ECE-255
FINAL EXAM
May/3/2010

Name: ______________________________
(Please print clearly)

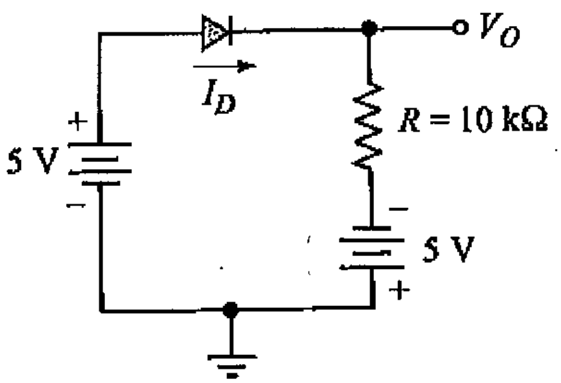
Student ID: ________________

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 V_o in the circuit shown below, for the diode assume V_{on}=0.7V and R_D=500Ω



(1) 3.86 V (2) -5V (3) 0V (4) 4.3V

(5) Open circuit (6) None of these

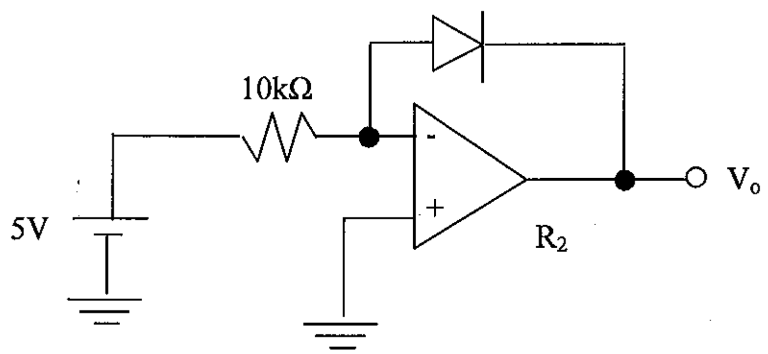
$$I_D = \frac{10 - 0.7}{10.5} = 0.886 \text{ mA}$$

$$V_o = 0.886(10) - 5 = 3.86 \text{ V}$$

2. In a power supply using full bridge rectifier, one can reduce the ripple voltage by

(1) Decreasing the input frequency
(2) Increasing the filter capacitor value and decreasing the input frequency
(3) Increasing the filter capacitor value and increasing the input frequency
(4) Decreasing the filter capacitor value
(5) Using Schottky diodes
(6) None of the above

3. What is V_o? for the diode $I_s=10^{-14}A$ (Assume $V_T=25mV$)



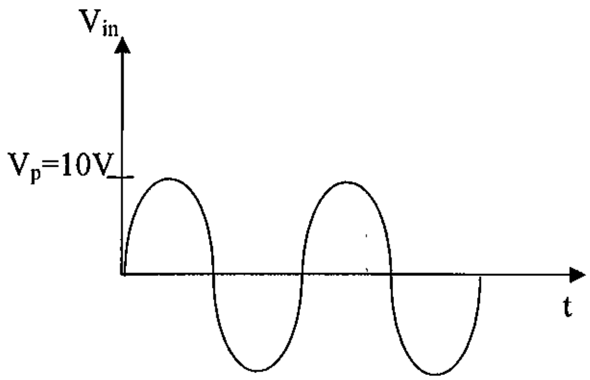
(1) 0.7V
(2) -0.61V
(3) 0.61V
(4) 0.7V
(5) 0V
(6) None of the above

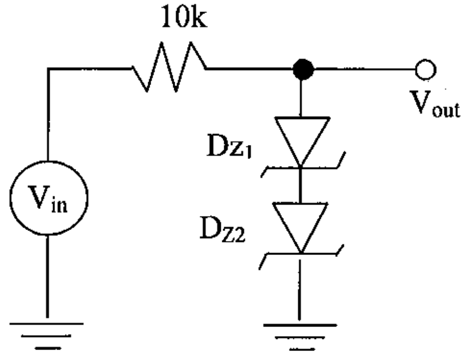
$$I_{in} = \frac{5}{10} = 0.5 \text{ mA}$$

$$V_o = -0.025 \ln \frac{0.5\times10^{-3}}{10^{-14}}$$

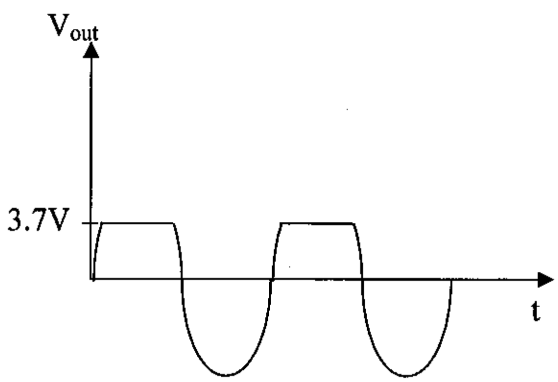
$$V_o = -0.61 V$$

4. For the circuit shown below, if a sinusoidal wave is applied to the input, which one of the curves is the output voltage? (V_{on}=0.7V, V_Z=3V)

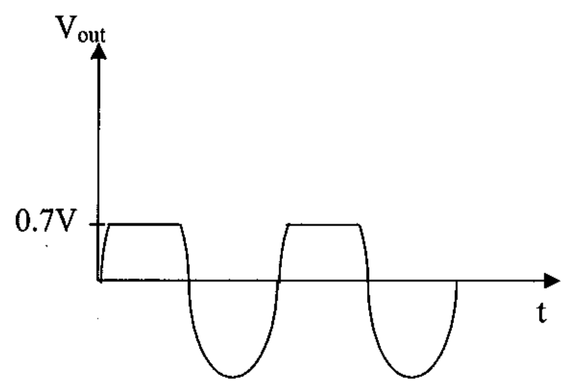




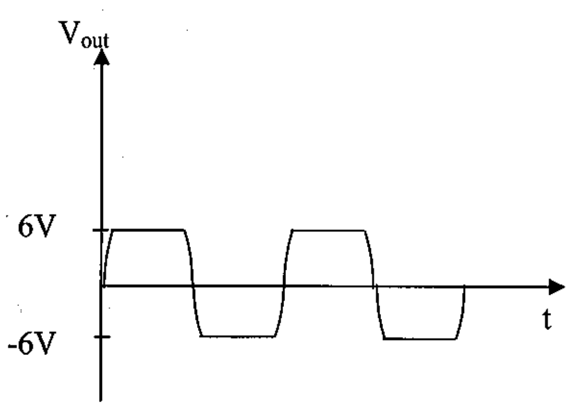
(1)



