CS150 Spring 1998
Midterm 2
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Problem #1

(a) A digital system is required to amplify a binary-encoded audio signal. The user should be able to control the signal amplitude from **minimum to maximum in 100 increments**. What is the **minimum number of binary bits** required to encode the user-specified amplitude?

(b) Excess-3 code (Katz page 499) is a variation of binary-coded decimal (BCD) code. Each decimal digit is represented by a 4-bit code that is **three more than the associated BCD code**. For example, 0 is encoded in excess-3 as 0011b, 1 is encoded in excess-3 as 0100b, etc. Design a **single-output combinational logic circuit** that **outputs a 1 when the input to the circuit in 4-bit excess-3 code is a prime number**. For all other (non-prime) **legal** 4-bit excess-3 numbers applied to the inputs, the output is a 0. **Assume complement inputs are available** and implement the circuit using:

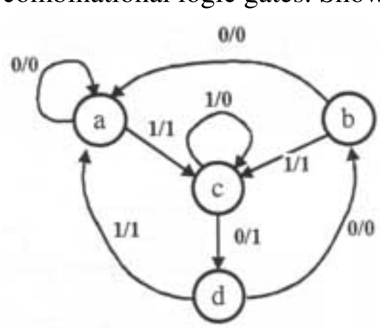
(i) One 16-input, four control-line multiplexer only
(ii) One 8-input, three control-line multiplexer only.
(iii) One 4-input, two control-line multiplexer and a minimum number of simple logic gates (INV,NAND, NOR, ND, OR, XNOR)

Problem #2

(a) What is the better way to implement arithmetic in a binary computer: **one's complement or two's complement**? Why? **Include all of the arguments you can think of for and against your answer**.

(b) Does the state-machine opposite have any **equivalent states**? If so, **which states are equivalent**? Show all work.

(c) Design a **4-bit ripple up-counter using positive edge-triggered D flip flops** and a minimum number of combinational logic gates. Show the schematic diagram.



Problem #3

Design a Moore machine that detects the number 9 encoded in binary (1001b) and in excess-3 (1100b). The **machine should reset after each detection** (i.e. overlapping sequences are ignored). Sample input (X) and output (Z) sequences are given below:

X = 1001100011001...

Z = 0001000000010...

(a) Draw a **state transition diagram** for the Moore machine.
(b) Use an **implication table** to determine if any states are equivalent. If so, **list the equivalent states** and then **redraw your (now minimized) state diagram.**
(c) Using **D flip-flops and the state-assignment rules discussed in class**, indicate **all adjacency constraints** for an optimal state encoding and **determine an optimal encoding**, listing the state codes for each state in the machine.
(d) Write equations **for the next-state logic only** (not the output logic) **using a minimal NOR-NOR** two-level representation.
