

KEY

00042

Your Name (first last)

Fall 2019 Midterm 1/B UC Berkeley EECS151

SID

← Name of person on left (or aisle)

TA name

Name of person on right (or aisle) →

Fill in the correct circles & squares completely...like this: ● (select ONE), and ■ (select ALL that apply)

Question	1	2	3	4	Total
Minutes	15	20	25	20	80
Max Points	12	16	24	18	70
Points					

1) It's all logical... (12 points, 15 minutes)

You need to design a circuit for the following truth table.

A	B	C	D	Y
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	0
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

a) Write the sum of products expression for output Y directly from this truth table.

$$Y = \bar{a}\bar{b}\bar{c}\bar{d} + \bar{a}\bar{b}c\bar{d} + \bar{a}b\bar{c}\bar{d} + \bar{a}b\bar{c}d + \bar{a}bcd + abcd$$

1) It's all logical... (continued)

b) Draw a Karnaugh map for this expression

		CD			
		00	01	11	10
AB	00	1	1	1	1
	01				
	11				1
	10		1		

c) Use the Karnaugh map from part b) to simplify the circuit and write the simplified sum-of-product representation.

$$Y = \bar{a}\bar{b} + \bar{b}\bar{c}d + abcd$$

2) State Machines (16 points, 20 minutes)

A state transition diagram for a finite state machine (FSM) is shown in Figure 2.

