EE5310/EE3002: Analog Circuits
Tutorial 6
Due on 16th Nov. 2015

For the transistors, assume that

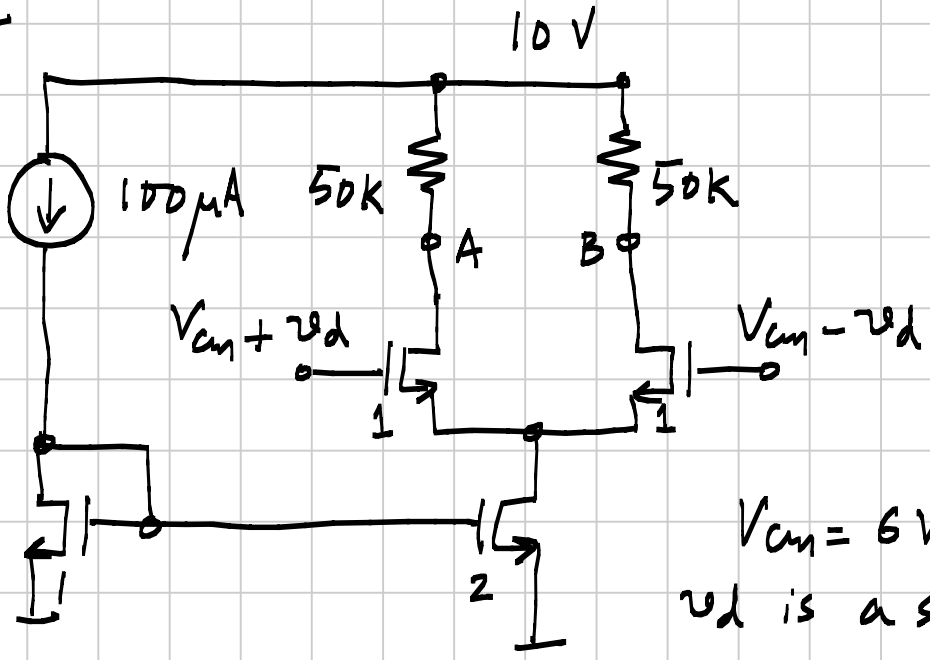
$\mu_n C_{ox} = 200\,\mu A/V^2$ $\quad V_{Tn} = 1V$

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

The $W/L$ is marked beside each device.

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

Problem 1:




$V_{cm} = 6V$

$v_d$ is a small signal

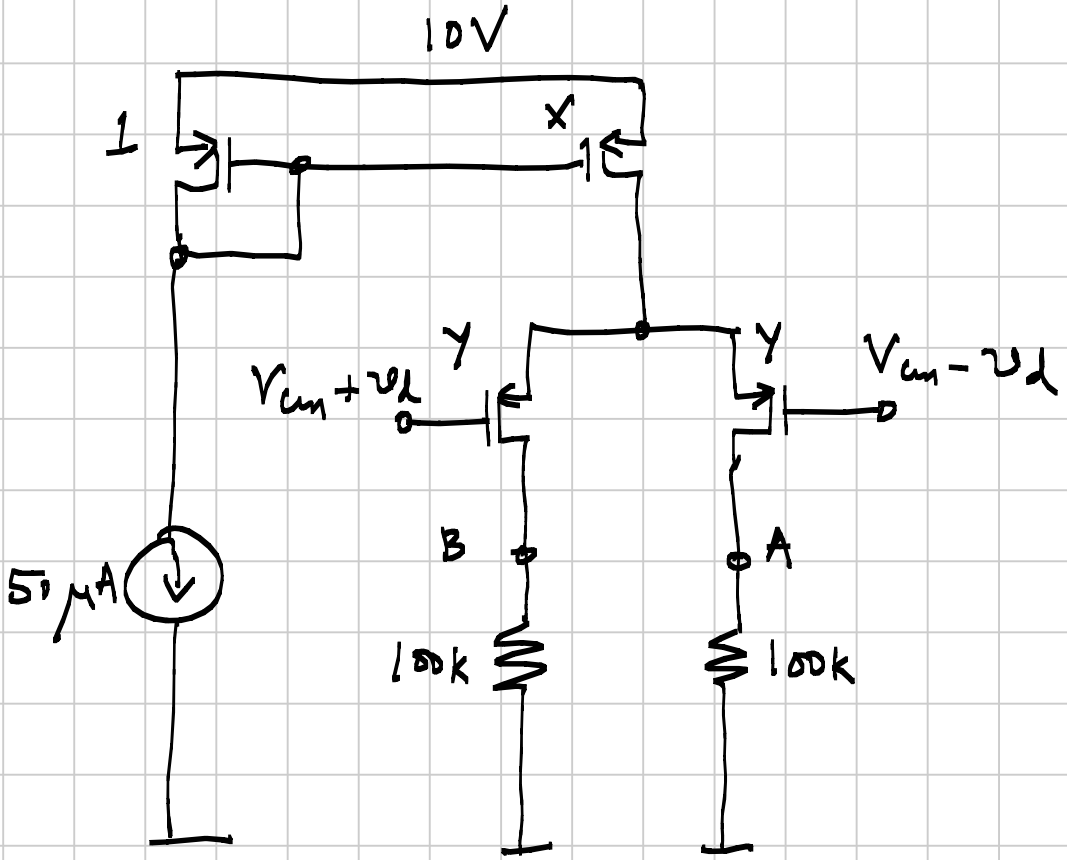
(i) Determine the quiescent voltages at A & B.

