

CS230-2023@IITB

Name: \_\_\_\_\_

Mid-term

23<sup>th</sup> September, 2023

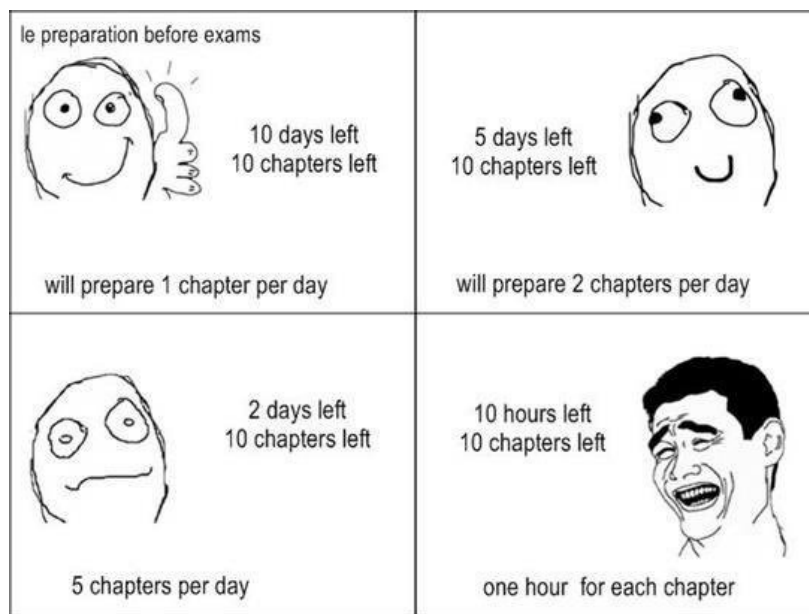
Time Limit: 120 Minutes

Roll No.: \_\_\_\_\_

**Tips:**

Be concise and cognizant.

There will be penalty for verbosity and “it depends” without justification. Do not spend too much or too little time on any particular question.



Question	Points	Score
1	12	
2	25	
3	20	
4	20	
Total:	77	

“I promise I will write this exam honestly and ethically”. Your Signature:

*Bima*

You must be kidding!!

2 points for correct answer  
Zero " for any other answer(s).

1. (12 points) [30 minutes]

(1.1) (2 points) No one (who) are the T.A.s of CS230 with their first names starting with the letter "X".

(1.2) (2 points) \_\_\_\_\_ How many clock pulses are needed to change the contents of an 8-bit up counter from 10101100 to 00100111. The contents are in the following order: MSB to LSB.

123 cycles

84 cycles to reach zero and then 39 more cycles

(1.3) (2 points) Which of the following statements is (are) TRUE?

(a) Set-up time is the time period after the clock becomes inactive during which the flip-flop inputs remain stable.

(b) Hold time is the time period after the clock becomes active during which the flip-flop inputs remain stable.

(c) Hold time is the time period prior to the clock becoming inactive during which the flip-flop inputs remain stable.

None

By definition. :)

(1.4) (2 points) (76543210) in base 8 is \_\_\_\_\_ in base 4.

33 223 0122020

(1.5) (2 points)  $(11)_2 + (22)_3 + (33)_4 + (44)_5 = (xyz)_6$ . What is xyz?

$$(3 + 8 + 15 + 24)_{10} = (xyz)_6$$

$$xyz = 122$$

(1.6) (2 points) What is 100 plus 100 divided by 100 plus 100 \_\_\_\_\_ :)

201

easy peasy lemon squeezy!!

2. (25 points) [45 minutes] Write in details.

(2.1) (3 points) Saksham is using flip flops with a setup time of 1 ns, a hold time of 0.5 ns, and a clock-to-Q time of 1 ns. What is the longest possible critical path in the input-forming logic that will allow for a maximum clock rate of 200 MHz?

$$\text{Setup} + \text{critical path} + \text{CLK-Q} = T_{\text{min}} \quad (1)$$

