University of Toronto

Dept. of Electrical and Computer Engineering

Final

Date - April 19, 2001

Duration: 2.5 Hr.

ECE231S — Introductory Electronics

Lecturers - D.A. Johns, N. Kherani, T. Kosteski

ANSWER QUESTIONS ON THESE SHEETS **USING BACKS IF NECESSARY**

1. Two handwritten aid-sheets allowed and calculator type unrestricted.
2. Grading indicated by [ ]. Attempt all questions since a blank answer will certainly get 0.

Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

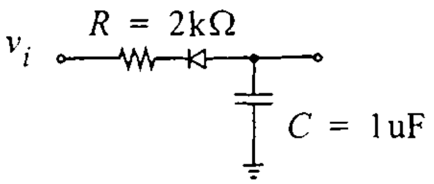
Last Name: ____________________

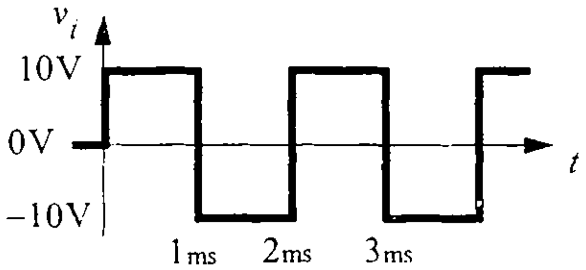
First Name: ____________________

Student #: ____________________

(max grade = 50)

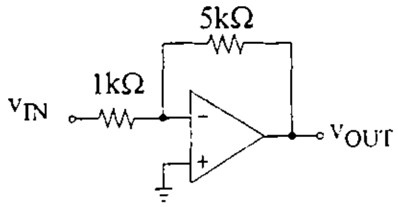
[5] Question 1: Consider the circuit below. Assuming the diode is ideal and the capacitor is initially discharged, find the output voltage at time just before $t = 3\text{ms}$. (Hint, make a sketch of the output waveform).





$$\left. v_o \right|_{t = 3\text{ms}} =$$

[5] Question 2: The opamp in the circuit below is ideal except for a unity-gain bandwidth of $\omega_t = 2 \times 10^7$ rad/sec and a slew-rate of $SR = 1\,\mathrm{V}/\mu\mathrm{sec}$. Given that the input will be a step function, find the maximum size of the input step before the opamp slew-rate limits

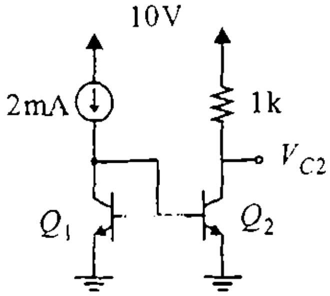


Max input step =

[5] **Question 3:** A given diode is measured to have an on voltage of 0.65V when a current of $1\,\text{mA}$ is applied through it. In addition, it is found that for every decade increase in current, the diode on voltage increases by 0.11V. Find n and I_s for this diode. ($V_T = 25\text{mV}$)

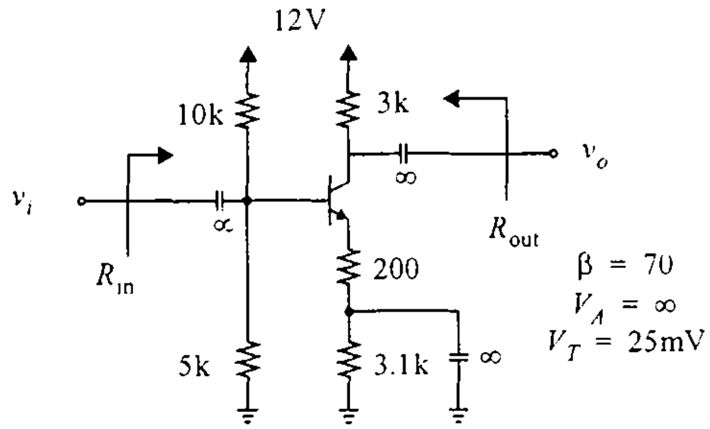
$n =$	$I_s =$

[5] **Question 4**: Assuming $\beta = 20$ and $I_{s2} = 2I_{s1}$, find the voltage, V_{C2}. Ignore the Early effect.



V_{C2} =

[5] **Question 5:** For the circuit below find the small-signal gain v_o / v_i, input resistance R_{in} and- output resistance R_{out}. For dc analysis assume β goes to infinity.