(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:



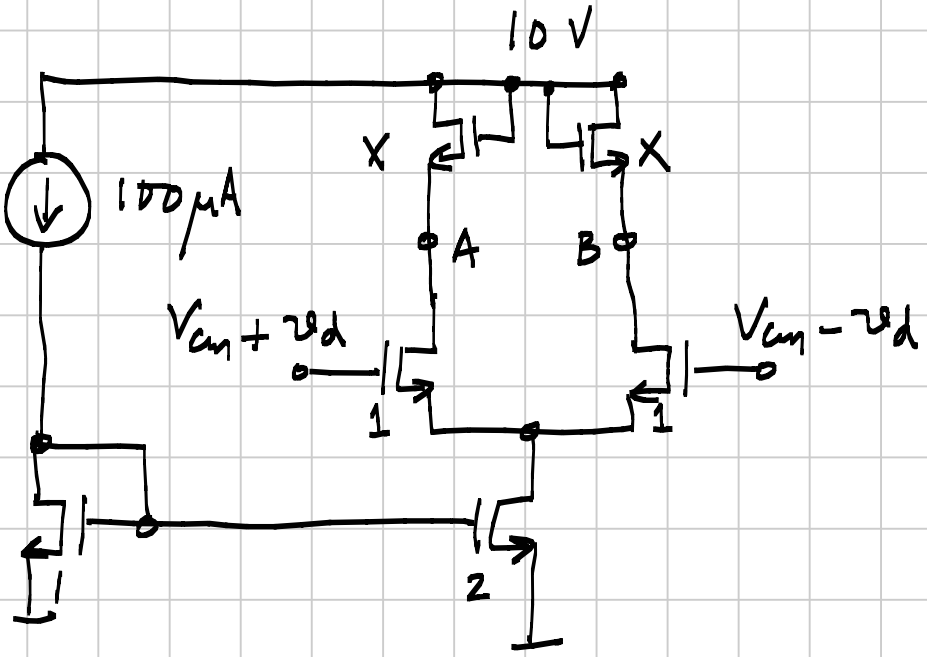

Determine the aspect ratios X & Y so that

(a) The quiescent potentials at A & B are the same as in problem 1

(b) The incremental gain is the same as in problem 1 (assuming all devices are in saturation)

(c) What is the common mode range?

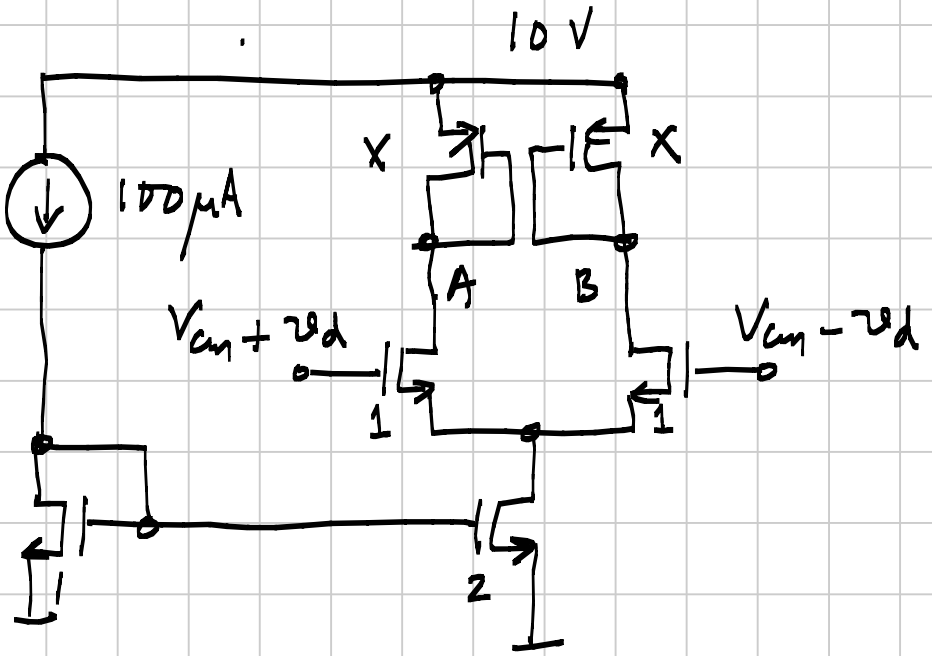
Problem 3:



