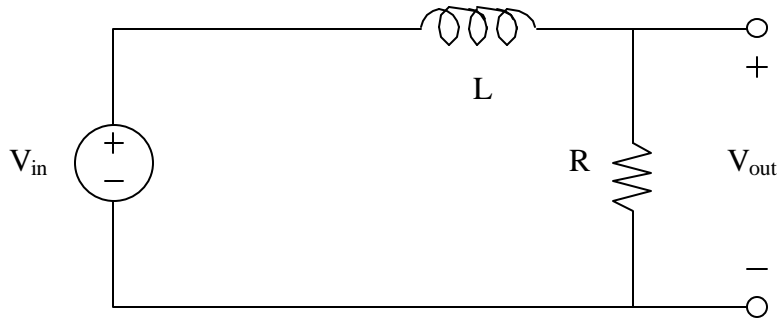


EE 70 Final Exam
Closed Book, Calculators Allowed
Two Pages of Notes Allowed (8.5" x 11", both sides ok)

Wednesday, June 11th (12 noon – 3 pm)
27 problems, 54 total points

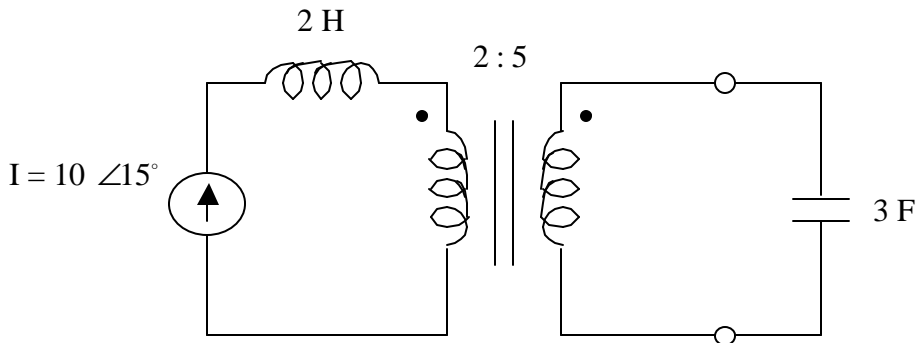
Please do all of your work on a separate sheet of paper
Final answers should be circled next to your work
To receive full (or partial) credit, you must show your work
Unless otherwise specified, each question is worth two points

For problems 1–7, consider the following circuit:



1. Find the transfer function, i.e. $V_{out}(\omega)/V_{in}(\omega)$, in terms of R , L , and ω .
2. What is the magnitude of the transfer function, i.e. $|H(\omega)|$, in dB?
- 3a. What is $|H(\omega)|$ equal to (in dB) for very low frequencies?
- 3b. What happens to $|H(\omega)|$ at high frequencies? What kind of a filter do we have here?
4. Derive the equation for the break frequency. The break frequency is defined as the frequency where $|H(\omega)| = -3.0103$ dB.
5. Sketch the magnitude Bode plot for this filter. Label all critical points and slopes. Show how you obtained the value for any non-zero slopes.
6. Suppose $R = 1 \Omega$, $L = 2$ H, and $V_{in} = 3 \cos(5t + 30^\circ)$. Find $V_{out}(t)$.
7. Draw a phasor diagram, indicating the voltage and current phasors of all the circuit elements.

For problems 8–12, consider the following circuit:

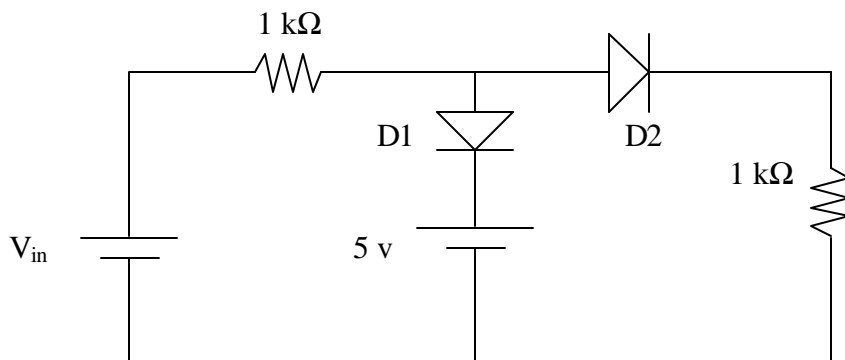


- 8a. Find the current that appears on the output side of the transformer.
- 8b. What is the voltage that appears across the capacitor. (phasor form is acceptable, assume an angular frequency of 1 rad/s)
9. Find the voltage that appears on each side of the transformer.
10. Find the voltage that appears across the current source.
11. Replace the transformer and input circuitry with an equivalent current source and inductor. In other words, draw a circuit which will have a current source, an inductor, and a 3 F capacitor all in series. Label the values for the current source and the inductor.

Check your answer to #11 by comparing the amount of power generated by the current source in each circuit.