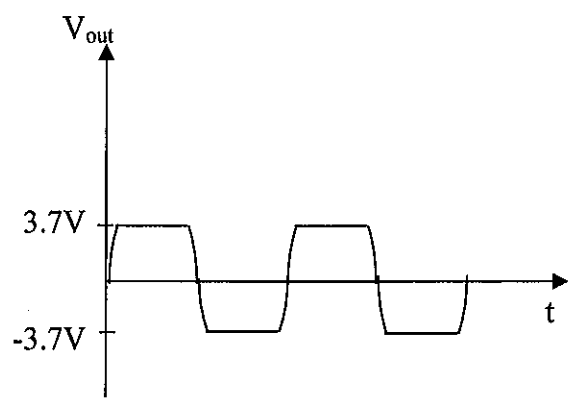
(2)



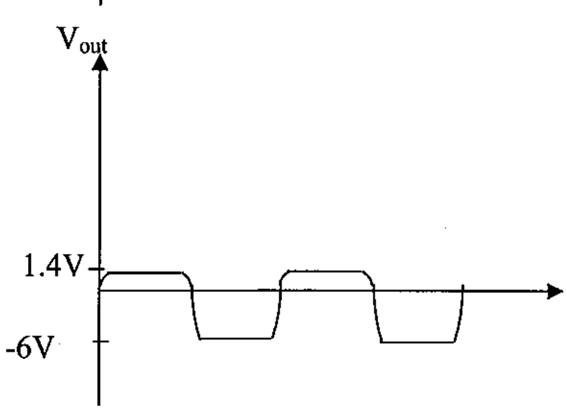
(3)



(4)

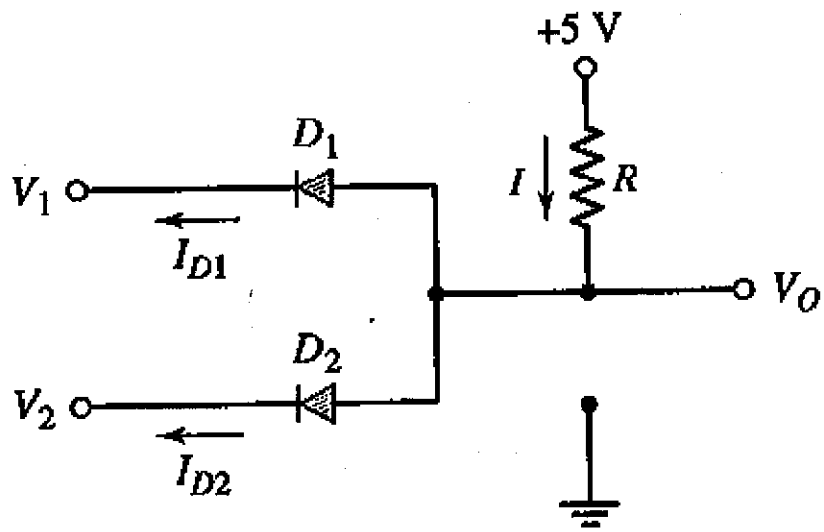


(5)



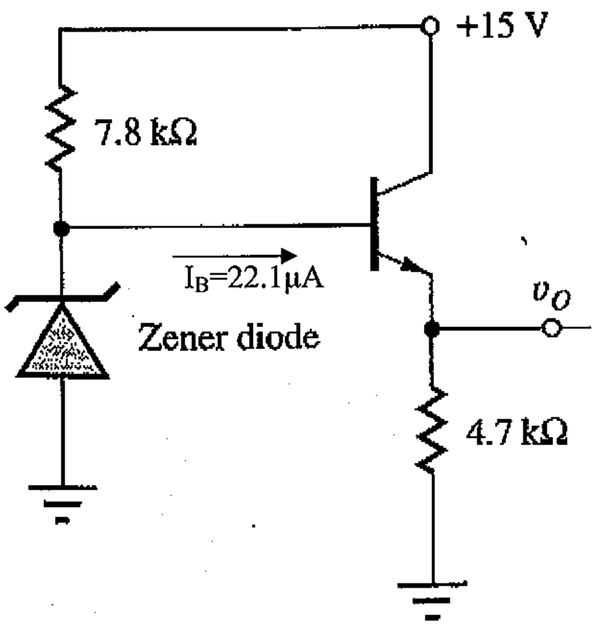
(6) None of these

5. The circuit shown below is a



(1) Two input AND gate
(2) Two input OR gate
(3) Two input NAND gate
(4) Two input NOR gate
(5) Two input XOR gate
(6) None of the above

6. For the circuit shown below what is the value of $\beta_F=50$? Assume for transistor $V_{BE}(on)=0.7V$. For Zener diode $V_Z=6V$, $R_Z=0$, $I_S=10^{-16}A$,



