Student Name:

Student ID:

Date: 20/05/2014

ELE222E Introduction to Electronics
FINAL EXAM

Duration: 120 Minutes

Grading: 1) 20%, 2) 20%, 3) 20%, 4) 20%, 5) 20%

Exam is in closed-notes and closed-books format; calculators are allowed

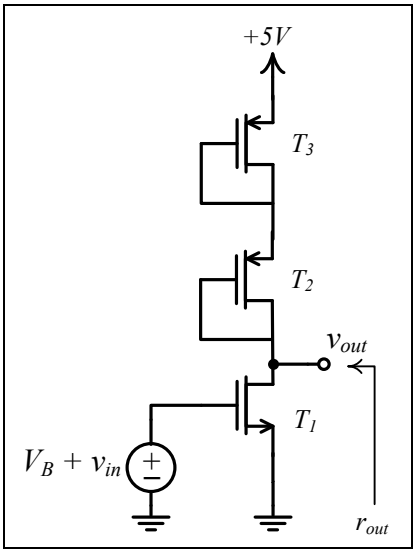
For your answers please use the space provided in the exam sheet

GOOD LUCK!

1) Suppose that ***V_B = 1,5V*** and all NMOS/PMOS transistors are identical. In DC analysis, use the following equation:

$$I_D = \frac{1}{2} k'_{p,n} \frac{W}{L} (V_{GS} - V_{T0\,p,n})^2 .$$

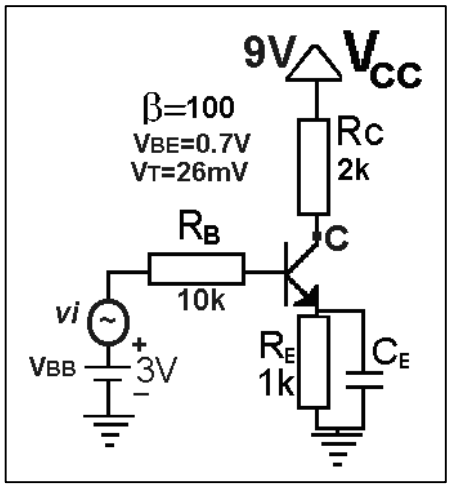
Transistor parameters: $k_p'=\mu_p C_{ox}$=50µA/V^2, $k_n'=\mu_n C_{ox}$=100µA/V^2, V_{An}= V_{Ap} =100V, $V_{T0,p}$=-1V, $V_{T0,n}$=1V, W_P=16µm, L_P=1µm, W_n=8µm, L_n=1µm.



Common Source Amplifier

Determine the small signal gain ***v_{out}/v_{in}*** and the small signal output resistance ***r_{out}*** of the amplifier shown above.

2) Consider an amplifier shown below. Suppose that the value of the coupling capacitor C_E is high enough, so it can be considered shorted in small signal analysis.
Transistor parameters: V_{BE} = 0,7V, $\beta = h_{fe}$ = 100, V_T =26mV, $V_A = \infty$.



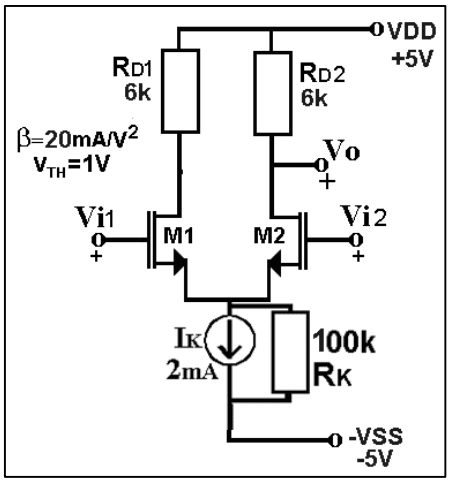
Common Emitter Amplifier

a) Find the DC value of the collector current I_C.
b) If a sine signal with 10mV peak-to-peak amplitude is applied to $\mathbf{v_i}$ then determine the collector voltage $\mathbf{v_C}$'s peak-to-peak amplitude.
- Hint: you should find the small signal gain $\mathbf{v_C/v_i}$ of the amplifier.

