Northeastern University
College of Engineering

EECE2150 Circuits and Signals: Biomedical Applications

Final Exam

April 29, 2015

Name: ____

- **Show all work** leading to the solutions.
- **Place a box or circle around all final results**.
- You may use your calculators, but are not permitted to share them.
- **Turn off your cell phone**, and remove it from your table.
- This test contains **5 problems and one 5-point extra credit problem**. If you need more space, you can write on the back of the pages.

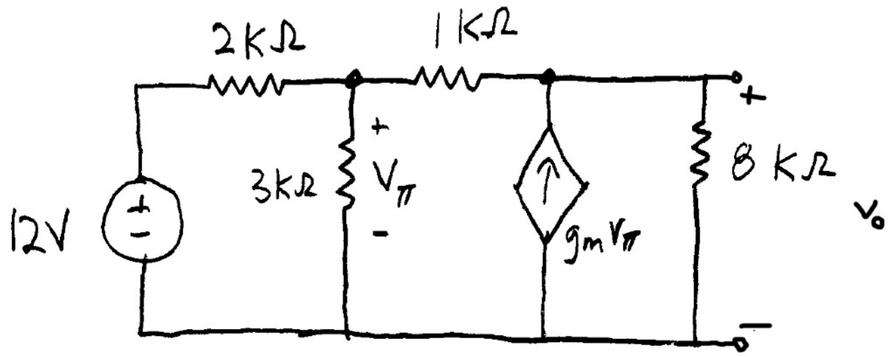
1. (20 pts) In the circuit below the $g_m = 0.03\frac{A}{V}$.

   a. Write a set of node-voltage equations and an equation of constraint expressing v_π in terms of your node voltages.

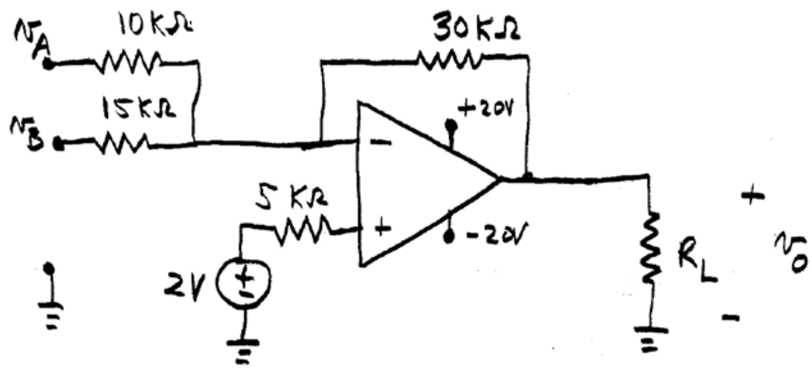
   b. Put your equations in standard form

$$\begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} V_A \\ V_B \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}$$

   c. Find the solution for v_o **OR** write the MATLAB commands you would use to find v_o.

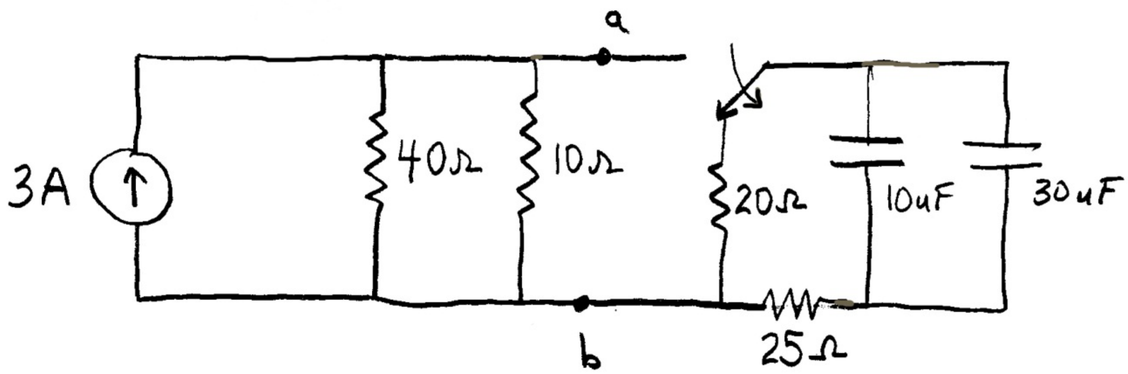


2. (20 pts) The op amp in the circuit below can be assumed to be ideal. If $v_A = 4$ V and $v_B = 1$ V find the output voltage v_o.



