ECE-255
Exam II
March/10/2009

Name: Solutions
(Please print clearly)

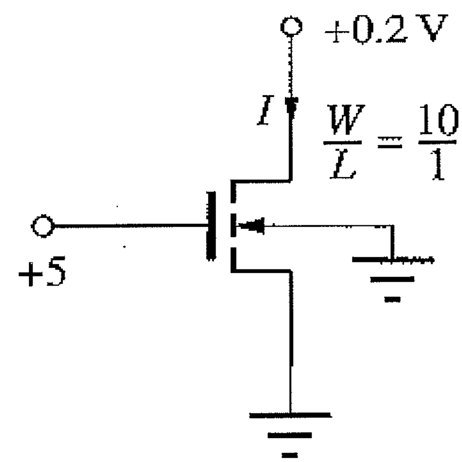
Student ID: ____________

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.

Perform all calculations to two decimal points

1) For the circuit shown below what is I_D? Assume $\lambda=0$, $V_{TN}=0.7V$, and $K'_N=100\mu A/V^2$



NMOS enhancement mode

V_t = +ve

(1) 0.84mA (2) 9.24mA (3) 0.084mA (4) 0mA
(5) 1.68mA (6) None of the above

$V_{gs} > V_T \Rightarrow$ transistor is ON

$V_{DS} < V_{GS} - V_t$

$0.2 < 5 - 0.7$ So triode or linear region.

$i_D = K_n \left(V_{GS} - V_t - \frac{V_{ds}}{2}\right) V_{ds}$

$= 100\mu \left(5 - 0.7 - 0.1\right) 0.2$

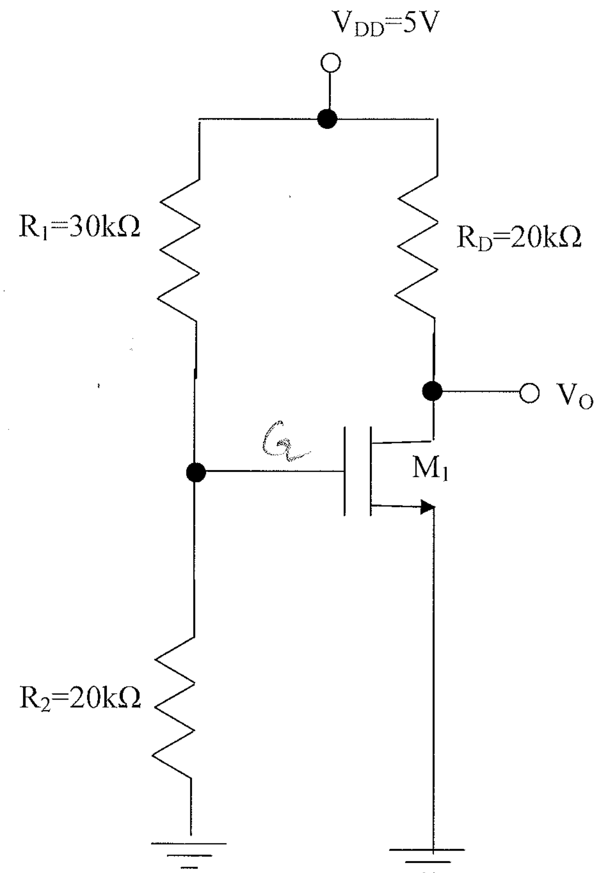
$= 100\mu \times 4.2 \times 0.2$

$= 84\mu$

$= .084m$ So Ans (1)

2) For the MOS circuit shown below, V_o=?

$\lambda=0$, $V_{TN}=1V$, $K_N=0.2\ mA/V^2$



$V_G = \frac{5}{50K} \times 20K$

$= 2$ Volt

$V_{GS} = 2$

$V_t = 1$

(1) 4V (2) 2.5V (3) 2V (4) 3.5V
(5) 3V (6) None of the above

let's assume in saturation as $V_{GS} - V_t = 1$ Volt & supply is 5 Volt (though it depends upon R_D). But I guess its good start.

