# ECE-255
# Exam III
# APRIL/7/2010

Name: _____

(Please print clearly)

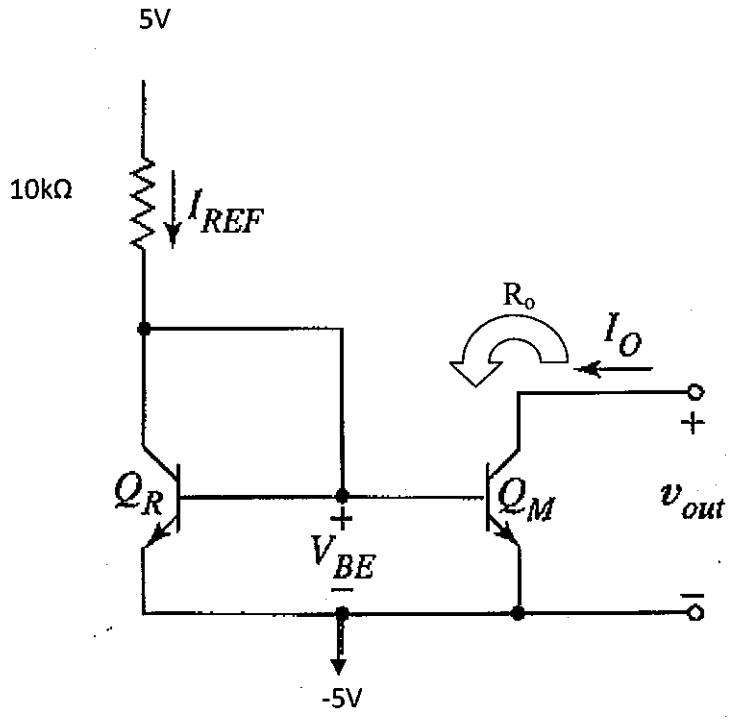
Student ID: _____

INSTRUCTIONS

- This is a closed book, closed notes exam.
- Carefully mark your multiple choice answers on the scantron form. Work on multiple choice problems and marked answers in the test booklet will not be graded. Nothing is to be on the seat beside you.
- When the exam ends, all writing is to stop. This is not negotiable. No writing while turning in the exam/scantron or risk an F in the exam.
- All students are expected to abide by the customary ethical standards of the university, i.e., your answers must reflect only your own knowledge and reasoning ability. As a reminder, at the very minimum, cheating will result in a zero on the exam and possibly an F in the course.
- Communicating with any of your classmates, in any language, by any means, for any reason, at any time between the official start of the exam and the official end of the exam is grounds for immediate ejection from the exam site and loss of all credit for this exercise.

**NOTE: Choose the answer that is closest to what you have calculated; many answers are rounded to the first non-decimal point**

1) What is the value of output impedance ($R_o$) for the current mirror shown below? Assume $\beta=\infty$, $V_{BE}(ON)=0.7V$, $V_A=100V$



