EECE 2150 – Circuits and Signals, Biomedical Applications
Final Exam – Section 3

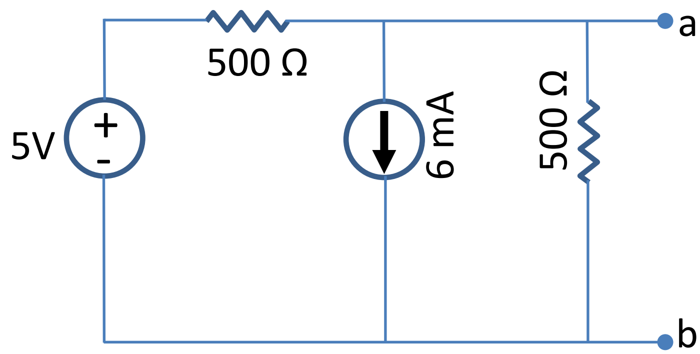
Name:

Instructions:

- Closed book, closed notes; Computers and cell phones are not allowed
- You may use the equation sheet provided but no other notes or papers
- Scientific calculators are allowed
- **Complete all 6 problems**
- The point value of each question correlates approximately with the length and/or difficulty of the solution. The problems are not necessarily meant to be in order of difficulty.
- Show all work and **place a box around all your final answers.** The more clear your work is the better the chance you will get any appropriate partial credit.
- Show your work for partial credit
- You may write on both sides of the pages but be sure it is clear what problem any work corresponds to.
- Write your name on both sides of all pages. Do that now !!

Question 1 (10 Points) **Name:**

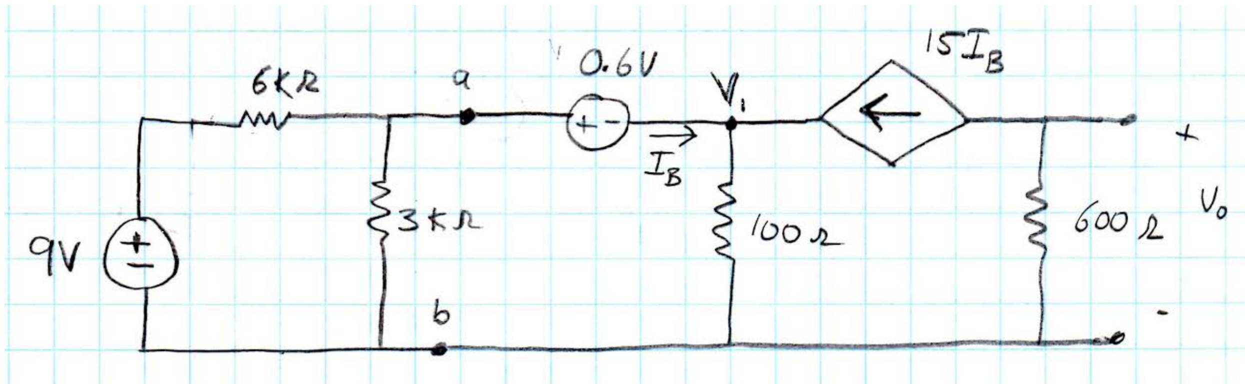
1) Find the Thevenin equivalent circuit across terminals a,b for the circuit below:



Answers: **V_{Th} =**

R_{Th} =

Question 2 (20 Points) **Name:**



2A) (***15 points***) Use the node-voltage or mesh-current circuit analysis methods (or any other method you prefer) to solve for V_1 and I_B in the circuit above. Hint: It may simplify your analysis to consider the Thevenin equivalent circuit to the left of terminals (*a,b*), but this is optional

2B) (***5 points***) Find **Vo**

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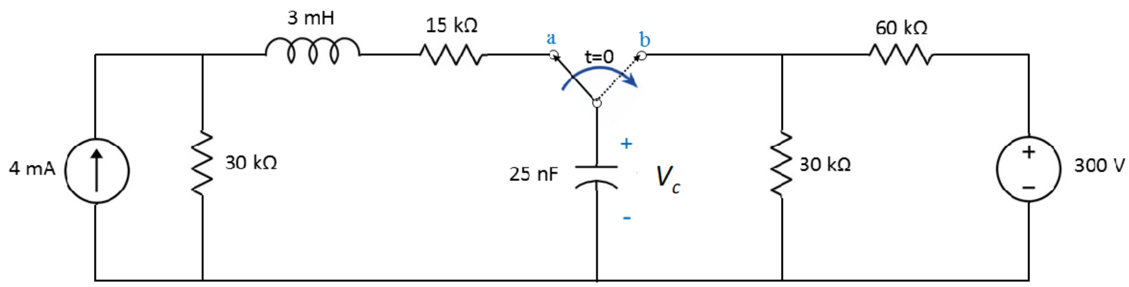
Question 2 (extra space) Name:

Question 3 (16 Points) **Name:**

For the circuit below, the switch has been in position (a) for a long time. At time t=0 the switch changes to position (b).



