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:

1. **If your name is not «Name», you have the wrong exam!**
2. **Be sure the name and Exam ID printed on the Scantron sheet match your own name and the Exam ID printed above.**
3. **Answer multiple choice questions on your Scantron sheet *in pencil.***
4. **Answer other questions on the backs of the exam sheets.**
5. **You *may* use a calculator.**

1. (100 Points!) Read the instructions printed above! You will lose up to 100 points if you ask me a question that is answered there or if you don't follow those instructions!!

2. (5 Points) What is the period of a 2 GHz clock signal in *seconds*?
   A) 0.000000000500
   B) 0.000000500
   C) 0.000500
   D) 0.500
   E) 500

3. (5 Points) What is the period of a 2 GHz clock signal in *microseconds*?
   A) 0.000000000500
   B) 0.000000500
   C) 0.000500
   D) 0.500
   E) 500

4. (5 Points) What is the period of a 2 GHz clock signal in *picoseconds*?
   A) 0.000000000500
   B) 0.000000500
   C) 0.000500
   D) 0.500
   E) 500

5. (5 Points) What is the frequency of a clock signal with a period of 0.125 nanoseconds?
   A) 8 KHz
   B) 8 MHz
   C) 8 GHz
   D) 80 KHz
   E) 80 MHz

6. (5 Points) What is the frequency of a clock signal with a period of 0.125 microseconds?
   A) 8 KHz
   B) 8 MHz
   C) 8 GHz
   D) 80 KHz
   E) 80 MHz

A computer requires 2 clock pulses to execute 5% of its instructions, 3 clock pulses to execute 10% of its instructions, and just one pulse to execute all other types of instructions.

7. (5 Points) What is the average number of clock pulses per instruction for this computer?
   A) 1.45
   B) 1.90
   C) 1.70
   D) 2.20
   E) 0.67

8. (5 Points) How long would it take this computer to execute 1.5 million instructions if it has a clock frequency of 2 MHz?
   A) 1.088 seconds
   B) 1.088 milliseconds
   C) 1.088 microseconds
   D) 1.088 nanoseconds
   E) 1.088 picoseconds

9. (5 Points) A small computer has 2^{12} bytes of memory. An address is a binary number that can be used to select any byte for reading or writing. How many bits must an address contain?
   A) 2
   B) 12
   C) 2^{12}
   D) $8 * 2^{12}$
   E) None of the above.

10. (5 Points) Which statement describes a *characteristic table* for an R-S flip-flop?
   A) There are four rows, one for each combination of values for Present State and Next State, and the outputs show the values of Q and ~Q.
   B) There are four rows, one for each combination of values for Present State and Next State, and the outputs show the values of R and S that will cause the flip-flop to change from one state to another.
   C) There are four rows, one for each combination of values for Q and ~Q. There is one output, which shows the state of the flip-flop.
   D) There are four rows, one for each combination of values for R and S, and the outputs show the Next State.
   E) There are two rows, one for each value of D, and the output shows the value of ~Q.

11. (5 Points) Which statement describes an *excitation table* for an R-S flip-flop?
   A) There are four rows, one for each combination of values for Present State and Next State, and the outputs show the values of Q and ~Q.
   B) There are four rows, one for each combination of values for Present State and Next State, and the outputs show the values of R and S that will cause the flip-flop to change from one state to another.
   C) There are four rows, one for each combination of values for Q and ~Q. There is one output, which shows the state of the flip-flop.
   D) There are four rows, one for each combination of values for R and S, and the outputs show the Present State and Next State.
   E) There are two rows, one for each value of D, and the output shows the value of Q.

12. (5 Points) Which statement describes the difference between an edge-sensitive circuit and a level-sensitive circuit?
   A) Level-sensitive circuits can change state multiple times during a clock pulse, but edge-sensitive circuits never change state more than once per clock period.
   B) Level-sensitive circuits never have clock inputs, but edge-sensitive circuits always do.
   C) Level-sensitive circuits work more like flip-flops, but edge-sensitive circuits work like latches.
   D) Level-sensitive circuits are constructed from AND and NOR gates, but edge-sensitive circuits are constructed from NAND gates.
   E) Level-sensitive circuits have better fan-outs than edge-sensitive circuits.

13. (5 Points) Which of the following is the best definition of *propagation delay*?
    A) The interval between the leading and trailing edges of a clock pulse.
    B) The proportion of the time a clock signal is true.
    C) The number of bits per pixel.
    D) The time it takes a gate to change state.
    E) The number of wires connected to the output of a gate.

14. (5 Points) Which of the following is the best definition of *fan-in*?
    A) It's like a shoe-in, but done with a fan.
    B) The number of input wires to a gate.
    C) The number of states a flip-flop can be in.
    D) The number of wires connected to the output of a gate.
    E) The time it takes for the inputs to arrive at a gate.

15. (5 Points) What is the reason for using Carry Lookahead logic?
    A) It's smaller.
    B) It's bigger.
    C) It costs less.
    D) It's simpler.
    E) It's faster.

16. (5 Points) Which of the following describes a 2×4 decoder?
    A) Two AND gates, four Inverters, and one OR gate.
    B) Two Inverters, four AND gates, and one OR gate.
    C) Two OR gates, four AND gates, and one Inverter.
    D) Two Inverters, four OR gates, and one AND gate.
    E) Two Inverters, four AND gates, and no OR gates.

17. (5 Points) What is the gate input count for a 2×4 decoder?
    A) 10
    B) 12
    C) 14
    D) 16
    E) 18

18. (10 Points) Draw all the gates to implement a J-K Master-Slave flip-flop. Draw it on the back of any exam sheet. Label all inputs and outputs meaningfully.

19. (15 Points) A stopwatch has three states named Zero, Running, and Stopped. There are two buttons, named B1 and B2. B1 works as follows: if the stopwatch is in the Zero state, pressing B1 causes it to advance to the Running state. If it is in the Running state, pressing B1 causes it to advance to the Stopped state. If it is in the Stopped state, pressing B1 causes it to return to the Running state. Pressing B2 has no effect unless the stopwatch is in the Stopped state, in which case pressing B2 causes the it to go to the Zero state. (This stopwatch has no "lap" function, so don't worry about that feature.) You are to design a finite state machine controller for this stopwatch that has two inputs (B1 and B2) and three outputs, one for each of the three states. Use two D flip-flops for the state of the controller. Answer this question by drawing the State Diagram for the controller next to the state mapping table below. Then use the state mapping table and your state diagram to complete the state table on the last page. *You are not to draw a circuit for this question.*
    Help: I suggest you mark the values of S_1 and S_0 next to the circles of your state diagram; it will lessen the chance of getting mixed up while completing the state table..

S_1	S_0	State Name
0	0	Not Used
0	1	Zero
1	0	Running
1	1	Stopped

Inputs		Present State		Next State		FF Inputs		Outputs		
B1	**B2**	**S_1**	**S_0**	**S_1**	**S_0**	**D_1**	**D_0**	**Zero**	**Running**	**Stopped**
0	0	0	0							
0	0	0	1							
0	0	1	0							
0	0	1	1							
0	1	0	0							
0	1	0	1							
0	1	1	0							
0	1	1	1							
1	0	0	0							
1	0	0	1							
1	0	1	0							
1	0	1	1							
1	1	0	0							
1	1	0	1							
1	1	1	0							
1	1	1	1							