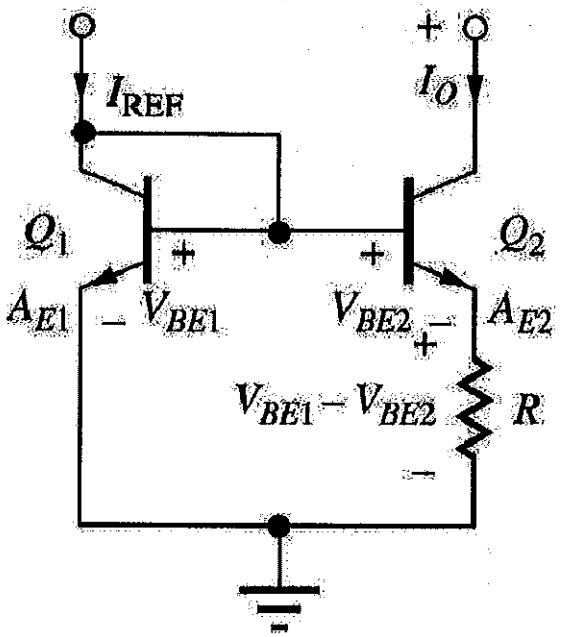

(1) ∞ (2) 232kΩ **(3) 107kΩ** (4) 0 (5) 116kΩ

(6) None of the above

$$I_o = I_{ref} = \frac{10 - 0.7}{10} = 0.93\ mA$$

$$r_o = \frac{V_A}{I_o} = \frac{100}{0.93} = 107\ k\Omega$$

2) For the Widlar current source shown below, what value of R is required to set $I_o$=25μA, if $I_{ref}$=100μA and $A_{E2}/A_{E1}$=5 Assume $V_T$=25mV , $V_{BE}(ON)$=0.7V and ignore base width modulation