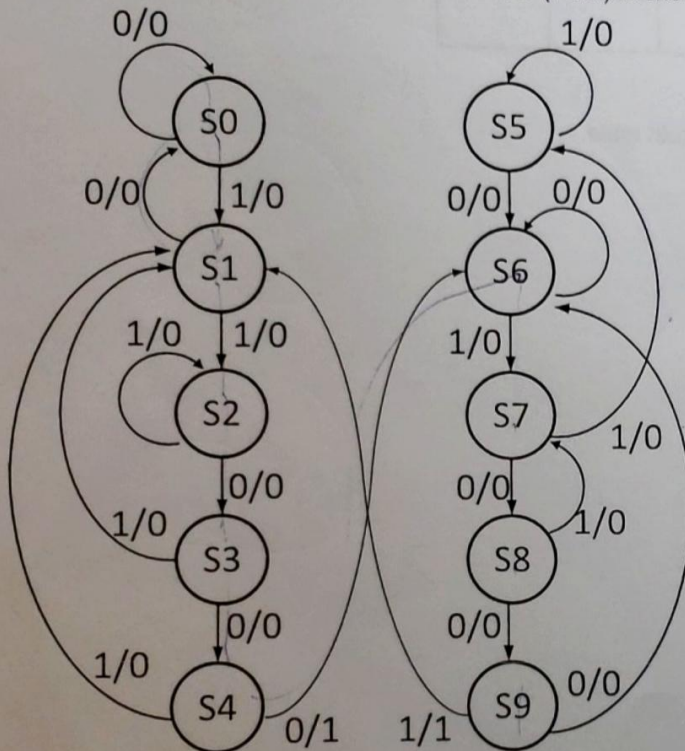


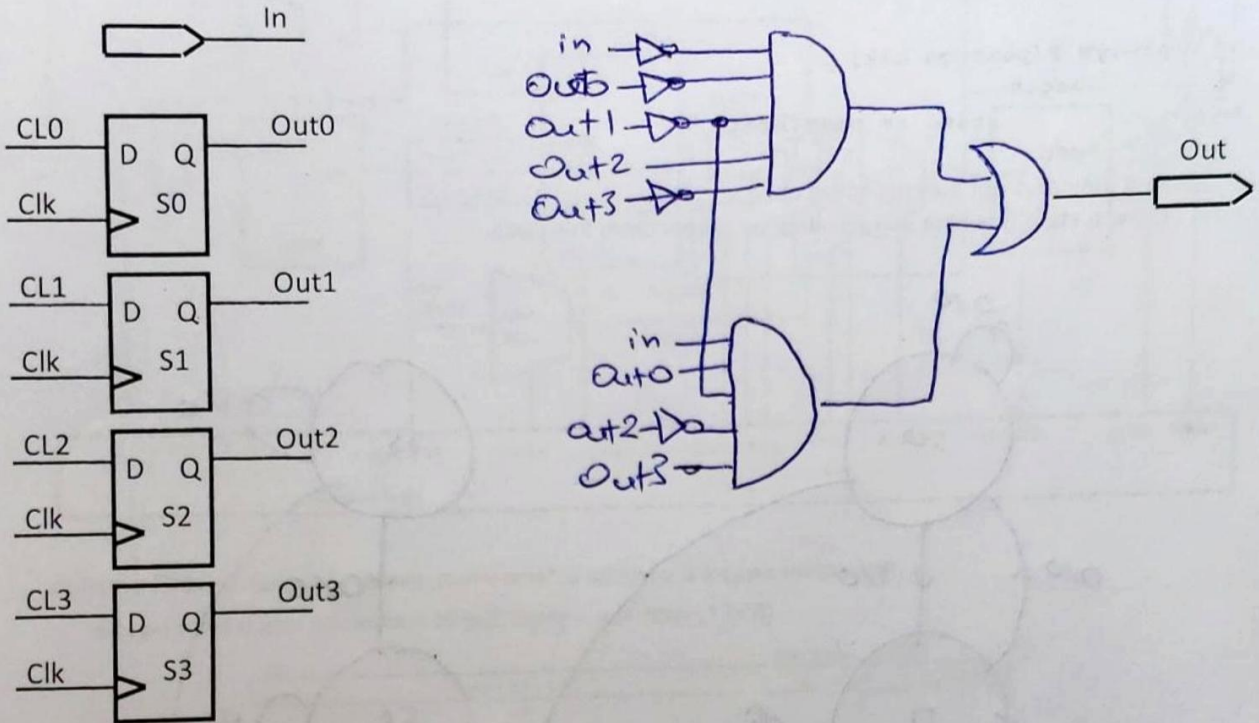
Figure 2.

a) If the FSM starts in state S0, in which state will it be after the input pattern 01011000100?

- ☐ S1 ☐ S0 ☐ S7 ☐ S2 ☐ S8
☐ S6 ☐ S4 ☐ S3 ☒ S9 ☐ S5

2) State Machines (continued)

- b) If the state is represented by a four-bit register S[3:0] and S4 = 4'b0100 and S9 = 4'b1001, complete the following diagram:



$$Out = S4.\overline{in} + S9.in$$

2) State Machines (continued)

