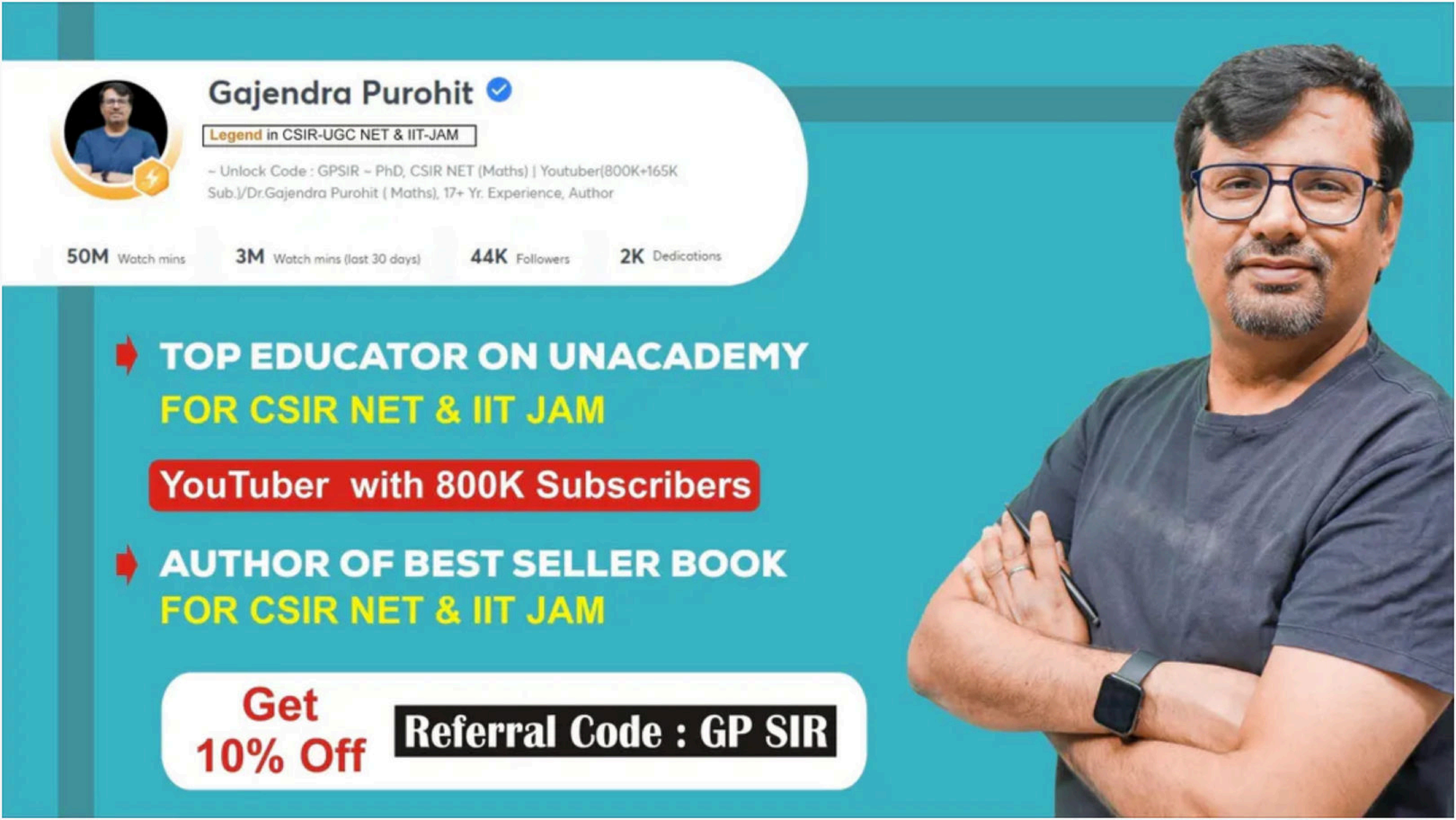
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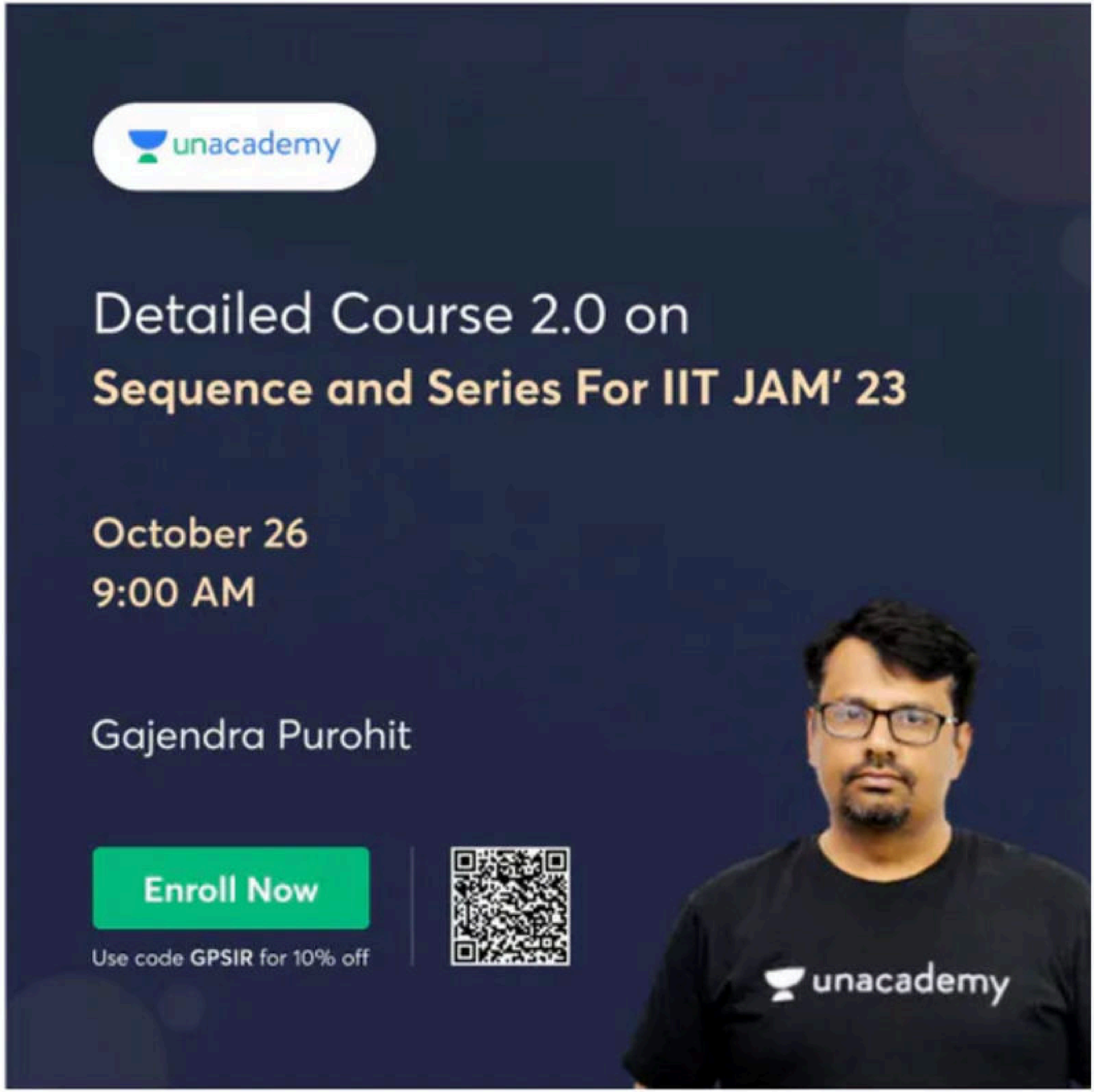
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Power series : A series of the form $\sum_{n=0}^{\infty} a_n (x - x_0)^n$ is known as real infinite power series where a_n are constant.