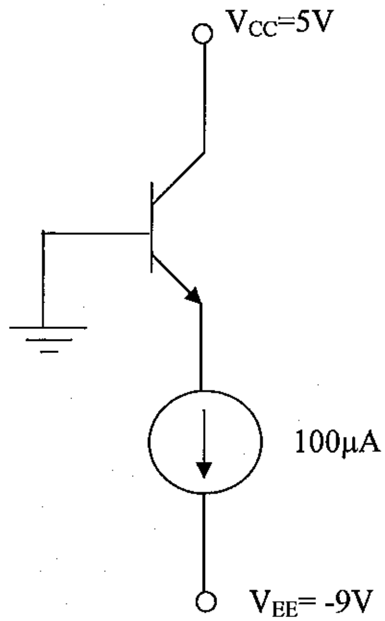
(1) 100
(2) 80
(3) 75
(4) 125
(5) 50
(6) None of the above

$$I_E = \frac{6-0.7}{4.7K} = 1.128 \text{ mA}$$

$$\beta+1 = \frac{I_E}{I_B} = \frac{1.128}{0.0221}$$

$\beta = 50$

7. For the bipolar circuit shown below, V_{CE}=?
β=100, $I_s=10^{-14}$A, and V_T=25mV



(1) 14V (2) 5.57V (3) 0.7V (4) 5V
(5) 4.42 (6) None of the above

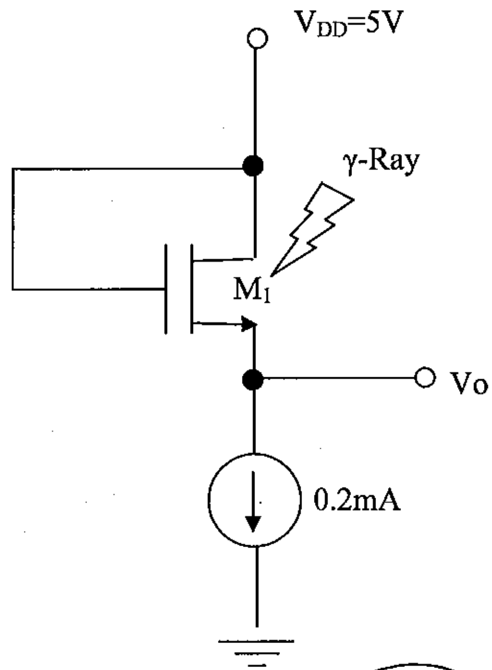
$$V_{BE} = 0.025 \ln \frac{100 \times 10^{-6}}{10^{-14}} = 0.576$$

$$V_E = -0.576$$

$$V_{CE} \cong 5.57$$

8. The circuit shown below can be used to measure the ionizing radiation (X rays and γ rays). The FET is called a RADFET and its threshold voltage is a function of the amount of radiation. What is the MOSFET threshold voltage if V_o is measured to be 1.5V. **(10 Points)**

Assume K_N=0.1 mA/V^2



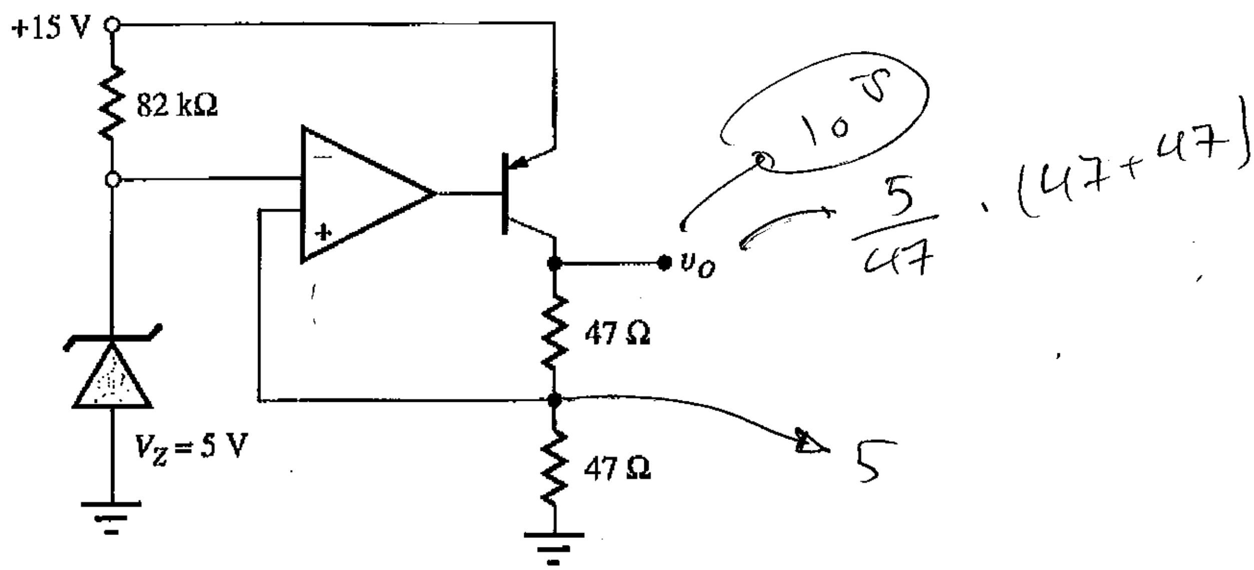
(1) 1V (2) 2V (3) -5V (4) 3V **(5) 1.5V**
(6) None of the above

$V_{GS} = 5 - 1.5 = 3.5$

$I_D = \frac{K_N}{2}(V_{GS} - V_{TN})^2$

$0.2 = \frac{0.1}{2}(3.5 - V_{TN})^2 \Rightarrow V_{TN} = 1.5V$

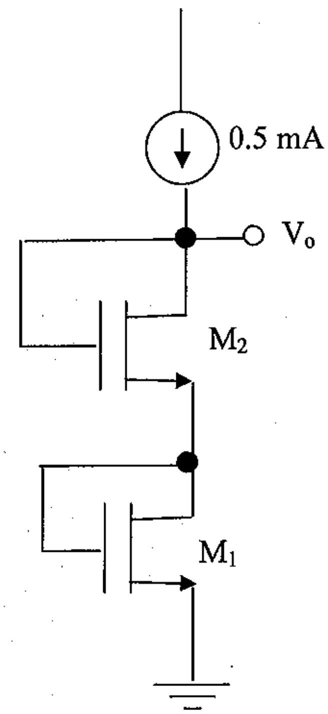
9. For the circuit shown below VCE? Assume OpAmp is ideal and β=40