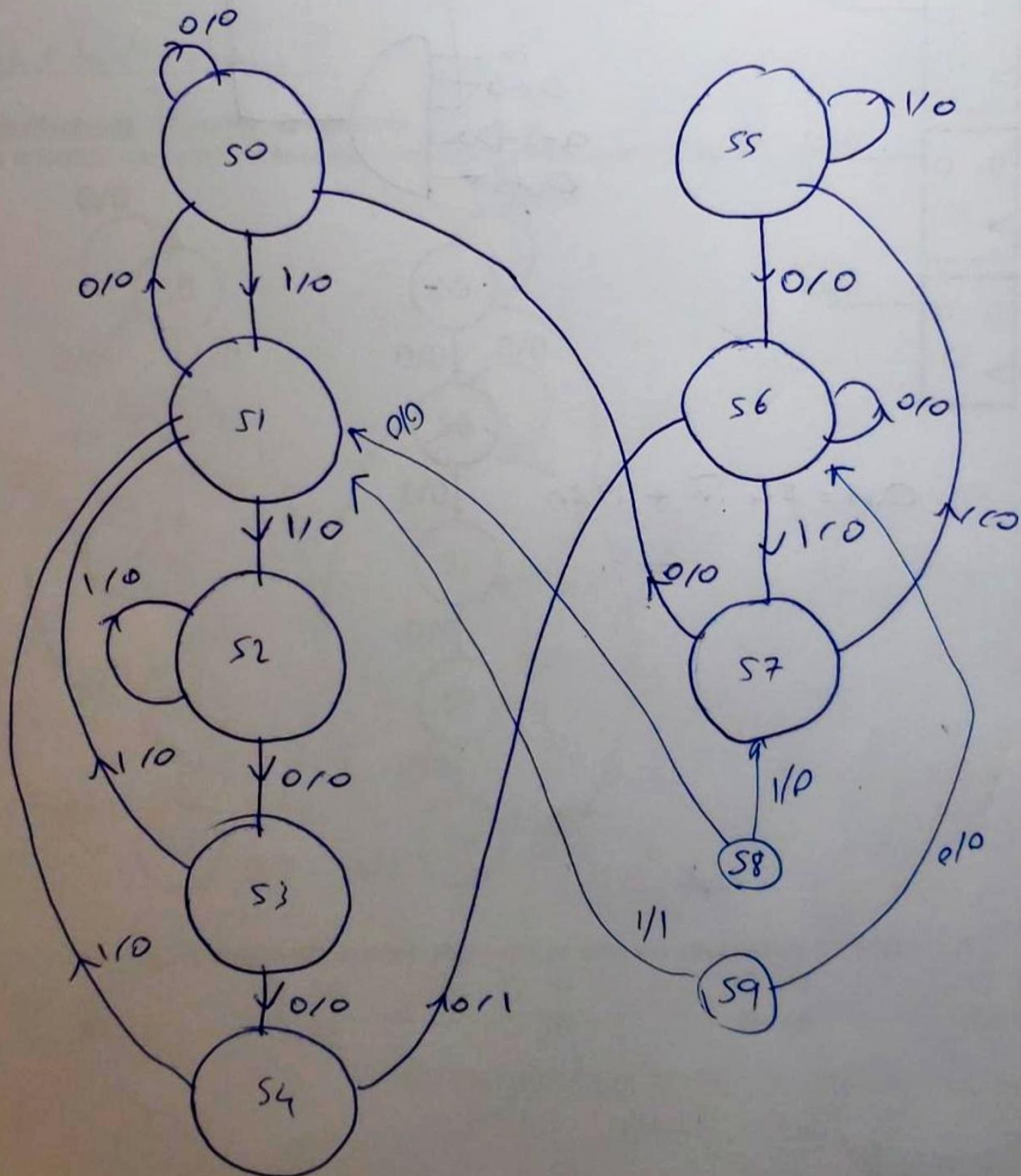
c) Your colleague wrote the following code to represent this FSM:

```
wire[2:0] next_state;
reg[3:0] state;
```

```
always @(posedge clk)
begin
    state <= next_state;
end
```

