Important instructions for on-line version of S20 CMPE306 Final Exam

1. Academic Integrity

By submitting this paper exam on-line via Blackboard, I affirm that I have complied with the UMBC Policy on Academic Integrity. This exam is my work and my work alone. I have not had access to the content of this exam prior to the exam. **I acknowledge that it is a violation of UMBC's policy on academic integrity to have discussed this exam in any way with any person other than Dr. LaBerge during the exam period.**

2. Test metrics

This is 100 point test**.** There are fourteen problems.. Partial credit can be earned on any problem, up to the **maximum score** of 100 points. Consideration of partial credit will be as described below.

3. Partial Credit.

My usual process in CMPE306 is to examine your written work and to award partial credit for answers that may not be entirely correct, but which display knowledge of the proper process. **This exam is different!** There will be **no partial credit** for process, and there will be **no credit** for answers that fail to meet the formatting standards established in these instructions. In return, the exam has been constructed in a manner that leads students through the solutions, thereby providing a suggested process for solution. There are multiple responses required to each problem, with each response indicating successful completion of one step along the proper process. Therefore, the multiplicity of responses will become the "partial credit" usually assigned to problem-solving process.

4. Answer Formatting (Critically Important!)

It is critically important that your answers follow these standard formatting practices

a) All numeric answers **must** use three significant figures. Thus, BB will mark your answer wrong if you provide 3.14159265 instead of 3.14. If the number is a perfect integer, still use three significant digits, thus 2.00 and not 2. **Do not** e-mail me after submission claiming that you did not understand this provision. You **must** use three significant digits.

b) **Round**, do not truncate. A value of 5 should be rounded up.

c) All digital fractions have a leading zero. Thus $\frac{1}{2} = 0.500$ (leading zero, 3 sig figs)

d) All numeric answers **must** include applicable units unless otherwise instructed. Such instructions will be specific and unambiguous. If you don't see "do not include units", then units are required. Unitless quantities should be submitted as a number. complying with a) even if the number is a perfect integer. Use these standard units: A, F, H, Hz, kHz, kohm, r/s (radians/second), /s ("per second"), ohm (**not "ohms")**, V (**not "Volts" or "volts"),** W. Use ms for milliseconds, mW for milliwatts, and uF for microfarads and indicated in the question.

e) Do not insert a space between the number and the unit (see examples, below)

f) Examples

   a. 2.3175 volts should be entered as 2.32V **Note that there are no spaces!**
   b. 3274W should be entered as 3270W (see rounding instruction) **Note that there are no spaces!**
   c. 10325 VAR should be entered 10300VAR **Note that there are no spaces and 3 sig figs! The trailing zeros are not significant.**
   d. $10\angle 45^{\circ}$ V should be entered 7.07+j7.07V. **Note that there are no spaces and 3 sig figs!**
   e. 0.3125W should be entered as 0.313W. **Note that there are no spaces and 3 sig figs!**
   f. 0.03125W should be entered as 0.0313W **Note that there are no spaces and 3 sig figs, the leading zero is not significant!**
   g. 0.14725W should be entered as either 0.147W or 147mW, **depending on the instructions in the question.**
   h. The value 0V should be entered as 0.000V. **Note that there are no spaces, 3 significant figures and the value is treated as a decimal fraction.**

g) Only the following units require multipliers, and **only as specifically instructed in the question**: ms for milliseconds, mW for milliwatts, and uF for microfarads.
h) Use full precision in intermediate computations, and only round or truncate when you are ready to enter the answers into BB. Having entered the answers, continue to use full precision for subsequent computations until entering another answer.

5. Test Organization

The test is divided into two sections.

Section 1 consists of six problems. You must earn 40 points on Section 1 in order to take full advantage of the extra credit in Section 2. It is permissible (even encouraged) to do all six of the Section 1 problems.

Section 2 consists of eight problems. The problems are either directly from the homeworks, exams, and labs with *slight* modifications, or they are very similar to the homework and exam problems. The test is long, but the answers are pretty straightforward and you've seen all before. You will recognize many of the problems, but look at them closely for subtle differences. There are a few tricks!

6. Permissible sources and tools

You are permitted to use your text, your notes, the homework solutions, solutions to the previous exams, and the internet. Internet use is restricted to general research on the question.

You **may** use *MATLAB*, *Mathematica, Maple,* or other computational or symbolic tools.

You **may not** consult or discuss this exam with any human other than Dr. LaBerge during the exam release period.