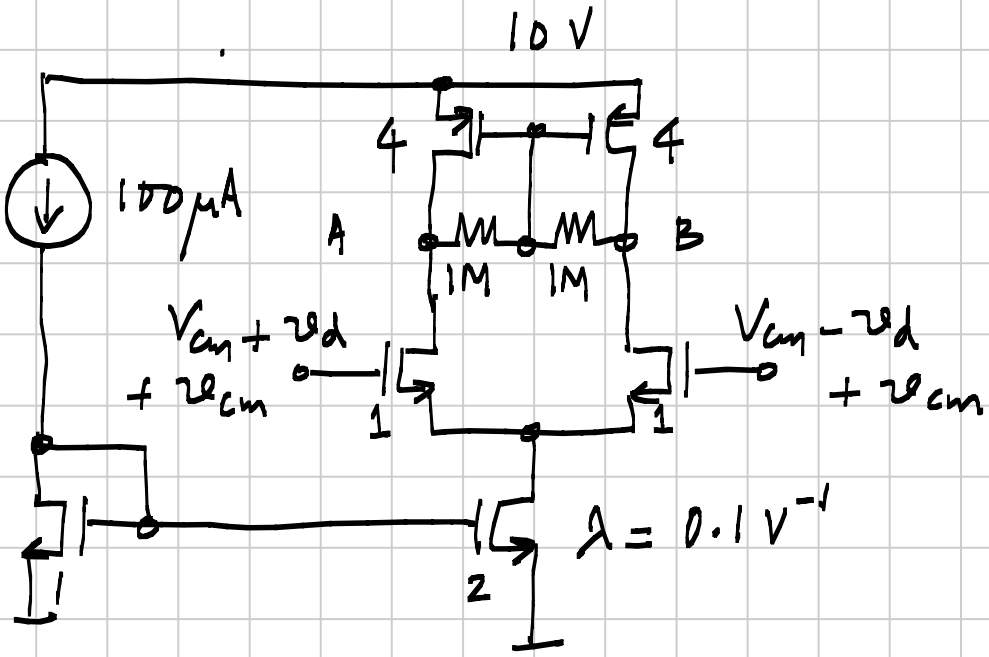

Determine the aspect ratio X, so that the incremental voltage between B & A is $4v_d$. What is the quiescent voltage at A?

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 $\lambda$ to find the quiescent operating point.

