Computer Organisation

Lecture Notes

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1.1

Questions

Level 1	Skill Demonstrated	Question cues / Verbs for tests
Remember	• Ability to recall of information like facts, conventions, definitions, jargon, technical terms, classifications, categories, and criteria • ability to recall methodology and procedures, abstractions, principles, and theories in the field • knowledge of dates, events, places • mastery of subject matter	list, define, tell, describe, recite, recall, identify, show, label, tabulate, quote, name, who, when, where

1. Define two types of digital circuits.
2. Write the steps involved in designing a combinational circuit.

Level 2	Skill Demonstrated	Question cues / Verbs for tests
Understand	• understanding information • grasp meaning • translate knowledge into new context • interpret facts, compare, contrast • order, group, infer causes • predict consequences	describe, explain, paraphrase, restate, associate, contrast, summarise, differentiate interpret, discuss

3. A gate or set of gates is universal if it can be used to construct any Boolean function, For example, the set {AND, OR, NOT} is universal.
    a. Is an AND gate by itself universal? Why or why not?
    b. Is the set {OR, NOT} universal? Why or why not?
    c. Is a NAND gate by itself universal? Why or why not?
4. Differentiate combinational and sequential circuits.
5. What is a decoder? Explain 3 x 8 line decoder.
6. What is a multiplexer? Construct 4 x 1 multiplexer.
7. What is flip-flop? Explain with the help of a logic diagram.
8. What is the difference between a latch and a flip-flop? Under what circumstances is each one preferable?

Level 3	Skill Demonstrated	Question cues / Verbs for tests
Apply	• use information • use methods, concepts, laws, theories in new situations • solve problems using required skills or knowledge • Demonstrating correct usage of a method or procedure	calculate, predict, apply, solve, illustrate, use, demonstrate, determine, model, experiment, show, examine, modify

9. Draw a truth table for each of the following:
   a. Q = X' Z + Y' Z' + X Y Z
   b. Q = A B C' D + A' + B' + D' + B C D
   c. Q = M(N + P')(N' + P)

10. Given the Boolean function $F = xy'z + x'y'z + xyz$
    a. List the truth table of the function.
    b. Draw the logic diagram sing the original Boolean expression.
    c. Simplify the algebraic expression using Boolean algebra.
    d. List the truth table of the function from the simplified expression and show that it is the same as the truth table in part (a).
    e. Draw the logic diagram from the simplified expression and compare the total number of gates with the diagram of part (b).

11. Simplify the following Boolean functions using three-variable maps.
    a. $F(x, y, z) = \sum(0, 1, 5, 7)$
    b. $F(x, y, z) = \sum(1, 2, 3, 6, 7)$
    c. $F(x, y, z) = \sum(3, 5, 6, 7)$
    d. $F(A, B, C) = \sum(0, 2, 3, 4, 6)$

12. Simplify the following Boolean functions using four-variable maps.
    a. $F(A, B, C, D) = \sum(4, 6, 7, 15)$
    b. $F(A, B, C, D) = \sum(3, 7, 11, 13, 14, 15)$
    c. $F(A, B, C, D) = \sum(0, 1, 2, 4, 5, 7, 11, 15)$

d. $F(A, B, C, D) = \sum(0, 2, 4, 5, 6, 7, 8, 10, 13, 15)$

13. Simplify the following Boolean function in sum-of-products form by means of a four-variable map. Draw the logic diagram with (a) AND-OR gates; (b) NAND gates.

$$F(A, B, C, D) = \sum(0, 2, 8, 9, 10, 11, 14, 15)$$

14. Simplify the Boolean function *F* together with the don't-care conditions *d* in sum-of-products form.

$$F(w, x, y, z) = \sum(0, 1, 2, 3, 7, 8, 10); \quad d(w, x, y, z) = \sum(5, 6, 11, 15)$$

15. A majority function is generated in a combinational circuit when the output is equal to 1 if the input variables have more 1's than 0's. The output is 0 otherwise. Design a three-input majority function.

16. Design a combinational circuit with three inputs x, y, z and three outputs A, B, C. When the binary input is 0, 1, 2, or 3, the binary output is one greater than the input. When the binary input is 4, 5, 6, or 7, the binary output is one less than the input.

17. Design a combinational circuit that checks a 4-digit binary number to determine if it is an integer multiple of 3 and outputs 1 if it is and 0 otherwise.

18. Design a combinational circuit that outputs 1 if its 4-bit input contains an even number of 1s and 0 otherwise. Consider 0 an even number.