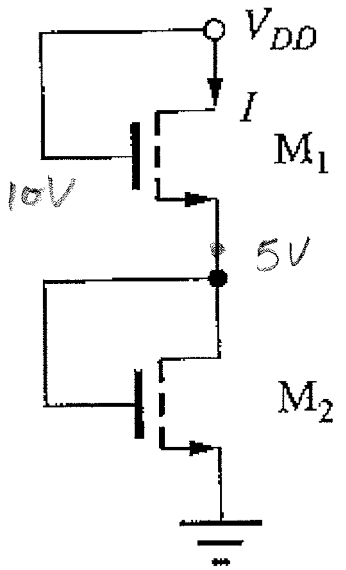
$I_D = \frac{K_n}{2}(V_{GS}-V_t)^2 = \frac{0.2m}{2}(1)^2 = 0.1\ mA$

drop in $R_D \Rightarrow 20 \times 1K \times 0.1 \times m = 2$ volt.

so $V_o = 3$ Volt check $V_{DS} = (3) \geq V_{GS} - V_t\ (1)$

so Ans (5)

3) Find the current I in the circuit below if V_{DD}=10V and λ=0. Both transistors have W/L=10/1, V_{TN}=0.75V, and K'_N=100μA/V^2



If we ignore body effect & λ=0 which we will do, Vdrop across both the transistor will be same. mid point will be

$\frac{V_{dd}}{2} = 5$

This is true b'coz W/L of both of them are same

(1) 18mA (2) 0.9mA (3) 9.03mA (4) 42mA
(5) 0mA since gates are tied to drains (transistors are off)
(6) None of the above

diode connected transistor is always in saturation as ($V_{ds} \geq V_{gs} - V_t$ always)

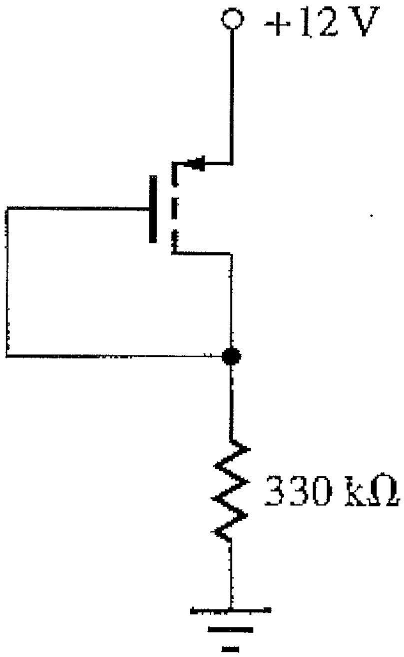
$I = \frac{10 \times 100\mu}{2}(5 - .75)^2$

$= \frac{100\mu \times (4.25)^2 \times 10}{2}$

$= 9030\mu = 9.03\,m$

Ans (3)

4) What is the value of V_{GS} for the circuit shown below? Assume $\lambda=0$, $V_{TP}=-1V$, $W/L=10/1$, and $K'_P=40\mu A/V^2$



transistor is always ON & always in saturation

$|V_{DS}| \geq |V_{GS} - V_{TP}| \geq 0$

$i_D = \frac{10 \times 40\mu}{2}(V_{SG} + V_{TP})^2$

$i_D = 200\mu(12 - V_G - 1)^2$

& $\frac{V_G}{330k} = i_D$

(1) 0V (2) -1.4V (3) 12V (4) -0.7V
(5) 1.4V (6) None of the above

So $\frac{V_G}{330k} = 200\mu(11 - V_G)^2$

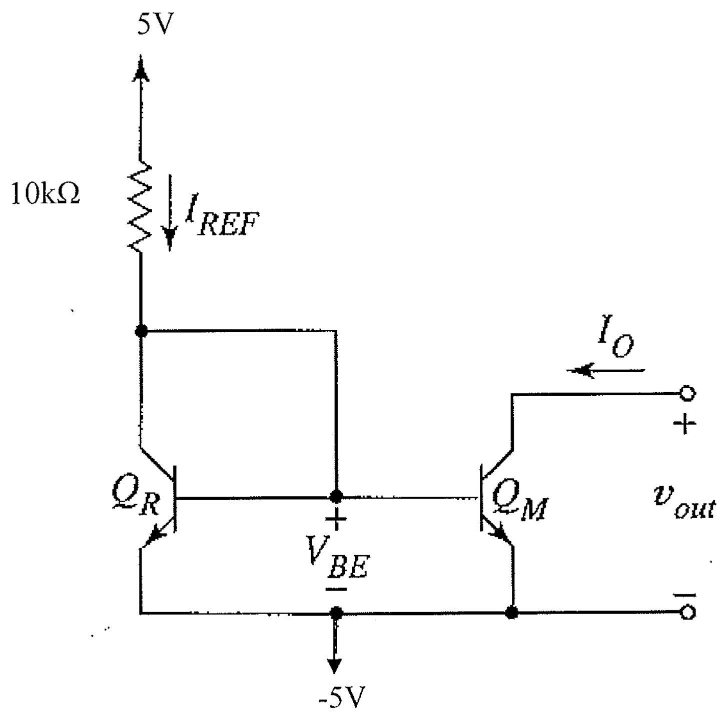
$V_G = 330k \times 200\mu(11 - V_G)^2$

$V_G = 66(11 - V_G)^2$

$V_G \simeq 10.56\ V$

$V_{GS} \simeq -1.4V$ so Ans (2)