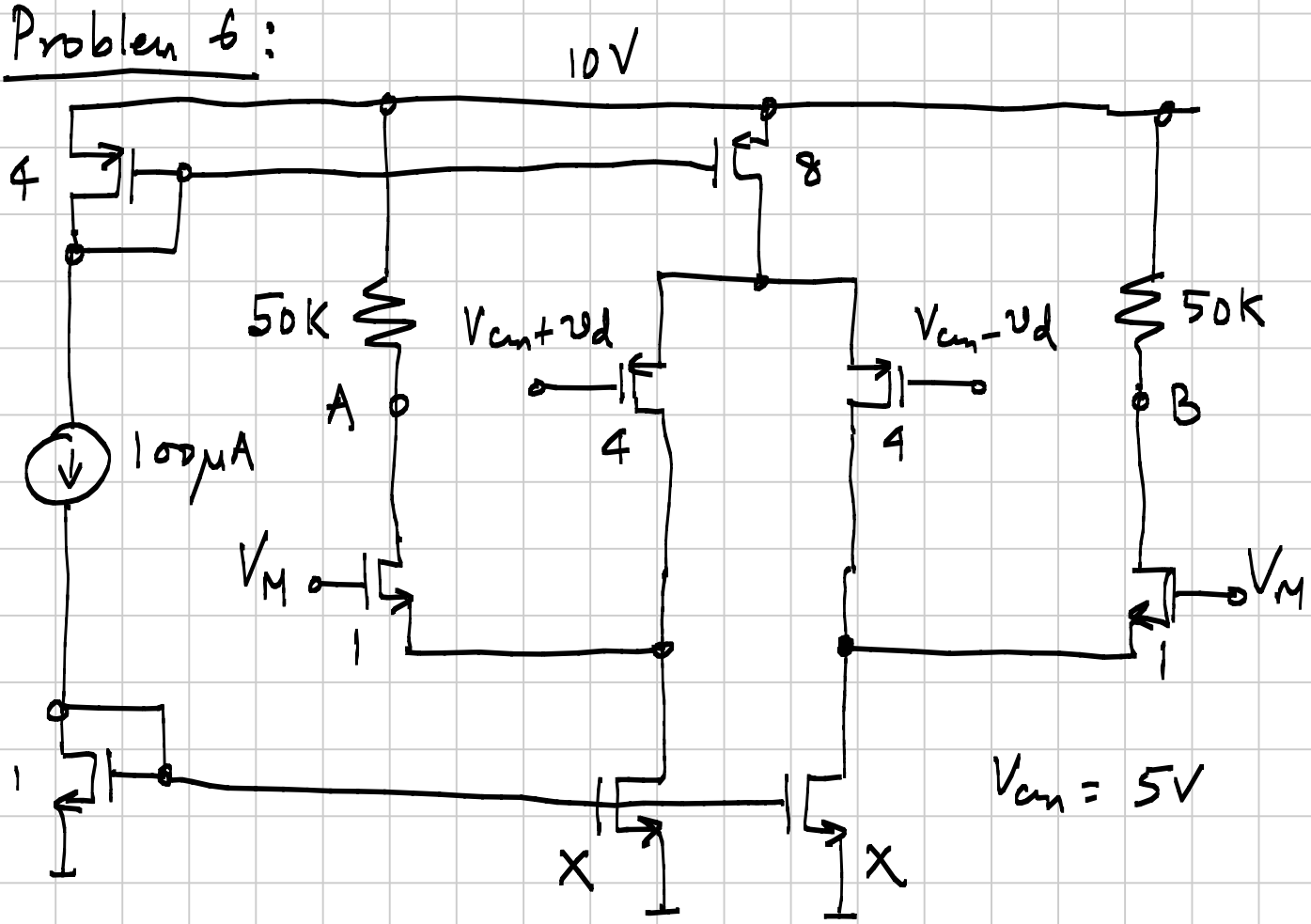
(a) Determine the quiescent potentials at A & B.

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

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

(d) 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.