3. (20 pts) In the circuit shown, the switch is thrown as shown at time $t = 0$.

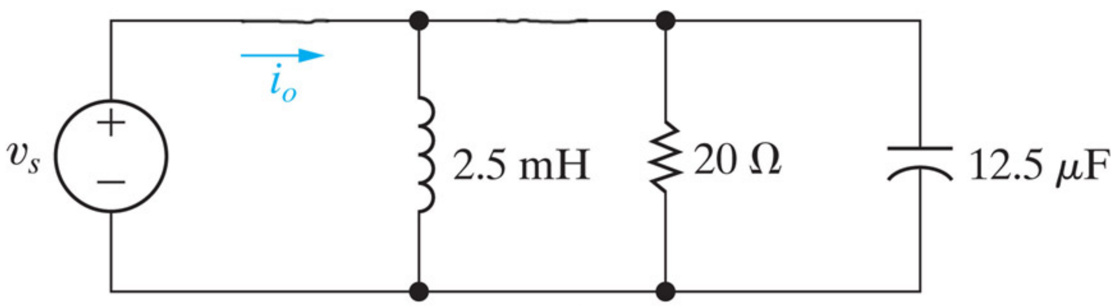
a. Convert the circuit to the left of points (a)-(b) to a Thevenin voltage source.
b. What is the equivalent capacitance of the two capacitors?
c. Find an expression for the voltage across the capacitors as a function of time $V_C(t)$.
d. What is V_C at = 4 ms ?



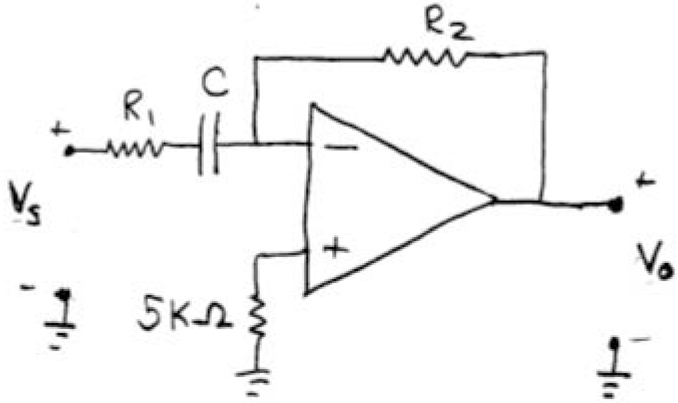
4. (20 pts) In the circuit below $v_s(t) = 3\cos 8000t$ V

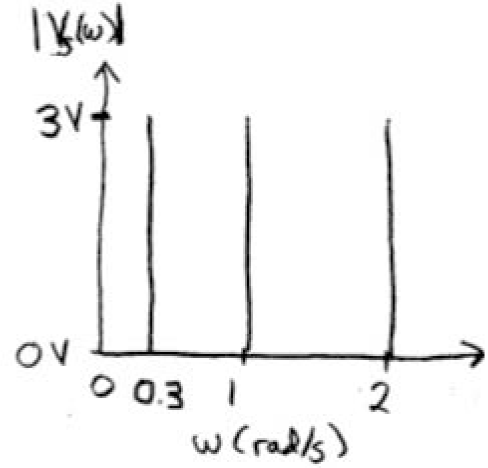
a. Find the steady-state expression for $i_o(t)$

b. Find the real power dissipated in the circuit (or equivalently the real power supplied by the source).



5. (20 pts) The following questions refer to the circuit shown.
   a. Is the op am circuit shown below a low-pass or high-pass filter?
   b. Assuming that the capacitor has a value C=10 μF, select values of R_1 and R_2 to give a cut-off frequency of $\omega_0 = 1.0$ radians/s and a high-frequency gain $\left|\frac{V_o}{V_s}\right|$=5.
   c. Assuming that you have a V_s that has Fourier components as shown in the graph, sketch what you would expect the Fourier components of V_o to be – i.e. make a plot similar to the one shown below for $V_o(\omega)$.





Extra Credit: (5 pts) Derive the frequency at which the transfer function $H(\omega) = {}^{V_o}/_{V_i}$ of the following circuit is equal to zero.