

Operating System:

Page Replacement: FIFO, Optimal, LRU

By: Vishvadeep Gothi



VISHVADEEP GOTHI SIR

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



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



**14+ Years of Teaching Experience,
10+ Years in GATE/IES**



Subjects Taken:
Computer Organization & Architecture,
data structure, operating system,
C-Programming, Data science,
Machine Learning, Python,
coding interview problems,





Vishvadeep Gothi

special

#1 Educator in CS & IT · GATE & ESE

- GATE AIR-19, 119, 440, 682 - ME from IISc, - MTech BITS Pilani (Data Science) - 14 years experience

Follow Me on  unacademy

http://www.unacademy.com/@vd_gothi

<http://tiny.cc/VDEEP10>

VDEEP10



Study Planner

Customized study plan and track your performance.

doubt



Study Booster Sessions

Receive Essential Guidelines via Regular workshops



Personal Coach

One on one guidance on preparation strategy.



Live Classes



Crash Courses



Personalised Test Analysis

Get in-depth analysis of tests by section & question type.



ICONIC



PLUS



RIB



English & Hindi



Preparatory Study Material

Specialised notes & practice sets.

GATE & ESE

PLUS **ICONIC**

6 MONTHS <small>SAVE 25%</small> ₹3,713/mo	12 MONTHS <small>SAVE 54%</small> ₹2,269/mo	18 MONTH <small>SAVE 61%</small> ₹1,925/mo
------------------------------------------------------------	-------------------------------------------------------------	------------------------------------------------------------

No cost EMI available on 6 months ... >

VDEEP10

~~₹27,225~~ for 12 months

Proceed to payment

GATE & ESE

PLUS **ICONIC**

<small>Most Popular</small>	12 MONTHS <small>SAVE 54%</small> ₹2,269/mo	18 MONTHS <small>SAVE 61%</small> ₹1,925/mo	24 MONTH <small>SAVE 67%</small> ₹1,650/mo
-----------------------------	-------------------------------------------------------------	-------------------------------------------------------------	------------------------------------------------------------

No cost EMI available on 6 months ... >

VDEEP10

~~₹34,650~~ for 18 months

Proceed to payment

GATE & ESE

PLUS **ICONIC**

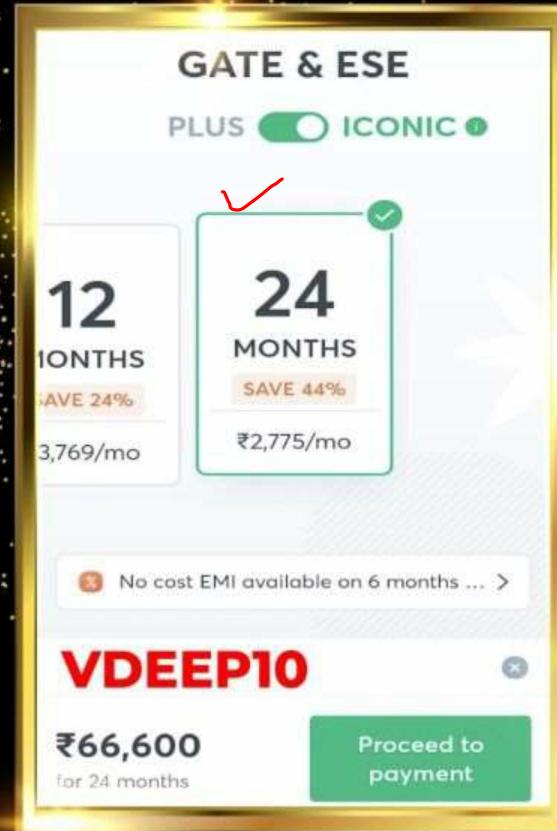
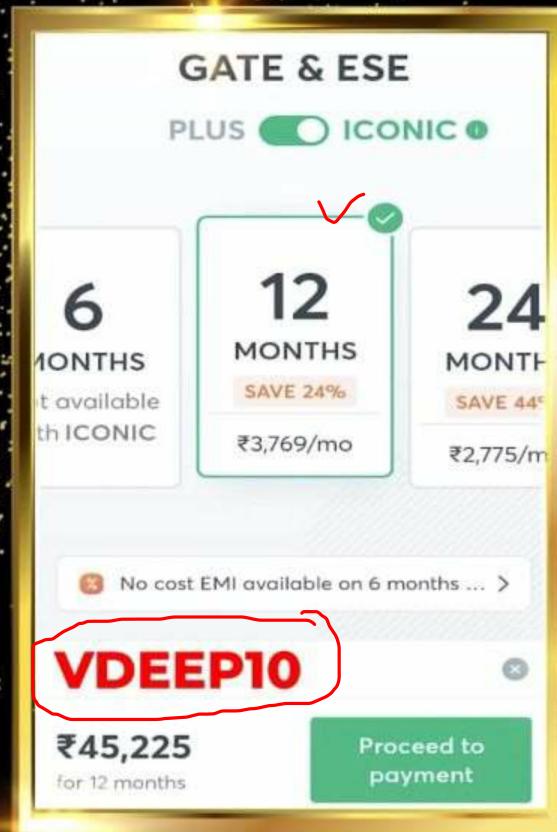
18 MONTHS <small>SAVE 61%</small> ₹1,925/mo	24 MONTHS <small>SAVE 67%</small> ₹1,650/mo
-------------------------------------------------------------	-------------------------------------------------------------