You **may** ask questions or clarifications from Dr. LaBerge. I will be available via the discussion forum on Blackboard throughout the exam period. Postings between 9PM and 6AM will not be responded to until I get rolling in the morning. Otherwise, you can expect a response in 2-3 hours. While you're waiting for a response, you should **move on to other problems.**

You may not post, consult or use any homework or problem-solving site such as Chegg. There will be severe consequences if I find any of this material on Chegg, possibly leading the guilty individual(s) failing CMPE306. Do not try me on this! Such use violates the immediately preceding condition by consulting another human, even though that human is unknown to you. You will FAIL CMPE306 if I catch you at this.

Do Not Get Hung Up on One Problem!! If you're working more than about 30 minutes on any one problem (much less any one question), move on to another problem.

The numbering of each problem and each question within each problem have been coordinated between the BB Test and the exam paper. You may capture your answer to the problems on the exam paper (if you can print it out) or on a separate piece of paper, organized by Problem and question number.

You need not complete the exam at one sitting, and you are permitted to back up. It's long, but you can do it all!

Good Luck!

Problem 1: Confirmation of General Instructions and Academic Integrity

1. I have read and understood the "Important Instructions" for this exam, specifically including the statements on Academic Integrity and answer formatting. I agree to be bound by the constrains. I understand that failure to comply with the formatting may result in my losing credit for that answer. I understand and will comply with the limitations on permissible sources and collaboration.

Problem 2. Units (10 pts, 1 point each). Write down the term from the right column that most appropriately matches with the term on the left. (Multiple choice on the BB test.)

BB Answer	Term	Your Answer (a, b, c, etc)	Possible answers
2	**S**		a) Admittance
3	Q (not related to frequency response)		b) Angular frequency
4	P		c) Apparent Power
5	$S = \lvert S \rvert$		d) Average power
6	**Z**		e) Capacitance or Farad
7	R		f) Coulomb per second
8	X		g) Circular frequency
9	f		h) Complex Power
10	ω		i) Complex Impedance
11	ω_0 / B		j) $P/S = P/\lvert \mathbf{S} \rvert$
			k) Mho-second or Sieman-second
			l) Ohm-second
			m) Potential or electromotive force
			n) Power
			o) Reactance
			p) Re[Impedance]
			q) Resonant circuit "Q" factor
			r) $\omega_0 = 1/\sqrt{LC}$
			s) Lord Voldemort
			t) VAR
			u) $10\log_{10}(P_2/P_1)$, P_2, P_1 are powers

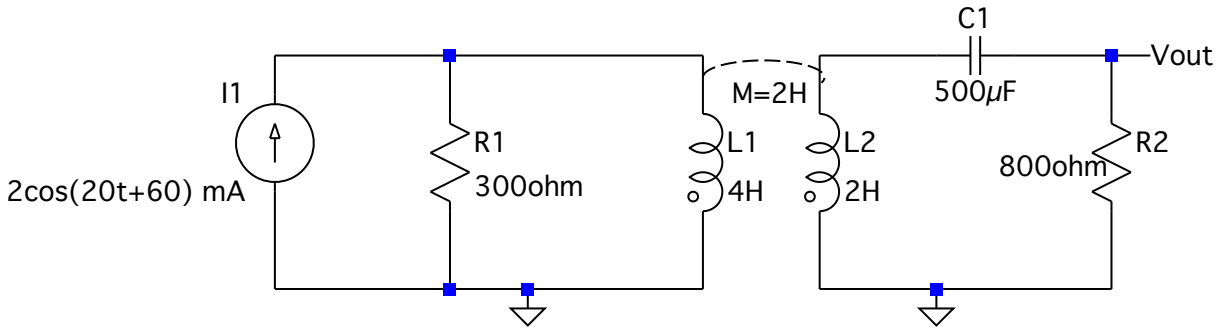
Problem 3. (10 pts) Complex Power

If $v(t) = 110\cos 377t$ Vrms and $i(t) = 5\cos(377t + 30^\circ)$ Arms calculate the following quantities.

BB Test question #	Complex Qty	Your answer (for your use while taking the exam). All answers should be recorded in the appropriate question in the Blackboard test. Follow the formatting guidelines exactly. If you're not sure, review the instructions.
12	$\mathbf{Z}$	
13	R :	
14	X :	
15	$\mathbf{S}$:	
16	S :	
17	P :	
18	Q :	
19	pf : (amplitude only)	
20	Lead/lag	
21	θ_v	

Problem 4: (10 pts) Mutual Inductance

Transform the current source and 300 ohm resistor. Take both mesh currents to be clockwise, with $\mathbf{i}_1$ on the left and $\mathbf{i}_2$ on the right. Then, answer the following questions about the circuit shown here. *Note the dots!*



22. (1) What is the numerical expression for the mutual coupling effect of $\mathbf{i}_2$ on KVL in the $\mathbf{i}_1$ mesh? Include *only* the mutual coupling, **not** all of the KVL terms and **not the sign term**.