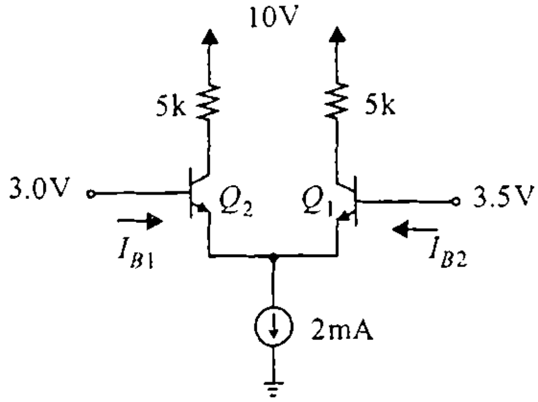


$\frac{v_o}{v_i} =$

$R_{in} =$

$R_{out} =$

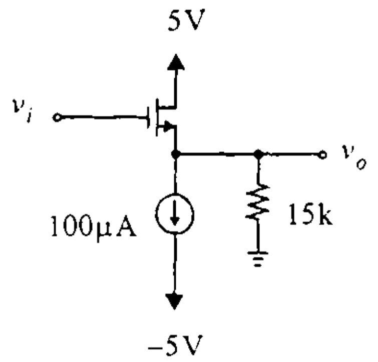
[5] **Question 6:** For the circuit below, find the base currents, I_{B1} and I_{B2}. For the transistors, $\beta = 100$, $V_A = \infty$, and $V_{CESAT} = 0.2\text{V}$.



$I_{B1} =$

$I_{B2} =$

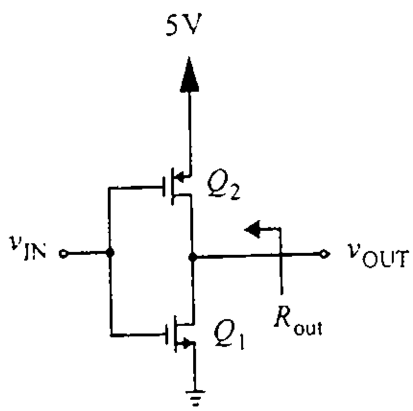
[5] Question 7: An NMOS transistor with $W = 10\mu m$ and $L = 0.5\mu m$ in a technology with $\mu_n C_{ox} = 100\mu A/V^2$ and $V_t = 1V$ is used in the circuit below. Ignoring the Early effect, find v_o/v_i when the dc value of v_i is adjusted such that v_o is biased to zero volts. Also find the minimum output voltage.



$$\frac{v_o}{v_i} =$$

$$v_o\big|_{min} =$$

[5] Question 8: For the CMOS inverter shown below, find the output resistance when $v_{IN} = 0V$.



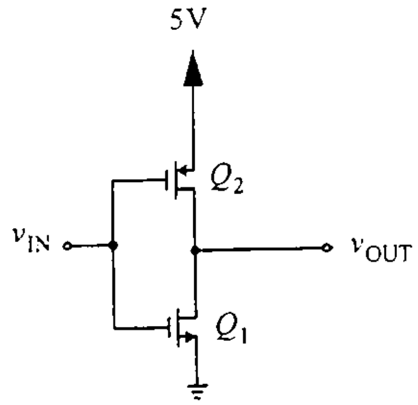
$\mu_n C_{ox} = 3\mu_p C_{ox} = 100\mu A/V^2$

$V_{tn} = |V_{tp}| = 1V$

$\left(\frac{W}{L}\right)_1 = 10 \quad \left(\frac{W}{L}\right)_2 = 20$

$R_{out} =$

[5] **Question 9**: For the CMOS inverter shown below, find the size of Q_2 such that when the Early effect is ignored, the small-signal gain goes to minus infinity at $v_{IN} = 2.0\text{V}$.



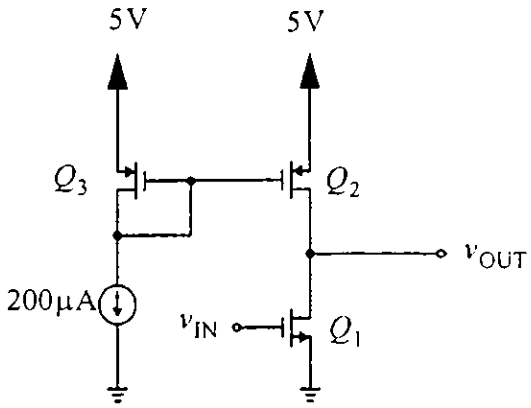
$$\mu_n C_{ox} = 3\mu_p C_{ox} = 100\mu\text{A/V}^2$$

$$V_{tn} = |V_{tp}| = 1\text{V}$$

$$\left(\frac{W}{L}\right)_1 = 10$$

$$\boxed{\left(\frac{W}{L}\right)_2 = \quad}$$

[5] Question 10: Consider the circuit below. Given that the output voltage is equal to $v_{OUT} = 4.9\text{V}$, find the current, I_{D2}. Ignore the finite-output impedance of the transistors.



$$\mu_n C_{ox} = 3\mu_p C_{ox} = 100\mu\text{A/V}^2$$

$$V_{tn} = |V_{tp}| = 1\text{V}$$

$$\left(\frac{W}{L}\right)_1 = 10 \qquad \left(\frac{W}{L}\right)_2 = 10 \qquad \left(\frac{W}{L}\right)_3 = 20$$

$I_{D2} =$

Scratch sheet (can be used for rough calculations)