Name: 

Tufts University, ECE Dept. 
EE 12: Midterm Exam, Spring 2008

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points:</td>
<td>15</td>
<td>30</td>
<td>25</td>
<td>20</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>Score:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructions

- This is a **closed book** and **closed notes** exam. You are allowed hand-written two-sided 8”x11” sheet and a calculator.

- This exam has total 5 questions, for a total 110 points (10 bonus points).

- There are two blank pages provided at the end.

- Please try to enclose your answers in a box, wherever possible.
1. [15 points] Find $I_C$, $V_{CE}$ and region of operation (ie. active, saturation) for the given circuit.

Given values: $\beta = 50$, $V_{BE} = 0.7V$
2. For the common-base amplifier shown in the figure, assuming the transistor is in forward-active mode:
   (a) [15 points] Draw the small-signal model. (Neglect the output impedance ($r_o$) and assume $C_i$ to be a short for the frequency of interest.)
   (b) [15 points] Find the expression for the voltage gain ($v_o/v_i$) from the small-signal model and calculate its value for the given operating point.

**Given Values:** $V_T = 25mV$, $\beta = 100$
3. For the voltage and current equations given below:

(a) [10 points] Draw the graph with the appropriate transmission values using the nodes already drawn.

(b) [15 points] Using Mason’s Gain Formula derive the transfer function $i_s/v_s$.

\[
\begin{align*}
   i_s &= \frac{v_s - v_e}{R_s} \\
   i_e &= g_m \cdot v_e \\
   v_e &= (i_s - i_e) \cdot r \pi \\
   v_o &= i_e \cdot R_C
\end{align*}
\]

\[\begin{array}{cccccc}
   v_s & i_s & v_e & i_e & v_o \\
   \bullet & \bullet & \bullet & \bullet & \bullet
\end{array}\]
4. [20 points] Figure shows the block diagram of a sinusoidal oscillator consisting of an amplifier with frequency-independent gain $A_v$ and a frequency selective network $\beta(s)$. Find the frequency of oscillation ($\omega_o$) and $A_v$ by satisfying Barkhausen Criterion.

$$\beta(s) = \frac{s \cdot R \cdot C}{s^2 R^2 C^2 + 3 \cdot s \cdot R \cdot C + 1}$$
5. [20 points] Using the small-signal model of the common-base amplifier in Problem-2, derive the two-port model parameters shown in figure in terms of $r_\pi$, $R_C$ and ($\beta$ or $g_m$).

\[
G_m = \left| \frac{i_o}{v_i} \right|_{v_i=0} \quad G_{mr} = \left| \frac{i_i}{v_o} \right|_{v_i=0} \quad Z_{in} = \left| \frac{v_i}{i_i} \right|_{v_i=0} \quad Z_o = \left| \frac{v_o}{i_o} \right|_{v_i=0}
\]