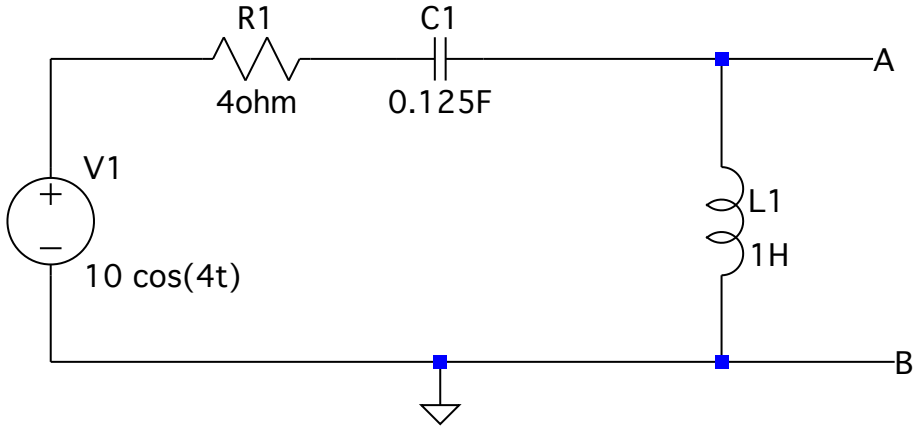
23. (1) Is the sign of the mutual coupling of $\mathbf{i}_1$ on KVL in the $\mathbf{i}_2$ mesh positive?

24. (2) Select the proper form for KVL for the $\mathbf{i}_1$ mesh.

25. (2) Select the proper form for KVL for the $\mathbf{i}_2$ mesh.

26. (4) Solve the combined KVL equations and determine the value of $\mathbf{V}_{out}$.

Problem 5. (10 pts) AC Thevenin
Find the (possibly complex) load impedance connected across terminals A-B that absorbs the maximum power. Find the maximum power when matched load is present. The sinusoidal amplitude is the peak voltage, not the rms.



27. (1) Select the proper action to take to compute the Thevenin impedance, $\mathbf{Z}_{TH}$.

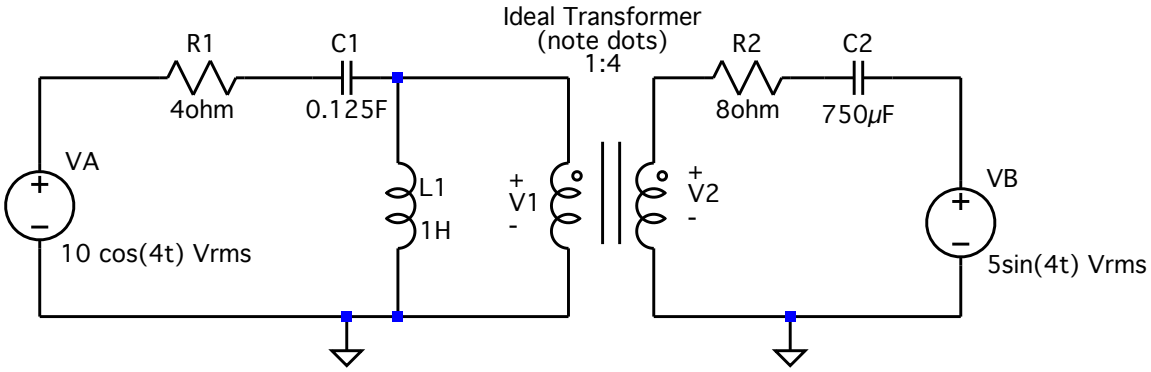
28. (2) Compute the complex Thevenin impedance, $\mathbf{Z}_{TH}$, and express it in rectangular form. Be sure to follow the formatting instructions, or your answer will not be counted. Be sure to follow the formatting instructions, or your answer will not be counted. Include the singular unit.

29. (2) Compute the Thevenin Voltage, $\mathbf{V}_{TH}$, and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted. Include the singular unit.

30. (3) Compute the value of the load impedance, $\mathbf{Z}_L$, that maximizes the average load power, and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted. Include the singular unit

31. (2) Compute the maximum average load power when $\mathbf{Z}_L$ is connected between A-B, and express it in rectangular form. **Express your answer in Watts**! Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 6: (10 points) Transformers Determine the power dissipated in the 8Ω resistor.



32. (1) Look at the primary circuit not including the transformer *very carefully*. Determine Thevenin impedance, $\mathbf{Z}_{TH}$, and express it in rectangular form. Be sure to follow the formatting instructions, or your answer will not be counted.

