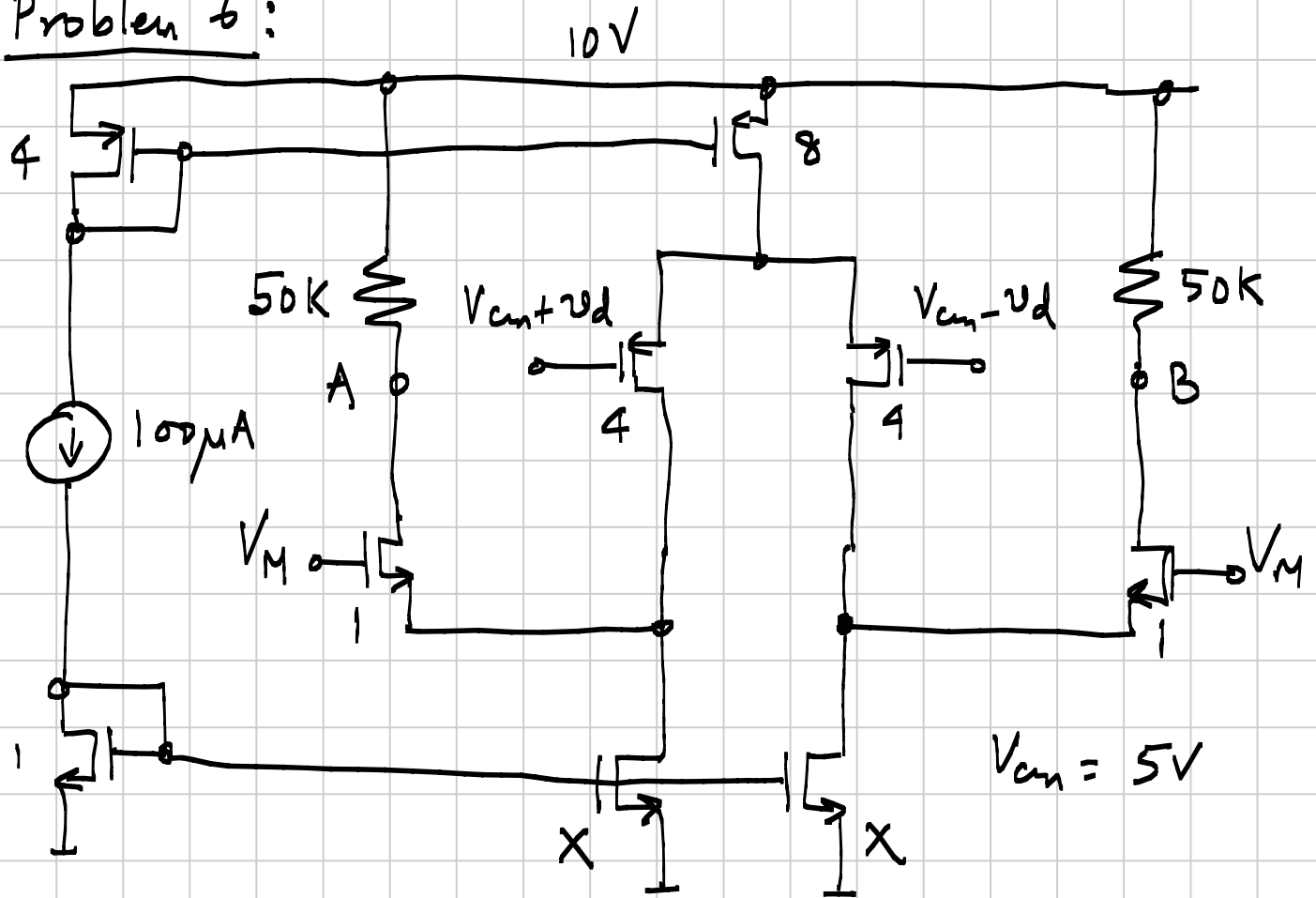
v_{cm} & v_d are small signals. Only for the tail current source, use $\lambda = 0.1 V^{-1}$. Neglect λ to find the quiescent operating point.

- (a) Determine the quiescent potentials at A & B.
- (b) Determine the incremental voltages at A & B.

(r) What is the common-mode rejection ratio?

(a) What is the common-mode range?

Problem 6:



(a) Assuming all devices are in saturation, determine X so that the quiescent voltage at A & B is $5V$.