(1) 5V (2) 10V (3) -5V (4) -10V (5) -0.7V
(6) None of the above

$U_o = 10$ V → $V_{CE} = 10 - 15 = -5$ V

10. Find the output voltage (V_o) for the circuit shown below, $V_{TN}=0.75V$, $K'_N=100\mu A/V^2$, $(W/L)_1=(W/L)_2=10/1$



(1) 3.5V (2) 1.75V (3) 0V since both MOSFETS have their gate and drain shorted
(4) 7.8V (5) it is open circuit (6) None of the above

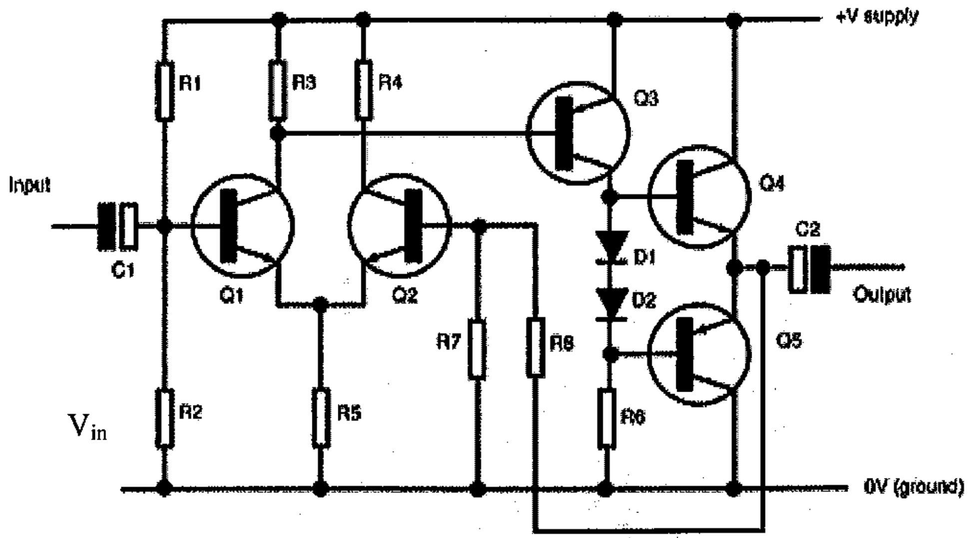
$$V_o = V_{GS1} + V_{GS2} = 2V_{GS1}$$

$$I_D = \frac{K_N}{2}(V_{GS} - V_T)^2$$

$$0.5 = \frac{0.1}{2} \times 10\,(V_{GS} - 0.75)^2$$

$$V_{GS} = 1.75 \rightarrow V_o = 3.5\ V$$

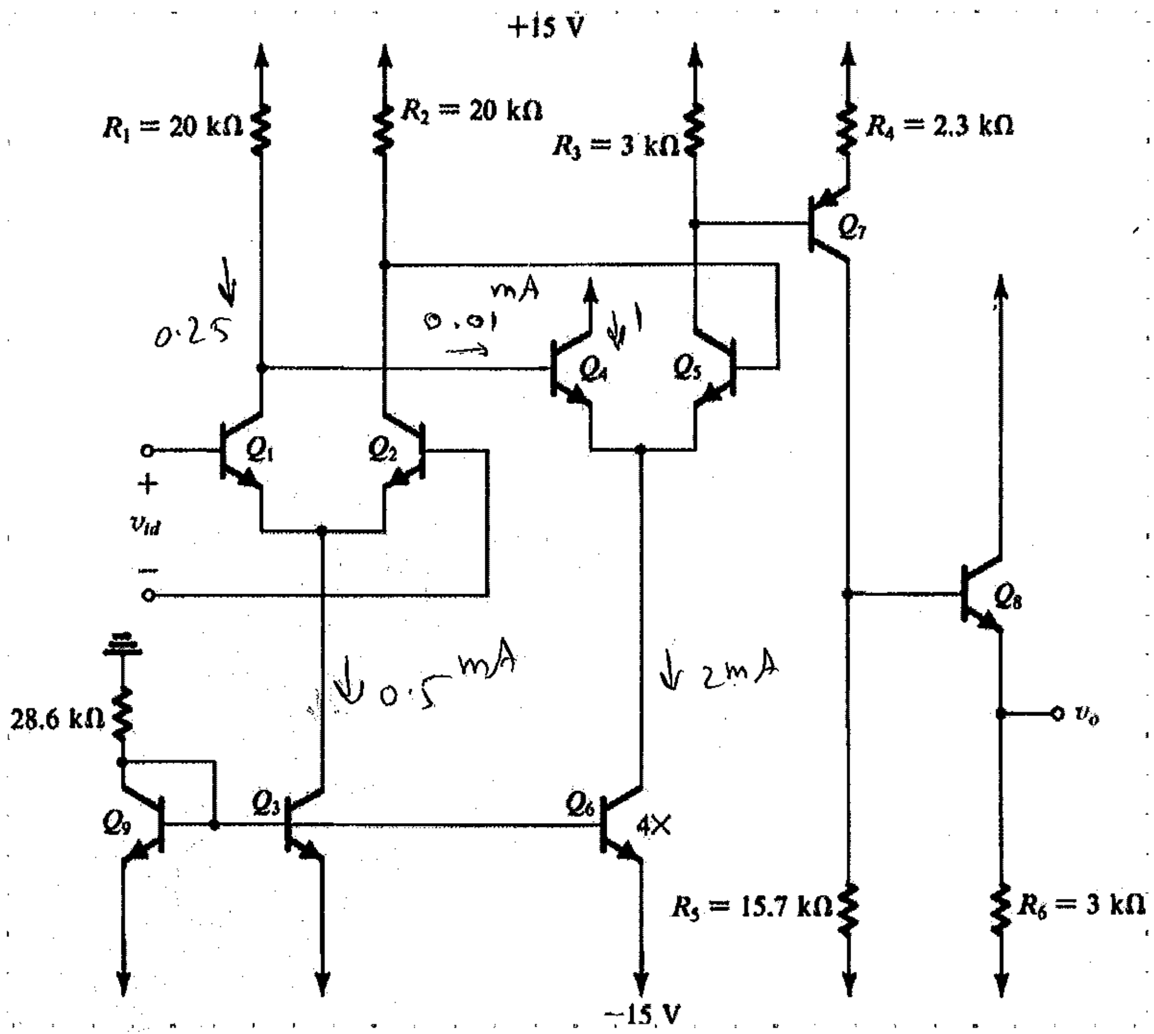
11. What is the configuration of the multi-stage amplifier shown below?