**(1) 3kΩ** (2) 30kΩ (3) 300Ω (4) 150Ω (5) 150kΩ

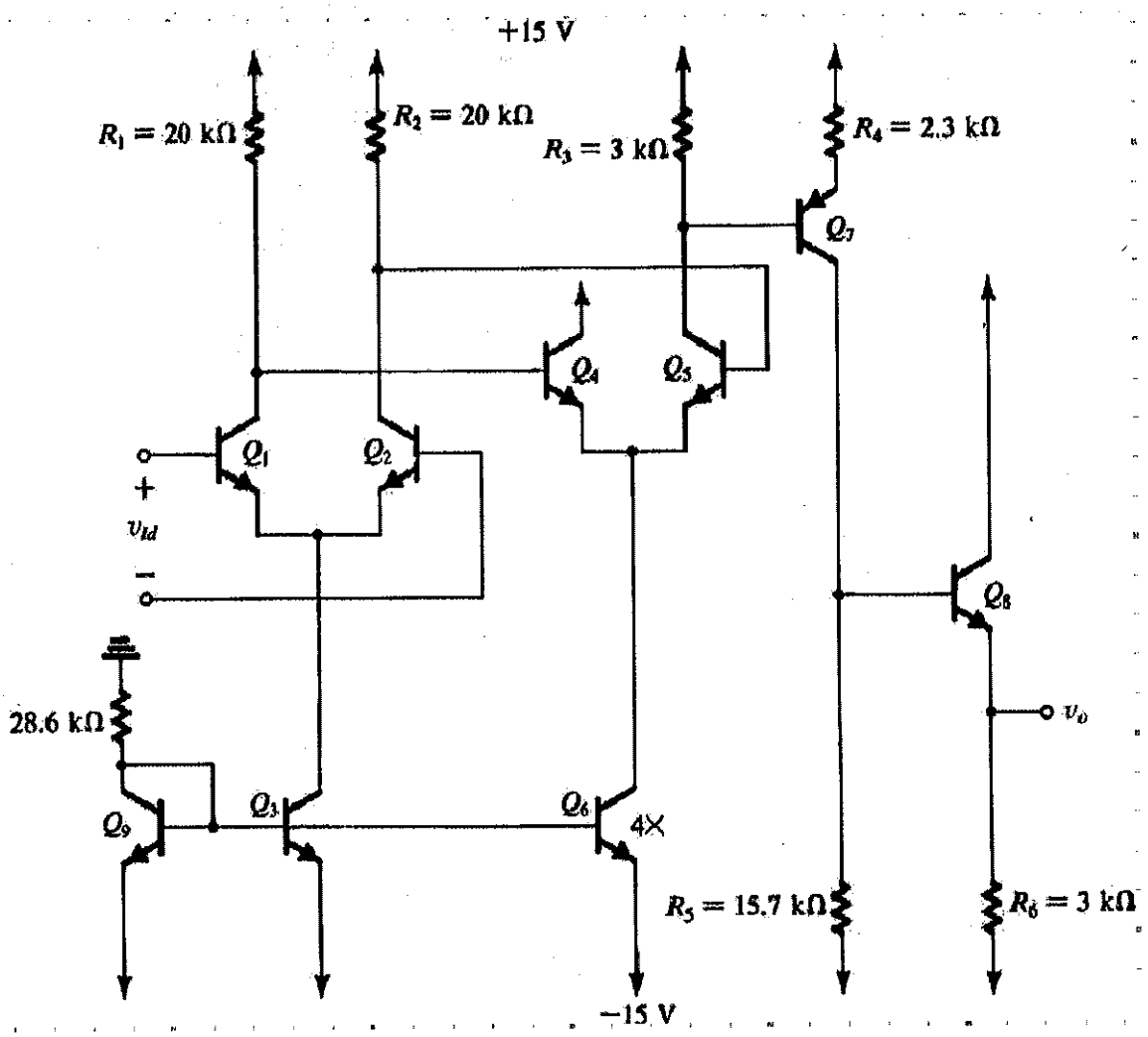
(6) None of the above

$$I_o = \frac{V_T}{R} \ln\left(\frac{I_{ref}}{I_o} \cdot \frac{A_{E2}}{A_{E1}}\right)$$

$$25 \times 10^{-6} = \frac{0.025}{R} \ln\left(\frac{100}{25} \cdot 5\right)$$

$$R = 3\,k\Omega$$

3) Figure below is internal structure of an OpAmp, what is the current $I_{CQ4}$? Assume $Q_4$ and $Q_5$ are identical, $\beta$=100, and $V_{BE}(ON)$=0.7V (the circuit is symmetric and since $Q_4$ and $Q_5$ are identical $I_{CQ4}=I_{CQ5}$)