33. (1) Look at the primary circuit not including the transformer *very carefully*. Compute the Thevenin Voltage, $\mathbf{V}_{TH}$, and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted. Note that the units carefully.

34. (1) Determine the secondary impedance, $\mathbf{Z}_2$ and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted. Three significant digits! *Hint: No decimal point on the imaginary part!*

35. (1) Reflect the secondary impedance to the primary side of the transformer to get the reflected impedance $\mathbf{Z}_{2R}$, and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted.

36. (1) Reflect the secondary voltage source to the primary side of the transformer, and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted.

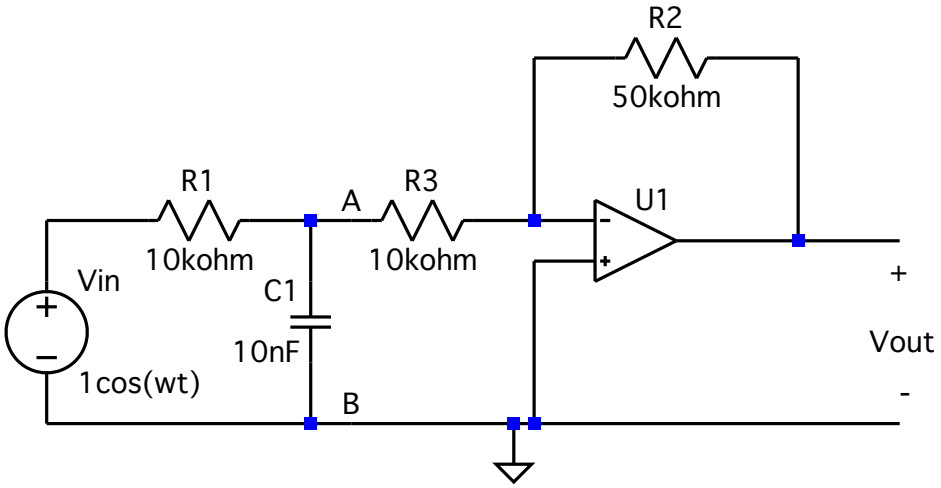
37. (2) Using the Thevenin equivalent of the primary side and the reflected version of the secondary side, compute the current $\mathbf{i}_1$ flowing from the primary side source and express it in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted.

38. (2) Using the value of $\mathbf{i}_1$, compute the value of $\mathbf{i}_2$ on the secondary side of the transformer. Be sure to properly account for the dots. Express $\mathbf{i}_2$ in rectangular form. Be sure to follow the formatting instructions, or your answers will not be counted.

39. (1) Compute the average power dissipated by the 8Ω resistor. **Express your answer in milliwatts (mW)!** Be sure to follow the formatting instructions, or your answers will not be counted. *Hint: No decimal point!*

Problem 7: (10 points) Filters and transfer functions

Follow the given steps to find the transfer function $\mathbf{H}(j\omega)=\frac{\mathbf{V}_{out}(j\omega)}{\mathbf{V}_{in}(j\omega)}$ in terms of $R1, R2, R3,$ and $C1.$ Is this a high pass, low pass or band pass filter? You will not need the specific values of the components for this problem: use the labels ($R1, R2, R3,$ and $C1.$) instead.



40. (1) Select the answer corresponding to the Thevenin impedance, $\mathbf{Z}_{TH}(s)$ of the Vin, R1, C1 combination, where the open circuit is across the points A-B.

41. (1) Select the answer corresponding to the Thevenin voltage, $\mathbf{V}_{TH}(s)$ of the Vin, R1, C1 combination, where the open circuit is across the points A-B. *Hint:* $\mathbf{V}_{TH}(s)$ includes $\mathbf{V}_{in}(s)$. *Hint 2: Do Not Panic! Just follow it along and be careful with your algebra.*

42. (2) After substituting the Thevenin equivalent for the Vin, R1, C1 combination, determine the input impedance to the op amp, $\mathbf{Z}_{in}$. *Hint: You might want to sketch the circuit with the Thevenin equivalent first!*

43. (1) Select the answer corresponding to the type of standard op amp configuration in this circuit

44. (2) The output voltage for this circuit is $\mathbf{V}_{out}=\mathbf{V}_{TH}(s)\times\left(-\frac{\mathbf{Z}_f(s)}{\mathbf{Z}_i(s)}\right)$. Select the correct expression for the output voltage.

45. (2) The transfer function for this circuit is $\mathbf{H}(s)=\frac{\mathbf{V}_{out}(s)}{\mathbf{V}_{in}(s)}$. Select the correct expression for the transfer function.