$$1 / 200 \text{ MHz} = 5 \text{ ns} = T_{\text{min}} \quad (1)$$

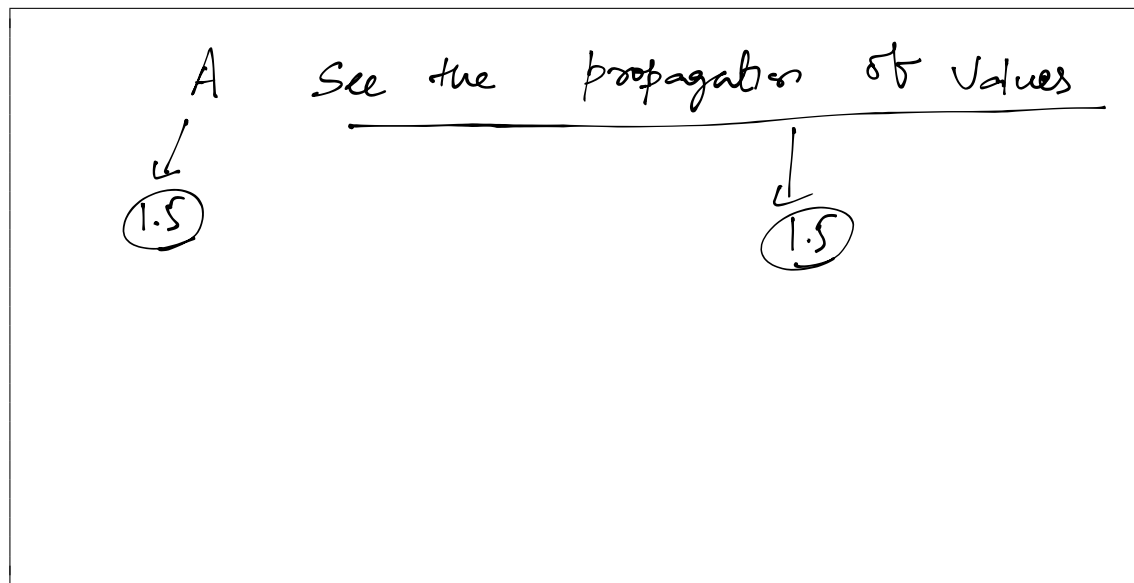
$$\text{critical path} = 5 - 1 - 1 = 3 \text{ ns} \quad (1)$$

Have a break. Have a kitkat!!

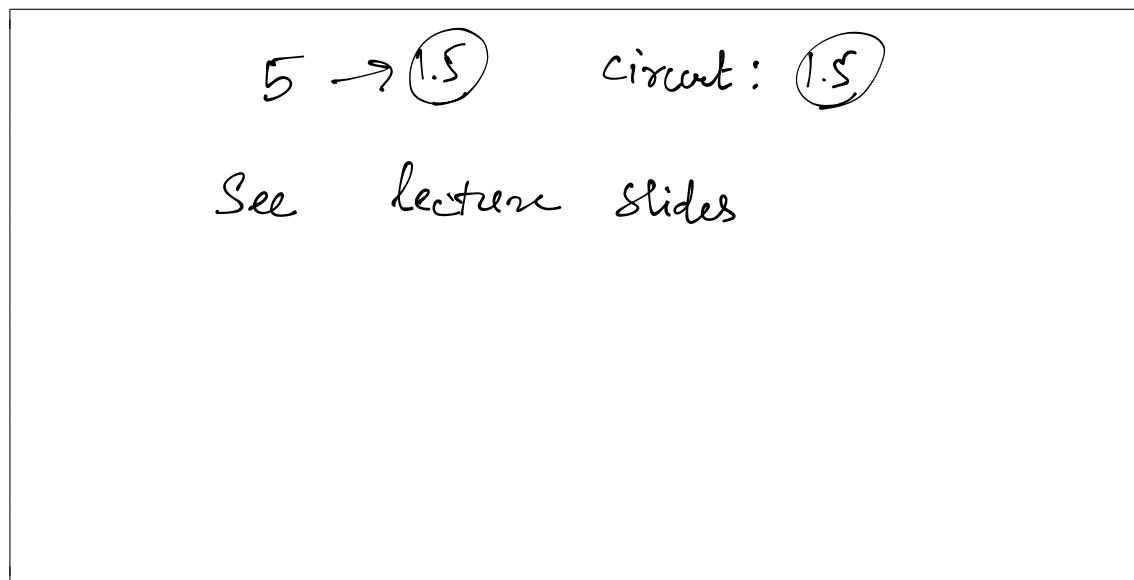


- (2.2) (3 points) Deeksha designed a Div-by-4 FSM that accepts a binary number entered one bit at a time (MSB to LSB) and indicates if the number entered so far is divisible by 4. The minimum number of states in this FSM are \_\_\_\_\_





- (2.5) (3 points) Arihant is designing a  $4 \times 16$  decoder using  $2 \times 4$  decoders. How many  $2 \times 4$  decoders are required to construct a  $4 \times 16$  decoder? Show your work.

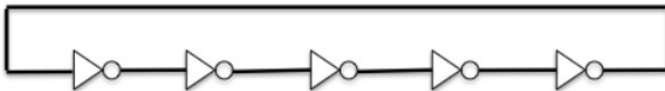


- (2.6) (3 points) There exists a Boolean function  $f(a,b,c,d)$  created by Satyankar such that
- $f(a,0,0,d)=1$
  - $f(1,b,1,d)=b+d$
  - $f(a,1,c,d)=ad+c$
- How many literals are there in the minimum SOP expression of function  $f$ ?

