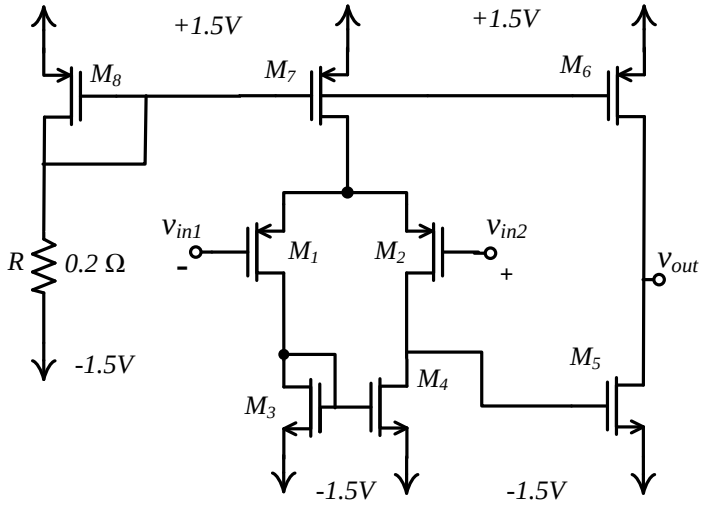
**Student Name:**

**Student ID:**

# EHB262E Electronics II
# Homework 4

Deadline: before the final exam



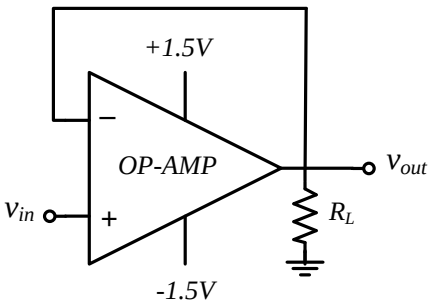

| Transistor | $L$ (µm) | $W$ (µm) |
|---|---|---|
| $M_1$ | 1 | 50 |
| $M_2$ | 1 | 50 |
| $M_3$ | 1 | 20 |
| $M_4$ | 1 | 20 |
| $M_5$ | 1 | 20 |
| $M_6$ | 1 | 10 |
| $M_7$ | 1 | 20 |
| $M_8$ | 1 | 20 |

Operational Amplifier

Consider an operational amplifier (OP-AMP) shown above. Assume that all MOSFETs are operating in saturation region. Also assume that input and output DC operating points are all **zero**. Transistors have the following parameters: $k_p' = \mu_p c_{ox} = 45A/V^2$, $k_n' = \mu_n c_{ox} = 80A/V^2$, $V_{An}=500$, $V_{Ap}=50V$, $V_{T0,p}=-0.9V$, $V_{T0,n}=1V$.

a) Calculate the small signal differential gain $\boldsymbol{v_{out} / (v_{in2} - v_{in1})}$ of the amplifier for the following cases. (You can assume that currents flowing on $M_7$ and $M_6$ are 10A and 5A, respectively).
   - **Case 1**: The amplifier drives a load resistance of 1Ω ($R_L$=1Ω).
   - **Case 2:** The amplifier drives a load resistance of 1kΩ ($R_L$=1kΩ).

b) Use the OP-AMP as a voltage follower, shown below. Construct this circuit in SPICE. Apply a sine signal to the input ($\boldsymbol{v_{in}}$) with 1mV peak-to-peak amplitude and 1kHz frequency. Print out $\boldsymbol{v_{out}}$ and $\boldsymbol{v_{in}}$ in time domain for different load resistance values: $R_L$=1Ω and $R_L$=1kΩ. Does $\boldsymbol{v_{out}}$ follow $\boldsymbol{v_{in}}$ for both cases? Why? Justify your answer using the results calculated in a).
   - Use FDR840P and FDR6580 SPICE models for PMOS and NMOS transistors, respectively.




Voltage follower

*Grading: a) 50%, b) 50%,*

Note: *Do not forget to attach SPICE **output file** prints to your homework!*