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



(1) 0.93mA (2) 0.43mA (3) 1.07mA (4) 5.07mA
(5) 0mA since emitters are connected together
(6) None of the above

$V_A = \infty \Rightarrow$ current will match exactly.

$I_o = I_{ref}$

$5 - I_{ref} \times 10k - 0.7 = -5$

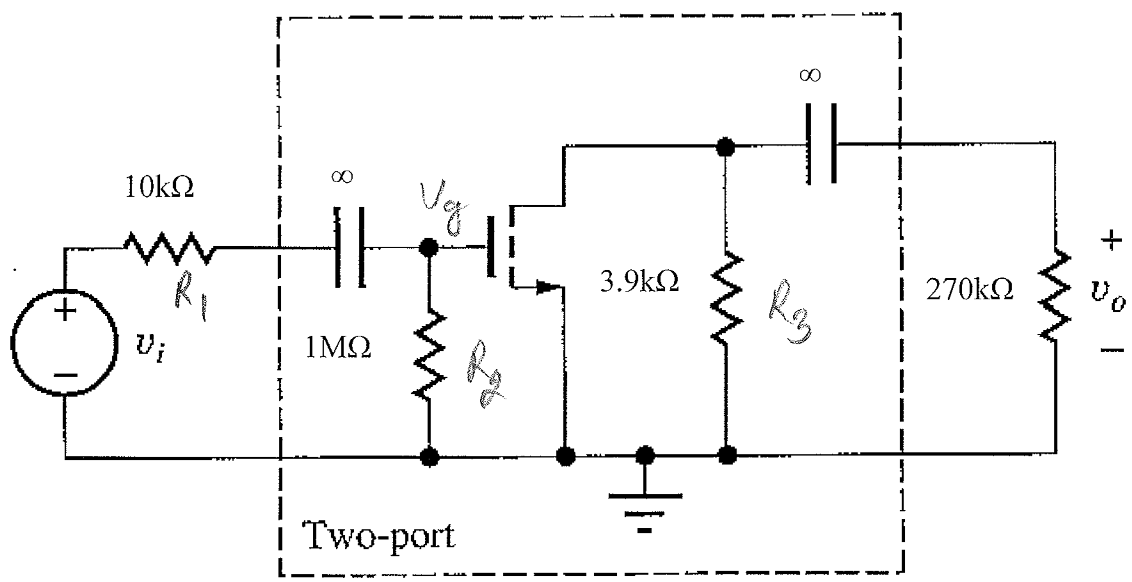
$I_{ref} = \frac{10 - 0.7}{10k}$

$= \frac{9.3}{10k}$

$= .93m$

so ans (1)

6) What is the voltage gain (v_O/v_i) for the common source amplifier whose ac equivalent circuit is shown below? Assume the MOSFET Q points are (2mA, 7.5V), K_n=1mA/V^2, and λ=0



(1) -7.8 (2) -7.61 (3) -540 (4) -25
(5) gain is zero since we ignored the channel length modulation
(6) None of the above

