NOTE: It is my policy to give a failing grade in the course to any student who either gives or receives aid on any exam or quiz.

INSTRUCTIONS: Circle the letter of the one best answer for each multiple choice question. Draw diagrams on the backs of the exam sheets. Be sure to put the question number next to each diagram. Unless otherwise indicated, all questions count equally.

1. How many picoseconds in one nanosecond?
   A. 0.000001
   B. 0.001
   C. 1
   D. 1,000
   E. 1,000,000

2. How many nanoseconds in one millisecond?
   A. 0.000001
   B. 0.001
   C. 1
   D. 1,000
   E. 1,000,000

3. If you know the period of a signal in microseconds, how do you represent that value in nanoseconds?
   A. Multiply the number of microseconds by 1,000.
   B. Divide the number of microseconds by 1,000.
   C. Add 1,000 to the number of microseconds.
   D. Subtract 1,000 from the number of microseconds.
   E. Take the reciprocal of the number of microseconds.

4. Which of the following is a unit of measure for *frequency*?
   A. Inches
   B. Centimeters
   C. Seconds
   D. Hertz
   E. Grams

5. Which of the following might represent the *period* of a clock signal?
   A. 1 gigahertz
   B. 1 nanosecond
   C. 1 micron
   D. 1 foot
   E. 1 hand

6. What is the period of a 4 GHz signal?
   A. 4 nanoseconds
   B. 250 nanoseconds
   C. 4 picoseconds
   D. 250 picoseconds
   E. 4,000,000,000 seconds

7. What is the number of bits needed to identify one of *m* choices? That is, if there are *m* choices, how many bits are needed to encode each of the choices?
   A. m
   B. 2^m
   C. $2 \times m$
   D. $log_2(m)$
   E. m^2

8. How many rows would there be in the truth table of a function that has 4 input variables?
   A. 0
   B. 1
   C. 4
   D. 16
   E. 64

9. Which statement best describes a truth table with 3 inputs and 2 outputs?
   A. It is a half adder.
   B. It has 2 input literals.
   C. It represents two functions that have the same three input variables.
   D. It represents three functions that have the same two input variables.
   E. One output will be eliminated when the function is minimized.

10. Which of the following rules of boolean algebra is the basis of both Karnaugh Map and algebraic minimization?

    A. $a \wedge b \equiv b \wedge a$

    B. $a \vee b \equiv b \vee a$

    C. $a(\sim b \vee b) \equiv a$

    D. $a(b \vee c) \equiv ab \vee ac$

    E. $\sim(a \vee b) \equiv (\sim a \wedge \sim b)$

11. On the back of this sheet, write the truth table for a *full adder*. Be sure to label inputs and outputs meaningfully.

12. On the back of this sheet, use a Karnaugh Map to minimize the C_{out} function for a full adder. Draw the Karnaugh Map with all rows and columns labeled properly, *and* write the minimized equation that the Karnaugh Map produces.

13. On the back of this sheet, draw a schematic diagram showing the gates to implement your minimized function for C_{out} in Question 12. Label all inputs and outputs so they agree with the names used in Questions 11 and 12.

14. How many propagation delays are there in you schematic for Question 13?
   A. 0
   B. 1
   C. 2
   D. 3
   E. 4

15. What factor limits the maximum speed of a processor's clock?
   A. The number of AND gates.
   B. The number of OR gates.
   C. The number of inverters (NOT gates).
   D. The total number of gates of any type.
   E. The propagation delays in the datapath.

16. Any logic equation can be represented in *sum of products* form. Even without minimization, what is the maximum number of propagation delays that would be required to implement a logic equation, based on its sum of products representation?
   A. 0
   B. 1
   C. 2
   D. 3
   E. 4

17. On the back of this sheet, draw a schematic diagram for a multiplexer with four data inputs. Use AND, OR, and NOT gates only. Label all inputs and outputs meaningfully.

18. Using symbols to represent the multiplexer(s) and full adder, draw a schematic diagram showing the internal structure of *one slice* of the MIPs ALU. Label all inputs and outputs appropriately.

19. For the full MIPS ALU, when would the C bit of CVNZ be true?
    A. Whenever there is an error.
    B. Whenever there is no error.
    C. Whenever C_{32} is true.
    D. Whenever $Result_{31}$ is true.
    E. Whenever the Result bits are all false.

20. For the full MIPS ALU, when would the N bit be true?
    A. Whenever there is an error.
    B. Whenever there is no error.
    C. Whenever C_{32} is true.
    D. Whenever $Result_{31}$ is true.
    E. Whenever the Result bits are all false.

21. Fill in the blanks for the full MIPS ALU. All values are in hexadecimal; give your answers in hexadecimal too. Do not fill in the condition code values for the shaded cells. (*Help:* the *func* bits from left to right are A_{inv} B_{neg} F_1 F_0)

A	*B*	*func*	*CVNZ*	*Result*
00000005	0000000C	0		
00000005	0000000C	1		
00000005	0000000C	2		
00000005	0000000C	7		

22. What would be the setting of *func* to calculate *A* minus *B*?
    A. 2
    B. 4
    C. 6
    D. 8
    E. A

23. If a two's complement ALU works with 4-bit values to produce a 4-bit result, which *one* of the following operations will result in *overflow*?
    A. 0 minus 7
    B. +5 minus 2
    C. -5 plus -2
    D. +7 plus +1
    E. -7 plus -1

24. What is the decimal value of the 14-bit two's complement number 11111111111001_2?
    A. Some big negative number.
    B. Some big positive number.
    C. +9
    D. -9
    E. -7

25. How much memory is 64MB?
    A. 2^4 bytes
    B. 2^{15} bytes
    C. 2^{26} bytes
    D. 2^{37} bytes
    E. 2^{48} bytes