

# Operating System: Questions on Semaphores

By: Vishvadeep Gothi



# VISHVADEEP GOTHI SIR

**AIR- 19, 119, 440, 682  
in GATE**



**ME from IISc Bangalore  
Mtech BITS Pilani in Data  
Science**



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10+ Years in GATE/IES**



**Subjects Taken:**  
Computer Organization & Architecture,  
data structure, operating system,  
C-Programming, Data science,  
Machine Learning, Python,  
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Vishvadeep Gothi

#1 Educator in CS & IT · GATE & ESE

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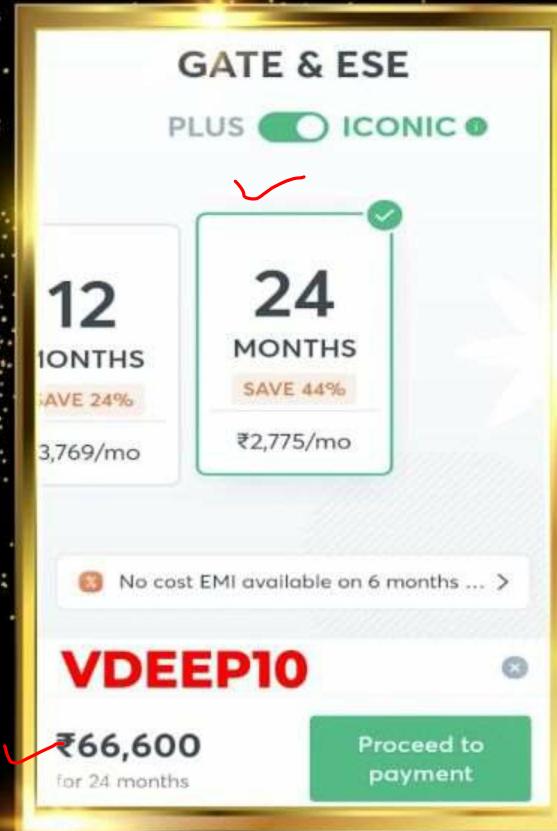
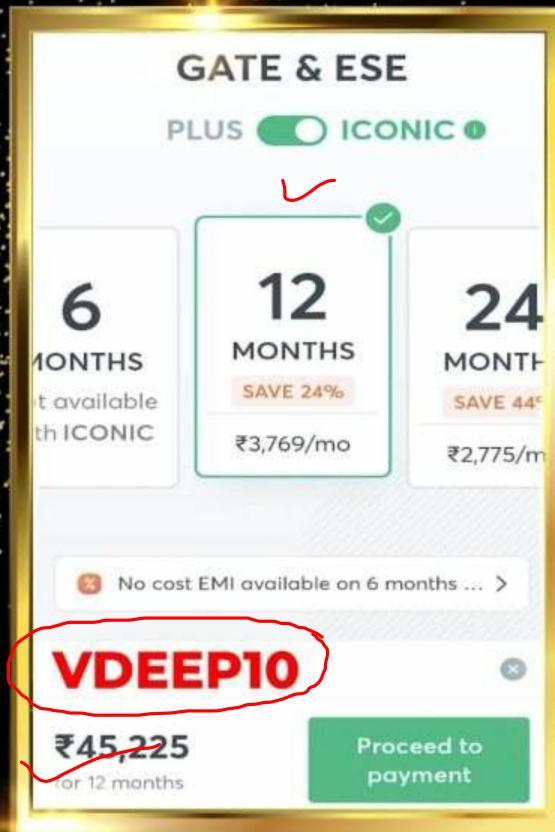
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wait(s) →  
while ( $s \leq 0$ );  
 $s--;$

Signal(s) →  $s++;$

# Are You Ready??

# Question 1

$S = 1$

Counting  
↑

Consider a semaphore  $S$ , initialized with value 1. Consider 10 processes  $P_1, P_2 \dots P_{10}$ . All processes have same code as given below but, one process  $P_{10}$  has  $\text{signal}(S)$  in place of  $\text{wait}(S)$ . If all processes can execute multiple times, then maximum number of processes which can be in critical section together ?

```
while(True)
{
    wait(S)
    C.S.
    signal(s)
}
```