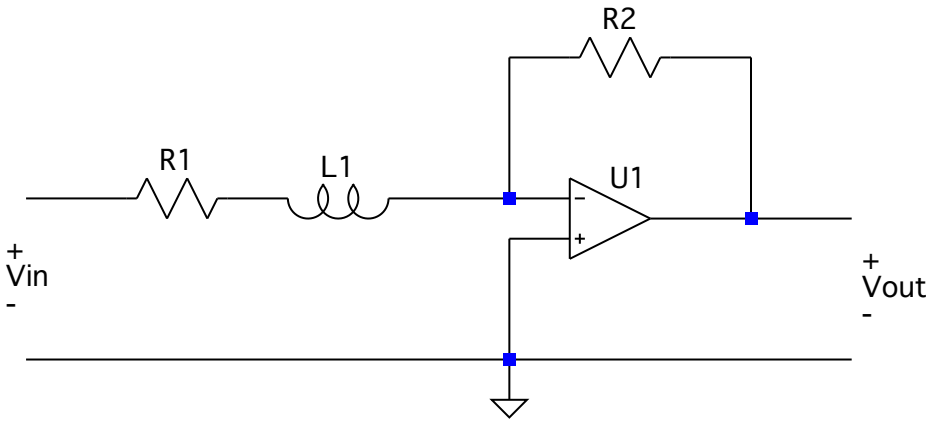
46. (1) Is this a high pass, low pass, band pass or band stop filter?

Section 2 Do as many of the following as you choose. Please be sure to box in your answers.

Problem 8: (10 points) First order circuits
In the circuit shown at the right,

$$R_1 = 250\Omega, R_2 = 1\text{k}\Omega, L = 250\text{mH}, V_{IN}(t) = u(-t) = \begin{cases} 1\text{V} & t < 0 \\ 0\text{V} & t > 0 \end{cases}$$

Determine $V_0(t)$ for $t > 0$. .



Read carefully! This is <u>not</u> a transfer function problem. (So what kind of problem is it?)

47. (1) Select the proper order for this circuit.

48. (2) With the given parameters and the given input signal, what is $v_{out}(0^-)$? Be sure to follow the formatting instructions, or your answers will not be counted.

49. (2) With the given parameters and the given input signal, what is $v_{out}(\infty)$? Be sure to follow the formatting instructions, or your answers will not be counted.

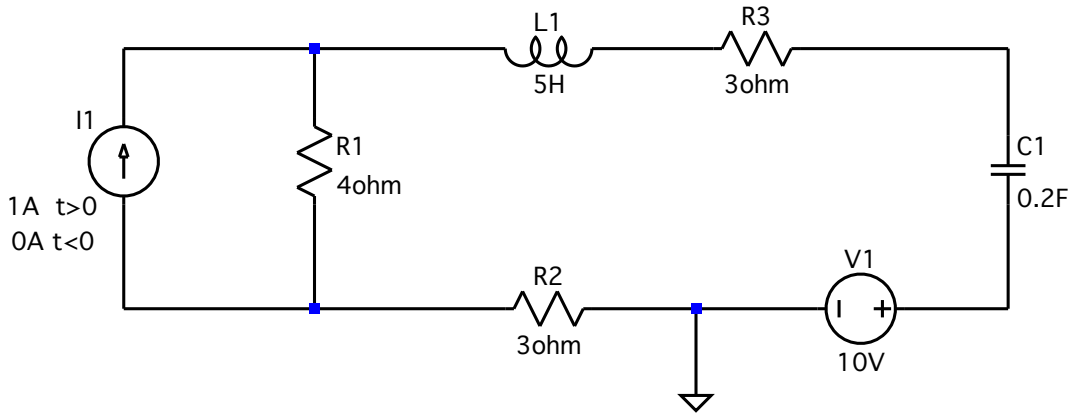
50. (2) With the given parameters and the given input signal, what is the value of the time constant, τ . Be sure to follow the formatting instructions, or your answers will not be counted. **Provide your answer in milliseconds!**

51. (1) Select the proper form for $v_{out}(t),\ t > 0$.

52. (2) Select the answer that best gives the output voltage as a function of t ?

Problem 9: (10 pts) LRC initial conditions

Find the initial conditions $i(0^+), v_C(0^+), v_C(\infty), \left.\frac{dv_C}{dt}\right|_{t=0^+}$, where $v_c(t)$ is the voltage across the capacitor, with positive at the top, and $i(t)$ is the current flowing left to right through the inductor. *Hint: What is changing in this circuit and how does it change?*



53. (1) Select the answer that best corresponds to the transformation of I1 and parallel R1 to an equivalent voltage source (V1) and series R1.

54. (1) What is the corresponding clockwise mesh current for $t = 0^-$? Be sure to follow the formatting instructions, or your answers will not be counted.

