ECE275 Midterm 2 (sample) exam Fall 2023

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Student Name: Student Email:

1 Instructions

- There are five questions.
- Maximum number of marks is 120 . This exam amounts 10% toward the final grade.
- Time allowed is 50 minutes.
- In order to minimize distraction to your fellow students, you may not leave during the last 10 minutes of the examination.
- The examination is closed-book. One 8×11 in two-sided cheatsheet is allowed.
- Non-programmable calculators are permitted.
- Please use a pen or heavy pencil to ensure legibility. Colored pens/pencils are recommended for K-map grouping.
- Please show your work; where appropriate, marks will be awarded for proper and well-reasoned explanations.

Problem 1. *A sequential circuit is to be used to control the operation of a vending machine which dispenses a \$0.25 product. The circuit has three inputs (N, D, and Q) and two outputs (R and C). The coin detector mechanism in the vending machine is synchronized with the same clock as the sequential circuit you are to design. The coin detector outputs a single 1 to the N, D, or Q input for every nickel (5 cents), dime (10 cents), or quarter (25 cents), respectively, that the customer inserts. Only one input will be 1 at a time. When the customer has inserted at least \$0.25 in any combination of nickels, dimes, and quarters, the vending machine must give change and dispense the product. The coin return mechanism gives change by returning nickels to the customer. For every 1 output on C, the coin return mechanism will return one nickel to the customer. The product is dispensed when the circuit outputs a single 1 on output R. The circuit should reset after dispensing the product.*

Example: *The customer inserts a nickel, a dime, and a quarter. The circuit inputs and outputs could look like this:*

Inputs: → 5 → 15 → 40 35 30 25 → count reset 5

	N=	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Inputs	*D=*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Q=	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*
	R=	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*
Outputs	*C=*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*1*	*0*	*0*	*0*

Note that any number of 0's can occur between 1 inputs. Complete the following Moore state table

Draw The

State table

Inputs | Present state → Next state | Outputs

Money inserted	change due	Present PS	Next state NDQ=000	100	010	001	Release the product RC
0	0	S_0	S_0	S_1	S_2	S_3	00
5	0	S_1	S_1	S_2	S_4	S_5	00
10	0	S_2	S_2	S_4	S_6	S_7	00
R=1 → 25	0	S_3	S_0	S_0	S_0	S_0	10
15	0	S_4	S_4	S_6	S_3	S_8	00
30	5	S_5	S_3	S_3	S_3	S_3	01
20	0	S_6	S_6	S_3	S_5	S_9	00
35	10	S_7	S_5	S_5	S_5	S_5	01
40	15	S_8	S_7	S_7	S_7	S_7	01
45	20	S_9	S_8	S_8	S_8	S_8	01

for the sequential circuit, and for each state indicate how much money the customer has inserted or how much change is due. (30 marks)

Problem 2. *Realize a BCD to excess-3 code converter using a minimum number of gates. (The excess-3 code is obtained from the binary numbers (0-9) by adding 3 (0011) to each of the binary numbers.) (10 marks)*

Problem 3. *Reduce the following state table to a minimum number of states using implication charts (20 marks).*

Present State	Next State $X = 0$	Next State 1	Output Z
A	A	B	1
B	C	E	0
C	F	G	1
D	C	A	0
E	I	G	1
F	H	I	1
G	C	F	0
H	F	B	1
I	C	E	0

Problem 4. *1. For the following state table, use the three guidelines to determine which of the three possible nonequivalent state assignments should give the best solution (20 marks).*

2. Using your answer to (a), derive J-K flip-flop input equations and the output equations (20 marks).

Present State	Next state $X_1X_2 = 00$	01	11	10	Outputs Z_1Z_2 $X_1X_2 = 00$	01	11	10
A	A	A	C	C	01	01	01	01
B	B	D	B	D	11	11	11	11
C	A	A	B	D	11	11	00	00
D	D	B	A	C	01	01	01	01

Problem 5. *Find the minimum cost circuit for the following function using K-map. Find both sum-of-products and product-of-sum forms and find the minimum cost one.*
$F(a, b, c, d, e) = \prod M(2, 4, 5, 6, 8, 10, 12, 13, 16, 17, 18, 22, 23, 24) + \prod D(0, 11, 30, 31)$ *(20 marks).*

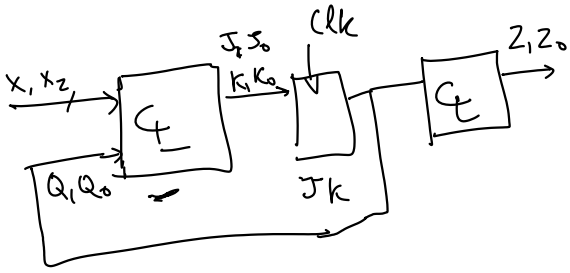
Prob 4.2 — C=00, A=01, D=11, B=10 — Solution 4.1

	PS	NS				Output (Z_1Z_0)			
	Q_1Q_0	$X_1X_2=00$	01	11	10	$X_1X_0=00$	01	11	10
C	00	01	01	10	11	11	11	00	00
A	01	01	01	00	00	01	01	01	01
D	10	11	10	01	00	01	01	01	01
B	11	10	11	10	11	11	11	11	11

States assigned table

J_1K_1 J_0K_0

Q_1 Q_0



Characteristic table of J-K ff

to excitation table

	set	reset	Q^+
	J	K	
hold	0	0	Q
reset	0	1	0
set	1	0	1
toggle	1	1	$\bar{Q}$

Excitation table

Q	Q^+	J	K
0	0	0	0/0
0	1	1	1/1
1	0	1	0/1
1	1	0/1	0

J K

0 *
1 *
* *
0 *

J_1 — X_1X_2 / Q_1Q_2

	0	0	1	1
	0	0	0	0
Q_1	d	d	d	d
	d	d	d	d

X_1

Q_2 $J_1 = X_1\bar{Q}_2$

Q^+_1 — X_1X_2 / Q_1Q_2

	0	0	1	1
	0	0	0	0
Q_1	1	1	0	0
	1	1	1	1

J_0

K_1

K_1 — X_1X_2 / Q_1Q_0, $Q_1=0$

	d	d	d	d
	d	d	d	d
	0	0	1	1
	0	0	0	0

$K_1 = X_1Q_2$