**(1) 1mA** (2) 2mA (3) 0.25mA (4) 5mA (5) 0mA

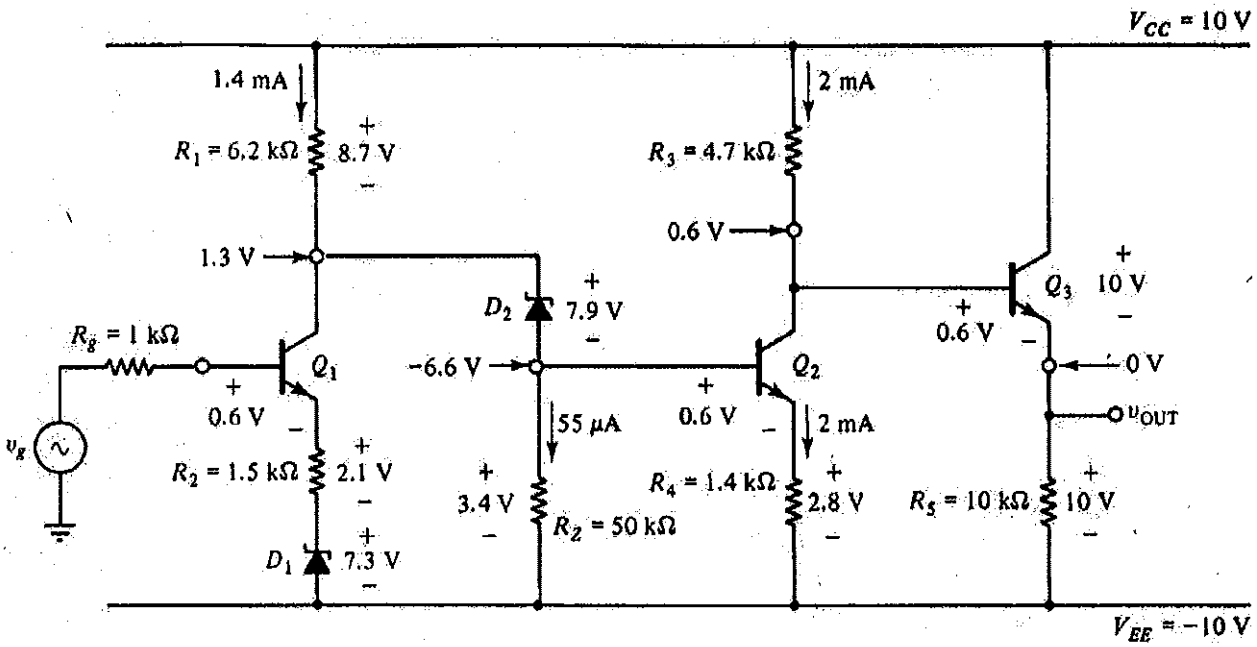
(6) None of the above

$$I_{ref} = \frac{15 - 0.7}{28.6} = 0.5 \text{ mA}$$

$$I_{CQ6} = 4 \times 0.5 = 2 \text{ mA}$$

$$I_{CQ4} = 1 \text{ mA}$$

4) What is the configuration of the multistage amplifier shown below?

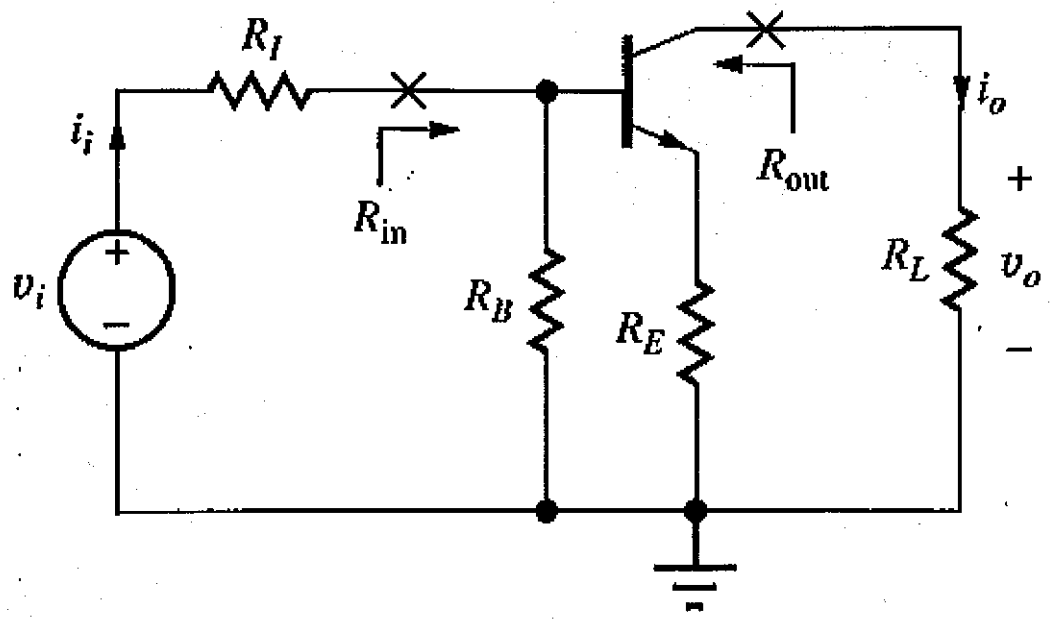



(1) CC-CE-CE (2) CC-CE-CC **(3) CE-CE-CC** (4) CE-CE-CE

(5) CB-CE-CC (6) None of the above

CE - CE - CC

5) What are the input impedance of the amplifier shown below, if $g_m$=20mS, β=75, $r_o$=100kΩ, $R_I$=500Ω, $R_B$= 15kΩ, $R_E$=300Ω, and $R_L$=12kΩ. $V_T$=25mV




(1) $R_{in}$=15kΩ (2) $R_{in}$=3kΩ (3) $R_{in}$=290Ω (4) $R_{in}$=100kΩ **(5) $R_{in}$=10kΩ**