55. (1) What is the current, $i(0^+)$ flowing through the inductor for $t = 0^+$? Be sure to follow the formatting instructions, or your answers will not be counted.

56. (1) Apply KVL to determine the voltage across the capacitor at $t = 0^-$, $v_C(0^-)$. For the voltage polarity, use the direction of $i(0^-)$. Be sure to follow the formatting instructions, or your answers will not be counted.

57 (2) Determine the voltage across the capacitor at $t = \infty$, $v_C(\infty)$. Do not forget the impact of the transformed voltage source. Be sure to follow the formatting instructions, or your answers will not be counted.

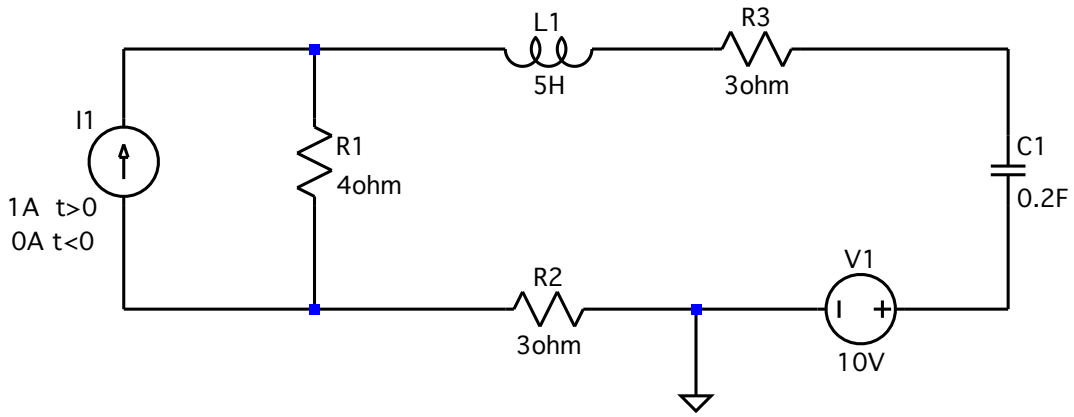
58. (2) Using the initial current through the inductor and the initial voltage across the capacitor, determine the current onto the capacitor at $t = 0^+$. Do not forget the impact of the transformed voltage source. Be sure to follow the formatting instructions, or your answers will not be counted.

59. (2) Using the information you have developed thus far, determine $\left.\frac{dv_C}{dt}\right|_{0^+}$. Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 10: (10 pts) LRC circuit solutions

In the previous problem, you should have determined the initial conditions for the circuit in question, which is repeated here.

Now ***assume*** that the initial conditions are $v_C(0^-) = 7\text{V}$, $v_C(\infty) = 22\text{V}$, $\left.\frac{dv}{dt}\right|_{t=0^+} = 0$ V/sec and solve for $v(t)$, $t > 0$.



60. (1) What is the numeric value of the decay constant, α, for this problem? Be sure to follow the formatting instructions, or your answers will not be counted.

61. (1) What is the value of the resonant frequency, ω_0, for this problem. Be sure to follow the formatting instructions, or your answers will not be counted.

62. (1) Select the type of damping for this problem.

63. (1) If this circuit is underdamped, provide the value for ω_D. If it is *not* underdamped, repeat the value for ω_0. Be sure to follow the formatting instructions, or your answers will not be counted.

64. (1) Select the form of the generic solution for this problem.

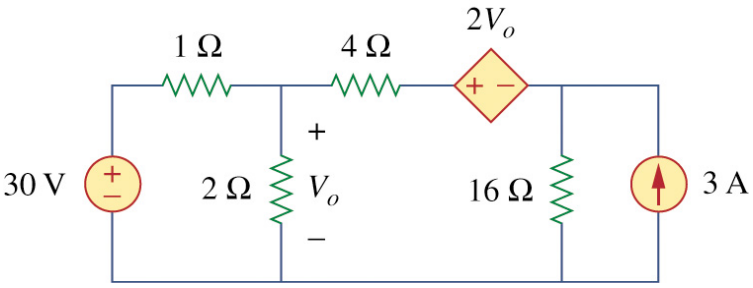
65. (2) Determine the value of the solution coefficient A_1 and record the numeric value, ***but not the units.*** Be sure to follow the formatting instructions, or your answers will not be counted.

66. (2) Determine the value of the solution coefficient A_2 and record the numeric value, ***but not the units.*** Be sure to follow the formatting instructions, or your answers will not be counted.

67. (1) Select the proper solution for $v_C(t)$, $t > 0$.