19. Design a circuit that will tell whether a given month has 31 days in it. The month is specified by a 4-bit input A(3):A(0). For example, if the inputs are 0001, the month is January, and if the inputs are 1100, the month is December. The circuit output X should be HIGH only when the month specified by the inputs has 31 days in it. Write the simplified equation, and draw the circuit diagram using a minimum number of gates. (Take advantage of don't cares)

20. Design a combinational circuit that acts as a 2 x 2 switch. The switch has data inputs *a* and *b*, one "cross" control signal *c*, and data outputs *x* and *y*. When *c*=0, *a* is connected to *x* and *b* to *y*. When *c*=1, *a* is connected to *y* and *b* to *x* (i.e., the inputs are crossed).

21. Rakesh is having a picnic. He won't enjoy it if it rains or if there are ants. Design a circuit that will output TRUE only if Rakesh enjoys the picnic.

22. Rakesh will enjoy his picnic on sunny days that have no ants. He will also enjoy his picnic any day he sees a hummingbird, as well as on days where there are ants and ladybugs. Write a Boolean equation for his enjoyment (E) in terms of sun (S), ants (A), hummingbirds (H) and ladybugs (L).

23. One way to detect single-bit errors when transmitting data is to attach a parity bit to the transferred data that indicates the number of 1s contained in the data. If the number of 1s in the received data does not agree with the parity bit, then the data was corrupted and an error output is produced. Design the parity bit checker circuit that receives the 4-bit data and the parity bit and detects single-bit errors by checking the total number of 1s in the data and the parity bit. Your circuit output (ERROR) should be 1 if the number of 1s in its 5-bit input is an even number and 0 if the number of 1s is an odd number.

24. A circuit has four inputs and two outputs. The inputs A(3):A(0) represent a number from 0 to 15. Output P should be TRUE if the number is prime (0 and 1 are not prime, but 2, 3, 5, and so on, are prime). Output D should be TRUE if the number is divisible by 3. Give simplified Boolean equations for each output and sketch a circuit.

25. Draw the truth table and design an octal to binary (8-to-3) encoder.

26. A *priority encoder* has 2^N inputs. It produces an N-bit binary output indicating the most significant bit of the input that is TRUE, or 0 if none of the inputs are TRUE. It also produces and output NONE that is TRUE if none of the inputs are TRUE. Design and eight-input priority encoder with inputs A(7):A(0) and outputs Y(2):Y(0) and NONE. For example, if the input is 00100000, the output Y should be 101 and NONE should be 0. Give a simplified Boolean equation for each output, and sketch a schematic.

27. Design a *priority encoder* that receives an 8-bit input, A(7):A(0), and produces two 3-bit outputs, Y(2):Y(0) and Z(2):Z(0). Y indicates the most significant bit of the input that is TRUE, Z indicates the second most significant bit of the input that is TRUE. Y should be 0 if none of the inputs are TRUE. Z should be 0 if no more than one of the inputs is TRUE. Give a simplified Boolean equation for each output, and sketch a schematic.

28. An *M-bit thermometer code* for the number *k* consists of *k* 1's in the least significant bit positions and *M-k* 0's in all the more significant bit positions. A *binary-to-thermometer code converter* has *N* inputs and $2^N - 1$ outputs. It produces a $2^N - 1$ bit thermometer code for the number specified by the input. For example, if the input is 110, the output should be 0111111. Design a 3:7 binary-to-thermometer code converter. Give a simplified Boolean equation for each output, and sketch a schematic.

29. Design a 3-to-8 decoder using 2-to-4 decoders.

Level 4	Skill Demonstrated	Question cues / Verbs for tests
Analyse	• break down a complex problem into parts • Identify the relationships and interaction between the different parts of a complex problem • identify the missing information, sometimes the redundant information and the contradictory information, if any	classify, outline, break down, categorise, analyse, diagram, illustrate, infer, select

30. Ramya has a lab kit of logic circuits to implement her project.

    a. She needs to implement the function X=AB'+B'C'+A'BC to finish her project, but when she looks in her lab kit, the only part she has left is an 8:1 multiplexer. How does she implement the function?

    b. Ramya turns on her circuit one more time before the final presentation of her project and blows up the 8:1 multiplexer. (She accidentally powered it with 20 V instead of 5 V after not sleeping all night). She begs her friends for spare parts and they give her a 4:1 multiplexer and an inverter. Can she build her circuit with only these parts?

31. The principal, HOD, T&P cell and ACE students use the seminar hall from time to time. Unfortunately, they occasionally conflict, leading to disasters such as the one that occurred when

the principal meeting with the staff happened at the same time as the birthday party of one of the ACE members. Ramya has been called in to design a room reservation system.

a. The system has four inputs, A(3):A(0), and four outputs, Y(3):Y(0). Each user asserts his/her input when he/she requests the seminar hall for the next day. The system asserts at most one output, granting the seminar hall to the highest priority user. The principal being the head of the institution has the highest priority (3). The HOD, T&P cell and students have decreasing priority.

Write a truth table and Boolean equations for the system. Sketch a circuit that performs this function.