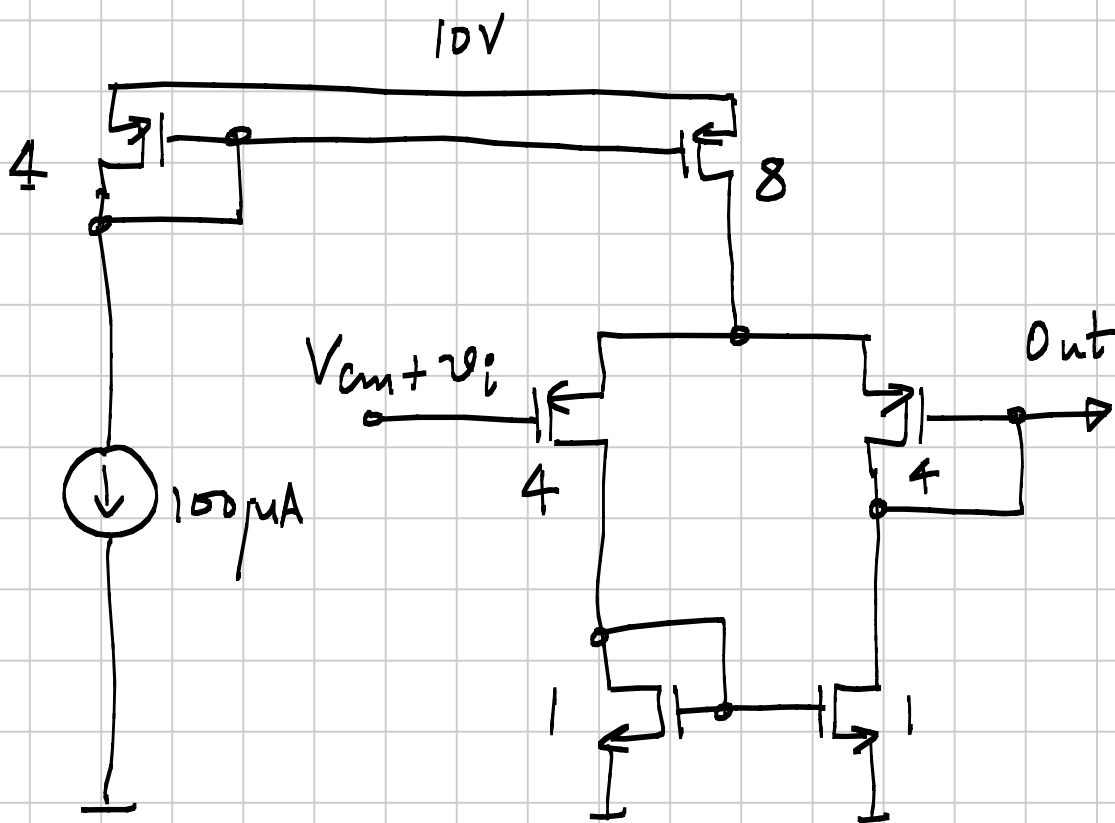
(b) For the value of X you just determined, find the range of V_M over which all devices remain in saturation.

(c) For $V_M = 3V$, determine the range over

which V_{cm} can vary while keeping all devices in saturation.

(d) What is the incremental gain $v_{BA}/2v_d$?

Problem 7:

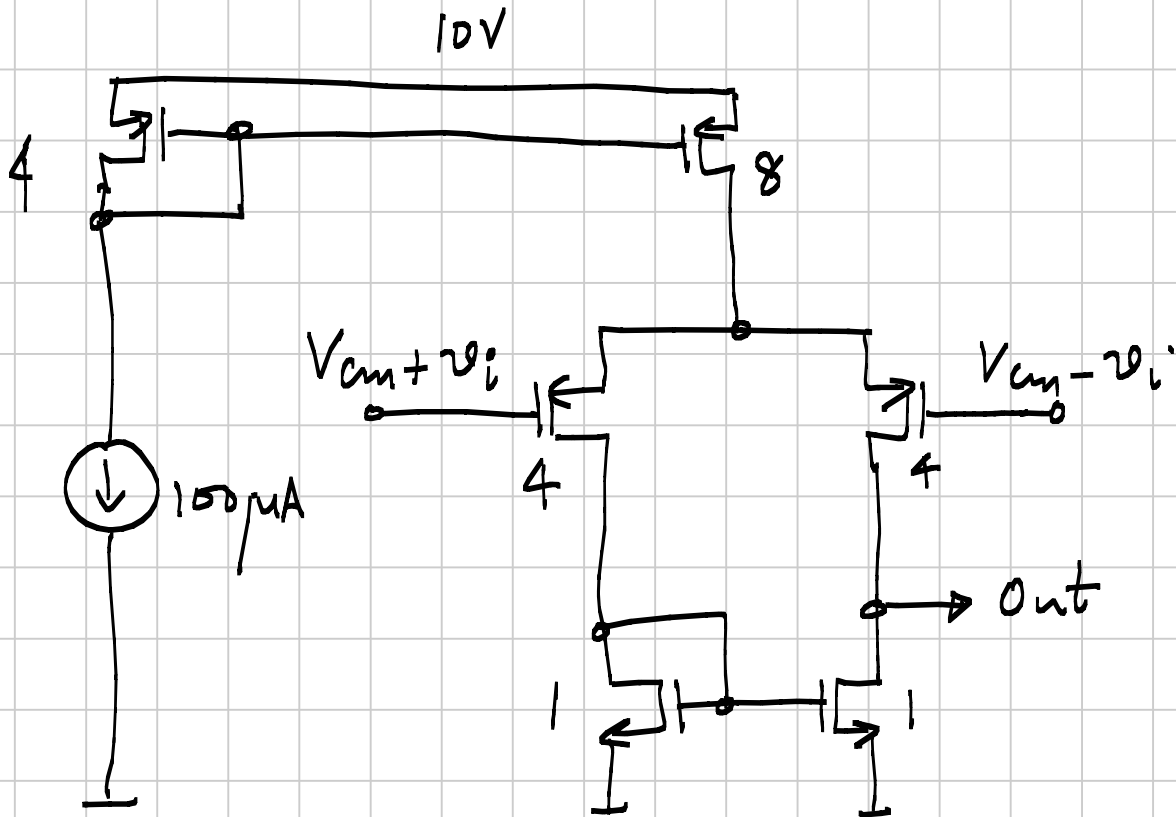


$$V_{cm} = 5V$$

(i) Determine the incremental gain from input to output.

(ii) Over what range of V_{cm} is this gain maintained?

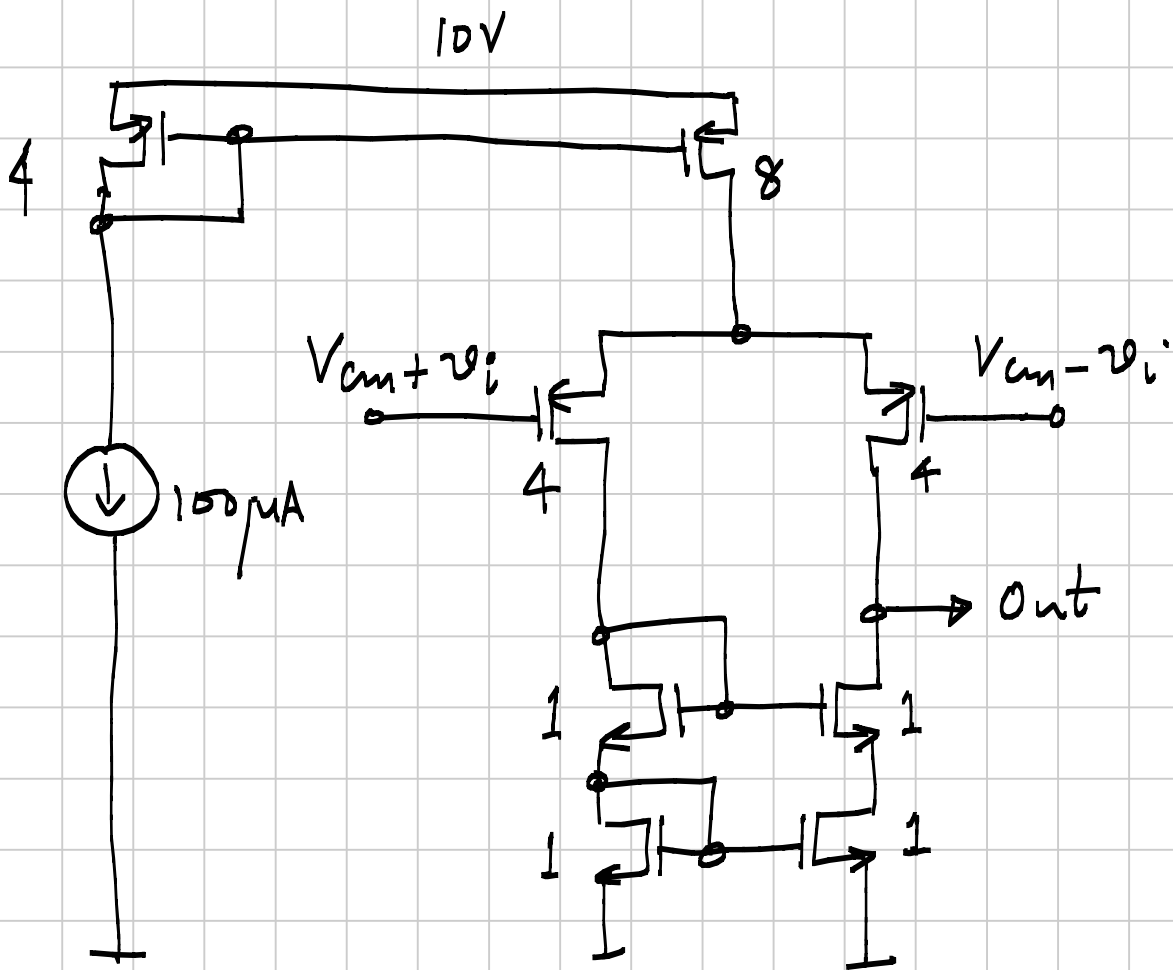
Problem 8 :



$$\lambda_p = 0, \quad \lambda_n = 0.1 \text{ V}^{-1}, \quad V_{cm} = 5 \text{ V}$$

(a) Determine the incremental output voltage in the circuit above.

(b) Now, repeat the above exercise for the circuit shown below.



$$\lambda_p = 0, \quad \lambda_n = 0.1 \text{ V}^{-1}, \quad V_{cm} = 5 \text{ V}$$