$g_m = \frac{2I_D}{V_{GS}-V_{tn}} = \sqrt{2K I_D} = \sqrt{4m \times 1m} = 2mA/V$

there is gain in two stages

(i) from v_i to v_g

⇓

$\frac{R_2}{R_1+R_2} = \frac{1M}{1M+10k} = .99$

(ii) from v_g to v_o

⇓

$-g_m \times R_3 \| R_L = -g_m \times 3.9k \| 270k = -2m \times = -7.68$

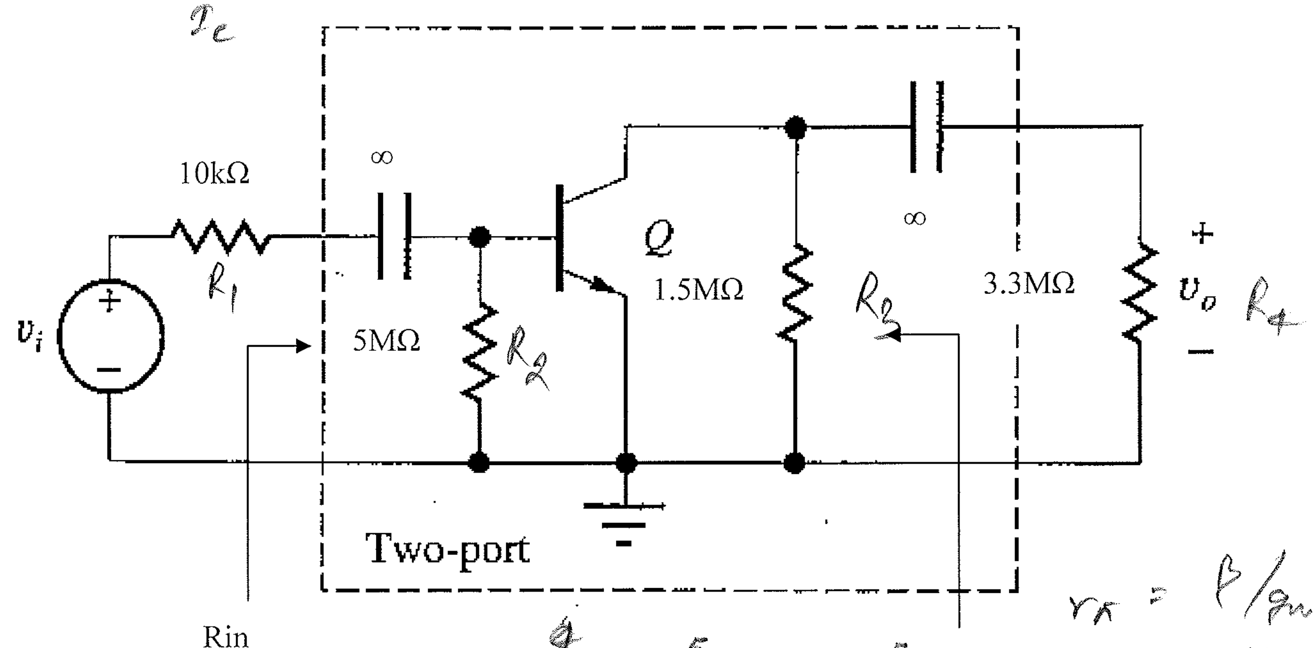
total

-7.6

so (2)

7) What is the input and output impedances for the common emitter amplifier whose ac equivalent circuit is shown below? Assume the BJT Q points are (2μA, 1.5V), $\beta=50$, $V_A=50V$, $V_T=25mV$, and $V_{BE}(ON)=0.7V$.

$r_o = \frac{V_A}{I_C}$



$g_m = I_C/V_T = \frac{2\mu}{25m} = 8\times10^{-5}$ $\frac{I}{V}$

$r_\pi = \beta/g_m = \frac{50}{8\times10^{-5}} = .625M$ or $R_E = 0$

(1) R_{in}=555kΩ, R_{out}=1.5MΩ
(2) R_{in}=5MΩ, R_{out}=1.41MΩ
(3) R_{in}=555kΩ, R_{out}=25MΩ
(4) R_{in}=625kΩ, R_{out}=1.41MΩ
~~(5)~~ R_{in}=555kΩ, R_{out}=1.41MΩ
(6) None of the above