Problem 11. (10 points) Mesh Analysis

Use mesh analysis to write a 2×2 matrix equation for the circuit below. Your solution must use *clockwise* mesh currents for the unknowns. Then provide a numeric value, with units, for V_0, where V_0 is the voltage across the 2Ω resistor



Let $\mathbf{A}$ be the 2×2 coefficient matrix for this problem, and let $\mathbf{b}$ be corresponding the 2×1 matrix of known values. The matrix equation for this circuit is then $\mathbf{Ax}=\mathbf{b}$, where $\mathbf{x}$ is the 2×1 matrix of unknowns suitable for this kind of analysis.

68. (1) Select the units for the vector $\mathbf{x}$, appropriate for the required solution technique.

69. (1) For normal mesh analysis (without a supermesh) select the units for the coefficient matrix, $\mathbf{A}$.

70. (1) What is the value for $\mathbf{A}(1,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

71. (1) What is the value for $\mathbf{A}(1,2)$? Be sure to follow the formatting instructions, or your answers will not be counted.

72. (1) What is the value for $\mathbf{A}(2,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

73. (1) What is the value for $\mathbf{A}(2,2)$? Be sure to follow the formatting instructions, or your answers will not be counted.

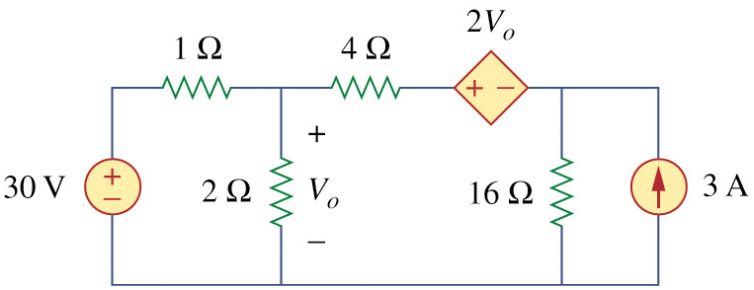
74. (1) After performing the appropriate numerical computations (MATLAB?), what is the numeric value of $\mathbf{x}(1,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

75. (1) After performing the appropriate numerical computations (MATLAB?), what is the value of $\mathbf{x}(2,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

76. (1) After performing the appropriate numerical computations (MATLAB?), what is the numeric value of V_0? Be sure to follow the formatting instructions, or your answers will not be counted.

77. (1) What is the power in the 2Ω resistor? Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 12: (10 points) Nodal analysis Use nodal analysis write a 2×2 matrix equation for the node voltages in the circuit of the mesh analysis problem. Then write an expression for V_0 in terms of the nodal analysis unknowns For nodal analysis you must clearly and explicitly define the nodes. *Hint #1: Is there are supernode or not? Can you get rid of it?*



Let $\mathbf{A}$ be the 2×2 coefficient matrix for this problem, and let $\mathbf{b}$ be corresponding the 2×1 matrix of known values. The matrix equation for this circuit is then $\mathbf{Ax}=\mathbf{b}$, where $\mathbf{x}$ is the 2×1 matrix of unknowns suitable for this kind of analysis.

78. (1) Select the units for the vector $\mathbf{x}$, appropriate for the required solution technique.

79. (1) For normal nodal analysis (without a super node) select the units for the coefficient matrix $\mathbf{A}$.

80. (1) What is the value for $\mathbf{A}(1,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

81. (1) What is the value for $\mathbf{A}(1,2)$? Be sure to follow the formatting instructions, or your answers will not be counted.

82. (1) What is the value for $\mathbf{A}(2,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

83. (1) What is the value for $\mathbf{A}(2,2)$? Be sure to follow the formatting instructions, or your answers will not be counted.

84. (1) After performing the appropriate numerical computations (MATLAB?), what is the numeric value of $\mathbf{x}(1,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

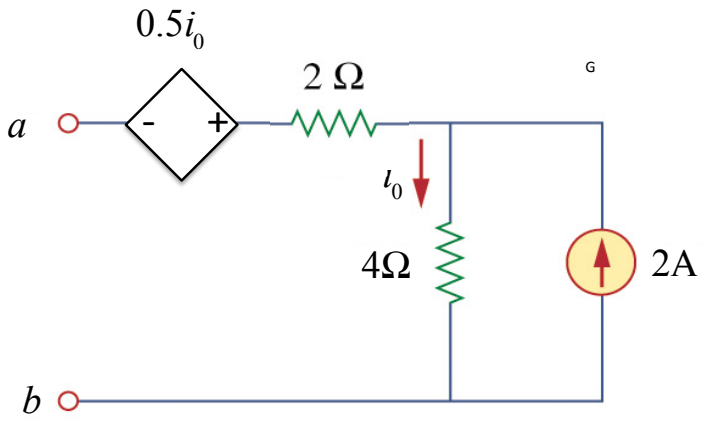
85. (1) After performing the appropriate numerical computations (MATLAB?), what is the value of $\mathbf{x}(2,1)$? Be sure to follow the formatting instructions, or your answers will not be counted.

