Texas A&M University
Department of Electrical and Computer Engineering

ECEN 326 – Electronic Circuits

Fall 2022

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are 5 pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

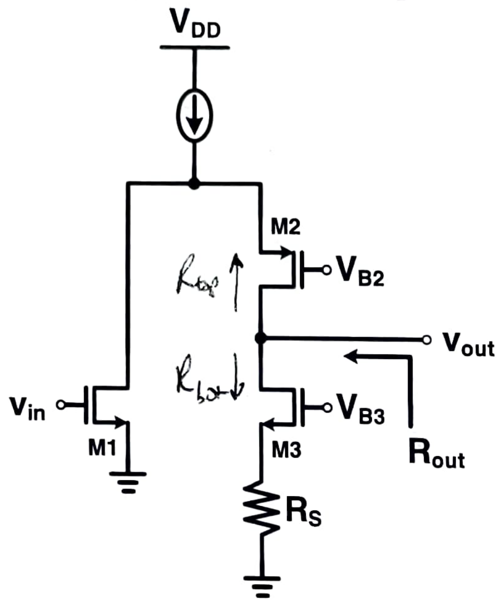
Problem	Score	Max Score
1		30
2		30
3		35
Total	95	~~**100**~~

Name: SAM PALERMO

UIN:

Problem 1 (30 points)

For the circuit shown below, assume that all transistors are operating in the saturation region. **Give an expression for the output resistance, R_{out}.** Assume that $\lambda > 0$.



$$R_{out} = R_{top} \,||\, R_{bot}$$

$$R_{top} = r_{o2} + r_{o1} + r_{o1} g_{m2} r_{o2}$$

$$R_{bot} = r_{o3} + R_S + R_S g_{m3} r_{o3}$$

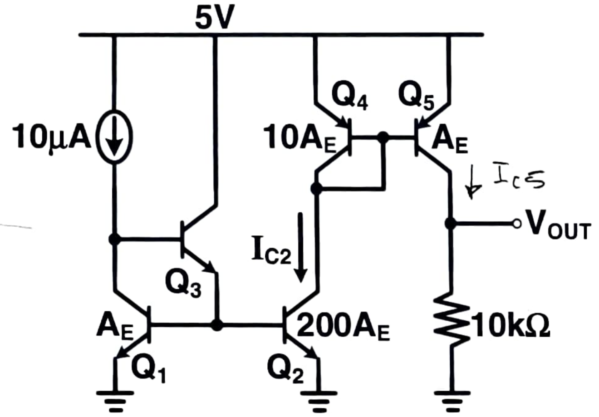
$$R_{out} = \left[r_{o2} + r_{o1} + r_{o1} g_{m2} r_{o2} \right] \,||\, \left[r_{o3} + R_S + R_S g_{m3} r_{o3} \right]$$

Problem 2 (30 points)

For the following circuit find the values for I_{C2} and V_{OUT}. Assume that all transistors are operating in the active region. **Make sure to include the impact of mirroring error due to the relevant transistor base currents.** Use the following transistor parameters.

NPN: $\beta=50$, $V_{BE}=0.7V$, $V_T=25.9mV$, $V_A=\infty$

PNP: $\beta=50$, $V_{EB}=0.7V$, $V_T=25.9mV$, $V_A=\infty$



$$I_{C2} = \frac{\left(\frac{200A_E}{A_E}\right) I_{REF}}{1 + \frac{\frac{200A_E}{A_E}+1}{\beta^2}} = \frac{200\,(10\mu A)}{1 + \frac{201}{(50)^2}} = 1.85\,mA$$

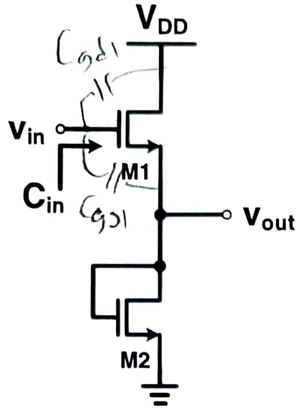
$$I_{C5} = \frac{\left(\frac{A_E}{10A_E}\right) I_{C2}}{1 + \frac{\frac{A_E}{10A_E}+1}{\beta}} = \frac{(0.1)(1.85\,mA)}{1 + \frac{1.1}{50}} = 181\,\mu A$$

$$V_{OUT} = I_{C5}(10k\Omega) = 1.81V$$

I_{C2} = 1.85mA

V_{OUT} = 1.81V

Problem 3 (35 points)
For the circuit shown below, assume that all transistors are operating in the saturation region and that $\lambda > 0$. **Using Miller's Theorem, give an expression for the input capacitance, C_{in}, including the appropriate transistor capacitors.**



$$C_{in} = C_{gd1} + C_{gs1}(1 - A_v)$$

$$A_v = g_{m1}\left(\frac{1}{g_{m1}} \,\|\, r_{o1} \,\|\, \frac{1}{g_{m2}} \,\|\, r_{o2}\right)$$

$$= \frac{g_{m1}}{g_{m1} + g_{o1} + g_{m2} + g_{o2}}$$

$$C_{in} = C_{gd1} + C_{gs1}\left[\frac{g_{o1} + g_{m2} + g_{o2}}{g_{m1} + g_{o1} + g_{m2} + g_{o2}}\right]$$