3A) (***6 points***) Find the voltage across the capacitor ***Vc*** for time *t = 0*, just before the switch changes

3B) (***10 points***) Find and sketch ***V_c(t)*** for *time t >= 0.*

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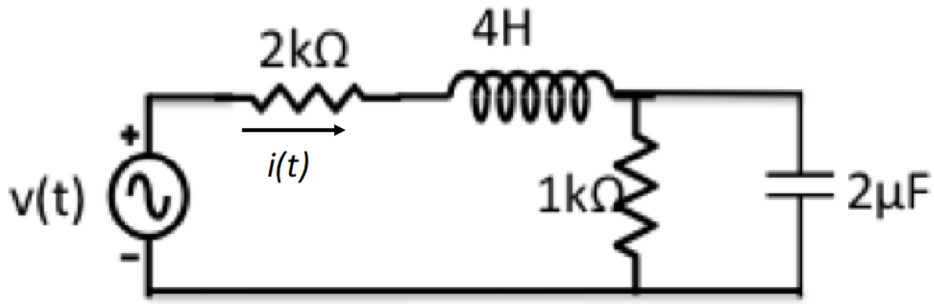
Question 3 (extra space) **Name:**

Question 4 (20 Points) **Name:**

For the circuit below, the voltage source is v(t) = 2 cos(500*t*)



(4A) (**8 points**) What is the equivalent impedance seen by the source? Reduce your answer to a single complex number in either polar or rectangular form.

(4B) (**4 points**) What two real circuit elements (e.g. R's, L's, C's, diodes etc.) in **series** will yield the equivalent impedance at the frequency above. State the physical component values, not just the impedance.

(4C) (**8 points**) Using the phasor domain analysis technique, find the current produced by the source ***i(t)***

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Question 4 (extra space) **Name:**

Question 5 (10 Points) **Name:**

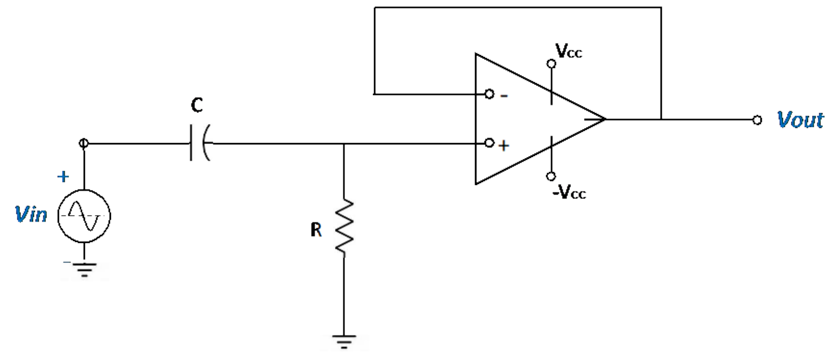
Assume that you are acquiring (digitizing) an analog signal that is fed directly into the input of an analog-to-digital converter (ADC) with a fixed input range of +/- 25V.

The analog signal has the form: $v(t) = 11 \cos(10{,}000t + 45^o)$ V

5A) (4 points) What is the minimum sampling frequency **Fs** (in samples / second) you would use to avoid distortion? What type of distortion would this prevent?

5B) (6 points) Given the input range of your ADC, assuming your application required a **maximum** quantization error of **1mV** in your digitized signal, what is the minimum number of bits (resolution) your ADC would need? Explain your answer.

Question 6 (24 Points) **Name:**



6A) (**6 points**) Assuming that the op amp is ideal, find an expression for the transfer function ***H(ω) = Vout (ω) / Vin(ω)*** of the circuit above (i.e. in phasor domain) in terms of R, C, and ω

6B) (**6 points**) On the diagram below, sketch **|*H(ω)*|= | *Vout(ω) / Vin(ω)* |** as a function of ω. Label your axes, and key points on the curve in terms of R and C. ***What kind of filter is this?***

(question continues on the next page)

6C) (**4 points**) Choose values for R and C so that the corner (i.e. cut-on or cut-off) frequency $\boldsymbol{\omega_c}$ of the filter is 30,000 radians/s. What is the maximum gain of the resulting circuit ?

6D) (**8 points**) With the values of R and C you picked above, find $V_{out}(t)$ if $V_{in}(t) = 5 + 5\cos(25{,}000t - 30^o) + 5\cos(10^6 t)$ If you could not answer the previous part, use R = 100kΩ and C = .5μF (Note these are not the correct values for the previous part of the problem!)

Extra credit: (***5 points***): How would you modify this circuit so that the corner (i.e. cut-off or cut-on) frequency is the same as in your design above but the maximum gain increases by a factor of 5 ?

Question 6 (extra space) **Name:**