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

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

12. Figure below is internal structure of an OpAmp, what is the common mode gain of the first stage ($|A_{dm}|$)? Assume identical transistors for differential pairs, β=100, V_A=100V, and $V_{BE}(ON)$=0.7V



(1) 200 (2) 125 (3) 400 (4) 22 (5) 12
(6) None of the above

$A_d = g_m R_L$

$\frac{0.25\times10^{-3}}{0.025} \times 2.2\times10^3$

22

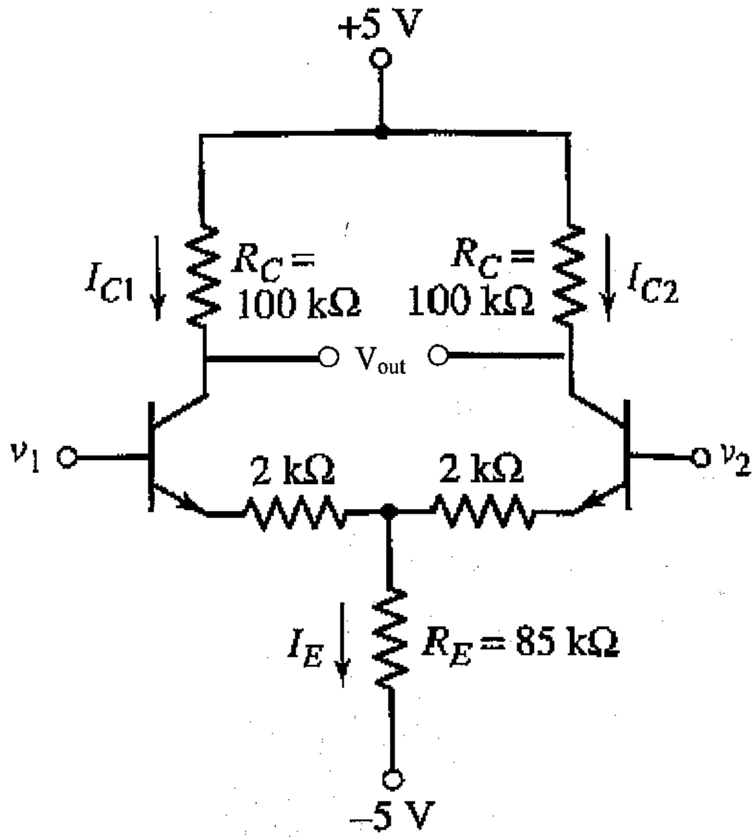
$R_L = 20^k \| r_{o1} \| r_{\pi 4}$

$r_{o1} = \frac{V_A}{0.25} = \frac{100}{0.25} = 400\ k\Omega$

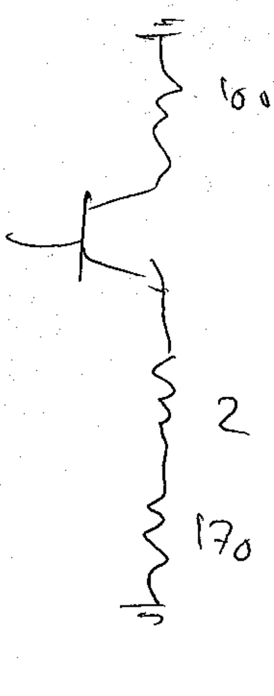
$r_{\pi 4} = \frac{V_T}{I_{B4}} = \frac{0.025}{0.01\times10^{-3}} = 2500\ \Omega$

$R_L = 20k \| 400k \| 2.5k = 2.2k$

13. What is the common mode gain ($|A_{cm}|$) for the circuit shown below?



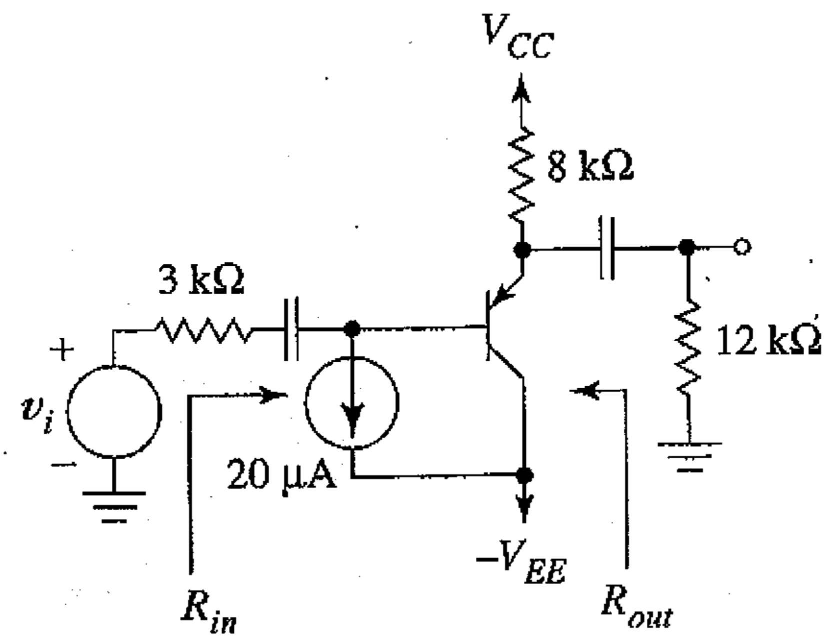
(1) 50 (2) 0 (3) 1 (4) 0.25 (5) 0.58
(6) None of the above



