ECE 341 Midterm Exam Solution

Problem No. 1

(a) True, (b) False, (c) False, (d) True, (e) False

Problem No. 2

(a)

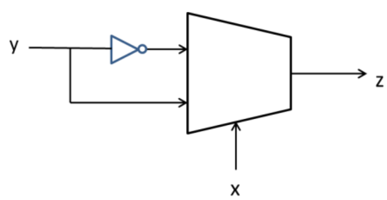
i. At t = 18 ns, **Q = 0** (Q retains its initial value until there is a positive clock edge)

ii. At t = 35 ns, **Q = 1** (Positive clock edge arrives at t = 20 ns and J= 1, K = 0)

iii. At t = 50 ns, **Q = 0** (Q toggles its value because there is a positive clock edge at 40 ns and J = 1, K = 1)

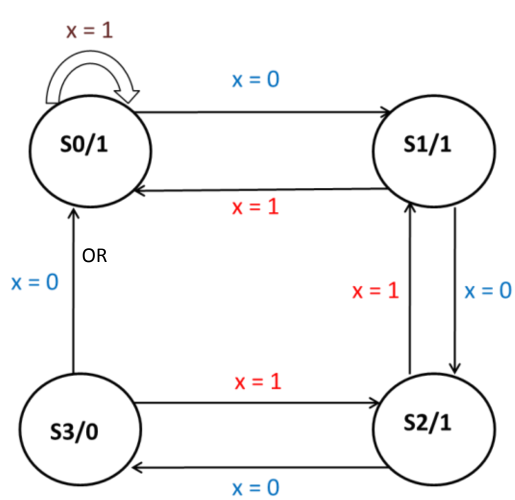
(b) $z = \overline{x \oplus y} = \overline{xy} + xy$

To implement the function with a 2-input multiplexer, we need one select input and two data inputs. We can choose either of the two variables as a select input. Then the second variable will appear in the data inputs as follows:



Problem No. 3

(a) The state machine for the given counter is as follows:



(b) The state-assigned state table is as follows:

Present State	Next State		Output z
	x = 0	x = 1	
y_2y_1	Y_2Y_1	Y_2Y_1	
00	01	00	1
01	10	00	1
10	11	01	1
11	00	10	0

(c) $z = \overline{y2}\,\overline{y1} + \overline{y2}\,y1 + y2\,\overline{y1}$
$= \overline{y2}\,(\overline{y1} + y1) + y2\,\overline{y1}$
$= \overline{y2}(1) + y2\,\overline{y1}$
$= \overline{y2} + y2\,\overline{y1}$
$= (\overline{y2} + y2)(\overline{y2} + \overline{y1})$
$= (1)(\overline{y2} + \overline{y1})$
$= \overline{y2} + \overline{y1}$

$Y_2 = \bar{x}\,\overline{y_2}\,y_1 + \bar{x}\,y_2\,\overline{y_1} + xy_2y_1$
$= \bar{x}\,(y_2 \oplus y_1) + xy_2y_1$

Problem No. 4

(a) X = 1101, Y = 1010, c_0 = 1
$G_0 = x_0$ AND y_0 = 1 AND 0 = 0
$G_1 = x_1$ AND y_1 = 0 AND 1 = 0
$G_2 = x_2$ AND y_2 = 1 AND 0 = 0
$G_3 = x_3$ AND y_3 = 1 AND 1 = 1

$P_0 = x_0$ OR y_0 = 1 OR 0 = 1
$P_1 = x_1$ OR y_1 = 0 OR 1 = 1
$P_2 = x_2$ OR y_2 = 1 OR 0 = 1
$P_3 = x_3$ OR y_3 = 1 OR 1 = 1

$c_3 = G_2 + P_2G_1 + P_2P_1G_0 + P_2P_1P_0c_0$
= 0 OR (1 AND 0) OR (1 AND 1 AND 0) OR (1 AND 1 AND 1)
= 0 OR 0 OR 0 OR 1
= 1

(b) Both these numbers can be represented as 5-bit binary numbers in 2's complement representation:

```
    0 1 0 0 0   (+8)                     0  1  0  0  0
X   1 1 0 1 1   (-5)      ==>            0 -1 +1  0 -1
  -----------                  -----------------------
                               1 1 1 1 1 1 0 0 0
                               0 0 0 0 0 0 0 0
                               0 0 0 1 0 0 0
                               1 1 1 0 0 0
                               0 0 0 0 0
                               ---------------------
                               1 1 1 0 1 1 0 0 0      (- 40)
```

(c) CPI = (10% * 3) + (30% * 5) + (20% * 4) + (40% * 4) = 4.2
Instruction Execution Rate = 500 million instructions per second = $5 * 10^8$ instructions per second
Since:
Execution time = (Number of Instructions * CPI) / Clock Rate
Therefore:
Clock Rate = (Number of Instructions * CPI) / Execution Time = CPI * Instruction Execution Rate
= $4.2 * 5 * 10^8 = 2.1 * 10^9$ = 2.1 GHz

Therefore the processor must operate at a clock speed of at least 2.1 GHz to satisfy the instruction execution rate target.

Problem No. 5

(a) (i) *MuxB* selects inputs **1**, **0**, and **1** for instructions 1, 2, and 3, respectively.

(ii)
For instruction 1:
Contents of *RY* = Contents of memory address (28000 + 200) = **500**
The contents of register R4 become 500 after instruction 1.

For instruction 2:
Contents of *RY* = [R2] + [R4] = 200 + 500 = **700**
The contents of register R5 become 700 after instruction 2.

(iii) *RF_write* has values of **1**, **1**, and **0** for instructions 1, 2, and 3, respectively.

(b) The "store" instruction writes the contents of R5 to the memory location at address 28000 + 400 = 28400.
Therefore the final contents of memory location 28400 are **700**.
The final contents of memory location 28200 remain unchanged at **500**.