No cost EMI available on 6 months ... >

VDEEP10

~~₹39,600~~ for 24 months

Proceed to payment





Use Code:
VDEEP10

PRICE HIKE UPCOMING GATE & ESE - PLUS SUBSCRIPTION

Subscription Duration	Current Price	NEW PRICE +7.25%
3 Month	₹ 13,750	₹ 14,750
6 Month	₹ 24,750	₹ 26,650
12 Month	₹ 30,250	₹ 32,450
18 Month	₹ 38,500	₹ 41,300
24 Month	₹ 44,000	₹ 47,200

Last Date to Avail these prices : **21st July 2021**

Beat it and

SUBSCRIBE NOW



COMBO OFFER

GATE & ESE + CAMPUS PLACEMENT-IT JOBS

It's time to widen your horizon - Prepare for Campus Placement and GATE & ESE with one subscription !



GATE & ESE



CAMPUS PLACEMENT - IT JOBS

CHEMICAL

MECHANICAL

CS & IT

CIVIL

ELECTRICAL

ECE



VERBAL ABILITY

REASONING
ABILITY

NUMERICAL
ABILITY

CODING SKILLS

PROGRAMMING
LOGIC

TOTAL VALUE OFFERING

₹43,250

OFFER PRICE

₹35,033

Use Code:
VDEEP10



Use Code:
VDEEP10

BATCH - W

NEW
BATCH
ALERT

EVOLVE FOR GATE 2022

COMPUTER SCIENCE & IT



RAVINDRABABU
RAVULA



SUBBA RAO



SANCHIT JAIN



VENKAT RAO



VISHVADEEP
GOTHI



SWETA KUMARI

WE START WITH

~~OPERATING SYSTEMS~~
by ~~Sanchit Jain~~

07 : 00 PM

FOR 10% DISCOUNT

USE CODE

START DATE

21
JULY
2021

Are You Ready??

USE CODE

VDEEP10TO GET
MAX DISCOUNT ON

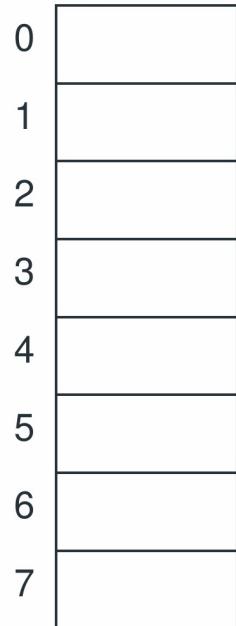
Virtual Memory

- ◎ Feature of OS
- ◎ Enables to run larger process with smaller available memory



Virtual Memory

Process



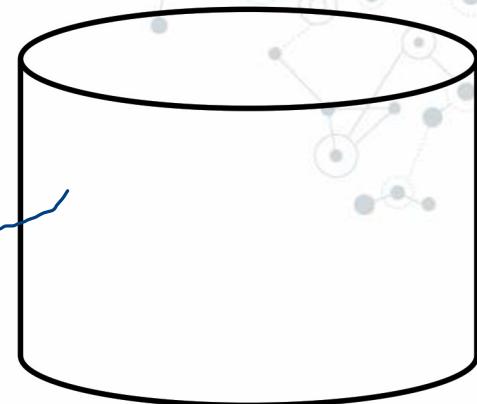
Page Table

0
1
2
3
4
5
6
7

Physical Memory

0
1
2
3
4
5
6
7

Secondary Memory



Page Replacement Policies

1. First In First Out (FIFO)
2. Optimal Policy
3. Least Recently Used (LRU)
4. Least Frequently Used (LFU)
5. Most Frequently Used (MFU)
6. Last In First Out (LIFO)
7. Second Chance

most imp.