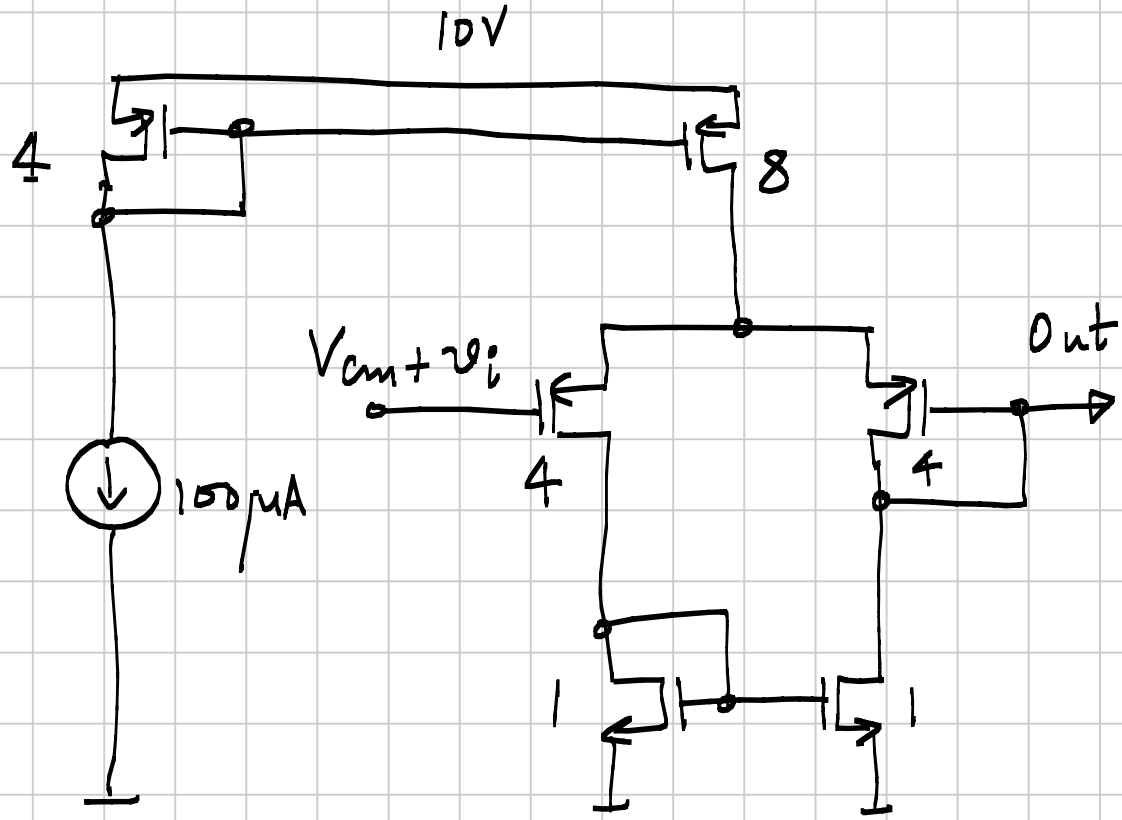
(b) For the value of X you just determined, find the range of $V_M$ over which all devices remain in saturation.

(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:

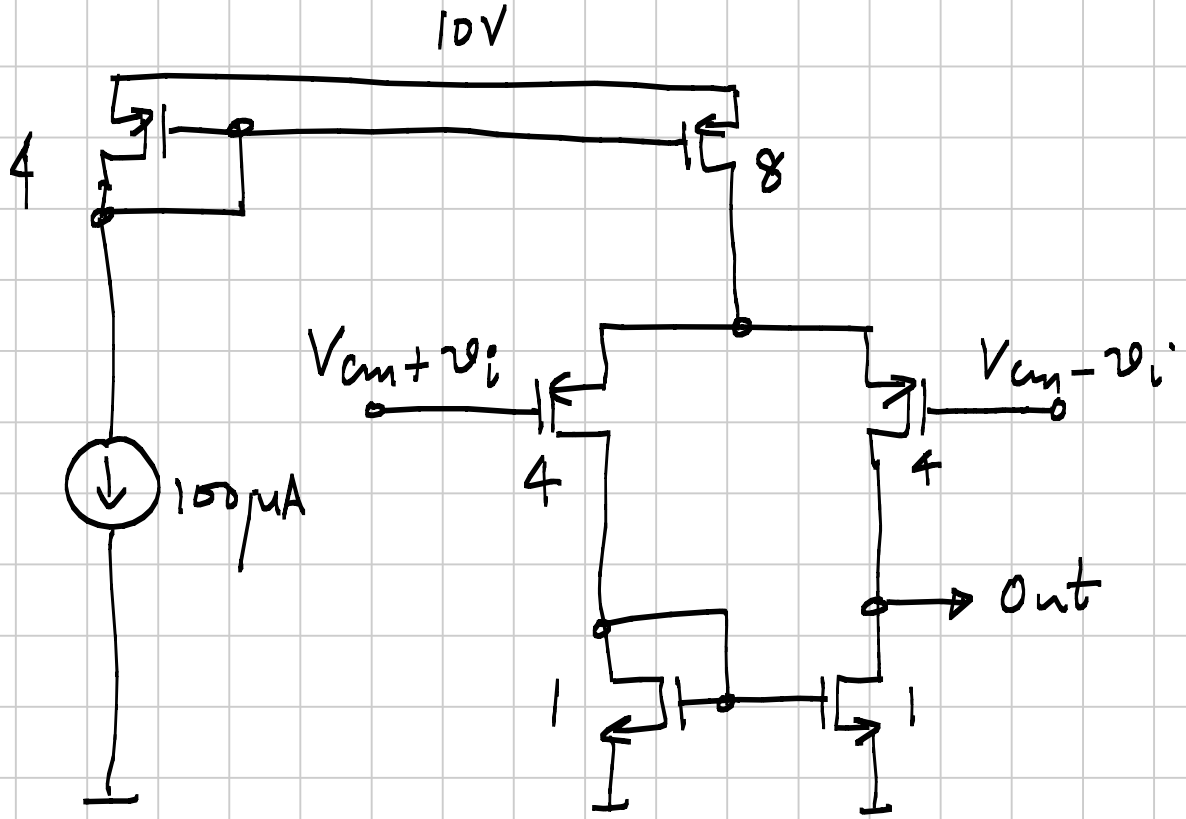



$V_{cm} = 5\,V$

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

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

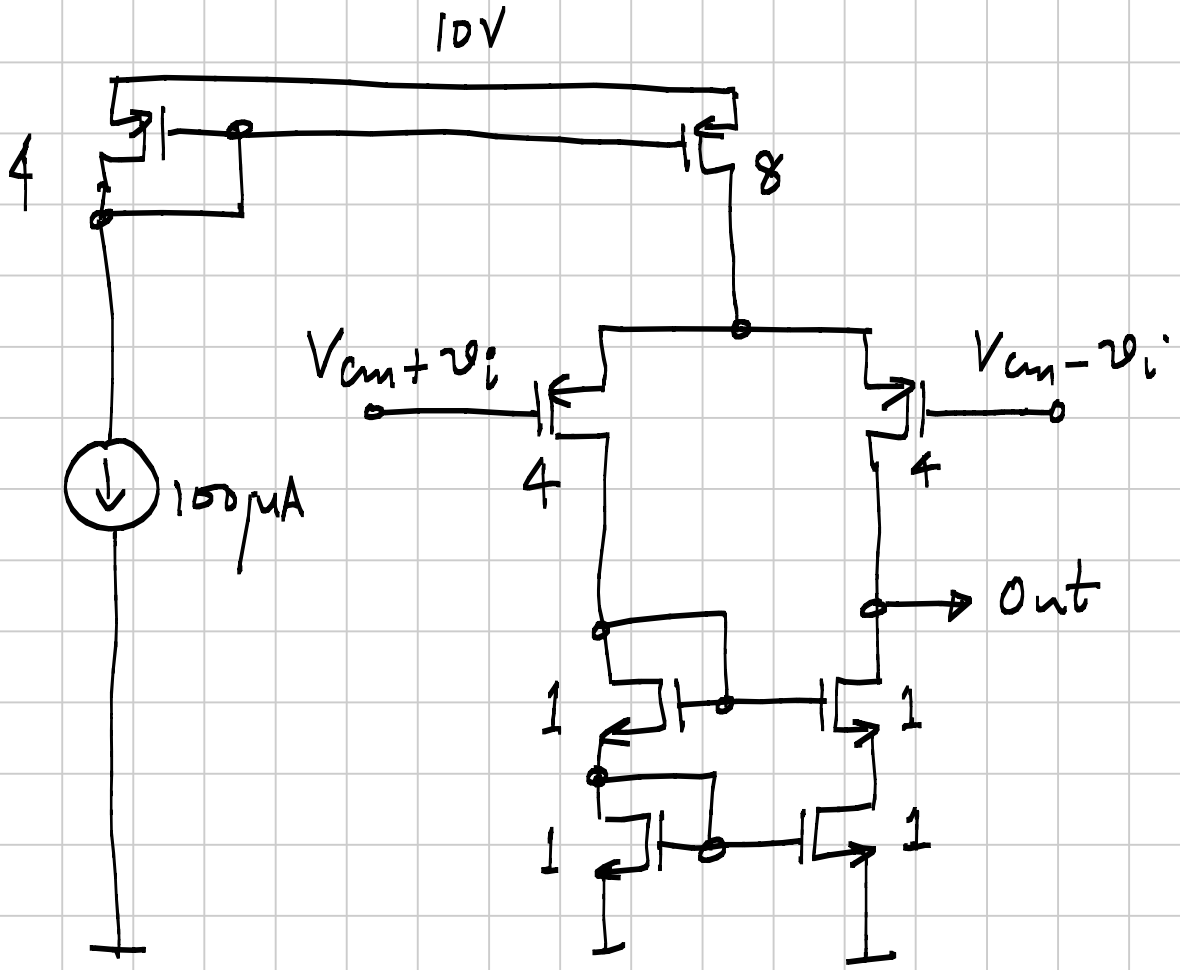
## Problem 8 :




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

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

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




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