(6) None of the above

$$r_\pi = \beta / g_m = \frac{75}{0.02} = 3750\,\Omega$$

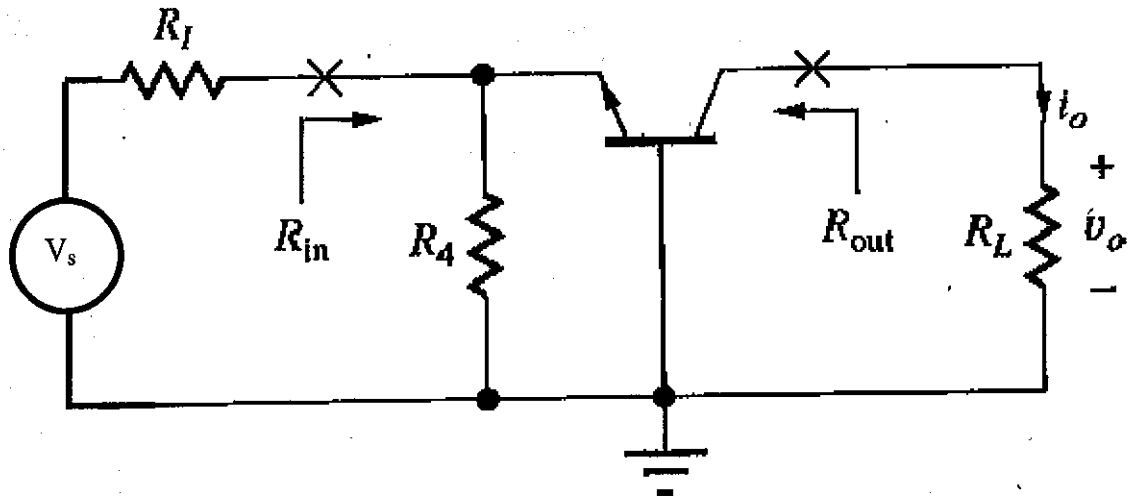
$$R_{in} = R_B \,||\, [r_\pi + \beta R_E]$$

$$= 15 \,||\, [3.75 + \underbrace{75 \times 300}_{22.5\,k}]$$

$$\underbrace{\qquad\qquad}_{26.25\,k\Omega}$$

$$R_{in} \approx 10\,k\Omega$$

6) What is the value of the input impedance for the amplifier shown below, if $I_C$=12.5μA, β=100, $V_A$=60V, $R_I$=50Ω, $R_4$=100kΩ, and $R_L$=100kΩ. $V_T$=25mV




(1) $R_{in}$=100kΩ (2) $R_{in}$=2kΩ (3) $R_{in}$=200kΩ (4) $R_{in}$=50kΩ (5) $R_{in}$=500Ω