$\sum_{n=0}^{\infty} n^n x^n$

i.e. $\sum_{n=0}^{\infty} a_n (x - x_0)^n = a_0 + a_1 (x - x_0) + a_2 (x - x_0)^2 + \ldots\ldots$

$x=0$

$u_n = n^n x^n$

$\lim_{n\to\infty} (u_n)^{1/n} = \lim_{n\to\infty} nx$

$= \infty$

Some important facts of power series when $x_0 = 0$**:**

(1) Every power series converges for $x = 0$, for all value of coefficient a_n. i.e. if power series is not convergent other than $x = 0$, then this series is called nowhere convergent.

(2) If a given series converge for all value of x, then we say that the given power series every where convergent.

Region of convergence :

(3) If the given power series converges for some value of x and diverge for other value of x then the set of all value of x for which it is convergent is known as region of convergence.

$|x| < r$

Radius of convergence :

Let $\sum a_n x^n$ is a power series and $|x| < R$ is region of convergence then R is called radius of convergence.

Formula for finding radius of convergence

$$\frac{1}{R} = \overline{\lim_{n\to\infty}}\left|\frac{a_{n+1}}{a_n}\right| = \overline{\lim_{n\to\infty}}\, |a_n|^{1/n}$$

$\frac{n}{n^2}$

$\sum \left(\frac{n+1}{(n+2)(n+3)}\right)^{1/n}$

$|x|<1$

$x=1$

$\sum \frac{n+1}{(n+2)(n+3)} x^n$

$a_n = \frac{n+1}{(n+2)(n+3)}$

$$\frac{1}{R} = \lim_{n\to\infty} \frac{a_{n+1}}{a_n} = \lim_{n\to\infty} \frac{(n+2)}{(n+3)(n+4)} \cdot \frac{(n+2)(n+3)}{(n+1)} = \lim_{n\to\infty} \frac{n^2\left(1+\frac{2}{n}\right)\left(1+\frac{2}{n}\right)\left(1+\frac{3}{n}\right)}{n^2\left(1+\frac{3}{n}\right)\left(1+\frac{4}{n}\right)\left(1+\frac{1}{n}\right)}$$

$= 1$

$R=1$

$[-1,1)$ $\quad (-1,1)$

$[-1,1)$

Some useful results :

(1) The radius of convergence of $\sum a_n x^n$ is equal to $\sum n a_n x^{n-1}$.

(2) The radius of convergence of $\sum a_n x^n$ is equal to $\sum \frac{a_n}{(n+1)} x^{n+1}$.

min (2,3) = 2

(3) If R is the radius of convergence of $\sum a_n x^n$ then radius of convergence of $\sum a_n x^{pm}$ and $\sum a_n x^{pm+k}$; $k \in N$ is $(R)^{1/p}$, $p > 0$.

(4) If R and R_1 are the radius of convergence of $\sum a_n x^n$ and $\sum b_n x^n$ then radius of convergence of $\sum (a_n x^n + b_n x^n)$ is $\min\{R, R_1\}$

$\sum_{n=0}^{\infty} \left(\frac{1}{2}\right)^n x^n \to R = 2$

$\sum_{n=0}^{\infty} \left(\frac{1}{3}\right)^n x^n$ $R = 3$

$\sum_{n=0}^{\infty} \left(\left(\frac{1}{2}\right)^n + \left(\frac{1}{3}\right)^n\right) x^n$

$R = 2$

Q1. The radius of convergence of the power series $\sum_{n=0}^{\infty}\left(\frac{n^2}{4^n}\right)x^{5n}$ is **IIT JAM 2022**

$|x| < (4)^{1/5}$

(a) 4

(b) $\sqrt[5]{4}$

(c) $\frac{1}{4}$

(d) $\frac{1}{\sqrt[5]{4}}$

$$\frac{1}{R^5} = \lim_{n\to\infty} \frac{a_{n+1}}{a_n}$$

$$= \lim_{n\to\infty} \frac{(n+1)^2}{4^{n+1}} \frac{4^n}{n^2}$$

$$= \lim_{n\to\infty} \frac{1}{4} \frac{\cancel{n^2}(1+1/n)^2}{\cancel{n^2}}$$

$$= 1/4$$

$$R^5 = 4$$

$$R = (4)^{1/5}$$

$$\sum_{n=0}^{\infty} \frac{n^2}{4^n} (x-1)^{5n}$$

$|x-1| < 4^{1/5}$

$-4^{1/5} < (x-1) < 4^{1/5}$

$1 - 4^{1/5} < x < 4^{1/5} + 1$

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Q2. Let r be the radius of convergence of the power series

$$\frac{1}{3}+\frac{x}{5}+\frac{x^2}{3^2}+\frac{x^3}{5^2}+\frac{x^4}{3^3}+\frac{x^5}{5^3}+\ldots\ldots\text{ then the value of } r^2$$

is **IIT JAM 2022**

(a) 1 (b) 3

(c) 5 (d) 7

$$\sum_{n=0} \left(\frac{x^{2n}}{3^{n+1}} + \frac{x^{2n-1}}{5^{n+1}} \right)$$

$R_1 = \sqrt{3}$ | $R_2 = \sqrt{5}$

Q. $x + \frac{2^2 x^2}{2!} + \frac{3^3 x^3}{3!} + \cdots$ is convergent if x belong to the interval

(a) $(0, 1/e)$

~~(b) $(\frac{1}{e}, \infty)$~~

~~(c) $(\frac{2}{e}, \frac{3}{e})$~~

~~(d) $(\frac{3}{e}, \frac{4}{e})$~~

$$\sum_{n=1}^{\infty} \frac{x^n n^n}{n!}$$

$$\frac{1}{R} = \lim_{n\to\infty} \frac{a_{n+1}}{a_n}$$

$$= \lim_{n\to\infty} \frac{(n+1)^{n+1}}{(n+1)!} \cdot \frac{n!}{n^n}$$

$$= \lim_{n\to\infty} \frac{\cancel{(n+1)}(n+1)^n}{\cancel{(n+1)}\,\cancel{n!}} \cdot \frac{\cancel{n!}}{n^n}$$