86. (1) After performing the appropriate numerical computations (MATLAB?), what is the numeric value of V_0? Be sure to follow the formatting instructions, or your answers will not be counted.

87. (1) What is the power in the 2Ω resistor? Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 13: (10 points) DC Thevenin's Theorem

Find the Thevenin equivalent of the circuit fragment within the dashed box of the following circuit and use it to solve for i_0, the current flowing across the 4Ω resistor. Determine the value of the load resistor that would dissipate the maximum power when connected across *a* and *b*. Determine the maximum power in that load resistor.



88. (1) Select the first step in computing the Thevenin resistance or impedance?

89. (1) Select the second step in computing the Thevenin resistance or impedance when there is a dependent source in the circuit.

90. (2) Compute the Thevenin resistance for this circuit and provide its numeric value. Be sure to follow the formatting instructions, or your answers will not be counted.

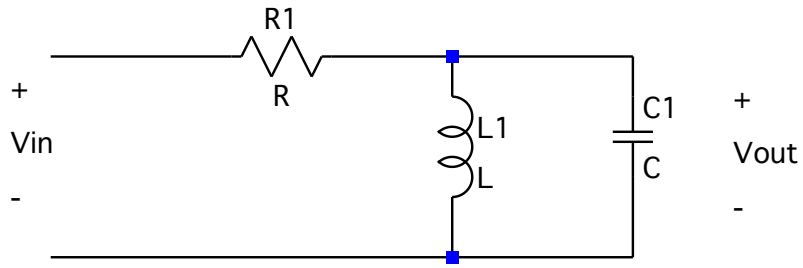
91.(2) Compute the Thevenin voltage for this circuit and provide its numeric value. Be sure to follow the formatting instructions, or your answers will not be counted.

92. (2) What is the numeric value of the load resistor that would maximize the load power? Be sure to follow the formatting instructions, or your answers will not be counted.

93. (2) What is the numeric value of the maximum power provided when the appropriate load resistor is installed? Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 14: Filter/Frequency Response (10 points)

Realize the transfer function $\mathbf{H}(s)=\frac{\mathbf{V}_{out}(s)}{\mathbf{V}_{in}(s)}=\frac{100s}{s^2+100s+10^6}$ using the circuit below. Let $R=1\text{k}\Omega$ and find the values of L and C. How many poles and how many zeros does this filter have? Is this a high-pass, low-pass, or bandpass filter?



94. (1) How many poles does this filter circuit have? Be sure to follow the formatting instructions, or your answers will not be counted.

95. (1) How many zeros does this filter circuit have? Be sure to follow the formatting instructions, or your answers will not be counted.

96. (1) Select the proper units for the magnitude of the transfer function.

97. (1) What is $|H(\omega)|$ as $\omega \to 0\text{rps}$? Be sure to follow the formatting instructions, or your answers will not be counted.

98. (1) What is $|H(\omega)|$ as $\omega \to \infty\text{rps}$? Be sure to follow the formatting instructions, or your answers will not be counted.

99. (1) What type of filter is this?

100. (1) What is the value of $C1$ to meet the specification? Be sure to follow the formatting instructions, or your answers will not be counted. Be sure to follow the formatting instructions, or your answers will not be counted.

101. (1) What is the value of $L1$ to meet the specification? Be sure to follow the formatting instructions, or your answers will not be counted.

102. (1) What is the resonant frequency of this circuit in rps? Be sure to follow the formatting instructions, or your answers will not be counted.

103. (1) What is the bandwidth of this circuit in rps? Be sure to follow the formatting instructions, or your answers will not be counted.

Problem 15: (10 points) Other Stuff Short Answer
If you've been keeping track, you'll see that you could have scored 130 points already, so there are already points of extra credit. Therefore, let's look at some things that you should remember, but were not on the homework. 1 point each question, up to a maximum of 10 points.

104. (1) How do we find the Thevenin impedance of a circuit with a dependent source?

105. (2) What are the two key assumptions about an ideal transformer.

106. (1) What is the condition that maximizes the power exchange between any circuit with a reactive element and its matched load impedance?

107. (1) If an LRC circuit has an *inductive* power factor, is that leading or lagging?

108. (2) What is the voltage/current relationship in a transformer between BGE power lines and your house?

109. (1) Why are is answers to 107 true?

110. (2) What are the two key assumptions about an ideal op amp?

111. (0) What was your favorite course this semester?