$A_{cm} = \frac{100}{172} = 0.58$

Half circuit

14. For the emitter-follower shown below, what is R_{in}? Assume β=100, $V_{BE}(on)$=0.7, $V_A=\infty$, V_T=25mV



(1) 1.25kΩ (2) 800kΩ (3) 48Ω **(4) 480kΩ**
(5) 500Ω (6) None of the above

$\frac{V_T}{I_B} = \frac{0.025}{20\times10^{-6}} = 1250\,\Omega$

~~$R_{in} = \frac{(12\|8)}{101} + r_\pi$~~

~~$R_{in} = \frac{(12\|8)}{101} + 1250$~~

960Ω

$R_{in} = (12\|8)(100) + r_\pi$

$= 480k + 1.25k \sim 480k$

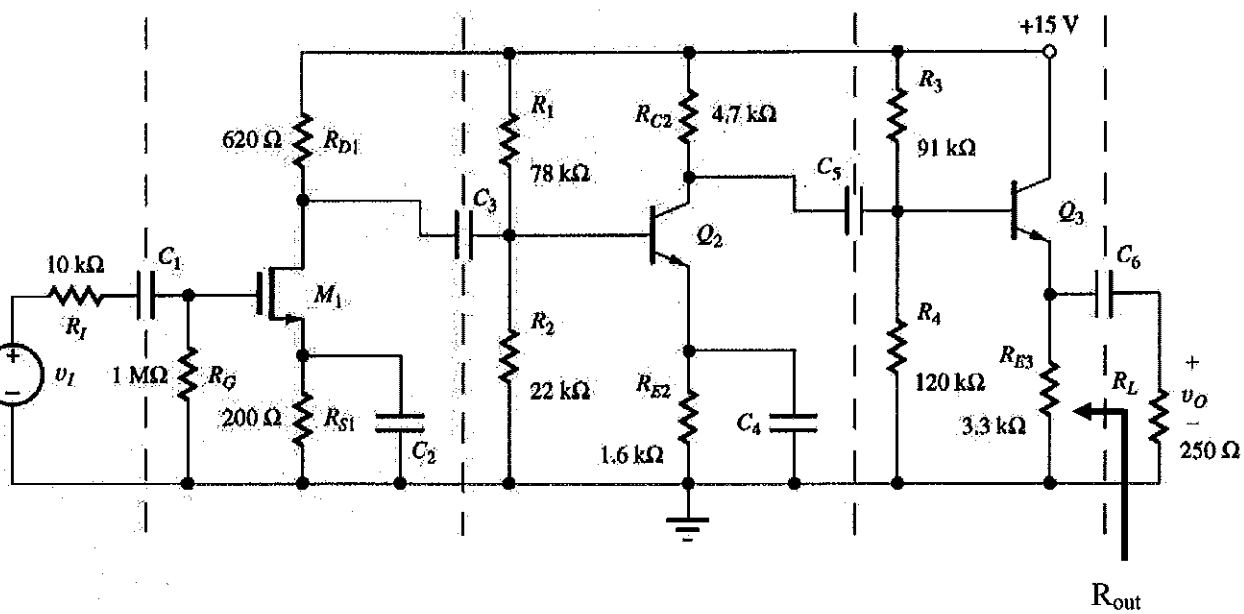
15. What is the output impedance of the following multi-stage amplifier? Assume the following parameters and small signal parameters for the transistors,

TABLE 14.17
Transistor Parameters for Figs. 14.38–14.43

M_1	$K_n = 10\ \text{mA/V}^2$, $V_{TN} = -2$ V, $\lambda = 0.02\ \text{V}^{-1}$
Q_2	$\beta_F = 150$, $V_A = 80$ V, $V_{BE} = 0.7$ V
Q_3	$\beta_F = 80$, $V_A = 60$ V, $V_{BE} = 0.7$ V

TABLE 14.18
Q-Points and Small-Signal Parameters for the Transistors in Fig. 14.39

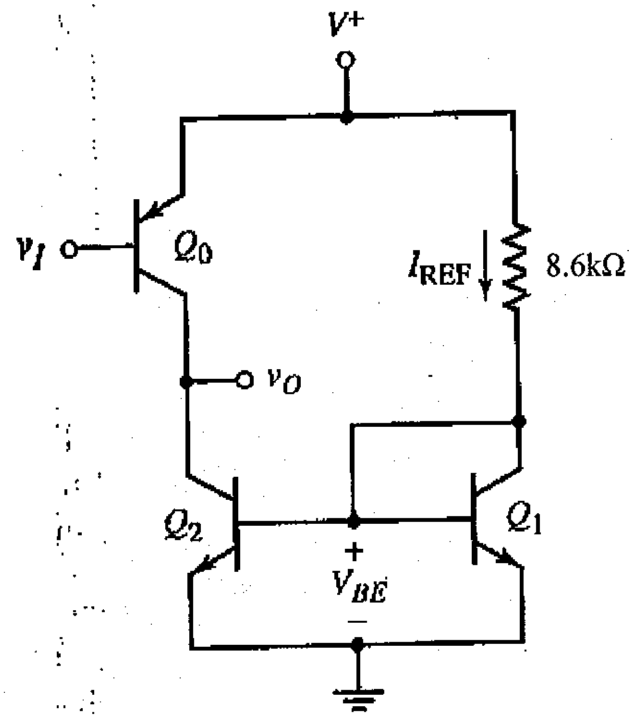
	Q-POINT VALUES	SMALL-SIGNAL PARAMETERS
M_1	(5.00 mA, 10.9 V)	$g_{m1} = 10.0$ mS, $r_{o1} = 12.2$ kΩ
Q_2	(1.57 mA, 5.09 V)	$g_{m2} = 62.8$ mS, $r_{\pi 2} = 2.39$ kΩ, $r_{o2} = 54.2$ kΩ
Q_3	(1.99 mA, 8.36 V)	$g_{m3} = 79.6$ mS, $r_{\pi 3} = 1.00$ kΩ, $r_{o3} = 34.4$ kΩ