$R_{in} = R_2 \| R_{ib}$
$= R_2 \| r_\pi$
$= 5M \| .625M$
$R_{in} =$ ~~1M~~ 555k

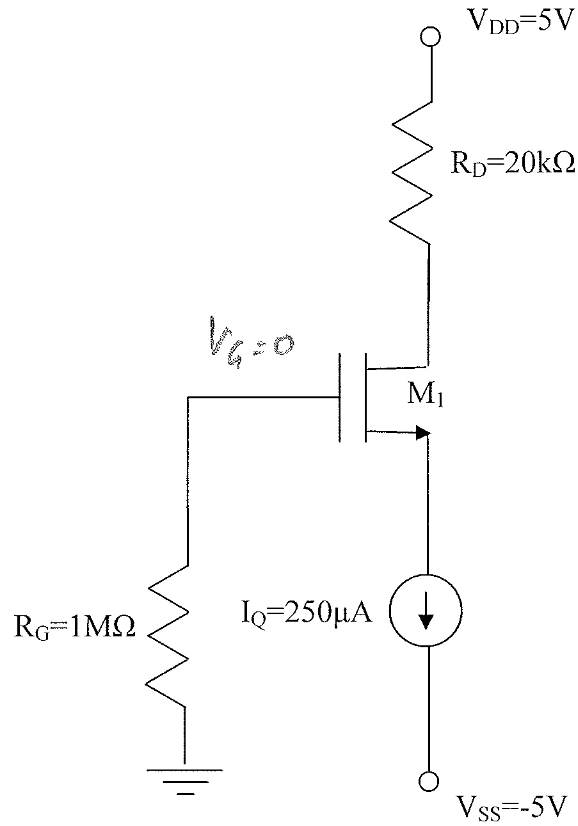
$r_{out} = R_3 \| r_o = 1.5M \| 2.5\times10^7$
$= 1.41M$

Ans 5

8) For the MOS circuit shown below, what is the V_{DS}?

V_{TN}=1V, K'_N=80 µA/V^2, (W/L)=3, λ=0

let's assume Tran. is in saturation.



$I_D = K_n' \frac{W}{L} \frac{(V_{GS} - V_t)^2}{2}$

$= \frac{80\mu \times 3 \, (-V_S - 1)^2}{2}$

$I_D = 120\mu (V_S + 1)^2$

$250\mu = 120\mu (V_S + 1)^2$

$V_S = -2.44$ Volt

other solution is dropped b/coz in that case transistor is off.

(1) 2.44V (2) 0V (3) 2V (4) 2.56V
(5) 5V (6) None of the above

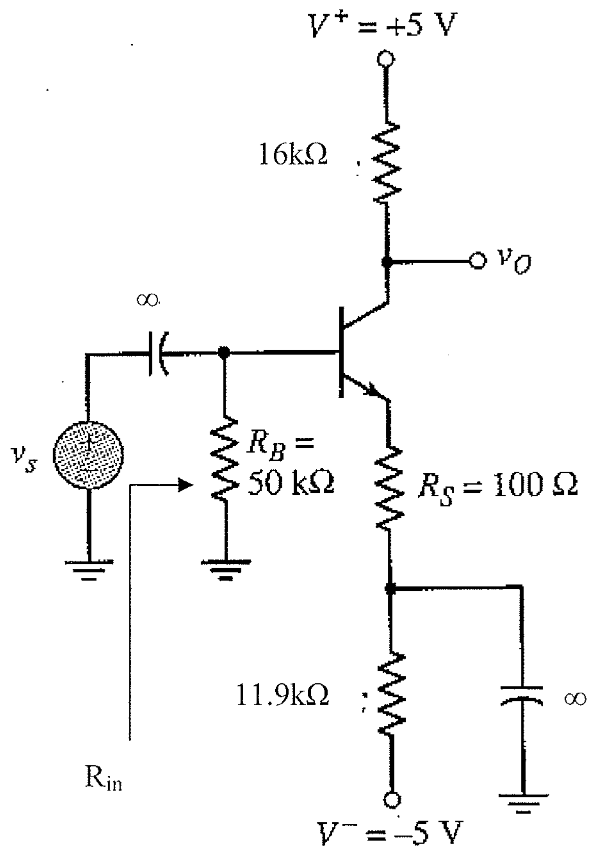
$V_D = 5 - 20K \times 250\mu$
$= 5 - 5$
$= 0$

$V_{DS} = 2.44$ Volt

Ans (1)

9) For the circuit shown below (Common emitter amplifier) the voltage gain and input impedance are? Assume $V_{BE}(ON)$=0.7V, β=100, V_A=∞, I_{CQ}=0.25mA, and V_{CEQ}=3V.