First In First Out (FIFO)

↳ replace the page which is brought to mm first.

Assume:

- Number of frames = 3 (All empty initially)
- Page reference sequence: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

no. of page fault = 9

page fault rate = $\frac{9}{12}$

1	2	3	4	1	2	5	1	2	3	4	5
1	1	1	4	4	4	5	1	1	5	5	5
2	2	2	2	1	1	1	2	2	3	3	3

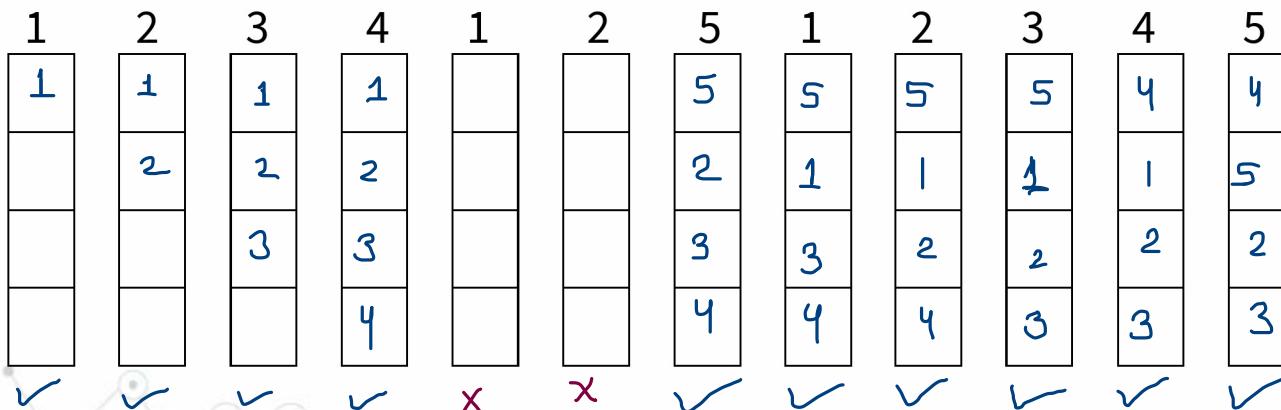
✓ ✓ ✓ ✓ ✓ ✓ ✗ ✗ ✓ ✓ ✗

First In First Out (FIFO)

Assume:

- Number of frames = 4 (All empty initially)
- Page reference sequence: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

no. of page fault = 10



Belady's Anomaly

- For some page reference sequence, increasing number of frames increases no. of page faults also.
- only FIFO suffers from this .



First In First Out (FIFO)

Advantages

1. Simple and easy to implement.
2. Low overhead.

Disadvantages:

1. Poor performance. *→ more page faults*
2. Doesn't consider the frequency of use or last used time, simply replaces the oldest page.
3. Suffers from Belady's Anomaly

Optimal Policy

→ replace page which is not (never) going to be referred in near future.

Assume:

- Number of frames = 3 (All empty initially)
- Page reference sequence: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

$$\text{no. of page faults} = 7$$
$$\text{page fault rate} = \frac{7}{12}$$

1	2	3	4	1	2	5	1	2	3	4	5
1	1	1	1	1	1	1	1	1	3	3	3
2	2	2	2	2	2	2	2	2	2	4	4

Below each row, there are three status indicators: ✓ (green), ✓ (blue), and ✗ (green).

"It provides min. no. of page fault"

Optimal Policy

Advantages

1. Easy to Implement
2. Simple data structures are used
3. Highly efficient → \min page fault

Disadvantages:

1. Requires future knowledge of the program
→ hence
practically
not
possible
to implement
2. Time-consuming

Least Recently Used (LRU)

↳ replace the page which CPU has not used since longest time.