(1) ~60Ω (2) ~3.3kΩ (3) ~33kΩ (4) ~120Ω (5) 1250Ω
(6) None of the above

$$R_{out} = \frac{(4.7 \| 54.2 \| 120 \| 91) + 1\ \text{k}\Omega}{81} \| 3.3\ \text{k}\Omega$$

16. What is the Mid-band gain ($|A_{mid}|$) of the following amplifier? V+=5V, Q_0, Q_1, and Q_2 are identical and have the following parameters, β=100, $V_{BE}(on)$=0.7, V_A=100, $V_T = 0.025$



(1) 1000 (2) 2000 (3) 4000 (4) 500 (5) 250
(6) None of the above

$$A = g_m R_L = \frac{0.5\times10^{-3}}{0.025} \times 100\times10^{3} = 2000$$

$$I_{ref} = \frac{5-0.7}{8.6} = 0.5\,mA$$

$$R_L = r_{o0} \| r_{o1} = 100\,k\Omega$$

$$r_o = \frac{V_A}{I_C} = \frac{100}{0.5} = 200\,k\Omega$$

17. For an amplifier, the high frequency gain transfer function is given by

$$A_H(s) = \frac{2.5\times10^{10}(s+2\times10^5)}{(s+10^5)(s+10^8)}$$

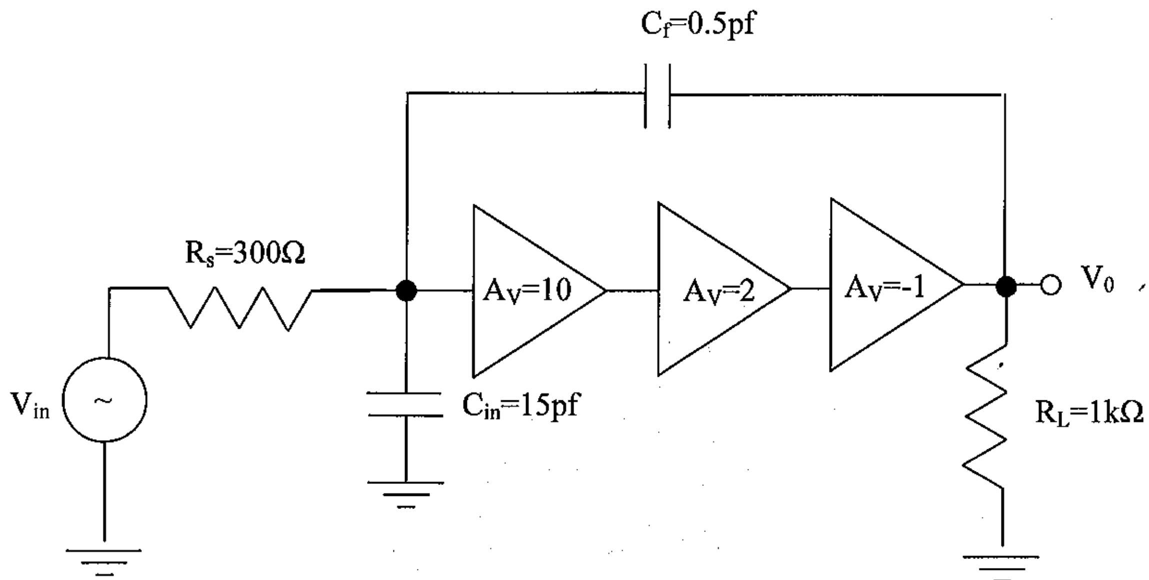
Mid-band gain (A_{mid}) and higher cutoff frequency (ω_H) are? Assume diminant pole approximation when trying to find ω_H

(1) A_{mid}=500, $\omega_H=10^8$ rad/s (2) A_{mid}=250, $\omega_H=10^5$ rad/s (3) $A_{mid}=2.5\text{x}10^{10}$ $\omega_H=10^5$ rad/s
~~(4) A_{mid}=500, $\omega_H=10^5$ rad/s~~ (5) $A_{mid}=2.5\text{x}10^{10}$, $\omega_H=10^8$ rad/s
~~(6) None of the above~~

$$A_H(s) = 2.5\times10^{10} \frac{2\times10^5\left(1+\frac{s}{2\times10^5}\right)}{10^5\times10^8\left(1+\frac{s}{10^5}\right)\left(1+\frac{s}{10^8}\right)}$$