Six (1.5)

$$f = ad + \overline{b}\overline{c} + bc$$

- (2.7) (3 points) Assume that the circuit shown below is designed by Aditya is negative edge triggered and the time to output is 100ms. Then the propagation delay of each of the NOT gates is

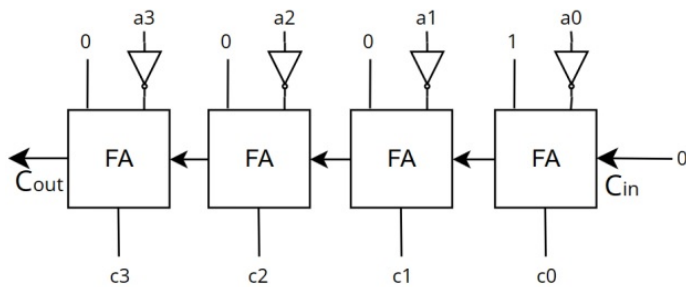


Negative level will be for 50ms (1)

there are 5 inverters

So each inverter will take 10ms. (2)

- (2.8) (3 points) What is the output of  $C=c_3,c_2,c_1,c_0$  for input  $A = 0101$ ? What does the above circuit do?



$$C = 1101$$

Circuit produces  $A$  complement + 1  
 $-A$

- (2.9) (1 point) If you have reached here and no one else has shouted “*Oh Captain My Captain*” then stand up and shout it loudly when Biswa is in your lecture hall. If you have made a plagiarised submission in Lab-2 then you won’t get +1 even if you shout :(

*Shout!!!!*

Exam Exaaaaaammmmmmm!!

3. (20 points) [25 minutes] Write in details.

- (3.1) (20 points) During the job interview of Ananya, Kavya, and Navya, they were asked to design a combinational circuit with a four-bit input, A, B, C, D (A is the most significant bit and D is the least significant bit), and two 1-bit outputs, Factorial and Div4. The value of each output is determined as follows: The output Factorial is 1 only when the input 4-bit number is a product of ALL positive integers that are less than or equal to the input number. The output Div4 is 1 only when the input 4-bit number is divisible by 4. Otherwise, the corresponding outputs are zero.
- (a) Express the output Div4 as the simplest sum of products representation. Show the details. (10 points)



inputs				outputs	
A	B	C	D	Factorial	Div4
0	0	0	0	1	1 ✓ (1)
0	0	0	1	1	
0	0	1	0	1	
0	0	1	1		1 ✓ (1)
0	1	0	0		
0	1	0	1		
0	1	1	0		
0	1	1	1		1 ✓ (1)
1	0	0	0		
1	0	0	1		
1	0	1	0		
1	0	1	1		1 ✓ (1)
1	1	0	0		
1	1	0	1		
1	1	1	0		
1	1	1	1		

Div4 =  $\bar{C}\bar{D}$  — (6)

(b) Find the simplest representation of the Factorial output by using only NOR gates. Show your work step-by-step. (10 points)

Remember only NOR gates

$$\text{factorial} = B + A + \overline{\overline{C + C} + \overline{D + D}}$$

Answer with non-NOR gates 5 points  
 based on  
 correct expression

4. (20 points) [25 minutes] Write in details.

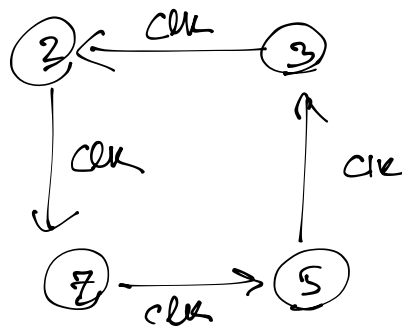
(4.1) (20 points) Kunal is planning to design a state machine for a counter that counts through the 3-bit prime numbers downwards. Note that there are only four 3-bit prime numbers: 2, 3, 5, and 7. You need to provide the state transition table and the state transition diagram. Assume that the state is stored in D flip-flops.

(a) Draw the state table with the present state and the next state and help Kunal. (10 points)

Current state				Next state		
	P2	P1	P0	N2	N1	N0
0	0	0	0	X	X	X
1	0	0	1	X	X	X
2	0	1	0	1	1	1
3	0	1	1	0	1	0
4	1	0	0	X	X	X
5	1	0	1	0	1	1
6	1	1	0	X	X	X
7	1	1	1	1	0	1

(b) Draw the state transition diagram with a proper initial state. (10 points)

Answer to (b) will be correct if  
(a) is answered correctly  
else zero points.



Ta ta, bye bye, khatam exam !!

Rough sheet

Rough sheet