V_T



(1) 50kΩ (2) 10kΩ (3) 8.33kΩ (4) 14.34kΩ
(5) 20.1kΩ (6) None of the above

$r_\pi = \frac{\beta}{g_m}$, $\frac{100}{.01} = 1 \times 10^4$

$g_m = \frac{I_C}{V_T} = \frac{.25m}{25m}$

$g_m = 1 \times 10^{-2}$

Common emitter amplifier

$R_{in} = R_B \| R_{iB}$

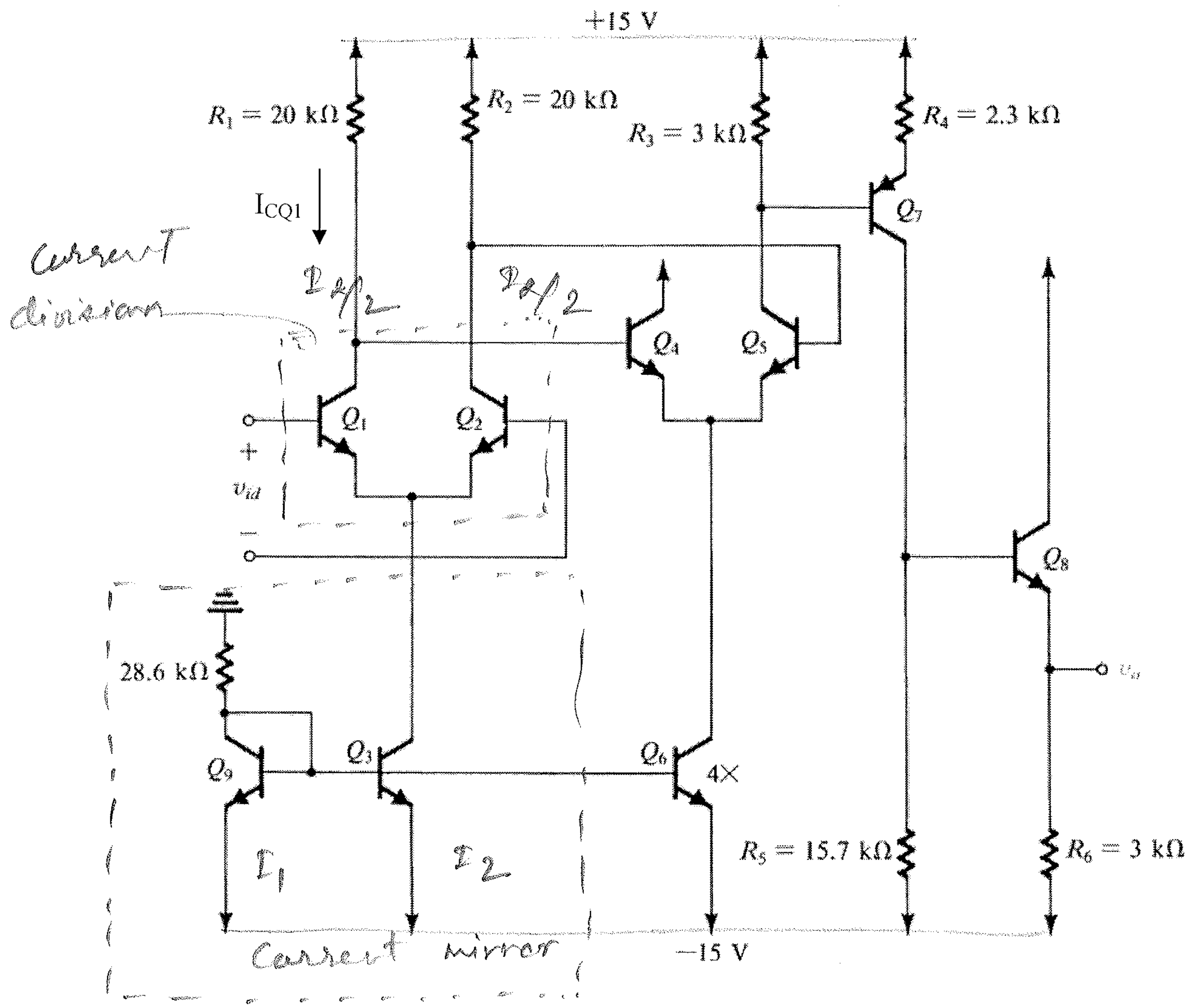
$= R_B \| r_\pi (1 + g_m R_E)$

$= 50k \| 1 \times 10^4 (1 + 10^{-2} \times 1k)$

$= 50k \| 20k$

$= 14.28k$

10) Figure below is internal structure of an OpAmp, what is the current I_{CQ1}? Assume Q_1 and Q_2 are identical, β=100, and $V_{BE}(ON)$=0.7V



(1) 0.5mA (2) 0.25mA (3) 0mA (4) 0.27mA
(5) 1mA (6) None of the above

Current divides equally if $V_{id} = 0$

$0 - I_1 \times 28.6k - 0.7 = -15$

$\frac{15 - 0.7}{28.6k} = I_1 = 0.5m$

$I_{cq_1} = I_1/2 = 0.25\,m$ Ans (2)