Ans = 10

# Solution 1

P1, P2, ...., P9

```
while(True)
{
    wait(S)
    ↓ C.S.
    signal(s)
}
```

P10

while(True)

```
{  
    signal(S)  
    C.S.  
    signal(s)  
}
```

run p10  $\Rightarrow$  S = 1

run p10  $\Rightarrow$  S = 5

—|—  $\Rightarrow$  S = 7

—|—  $\Rightarrow$  S = 9

p10 in CS  $\Rightarrow$  S = 10

all p1 to p9 in CS.

# Question 2

Counting  
↑

Consider a semaphore S, initialized with value 1. Consider 10 processes P1, P2 .... P10. All processes have same code as given below but, one process P10 has signal(S) and wait(S) swapped. If all processes can execute only one time, then maximum number of processes which can be in critical section together ?

```
while(True)
{
    wait(S)
    C.S.
    signal(s)
}
```

Ans = 3

# Solution 2

P1, P2, ...., P9

```
while(True)
{
    wait(S)
    C.S.
    signal(s)
}
```

P10

```
while(True)
{
    signal(S)
    C.S.
    signal(S) wait(s)
}
```

$S = 12$

run P10 & P10 in CS

$S = 2$

run any 2 processes  
in CS.

# Question 3

$P()$   $\Rightarrow$  wait  
 $V()$   $\Rightarrow$  signal

Given below is a program which when executed ~~executes~~ two concurrent processes:

Semaphore  $X:=0;$

*/\* Process now forks into concurrent processes P1 & P2 \*/*

*P1 : repeat forever      P2:repeat forever*

$V(X);$

$P(X);$

*Compute;*

*Compute;*

$P(X);$

$V(X);$

Consider the following statements about processes P1 and P2:

- I. It is possible for process P1 to starve.
- II. It is possible for process P2 to starve.

# Question 4

Ans = 4

A shared variable  $x$ , initialized to zero, is operated on by four concurrent processes  $W, X, Y, Z$  as follows. Each of the process  $W$  and  $X$  reads  $x$  from memory, increments by 2, stores it to memory and then terminates. Each of the processes  $Y$  and  $Z$  reads  $x$  from memory , decrements by 3, stores it to memory and then terminates. Each processes before reading  $x$  invokes the  $P$  operation (i.e., wait) on a counting semaphore  $S$  and invokes the  $V$  operation (i.e., signal) on the semaphore  $S$  after storing  $x$  to memory. Semaphore  $S$  is initialized to two. What is the maximum possible value of  $x$  after all processes complete execution?

# Solution

$$x = \cancel{0} - \cancel{3}x + \cancel{4}$$
$$5 = 2 \cancel{x} + \cancel{x} + \cancel{x} + 2$$

w

$$P(S) \\ R_1 = x = 0$$

$$2R_1 = R_1 + 2$$

$$x = R_1$$

V(S)

x

P(S)

$$2R_1 = x \\ 4R_2 = R_1 + 2 \\ x = R_2$$

V(S)

y

P(S)

$$R_3 = x \\ -3R_3 = R_3 - 3 \\ x = R_3$$

V(S)

z

P(S)

$$2R_4 = x \\ -1R_4 = R_4 - 3 \\ x = R_4$$

V(S)

w & y run Concurrently, y writes on x first  $\Rightarrow x=2$

x & z —||—, z writes on x first  $\Rightarrow x=4$

# Solution



# Question 5

w & y run concurrently & w writes first  $\Rightarrow x = -3$   
x & z ————— / | ————— & x writes first  $\Rightarrow x = -6$

A shared variable  $x$ , initialized to zero, is operated on by four concurrent processes  $W, X, Y, Z$  as follows. Each of the process  $W$  and  $X$  reads  $x$  from memory, increments by 2, stores it to memory and then terminates. Each of the processes  $Y$  and  $Z$  reads  $x$  from memory, decrements by 3, stores it to memory and then terminates. Each processes before reading  $x$  invokes the  $P$  operation (i.e., wait) on a counting semaphore  $S$  and invokes the  $V$  operation (i.e., signal) on the semaphore  $S$  after storing  $x$  to memory. Semaphore  $S$  is initialized to two. What is the minimum possible value of  $x$  after all processes complete execution?