12. Find the amount of power generated by the current source in the new circuit. Compare this with the amount of power generated by the current source in the original circuit. (they should be the same)

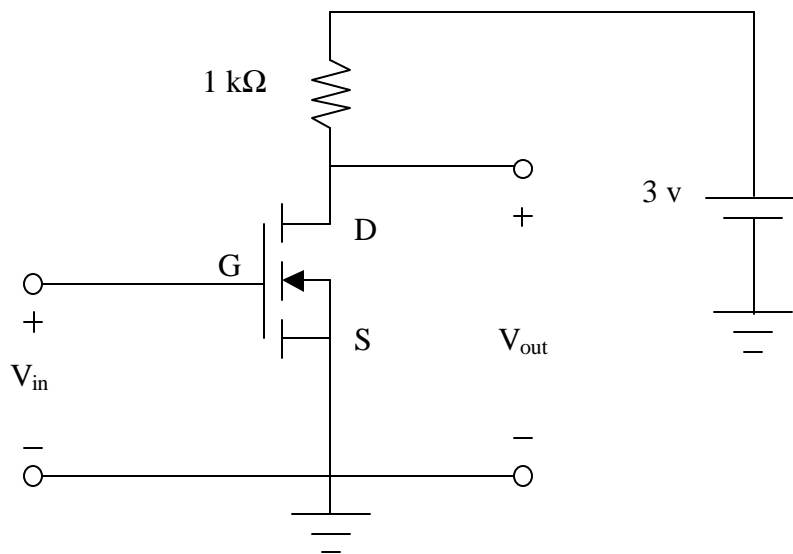
For problems 13–16, consider the following circuit:



Use $V_{in} = 8\text{ v}$ in problems 13–15.

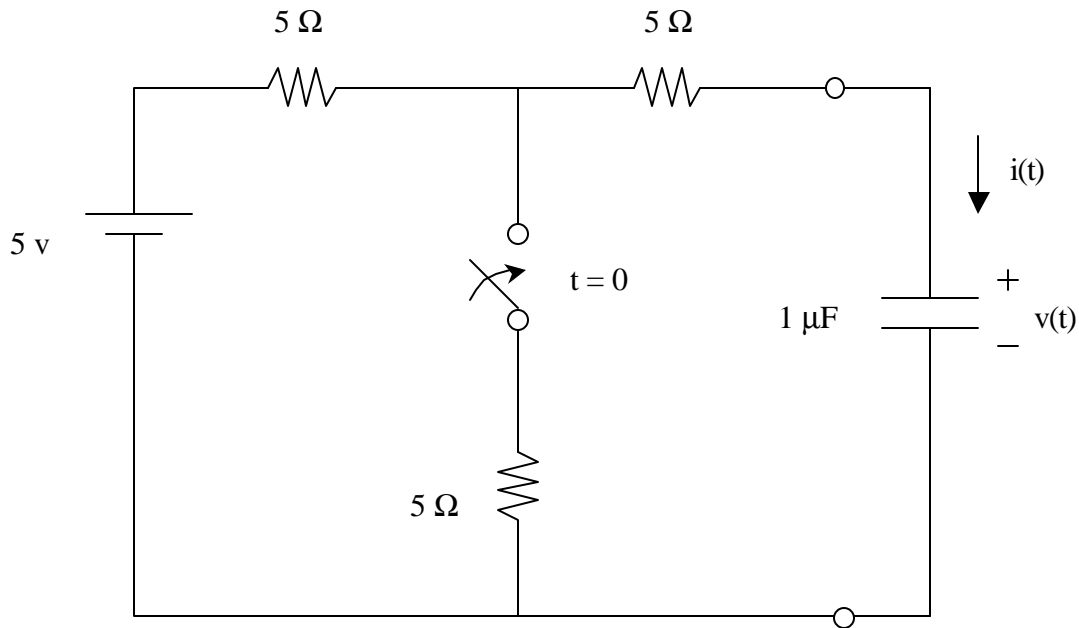
- 13–14. There are a total of 4 different possible states for the two diodes. Assuming an ideal diode model, analyze the circuit for each of the 4 possibilities. For each case, find the voltage and current through each diode and explain why or why not the original assumptions are valid.
15. Now assume a large-signal diode model. The diodes are made from silicon and require a 0.7 v bias in order to conduct. Using the valid case from the previous problem, calculate the voltage drop and current through each diode.
16. For what range of values of V_{in} would both diodes be forward biased? (for simplicity, use an ideal diode model again)

For problems 17–21, use the following circuit (which is an nMOS inverter):



17. Sketch the I_{ds} – V_{ds} characteristics of the MOS device. Assume that $K = 1\text{ mA}$ and $V_{to} = 1$. Show the curves for $V_{gs} = 0, 1, 2,$ and 3 v .
- 18a. What is V_{out} equal to in terms of the MOS voltages?
- 18b. What is V_{in} equal to in terms of the MOS voltages?
- 19a. What is the current through the resistor?
- 19b. Using the result in #19a, draw the load line through sketch you did in #17.
20. Using the graph, you have sketched, what is the output voltage when the input voltage is 0 v? 1 v? 2 v?
21. What is the output voltage when the input voltage is 3 v? (at this point, the transistor is in the triode regime, so you will need to use the IV equation in the triode regime and the load line equation to find an exact answer)

For problems 22–27, consider the following circuit:



The switch is initially open for a long period of time. At $t = 0$ s, the switch is closed. The goal is to find the voltage and current of the capacitor as a function of time, as indicated in the figure.

22. Find the voltage across and current through the capacitor before the switch is closed.
23. Find the current through the capacitor just after the switch has been closed. (Hint: use continuity/boundary conditions and model the capacitor as a voltage source at $t = 0+$.)
24. Simplify the circuit after the switch has been closed by finding the Thevenin equivalent circuit. In other words, redraw the circuit as a single voltage source, a single resistor, and the 1 μF capacitor. Find the values for the voltage source and resistance.
25. Using KVL, write an equation for the Thevenin equivalent circuit. Convert the voltages into currents. Express your equation as a first-order differential equation.
26. What is the solution to this differential equation? Substitute your solution into the differential equation and show what the time constant is. Use the boundary conditions to find any remaining values.
27. Sketch the current and voltage of the capacitor as a function of time.