Assume:

- Number of frames = 3 (All empty initially)
- Page reference sequence: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

$$\text{no. of page faults} = 10$$
$$\text{page fault rate} = \frac{10}{12}$$

1	2	3	4	1	2	5	1	2	3	4	5
1	1	1	4	4	4	5	5	5	3	3	3
2	2	2	2	1	1	1	1	1	4	4	4
3	3	3	3	3	2	2	2	2	2	2	5

Least Recently Used (LRU)

Advantages

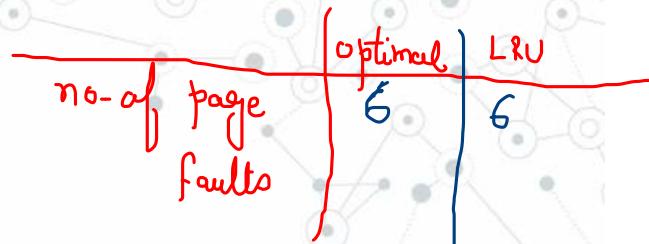
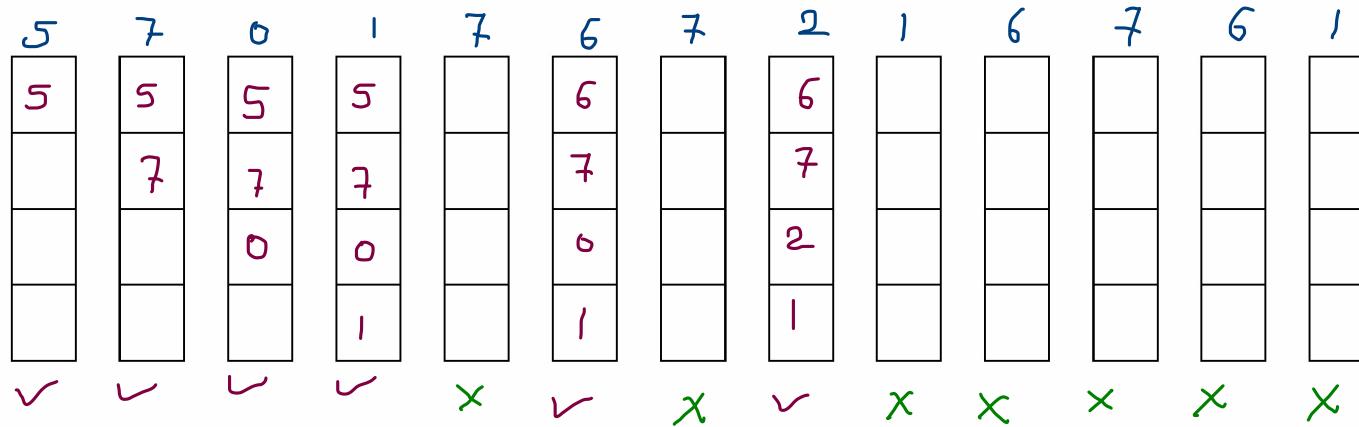
1. Efficient. (*in practical scenario*)
2. Doesn't suffer from Belady's Anomaly

Disadvantages:

1. Complex Implementation
2. Expensive
3. Requires hardware support

Question

- Number of frames = 4 (All empty initially)
- Page reference sequence: 5, 7, 0, 1, 7, 6, 7, 2, 1, 6, 7, 6, 1
- Number of page faults for optimal and LRU policies?



LRU

5	7	0	1	7	6	7	2	1	6	7	6	1
5	5	5	5	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7	7
0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1
✓	✓	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗

no. of page faults = 6

Question

no. of page faults = 5

A virtual memory system has only 2-page frames which are empty initially. Using demand paging the following sequence of page reference is passed through this system.

9, 8, 7, 8, 7, 9, 7, 9, 8, 9

Minimum possible number of page faults? *use optimal policy*

9 8 7 8 7 9 7 9 8 9

9 9 7 7 9

8 8 8 8

✓ ✓ ✓ ✗ ✗ ✓ ✗ ✗ ✗

Question

H. ω.

A main memory can hold 3 page frames and initially all of them are vacant. Consider the following stream of page requests :

2, 3, 2, 4, 6, 2, 5, 6, 1, 4, 6

If the stream uses FIFO replacement policy, the hit ratio h will be?

- (a) 11/3
- (b) 1/11
- (c) 3/11
- (d) 2/11

Question

H. W.

Consider the following page references:

2, 3, 4, 5, 6, 4, 5, 2, 7, 8, 9, 8, 9, 8, 9, 1, 6, 5, 6, 5, 3

Using optimal policy and 4 frames. Memory access time is 2ms and page fault service time is 40ms. The effective memory access time is?

