Show your work and/or explain your answers. 110 points possible. Graded on 100 points.

1) a) (7 pts) You have an aluminum enclosure that attenuates a 30MHz external signal by 40db (a factor of 100). How much thicker would the enclosure have to be to attenuate the signal by another 20db (another factor of 10)? Give your answer as a percentage of the original thickness (Ex: 20% thicker).

   b) (5 pts) You need to drill a hole in the above enclosure to run wires. What is the largest diameter hole you can drill and still maintain the original 40db shielding at 30MHz?

2) A 15V pulse is traveling down a 50Ω coax cable. If the cable were properly terminated the voltage across the terminator would be 15V.

   a) (4 pts) What is the voltage across the terminator when the pulse reaches the end of the cable if R = 25 ohms?

   b) (4 pts) What is the voltage across the terminator when the pulse reaches the end of the cable if R = 75 ohms?

3) (6 pts) Fill out the truth table for this logic circuit.
4) (8 pts) **Simplify** and implement this truth table with minimum number of gates.

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5) a) (16 pts) Design an audio amplifier using a **single op-amp**. It should have **gain of 10** in the pass band (20Hz-20KHz) and drop off below 20Hz and above 20KHz. There are no input impedance requirements. **Label all parts.** Use the following:

- LM741: **1MHz** gain bandwidth product
- +/-15V power supplies (add decoupling caps)

b) (4 Pts) If you were to redesign the circuit for a higher gain (still using only one op-amp), estimate the max gain possible before limiting the pass band. Give a one-sentence explanation.
6) Design a photodiode amplifier using the photodiode specified below and a single (ideal) op-amp. The amplifier should have a gain of $+1V/\mu A$ (i.e. positive output) and have as little DC offset as possible.

a) (8 pts) Draw the complete schematic. Include power connections and decoupling caps. Use a +/-15V power supply.

Photodiode Specs:
$I_{dark} = 10nA@15V$ reverse bias (at 25C)
Junction Capacitance = 100pf@0V reverse bias
Junction Capacitance = 10pf@15V reverse bias

b) (7 pts) If DC offset didn’t matter, how could the above single op-amp amplifier be sped up (redraw the schematic)? About how fast would it respond? Give a 1-2 sentence explanation.
7) (12 pts) Design a circuit using the 74HC123 that will trigger on the **rising edge of an input pulse**, **wait 10us**, and provide a **30us output pulse** as shown in the timing diagram. Tie all unused inputs high or low and add a decoupling cap on the power supply. Label the input and output. You can assume the pulse width is equal to the RC time constant of the external R & C.

8) (6 pts) Fill out the timing diagram for A, B, & C. Note: The **initial states** of the flip-flop are shown in the timing diagram. The flip-flop clocks in data on the **rising edge** of the clock.
9) a) (4 pts) Complete the power supply schematic by adding a transformer and bridge rectifier to the 5V regulator.

b) (4 pts) What is the minimum value for C (the filter capacitor) to limit the ripple voltage to 1V for the load shown?

c) (4 pts) Write the minimum voltages at each point on the schematic above. Calculate the minimum RMS voltage rating for the transformer to ensure the regulator works properly and write it below.

d) (4 pts) If the regulator’s thermal resistance is 5°C/W and it’s properly attached to a 25°C/W heatsink, how far above the ambient temperature would the regulator die be if operated with the load shown? Assume the input to the regulator is 8V.
10 (7 pts) Design a relay driver using the FET or BJT used in class. There is a \textbf{12V} (up to 100mA) power supply available. When a \textbf{5V} (up to 10mA) control line goes high the relay should come on. When the control line goes low \textbf{or is disconnected} the relay should go off. The relay, BJT, and FET specs are shown below. Label all component values on the schematic and show your calculations.

N channel FET: IRL2910 (see graph), \(V_{ds}_{\text{max}} = 100V, R_{ds}_{on} = 0.26 \text{ ohms}\)

NPN transistor: 2N3904 with \(H_{fe} = 100, \ V_{ce}_{\text{max}} = 40V, I_{c}_{\text{max}} = 200\text{mA}\)

Relay coil: 12V@50mA