CS & IT ENGINEERING

Operating System

Process Synchronization

Lecture -1

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Recap of Previous Lecture

Topic Multithreading

Topic System Call: Fork()

Topics to be Covered

Topic Synchronization

Topic Race Condition

Topic Critical Section

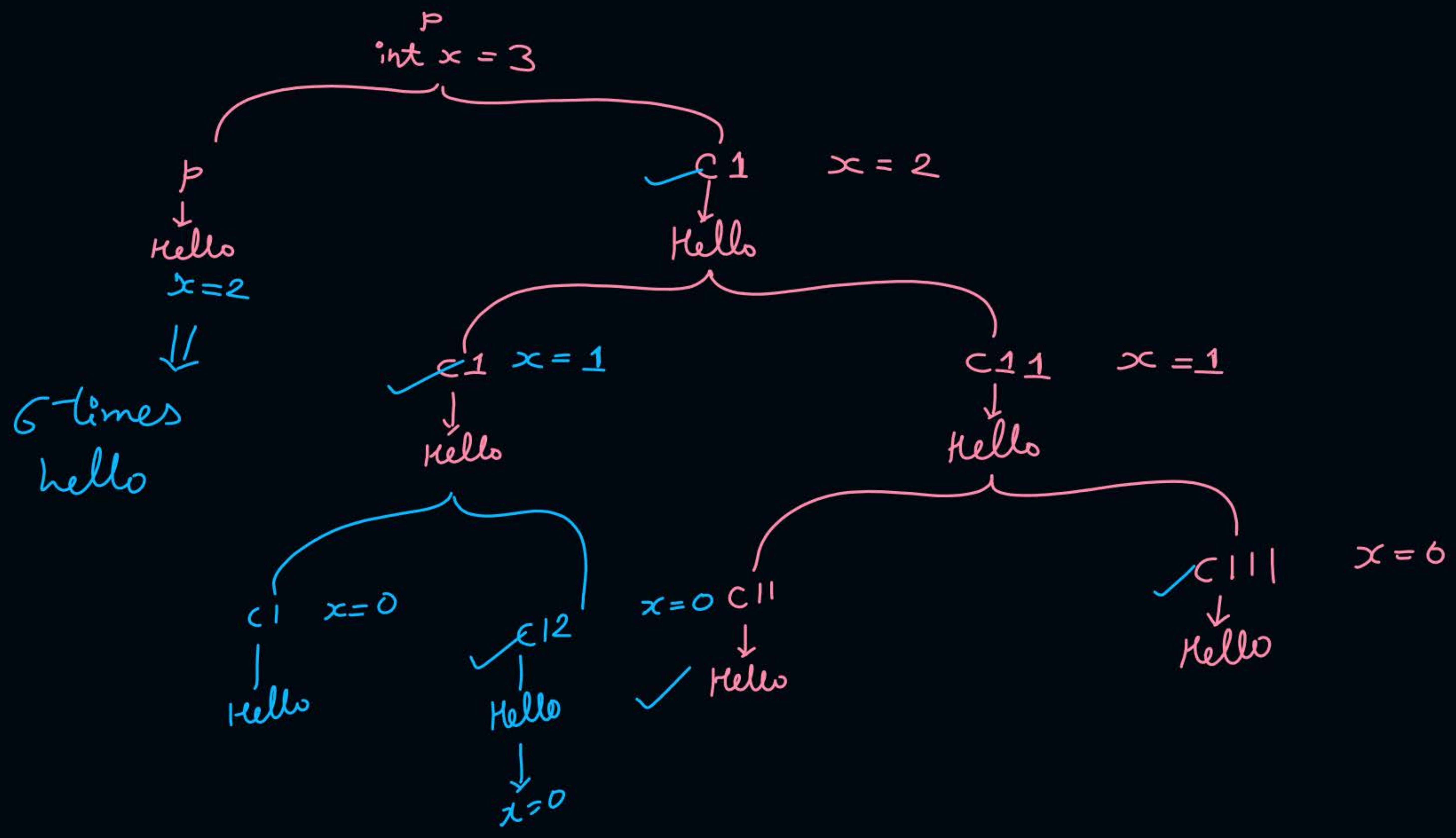
[NAT]

#Q. Consider the following code snippet using the fork() and wait() system calls. Assume that the code compiles and runs correctly, and that the system calls run successfully without any errors.

```
int x = 3;
while(x > 0) {
fork();
printf("hello");
wait(NULL);
x--;
}
```

The total number of times the printf statement is executed is 14 ______?