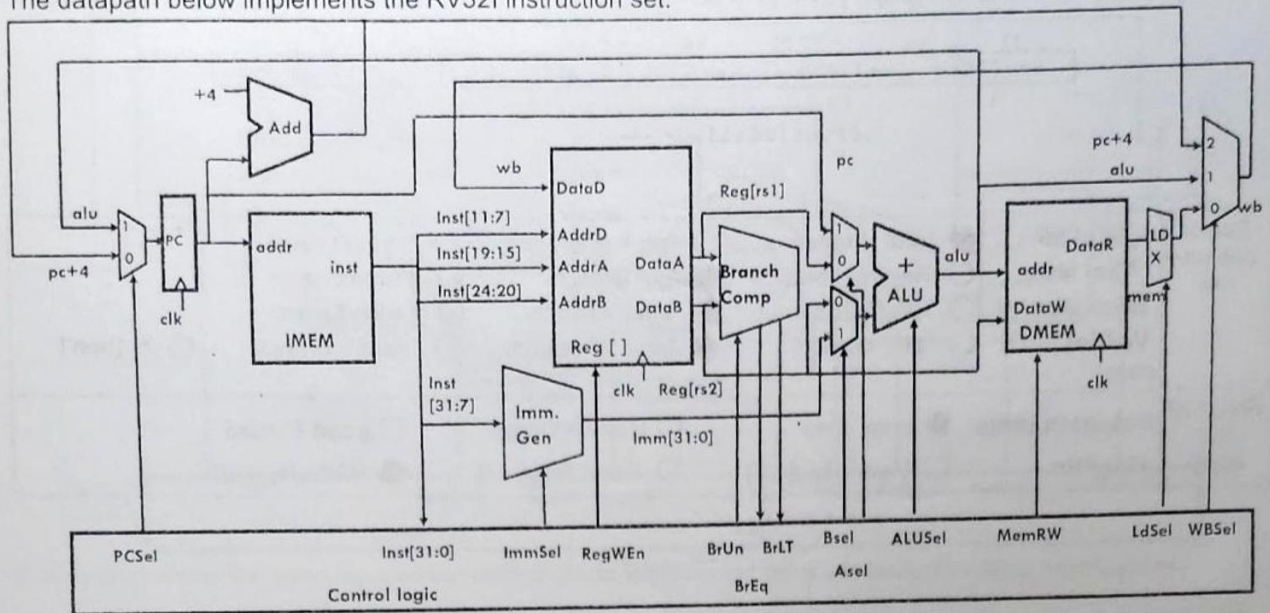
And they also got the rest of the code correctly.

Draw a state machine diagram that corresponds to this code.



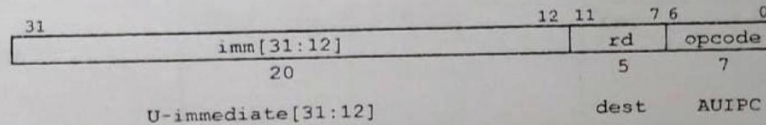
3) Datapathology (24 points, 25 minutes)

The datapath below implements the RV32I instruction set.



a) In the RISC-V datapath above, mark what is used by a `auipc` instruction.

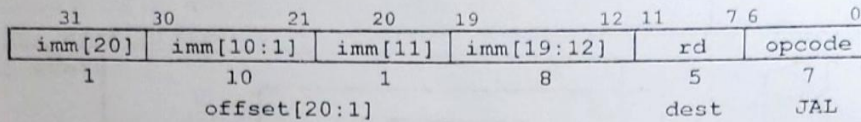
auipc (add upper immediate to pc): $R[rd] = pc + \{imm, 12b'0\}$



<p>Select one per row</p>	<p>PCSel Mux: <input type="radio"/> "alu" branch <input checked="" type="radio"/> "pc + 4" branch <input type="radio"/> * (don't care)</p> <p>ASel Mux: <input type="radio"/> Reg[rs1] branch <input checked="" type="radio"/> "pc" branch <input type="radio"/> * (don't care)</p> <p>BSEL Mux: <input type="radio"/> Reg[rs2] branch <input checked="" type="radio"/> "imm" branch <input type="radio"/> * (don't care)</p> <p>WBSel Mux: <input checked="" type="radio"/> "alu" branch <input type="radio"/> "pc + 4" branch <input type="radio"/> "mem" branch <input type="radio"/> * (don't care)</p>
<p>Select all that apply</p>	<p>Datapath units: <input checked="" type="checkbox"/> Imm. Gen <input type="checkbox"/> Branch Comp <input type="checkbox"/> Load Extend</p> <p>RegFile: <input type="checkbox"/> Read Reg[rs2] <input type="checkbox"/> Read Reg[rs1] <input checked="" type="checkbox"/> Write Reg[rd]</p>

b) In the RISC-V datapath above, mark what is used by a jal instruction.

