1. (4 marks) Simplify the Boolean function of four variables: f (w,x,y,z) = ∑(1,3,4,6,9,11,12,14). Note:1 stands for 0001 = wxyz. The simplification result is:____

2. (4 marks) Given the following data definitions: .data X: .word -8, 2, 4,10 Y: .half 3, 2 #.half means half-word Z: .byte 'A', 'B', 'C' Suppose the address for X is 0x10010000, the hexadecimal addresses for Z will be:___

3. (4 marks) Consider the conversion between two number systems. Suppose (123)5 = (x3)y , where x and y are positive integers less than 10. Then the value of x is _.

4. (5 marks) Suppose we want to load the address 0000 0000 0001 0000 1000 0000 0000 0000 into register $s0 using the following two instructions. lui $s0, 16 addi $s0, $zero, 32768 # 32768 is a decimal value (a) (3 marks) Can the two instructions successfully load the correct address? Explain your reason. (b) (2 marks) If your answer is NO, modify one instruction such that we can load the address correctly.

5. (6 marks) Consider the following circuit consisting of two D-Flip-Flops. The state is denoted as Q0Q1. Suppose at time t, the state is 00. Then, the states at time (t + 1), (t + 2), (t + 3) should be _.

6. (4 marks) Using Boolean algebra to simplify this function f = x′y′ + xy + x′y such that the result is a sum of two terms and each term contains a single variable or its complement. Show your solution steps.

7. (6 marks) Consider the following multiplexer where the four data lines (10, 11, 12, 13) are selected by two select lines (A1A0). Note: 10, 11, 12, 13, A1, and A0 are the names of pins in the circuit. Specifically, the combinations A1A0 = 00,01,10,11 will select the data line 10, 11, 12, 13, respectively. x,y,z are the inputs of this circuit and f is the output. EN is the Enable input such that when EN = 0, f= 0 regardless of the inputs. (a) (1 marks) What's the value of f when z = 1 ? (b) (2 marks) What's the value of f when x = 1, y = 1, z = 0 ? (c) (3 marks) f(x,y,z) =___

8. (4 marks) Assume x and y are negative integers stored in 2's complement form in registers $s1 and $s2, respectively. Complete the following MIPS assembly instructions that will store x +y in a register $s3 and if there is an overflow, branch to a symbolic address overflow. add **_, $s1, $s2 slt $t0, _, _ bne $t0, _,** overflow

9. Analyze the sequential circuit consisting of two D Flip-Flops shown in the following figure. Use A and B to denote the current state.Use AN and BN to denote the next state. Complete the following steps: • (6 marks) Observe the circuit, derive DA, DB and Z as the functions of current state and external input. • (4 marks) Derive the next state AN , BN as the functions of current state and external input. • (5 marks) We use the following encoding of the states: AB = 00, 01, 10, 11 represents state S0, S1, S2, S3 respectively. Derive the state table shown below.

10. Use a sequential circuit to implement an up-down counter. This counter will count through 0, 1, 2, 3 and an external input X will control the counting direction. Specifically, when X = 0, the counter will count up: 0,1,2,3,0,1,2,3, etc; when X = 1, the counter will count down: 0,3,2,1,0,3,2,1, etc. Complete the following design steps: (a) (5 marks) Draw a state diagram of this counter. Using '0', '1', '2', '3' to denote the state. (b) (4 marks) We use two bits Q1Q0 to encode the states as follows: Q1Q0 = 00, 01, 10, 11 represent 0, 1, 2, 3, respectively. Derive the state table. (c) (5 marks) Suppose we use two J-K flip-flops (JKFF0 and JKFF1) to implement this counter. Q0 and Q1 are the outputs of JKFF0 and JKFF1, respectively. (J0, K0) and (J1, K1) are the inputs of JKFF0 and JKFF1, respectively. Derive the excitation table for the circuit. (d) (6 marks) Derive J0, K0, J1, and K1 as functions of Q1,Q0,X, respectively.