Ans = -6

# Question 6

Ans = 8

A shared variable  $x$ , initialized to zero, is operated on by four concurrent processes  $W, X, Y, Z$  as follows. Each of the process  $W$  and  $X$  reads  $x$  from memory, increments by 2, stores it to memory and then terminates. Each of the processes  $Y$  and  $Z$  reads  $x$  from memory , decrements by 3, stores it to memory and then terminates. Each processes before reading  $x$  invokes the  $P$  operation (i.e., wait) on a counting semaphore  $S$  and invokes the  $V$  operation (i.e., signal) on the semaphore  $S$  after storing  $x$  to memory. Semaphore  $S$  is initialized to two. What is the total number of possible values of  $x$  after all processes complete execution?

$$S = 2$$

$$x = \cancel{0} - 3$$

↓

W

↓

X

↓ Y

↓ Z

P(S)

$$z = x + 2$$

V(S)

P(S)

$$z = x + 2$$

V(S)

P(S)

$$\rightarrow x = x - 3$$

V(S)

P(S)

$$x = x - 3$$

V(S)

Possible answers  
↓

$$= -6$$

$$= 4$$

$$= -4$$

$$= -1$$

$$= 1$$

$$= -2$$

$$= 2$$

$$= -3$$

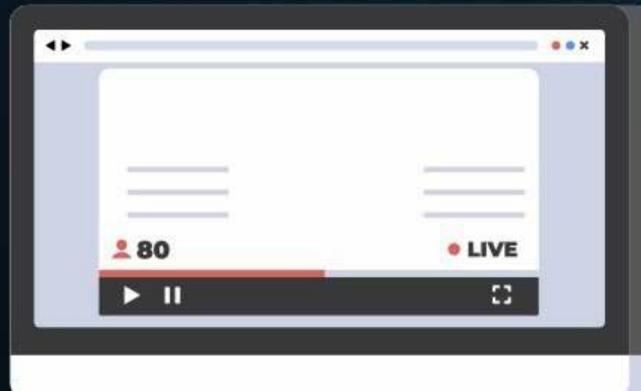
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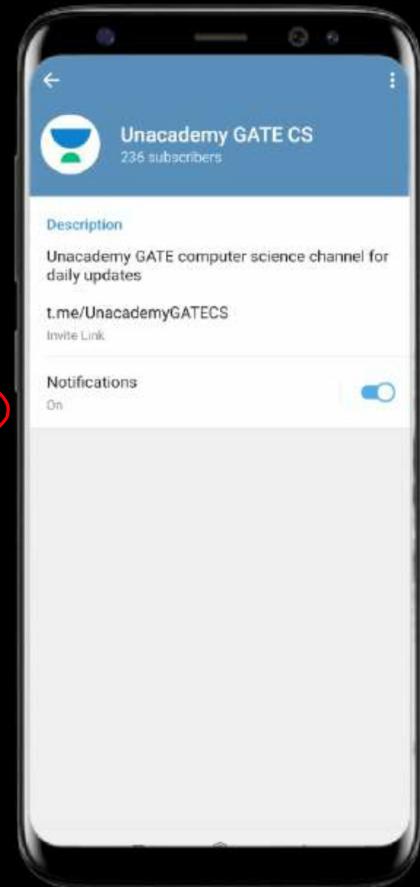
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MONTHS

SAVE 44%  
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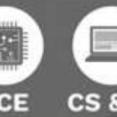
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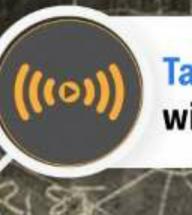
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