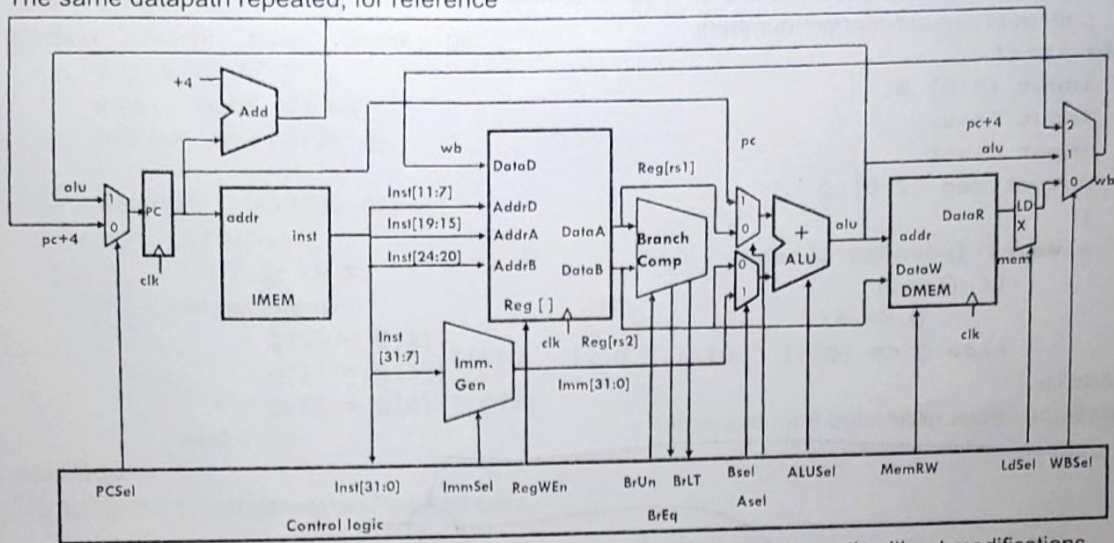
jal (Jump and link): $R[rd] = pc + 4$; $pc = pc + \{imm, 1b'0\}$



<i>Select one per row</i>	PCSel Mux:	<input checked="" type="radio"/> "alu" branch	<input type="radio"/> "pc + 4" branch	<input type="radio"/> * (don't care)
	ASel Mux:	<input type="radio"/> Reg[rs1] branch	<input checked="" type="radio"/> "pc" branch	<input type="radio"/> * (don't care)
	BSel Mux:	<input type="radio"/> Reg[rs2] branch	<input checked="" type="radio"/> "imm" branch	<input type="radio"/> * (don't care)
	WBSel Mux:	<input type="radio"/> "alu" branch	<input checked="" type="radio"/> "pc + 4" branch	<input type="radio"/> "mem" branch <input type="radio"/> * (don't care)
<i>Select all that apply</i>	Datapath units:	<input checked="" type="checkbox"/> Imm. Gen	<input type="checkbox"/> Branch Comp	<input type="checkbox"/> Load Extend
	RegFile:	<input type="checkbox"/> Read Reg[rs2]	<input type="checkbox"/> Read Reg[rs1]	<input checked="" type="checkbox"/> Write Reg[rd]

3) Datapathology (continued)

b) The same datapath repeated, for reference



Specify whether the following proposed instructions can be implemented using this datapath without modifications.

If the instruction can be implemented, specify an expression for the listed control signals, by following the example below.

Instruction	Description	Imple-mentable?	Control Signals
Add add rd, rs1, rs2	$R[rd] = R[rs1] + R[rs2]$	Yes	ALUSel = Add WBSel = 1
beq with writeback: beq rd, rs1, rs2, imm	$R[rd] = R[rs1] + R[rs2]$ if ($R[rs1] == R[rs2]$) $PC = PC + \{imm, 1'b0\}$	NO	WBSel = ✗ PCSel = ✗
Load word with add: lwadd rd, rs1, rs2, imm	$R[rd] = M[R[rs1] + imm] + R[rs2]$	NO	RegWEn = ✓ WBSel = ✗
Register offset load: lwreg rd, rs1, rs2	$R[rd] = M[R[rs1] + R[rs2]]$	yes	ASel = 0 Bsel = 0
PC-relative load: lwpc rd, imm	$R[rd] = M[PC + imm]$	yes	ASel = 1 Bsel = 1