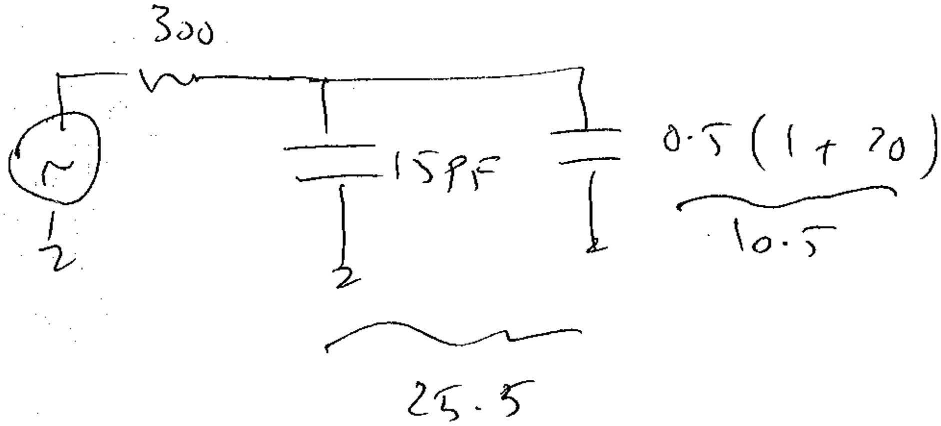
$$= 500 \frac{1}{1+\frac{s}{10^5}}$$

18. For the amplifier circuit shown below, find f_H?



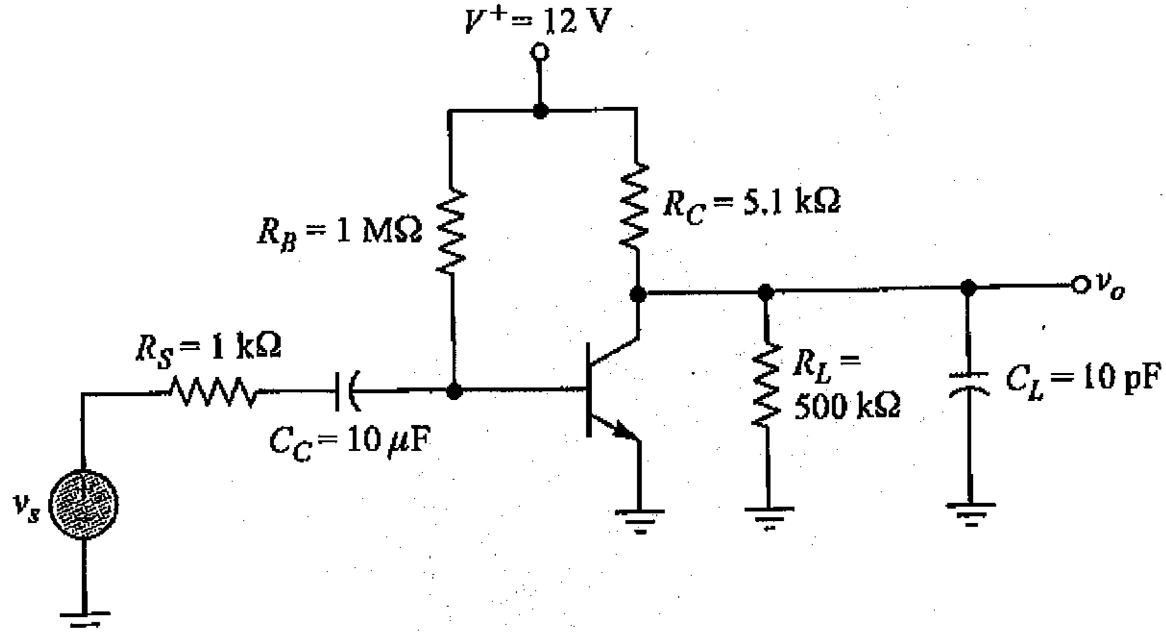
(1) ~106MHz (2) ~15MHz (3) ~35MHz (4) ~50MHz

(5) ~2[illegible]MHz (6) None of the above

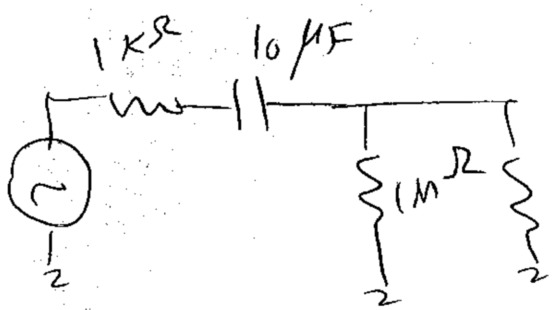


$$f_H = \frac{1}{2\pi \times 300 \times 25.5 \times 10^{-12}} \approx 21\ \text{MHz}$$

19. What is the lower cutoff frequency (f_L) of the common emitter amplifier shown below? Assume $\beta=100$, $V_{BE}(on)=0.7$, $V_A=\infty$



(1) ~0.016Hz (2) ~5Hz (3) ~0.3Hz (4) ~50Hz
(5) ~1Hz ~~(6) None of the above~~



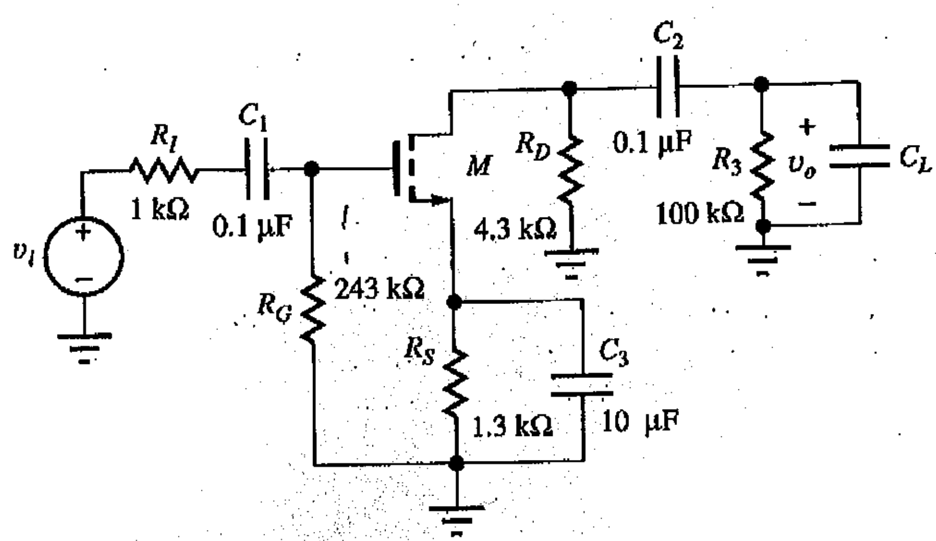
$r_\pi = \frac{V_T}{I_B} = \frac{0.025}{11.3\times10^{-6}} = 2212\ \Omega$

$I_B = \frac{12-0.7}{1\,M\Omega} = \frac{11.3}{1\,M\Omega} = 11.3\ \mu A$

$R_{total} = 2212 + 1000 = 3212$

$f_L = \frac{1}{2\pi\times10\times10^{-6}\times3212} = 5\ Hz$

20. The short circuit time constant associated with C_{gs} in the common source amplifier shown below is? (Assume C_{gs}=10pF)



(1) ~2.5s
(2) ~5ns
(3) ~10ns
(4) ~10μs
(5) ~1ns
(6) None of the above

C_{gs} = 10 pF

$\tau = (1^K \| 243^k) \cdot 10\,pF = 1^K \cdot 10\,pF = 10\ ns$