(6) None of the above

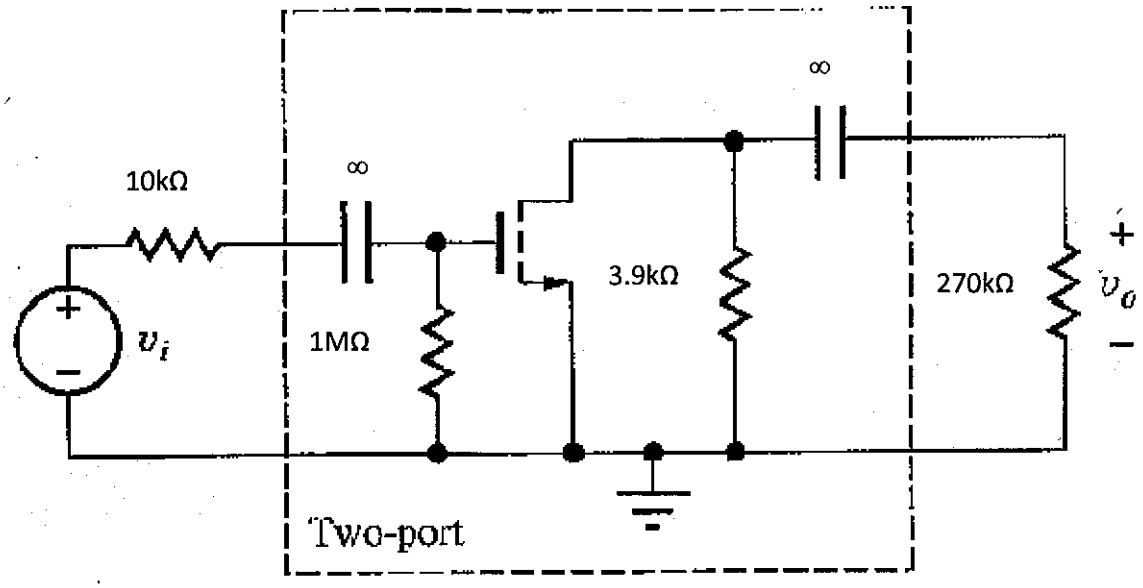
$$R_{in} = R_4 \,||\, 1/g_m$$

$$g_m = \frac{I_c}{V_T} = \frac{12.5 \times 10^{-6}}{0.025} = 5 \times 10^{-4} \ \frac{A}{V}$$

$$1/g_m = r_e = 2\,k\Omega$$

$$R_{in} \approx r_e = 2\,k\Omega$$

7) What is the absolute value of the voltage gain ($|v_0/v_i|$) for the amplifier whose ac equivalent circuit is shown below? Assume the MOSFET Q points are (2mA, 7.5V), $K_n$=1mA/V$^2$, and $\lambda$=0




(1) 16 **(2) 8** (3) 540 (4) 25

(5) gain is zero since we ignored the channel length modulation

(6) None of the above

Terminal Gain = $g_m R_L$

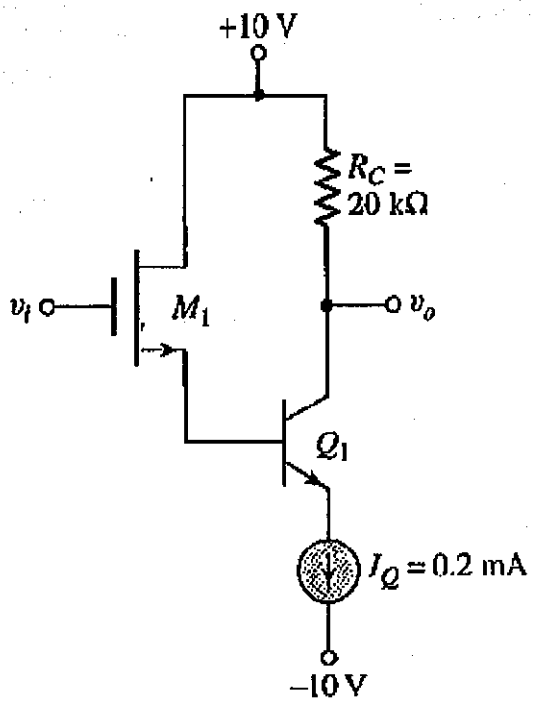
$g_m = \sqrt{2K I_D} = 2 \times 10^{-3}$

$R_L = 270k\Omega \parallel 3.9k\Omega$

Terminal gain = 7.68

Total = $7.68 \times \frac{1M}{10e1M} \sim 7.6 \sim 8$

8) For the two stage amplifier shown below, what is the absolute value of the voltage gain $A_v=|v_o/v_i|$? Assume for the MOSFET $V_{TN}=1V$, $K_N=0.2mA/V^2$, $\lambda=0$ and for the BJT, $\beta=80$, and $V_A=100V$. $V_T=25mV$