4) Verilog (points, 20 minutes)

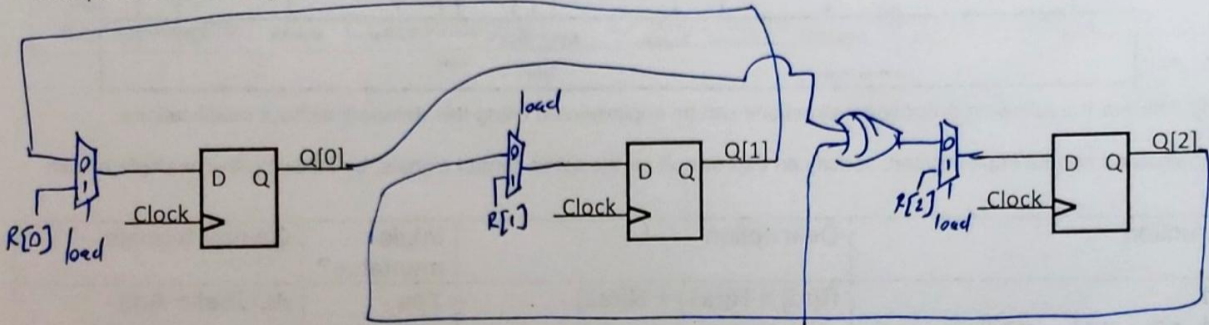
- a) The following code describes a 3-bit linear-feedback shift register (LFSR), which generates a repeating pattern of pseudo-random numbers.

```

module lfsr(
    input [2:0] R,
    input Load,
    input Clock,
    output reg [2:0] Q
);
    always@ (posedge Clock)
        if (Load)
            Q <= R;
        else Q <= {Q[0] ^ Q[2], Q[2], Q[1]};
endmodule

```

Complete the circuit generated from this code:



- b) If the initial state of Q[2:0] is 3'b001, write the outputs that correspond to the first 8 cycles:

Cycle	Q[2:0]
0	001
1	100
2	110
3	111
4	011
5	101
6	010
7	001

4) Verilog (continued)

c) Similar code is shown below:

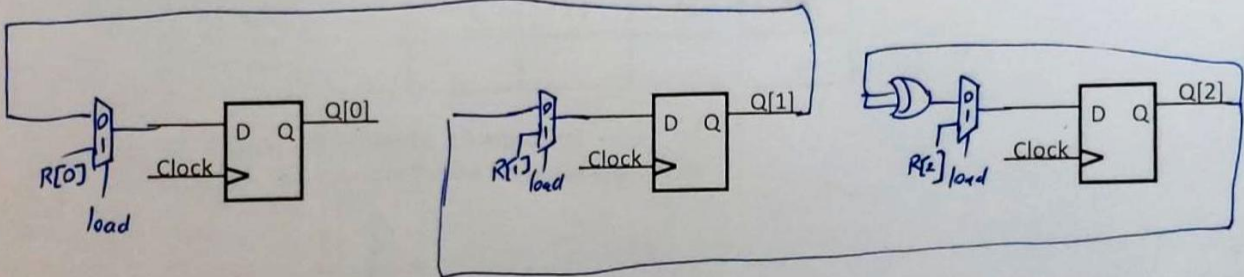
```

module lfsr(R, Load, Clock, Q) ;
    input [2:0] R;
    input Load, Clock;
    output reg [2:0] Q;

    always@ (posedge Clock)
        if (Load)
            Q <= R;
        else begin
            Q[0] = Q[1];
            Q[1] = Q[2];
            Q[2] = Q[0] ^ Q[2];
        end
endmodule

```

Complete the circuit generated from this code:



$$Q \leftarrow \{Q[0], Q[1], Q[2]\}$$

d) If the R[2:0] value of 3'b001 is loaded initially, write the outputs that correspond to the first 8 cycles:

Cycle	Q[2:0]
0	001
1	000
2	000
3	000
4	000
5	000
6	000
7	000