Next Class

Page Replacement Policies



✓ LIFO, LFU, MFU,
Second Chance

NEW INITIATIVE: FAQS OF GATE ASPIRANTS

SESSIONS ON:

LIST OF REFERENCE BOOKS

LIST OF IMPORTANT TOPICS

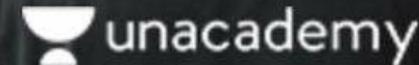
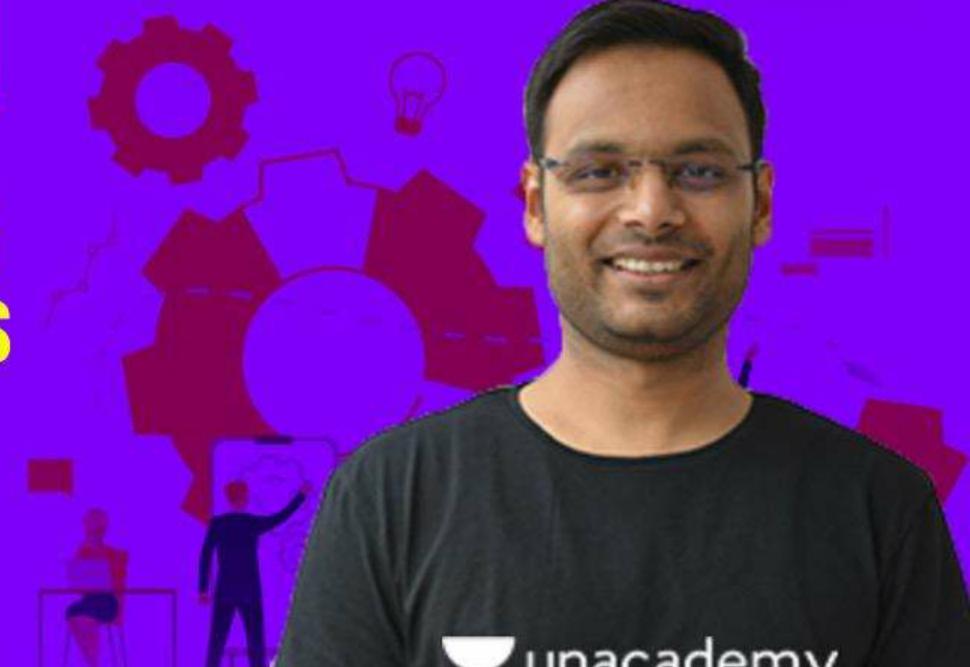
REVISION STRATEGY

HOW TO MAKE NOTES

STARTING FROM: 12 JULY

VISHVADEEP GOTHI SIR

TIME:
9:00AM
(MON-FRI)





Use Code:
VDEEP10

PRICE HIKE UPCOMING

GATE & ESE - PLUS SUBSCRIPTION

Subscription Duration	Current Price	NEW PRICE +7.25%
3 Month	₹ 13,750	₹ 14,750
6 Month	₹ 24,750	₹ 26,650
12 Month	₹ 30,250	₹ 32,450
18 Month	₹ 38,500	₹ 41,300
24 Month	₹ 44,000	₹ 47,200

Last Date to Avail these prices : 21st July 2021

Beat it and

SUBSCRIBE NOW

Use Code:
VDEEP10

COMBO OFFER

GATE & ESE + CAMPUS PLACEMENT-IT JOBS

It's time to widen your horizon - Prepare for Campus Placement and GATE & ESE with one subscription !



