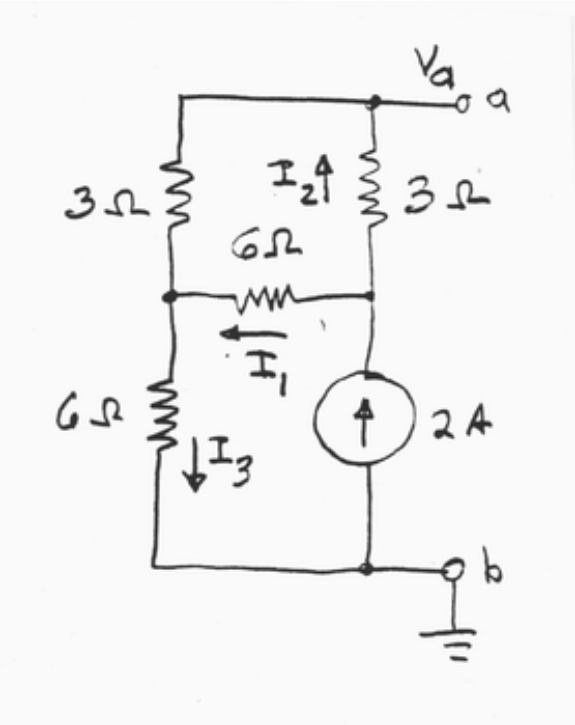
Physics 116A: Exam 1

2/3/2000

Closed book and notes except for one 8.5×11 in^2 sheet of paper. Show reasoning for full credit. There are 4 problems and 100 points.



1. Consider the circuit above with node b taken as the reference node ("ground").

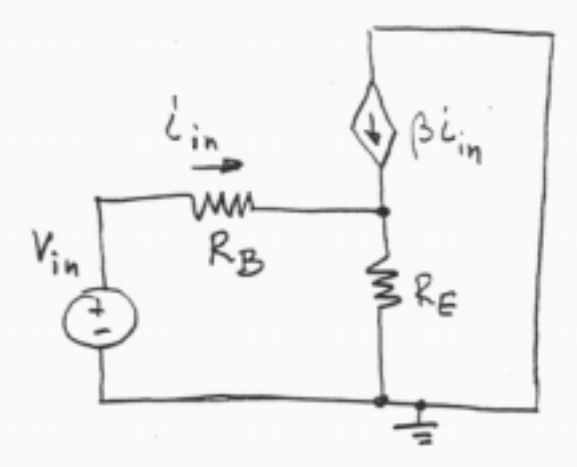
   (a) Find the currents, I_1, I_2 and I_3.

   (b) Find the open-circuit voltage, V_{oc}, between the nodes a and b (i.e., V_a).

   (c) Find the Thévenin equivalent of the circuit connected to the nodes a and b.

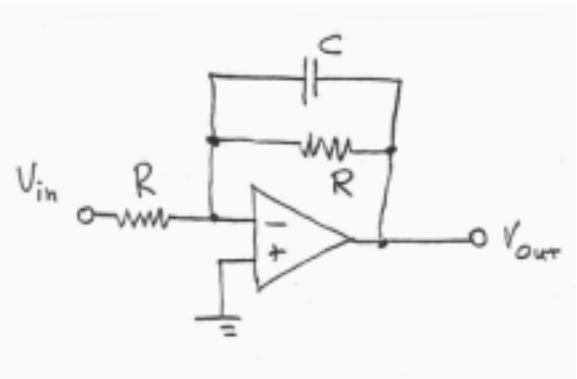
      i. Does setting the current source to zero result in (a) a short circuit or (b) an open circuit in its place?

   (d) Find the output voltage, V_a, if a 6.75 Ω resistor is connected between a and b.



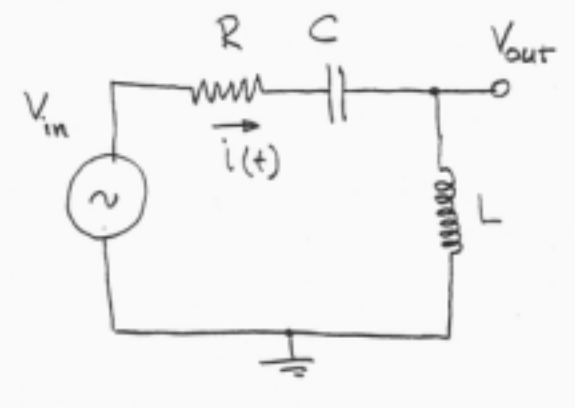
2. For the circuit above,
   (a) derive an expression for V_{in} in terms of i_{in}, R_B, R_E and β.
   (b) Find the effective resistance, $R_{eff} = \frac{V_{in}}{i_{in}}$.
   (c) Estimate R_{eff} for $R_B = 2500\ \Omega$, $R_E = 200\ \Omega$ and $\beta = 100$.

3. For the circuit below, assume the op-amp is ideal.



   (a) Is there a *virtual ground* in this circuit, and if so, where?
   (b) Find $\mathbf{H}(\mathbf{j}\omega) = \mathbf{V_{out}}/\mathbf{V_{in}}$. Note that complex quantities are given in **boldface** type.
   (c) Let $\omega_0 = 1/RC$. FInd an expression for $|\mathbf{H}(\mathbf{j}\omega)|$ and approximate expressions when
      i. $\omega >> \omega_0$
      ii. $\omega << \omega_0$.

      How would you characterize this circuit as a filter circuit (e.g., high pass, low pass, band pass, etc.)?
   (d) Suppose $V_{in} = 2.0$ V $\cos(\omega_0 t)$. Find the amplitude and relative phase of the output voltage.



4. (a) For the circuit above, find an expression for $\mathbf{H}(\mathbf{j}\omega) = \mathbf{V_{out}}/\mathbf{V_{in}}$ in terms of ω, R, L and C.

   (b) Let $\omega_R = 1/\sqrt{LC}$. Find $|\mathbf{H}(\omega/\omega_\mathbf{R})|$.

   (c) Find $\mathbf{H}(\mathbf{s})$.

   (d) Does $\mathbf{H}(\mathbf{s})$ have any zeros? If so, where?

   (e) Suppose the circuit has $L = 2.0$ mHy, $R = 2.0\ \Omega$ and $C = 0.10\ \mu$F. Then $f_R = \omega_R/2\pi = 11.3$ KHz and $Q = 70.7$. There is a sharp peak in a plot of the amplitude of the current against frequency. Estimate the full width of this peak at the half-power point.

   (f) For the values above, where would you expect the poles of $\mathbf{H}(\mathbf{s})$ to be in the complex $\mathbf{s}$ plane among the following choices:

      i. on the negative real axis;

      ii. complex conjugate points in the left half-plane;

      iii. complex conjugate points on the imaginary axis;

      iv. none of the above.