For problems 1–3, consider the following circuit:

Given $V_s = 2e^{0j}$, $\omega = 2$, $R_1 = 4 \Omega$, $R_2 = 4 \Omega$, $L = 2$ H, and $C = 0.25$ F. The objective is to use mesh analysis to find the two mesh currents.

1. Using KVL, write two equations in terms of phasor voltages. (Redraw the circuit and clearly define the phasor voltage polarities) Convert the phasor voltages of the passive elements into phasor currents. (make sure to clearly define your phasor currents)

2. Solve for the two mesh currents. Show all steps. (“done on calculator” is not a sufficient answer and will not result in full credit) Answers can be left in phasor form as a single, simplified complex number.

3. Find $V_s(t)$ and the two mesh currents as a function of time.

For extra credit (2 pts.): Draw a phasor diagram, showing $V_s$ and the two mesh currents.
For problems 4–7, consider the following circuit:

4. Find the transfer function, i.e. \( \frac{V_{out}(\omega)}{V_{in}(\omega)} \), in terms of \( R \), \( L \), and \( \omega \) (or \( f \)).

5. What is the magnitude of the transfer function, i.e. \( |H(\omega)| \)?

6. What is \( |H(\omega)| \) equal to for very low frequencies? For very high frequencies? What happens at resonance? (i.e. \( \omega = \omega_0 = \frac{1}{\sqrt{LC}} \) ) What kind of a filter do we have here?

7. Sketch the magnitude Bode plot for this filter. Label all critical points and slopes. Use \( R = 2 \Omega \), \( L = \frac{1}{4} H \), and \( C = \frac{1}{8} F \). Show how you obtained the value for any non-zero slopes.

For problems 8–9, consider the following circuit:

8–9. There are a total of 4 different possible states for the two diodes. Assuming a large–signal diode model, analyze the circuit for each of the 4 possibilities. Assume the diodes are made from germanium and thus require a 0.3 v bias in order to conduct. For each case, find the voltage and current through each diode and explain why or why not the original assumptions are valid.
For problems 10–14, use the following circuit (which is an CMOS inverter):

10. Sketch the $I_{ds}-V_{ds}$ characteristics of each MOS device. Assume that $K = 2 \text{ mA/V}^2$ for both the NMOS and PMOS device and $V_{to,\text{NMOS}} = 1$ and $V_{to,\text{PMOS}} = -1$. Show the curves for $V_{gs,\text{NMOS}} = 0, 1, 2, \text{ and } 3 \text{ V}$ and $V_{gs,\text{PMOS}} = 0, -1, -2, \text{ and } -3 \text{ V}$

11a. What is $V_{in}$ equal to in terms of the NMOS and PMOS voltages?

11b. What is $V_{out}$ equal to in terms of the NMOS and PMOS voltages?

12. Suppose that $V_{in} = 5 \text{ v}$. What region is each transistor operating in? Use these results to find $V_{out}$.

14. Now suppose that $V_{in} = 3 \text{ v}$. Using one of the curves from each of the graphs in #10, overlay the two curves to get an estimate of $V_{out}$. (Use your result from #13 to shift the PMOS graph)
For problems 15–18, use the following circuit:

For the NMOS transistor, assume $K = 2 \text{ mA/V}^2$ and $V_{to} = 0.5$

15. If $R_2 = 3 \text{ M}\Omega$ and $R_3 = 300 \text{ k}\Omega$, $V_{out}$ is independent of $R_1$. What is $V_{out}$?

16. Change the circuit by choosing a new value of $R_3$ such that $V_{GS} = 1.5 \text{ v}$.

17. Using the new value for $R_3$, if the transistor is operated in the triode region, what range of values for $V_{out}$ can be obtained?

18. Choose a value of $R_1$ such that $V_{out} = 0.5 \text{ v}$.

For extra credit, choose a value of $R_1$ such that $V_{out} = 2 \text{ v}$.

END OF FINAL EXAM
(total points available: 17 x 2 = 34...#13 is not counted since it is a repeat of #11b)