GATE & ESE

- CHEMICAL
- MECHANICAL
- CS & IT
- CIVIL
- ELECTRICAL
- ECE



CAMPUS PLACEMENT - IT JOBS

- VERBAL ABILITY
- REASONING ABILITY
- NUMERICAL ABILITY
- CODING SKILLS
- PROGRAMMING LOGIC



TOTAL VALUE OFFERING

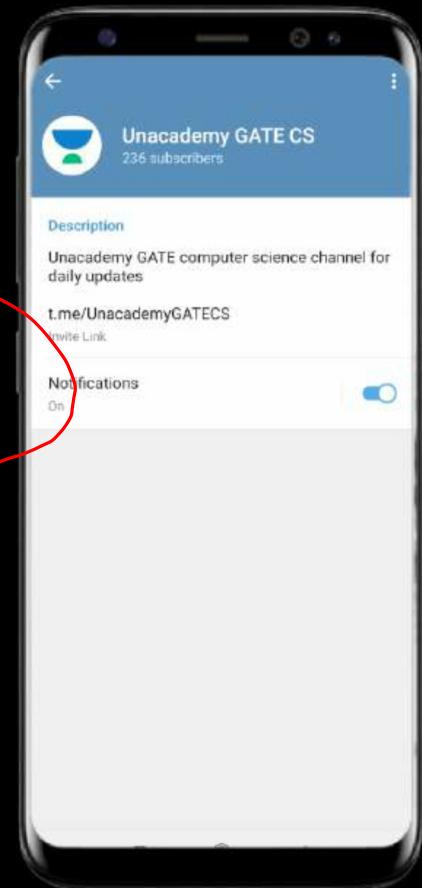
₹43,250

OFFER PRICE

₹35,033



<https://t.me/UnacademyGATECS>





COMBO OFFER

GATE & ESE + CAMPUS PLACEMENT-IT JOBS

It's time to widen your horizon - Prepare for Campus Placement and GATE & ESE with one subscription !



GATE & ESE



CAMPUS PLACEMENT - IT JOBS

CHEMICAL

MECHANICAL

CS & IT

CIVIL

ELECTRICAL

ECE



VERBAL ABILITY

REASONING
ABILITY

NUMERICAL
ABILITY

CODING SKILLS

PROGRAMMING
LOGIC

TOTAL VALUE OFFERING

₹43,250

OFFER PRICE

₹35,033

Use Code:
VDEEP10



Use Code:
VDEEP10

BATCH - W

NEW
BATCH
ALERT

EVOLVE FOR GATE 2022

COMPUTER SCIENCE & IT



RAVINDRABABU
RAVULA



+ SUBBA RAO



SANCHIT JAIN



VENKAT RAO



VISHVADEEP
GOTHI



SWETA KUMARI

WE START WITH

OPERATING SYSTEMS
by Sanchit Jain

07 : 00 PM

START DATE

21
JULY
2021

FOR 10% DISCOUNT

USE CODE

ICONIC

+ **PLUS**



**Preparatory Study
Material**

Specialised notes & practice sets.

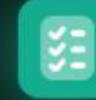


RIB

English & Hindi



Doubt Solving



Weekly Tests



Personalised Test Analysis

Get in-depth analysis of tests
by section & question type.



Crash Courses



Live Classes



Personal Coach

One on one guidance on
preparation strategy.



Study Planner

Customized study plan and
track your performance.



Study Booster Sessions

Receive Essential Guidelines
via Regular workshops



UNACADEMY COMBAT



India's Largest **Weekly**
Competition for GATE



Take it Live to compete
with the best

Access your GATE
preparation in **60 minutes**



Super fast and fun with
All India Live Leaderboard

Challenging & **Original** GATE
Questions curated by the Best
Educators



Identify & improve your
weak areas through **detailed**
video solutions

USE CODE

VDEEP10

July 18, **25** | Starts at **11 AM**



UNACADEMY
COMBAT



Unacademy
Subscription



Unacademy
Subscription



Unacademy
Subscription



Unacademy
Subscription

RANK 1-3

{ Complimentary
Unacademy Plus
subscription for One Year

RANK 4-10

{ 75% off on Unacademy
Plus subscription for the
tenure of your choice.

RANK 11-50

{ 50% off on Unacademy
Plus subscription for the
tenure of your choice.

RANK 51-100

{ 25% off on Unacademy
Plus subscription for the
tenure of your choice.

*Winners can choose from 6 months / 12 months / 18
months / 24 months GATE & ESE Plus subscription.

Terms & Conditions Apply



BUGS BOUNTY



Opportunity for all Learners to report any inappropriate content in the video

Be the first one to report a particular issue to claim your prize

Report any inappropriate content using the form in the description



India's No. 1 Study Channels

Kreatryx GATE
EE,ECE,IN



Unacademy GATE
ME,PI,XE



Unacademy
GATE CE



Unacademy
GATE Telugu



Unacademy
SSC JE



Unacademy
Computer Science



Unacademy GATE
Questions



Electrical
Junction



Engineering
Pathshala



GS Terminal -
RRB, SSC





Happy Learning

Thank You