(1) 4000 (2) 1 (3) 200 **(4) 154** (5) 80

(6) None of the above

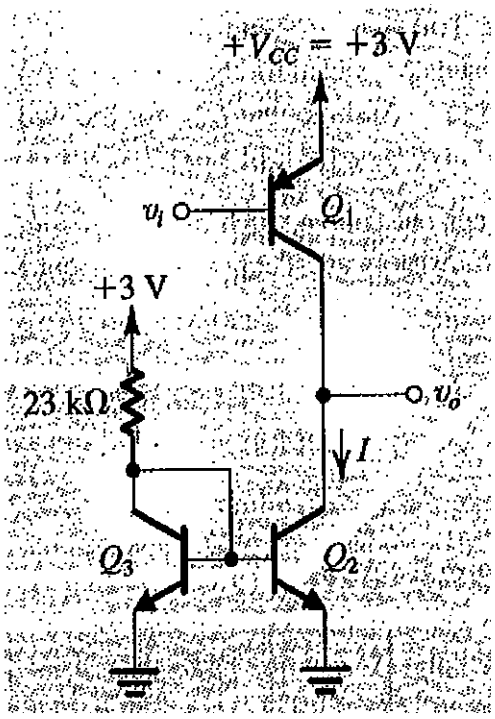
$g_{m1} = \frac{I_C}{V_T} = \frac{0.2}{25} = 8\times10^{-3}\ \frac{A}{V}$ , $r_o = \frac{V_A}{I_C} = 500\ k\Omega$

BJT $A_V = 8\times10^{-3} \times [500^{k} \,||\, 20^{k}] = 154$

$19.23\ k\Omega$

First stage gain ~1

9) What is the absolute value of the voltage gain ($|v_o/v_i|$) of the following amplifier biased with a current source, Assume $\beta$=100, and $V_A$=80V for all transistors. $V_{BE}(ON)$=0.7V




**(1) 1600** (2) 160 (3) 1 (4) 3200 (5) 800

(6) None of the above

$$I = I_{ref} = \frac{3 - 0.7}{23} = 0.1 \text{ mA}$$

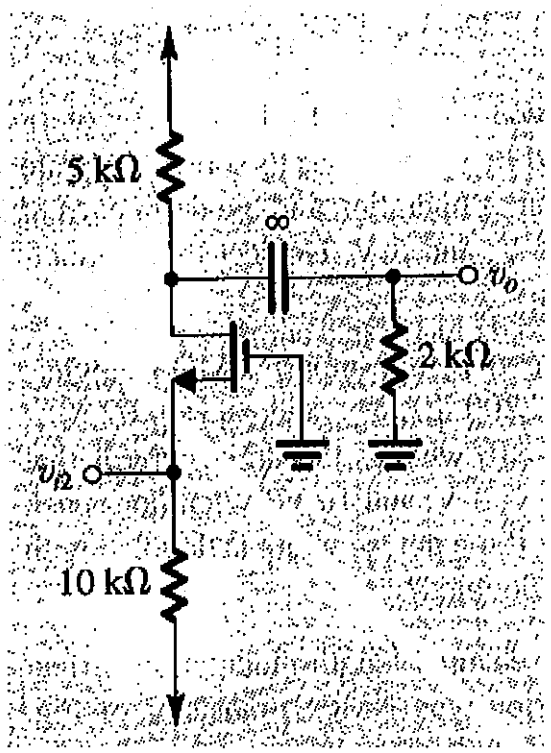
$$g_m = \frac{0.1}{25} = 4 \times 10^{-3} \frac{A}{V}$$

$$r_o = \frac{80}{0.1} = 800 \text{ k}\Omega$$

$$\text{Total } R_L = 800 \| 800 = 400 \text{ k}\Omega$$

$$A_v = g_m R_L = 4 \times 10^{-3} \times 400 \times 10^3 = 1600$$

10) What is the absolute value of the voltage gain of the amplifier shown below ($|v_o/v_{i2}|$), Assume $g_m$=5mA/V and $r_o$ is large.




(1) 25 (2) 10 (3) 1 (4) 14 (5) 7

(6) None of the above

$A_v = g_m R_L = 5 \times 10^{-3} [5 \| 2] \sim 7$