3) Consider a differential amplifier shown below. In DC analysis, use the following equation:

$$I_D = \frac{\beta}{2}(V_{GS} - V_{TH})^2 .$$

MOS transistor parameters: β = 20 mA/V^2, $V_A=\infty$, V_{TH}=1V.



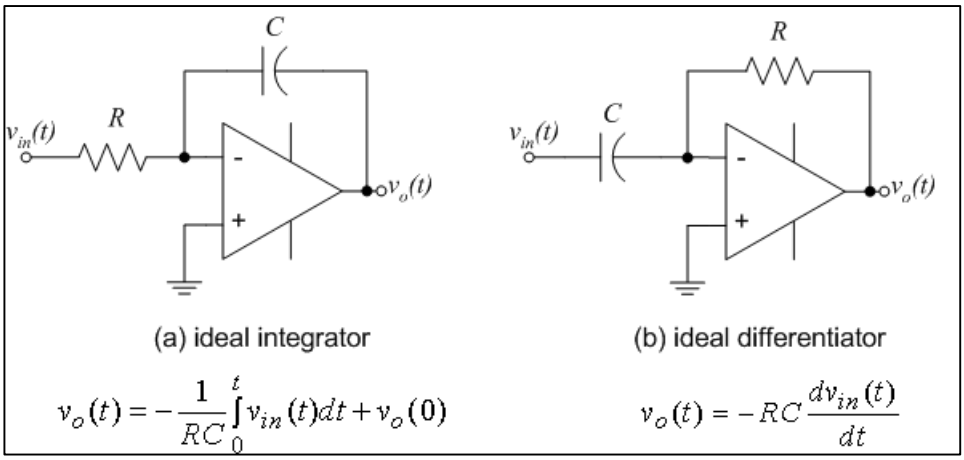
Differential Amplifier

a) If sine signals with 20mV and 5mV peak-to-peak amplitudes are applied to $\mathbf{v_{i1}}$ and $\mathbf{v_{i2}}$, respectively then determine $\mathbf{v_o}$'s peak-to-peak amplitude.
- Hint: you should find the small signal differential gain $v_o/(v_{i1}- v_{i2})$ of the amplifier.

b) If sine signals with 10mV and 10mV peak-to-peak amplitudes are applied to $\mathbf{v_{i1}}$ and $\mathbf{v_{i2}}$, respectively then determine $\mathbf{v_o}$'s peak-to-peak amplitude.
- Hint: you should find the small signal common-mode gain Vo/Vi of the amplifier.

c) Design a BJT current source for I_K. Suppose that V_{BE}=0,6V and β = 200 (base current is negligible) . Neglect Early effect.
- Hint: the current source preferably has two BJT transistors and a resistor.

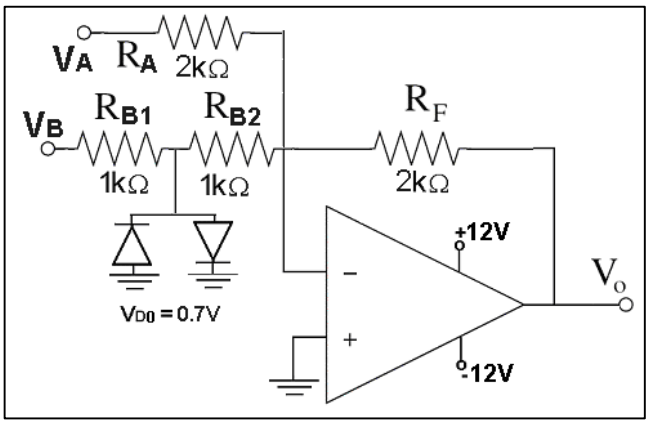
4) Consider ideal OP-AMP based integrator and differentiator circuits shown below. For an ideal OP-AMP, input voltage values are **same** and input current values are both **zero**.



Design an ideal OP-AMP based circuit satisfying the following specification:

$$V_o(t) = \frac{1}{RC}\int dtV_i(t) + RC\frac{dV_i(t)}{dt}$$

5) Consider the ideal OP-AMP based circuit shown below. For an ideal OP-AMP, input voltage values are **same** and input current values are both **zero**. Diodes have **0,7V** forward voltage values.



OP-AMP Based Circuit

For the circuit shown above, derive an expression of $\mathbf{V_o}$ in terms of the inputs $\mathbf{V_A}$ and $\mathbf{V_B}$.