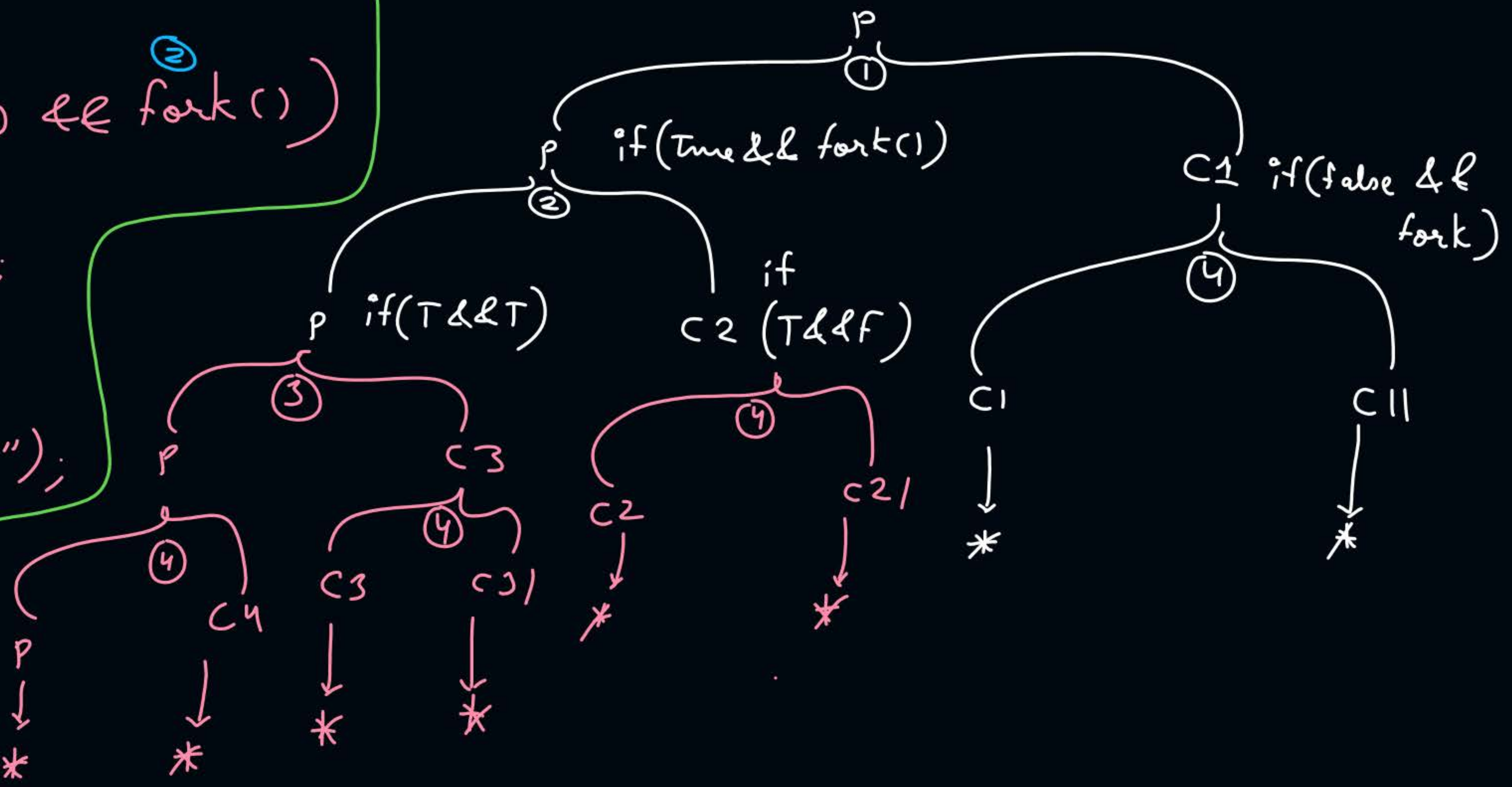
GATE-2024


P
int x = 3
P
Hello
x=2
6 times
hello
C1
x = 2
Hello
C1
x = 1
C11
x = 1
Hello
Hello
C1
x=0
C12
Hello
Hello
x=0
x=0
C11
Hello
C111
x=0
Hello

Ques)

```
if(fork() && fork())
{
    fork();
}
fork();
printf("*");
}
```

Ans = 8



Topic : Process Types

1. Independent

2. Cooperating/Coordinating/Communicating

Topic : Problems Without Synchronization

Problems without Synchronization:

- Inconsistency
- Loss of Data
- Deadlock

Topic : Race Condition

A race condition is an undesirable situation, it occurs when the final result of concurrent processes depends on the sequence in which the processes complete their execution.

due to lack of synchronization

x: $\boxed{5}$

$P1 \rightarrow P2$	$P2 \rightarrow P1$
$x = 8$	7

P1

$R1 \leftarrow \overset{5}{x}$

$\overset{7}{R1} \leftarrow R1 + 2$

$x \leftarrow R1$

P2

$R2 \leftarrow \overset{5}{x}$

$\overset{8}{R2} \leftarrow R3 + 3$

$x \leftarrow R3$

[NAT]

#Q. $X = 10$

P1

$\underset{5}{X} = \overset{10}{X}/2$

P2

$\underset{14}{X} = \overset{10}{X}+4$

How many different values of X are possible after both processes finish executing? Ans = 4 (5, 7, 9, 14)

Case 1 :- P1 then P2 9

Case 2 :- P2 then P1 7

Case 3 :- both read x concurrently then P2 writes last 14

Case 4 :- ——— || ——————— P1 —||— 5

[NAT]

$x = 4$

#Q. The following pair of processes share a common variable X.

Process A	Process B
int Y; Y = X*2; X = Y;	int Z; Z = X+1; X = Z;

9, 10, 8, 5

X is set to 4 before either process begins execution. As usual, statements within a process are executed sequentially, but statements in process A may execute in any order with respect to statements in process B.

How many different values of X are possible after both processes finish executing?

[NAT]

The following two functions $P1$ and $P2$ that share a variable B with an initial value of 2 execute concurrently.

3, 4, 2

```
P1() {
    C = B - 1;
    B = 2 * C;
}
```

```
P2() {
    D = 2 * B;
    B = D - 1;
}
```

The number of distinct values that B can possibly take after the execution is____3____.

[NAT]

Consider three concurrent processes P1, P2 and P3 as shown below, which access a shared variable D that has been initialized to 100.

$D = \cancel{120}\ \cancel{130}\ 50$

P1	P2	P3
:	:	:
:	:	:
100	100	
D = D + 20	D = D – 50	D = D + 10
:	50 :	130 120 :
:	:	:

$Y = 130$

$X = 50$

Ans = 80

The processes are executed on a uniprocessor system running a time-shared operating system. If the minimum and maximum possible values of D after the three processes have completed execution are X and Y respectively, then the value of Y – X is ___80___.

Ques) In prev. Questⁿ, no. of distinct possible values D can take?

Ans = 7

Solⁿ

$100 + 20 - 50 + 10$

$$\left.\begin{array}{l} \text{all } 3 \Rightarrow 80 \\ \text{any } 2 \Rightarrow 70,\ 130,\ 60 \\ \text{any } 1 \Rightarrow 120,\ 50,\ 110 \end{array}\right\} \text{7 distinct values}$$

Ques) $x = 20$

P1   P2   P3   P4

$x = x + 1$ $x = x + 2$ $x = x + 4$ $x = x + 8$

$$\left.\begin{array}{l} 21, 22, 24, 28 \\ 23, 25, 29, 26, 30, 34 \\ 27, 32, 33, 31, 35 \end{array}\right\} \text{15 distinct value}$$

Ques) In prev. Questn if value x can be operated only by one process at a time, then distinct possible values of x $\underline{1}$?

