

NAME: _____

Recall that student ID CPU has three instructions: JMP (opcode = 00) – unconditional jump, JC (opcode = 01) – jumps when ODD input =1, else goto next instruction, OUT (opcode 10) – output data to OUT register. The opcode formed the two most-significant bits with the lower four bits used for data.

1. (2 pts) Convert the instruction “OUT 3” to its binary machine code representation.

10 0011

2. (2 pts) Assume that instead of displaying digits, we wanted to display a sequence of 7-bit ASCII codes. What changes would have to be made to hardware components (Program counter, Memory, Output Register) to support this change?

Increase memory data width from 4 bits to 7 bits (memory is now 16 x 9). Increase output register width from 4 to 7. Program counter width does not change as we do not have to increase the number of program locations to accommodate wider output data.

3. (6 pts) Assume the ODD input bit is tied the least significant bit of the DATA output (the data output displays the binary code for the digit that is currently in the output register. List the instruction sequence that is executed – give the first 10 instructions that are executed by LOCATION and instruction (hint: if the number is ODD, then the ODD input will be a ‘1’). When a JC is encountered, you have to list it in the table regardless of whether the jump is actually performed or not.

Location	instruction
0	OUT 3
1	JC 6
2	OUT 4
3	JC 0
4	OUT 9
5	OUT 8
6	JC 2
7	OUT 5
8	OUT 1
9	JMP 0

	Location Executed	Instruction
1.	0	out 3 (output=0011)
2.	1	jc 6 (jump taken, output is odd, = 001 1)
3.	6	jc 2 (jump taken, output is odd, = 001 1)
4.	2	out 4 (output = 0100)
5.	3	jc 0 (jump not taken, output is even, = 010 0)
6.	4	out 9 (output = 1001)
7.	5	out 8 (output = 1000)
8.	6	jc 2 (jump not taken, output is even, = 100 0)
9.	7	out 5 (output = 0111)
10.	8	out 1 (output = 0001)