$\Downarrow$

mutual exclusion

value $\Rightarrow$ 35

Ques) $x = 20$

$20 - 1 + 2 - 2 + 3$

19, 22, 18,
23, 21, 17, 20, 25,
24,

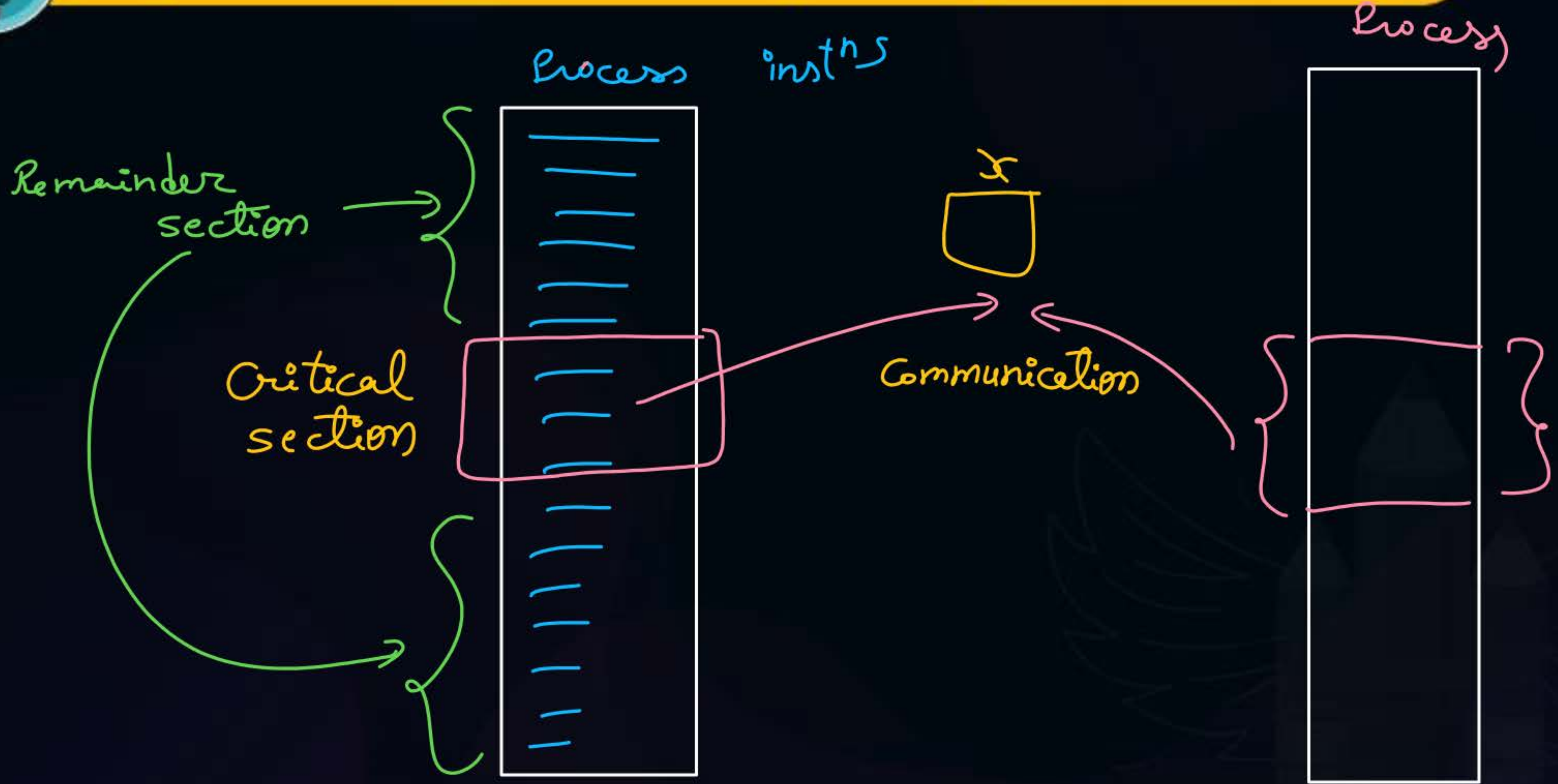
P1	P2	P3	P4
$x = x - 1$	$x = x + 2$	$x = x - 2$	$x = x + 3$

1. If no mutual exclusion then
   max $\underline{25}$?
   min $\underline{17}$?
   no. of distinct values $\underline{9}$?

2. If mutual exclusion then $\Rightarrow$ $\left.\begin{matrix}\text{max}\\ \text{min}\end{matrix}\right\}$ 22

   distinct $\Rightarrow$ 1

Topic : Entire Process Requires Synchronization?



Topic : Critical Section

The critical section is a code segment where the shared variables can be accessed.

$\Downarrow$

Communication happens.

Topic : Solution of Critical Section Problem

Requirements of Critical Section problem solution:

1. Mutual Exclusion
2. Progress
3. Bounded Waiting

Topic : Solution of Critical Section Problem

Mutual Exclusion:

If one process is executing the critical section, then other process is not allowed to enter into critical section.

Topic : Solution of Critical Section Problem

Progress:

If no any process is in critical section and any process wants to enter into critical section, then the process must be allowed.

Topic : Solution of Critical Section Problem

Bounded Waiting:

If a process p1 is executing in critical section and other process p2 is waiting for critical section, then the waiting time of p2 must be bounded. Which means p1 must not enter in to critical section again and again by keeping p2 in waiting for long.

2 mins Summary

Topic Synchronization

Topic Race Condition

Topic Critical Section

Happy Learning

THANK - YOU