$$\frac{1}{R} = \lim_{n\to\infty} (1 + 1/n)^n = e$$

$$R = 1/e$$

$$|x| < \frac{1}{e}$$

$$\left(-\frac{1}{e}, \frac{1}{e}\right)$$

Q3. The radius of convergence of the power series $\sum_{n1}^{\infty}\left(\frac{n+2}{n}\right)^{n^2} x^n$ is **IIT-JAM 2020**

(a) e^2

(b) $\frac{1}{\sqrt{e}}$

(c) $\frac{1}{e}$

~~(d)~~ $\frac{1}{e^2}$

$\frac{1}{R} = \lim_{n\to\infty} (a_n)^{1/n}$

$\frac{1}{R} = \lim_{n\to\infty} \left(\left(1+\frac{2}{n}\right)^{n^2}\right)^{1/n}$

$\frac{1}{R} = e^2$

$R = 1/e^2$

Interval of convergence of series

$$(x+1) - \frac{(x+1)^2}{4} + \frac{(x+1)^3}{9} - \frac{(x+1)^4}{16} + \dots$$

$$|x+1| < 1$$

$$-1 < (x+1) < 1$$

$$-2 \leq x \leq 0$$

$$(-2, 0)$$

$$[-2, 0]$$

$$u_n = \frac{(-1)^{n-1}}{n^2}$$

$$\frac{1}{R} = \lim_{n\to\infty} \frac{u_{n+1}}{u_n}$$

$$\frac{1}{R} = \lim_{n\to\infty} \frac{1}{(n+1)^2} n^2$$

$$\frac{1}{R} = 1$$

$$R = 1$$

Q#

$$\sum_{n=0}^{\infty} a_n x^n \qquad a_n = \begin{cases} \frac{1}{3^n} & n\text{- even} \\ \frac{1}{5^n} & n\text{- odd} \end{cases}$$

Radius of Convergence is

(a) 0 (b) 3

(c) 5 (d) 15

$R = 3$

$R_2 = 5$

£

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Q4. Let $a_n = \frac{(1+(-1)^n)}{2^n} + \frac{(1+(-1)^{n-1})}{3^n}$ then the radius of convergence of the power series $\sum_{n=0}^{\infty} a_n x^n$ about x = 0

IIT JAM 2018

(a) 1 (b) 2

(c) 3 (d) 4

$\sum \frac{1}{2^n} + \sum \frac{(-1)^n}{2^n} + \sum \frac{1}{3^n} + \sum \frac{(-1)^n}{3^n}$

2 , 2 , 3 , 3

Q5. Let k be a positive integer. The radius of convergence of the series $\sum_{n=0}^{\infty} \frac{(n!)^k}{(kn)!} z^n$ is **[CSIR NET 2014]**

(a) k

(b) k^{-k}

(c) k^k

(d) ∞

Q6. The sum of the finite series $S = \frac{1}{2} - \frac{1}{3\times 1!} + \frac{1}{4\times 2!} - \frac{1}{5\times 3!} + ...$ is equal to

[CSIR-NET Nov. 2020]

(A) $2 - \frac{1}{e}$

(B) $1 - \frac{2}{e}$

(C) $\frac{2}{e} - 1$

(D) $\frac{1}{e} - 2$

Q7. Let $S_1 = \frac{1}{3} - \frac{1}{2} \times \frac{1}{3^2} + \frac{1}{3} \times \frac{1}{3^3} - \frac{1}{4} \times \frac{1}{3^4} + ...$ and $S_2 = \frac{1}{4} + \frac{1}{2} \times \frac{1}{4^2} + \frac{1}{3} \times \frac{1}{4^3} + \frac{1}{4} \times \frac{1}{4^4} + ...$ Which of the following identities is true?

[CSIR-NET Feb. 2022]

(A) $3S_1 = 4S_2$ (B) $4S_1 = 3S_2$

(C) $S_1 + S_2 = 0$ (D) $S_1 = S_2$


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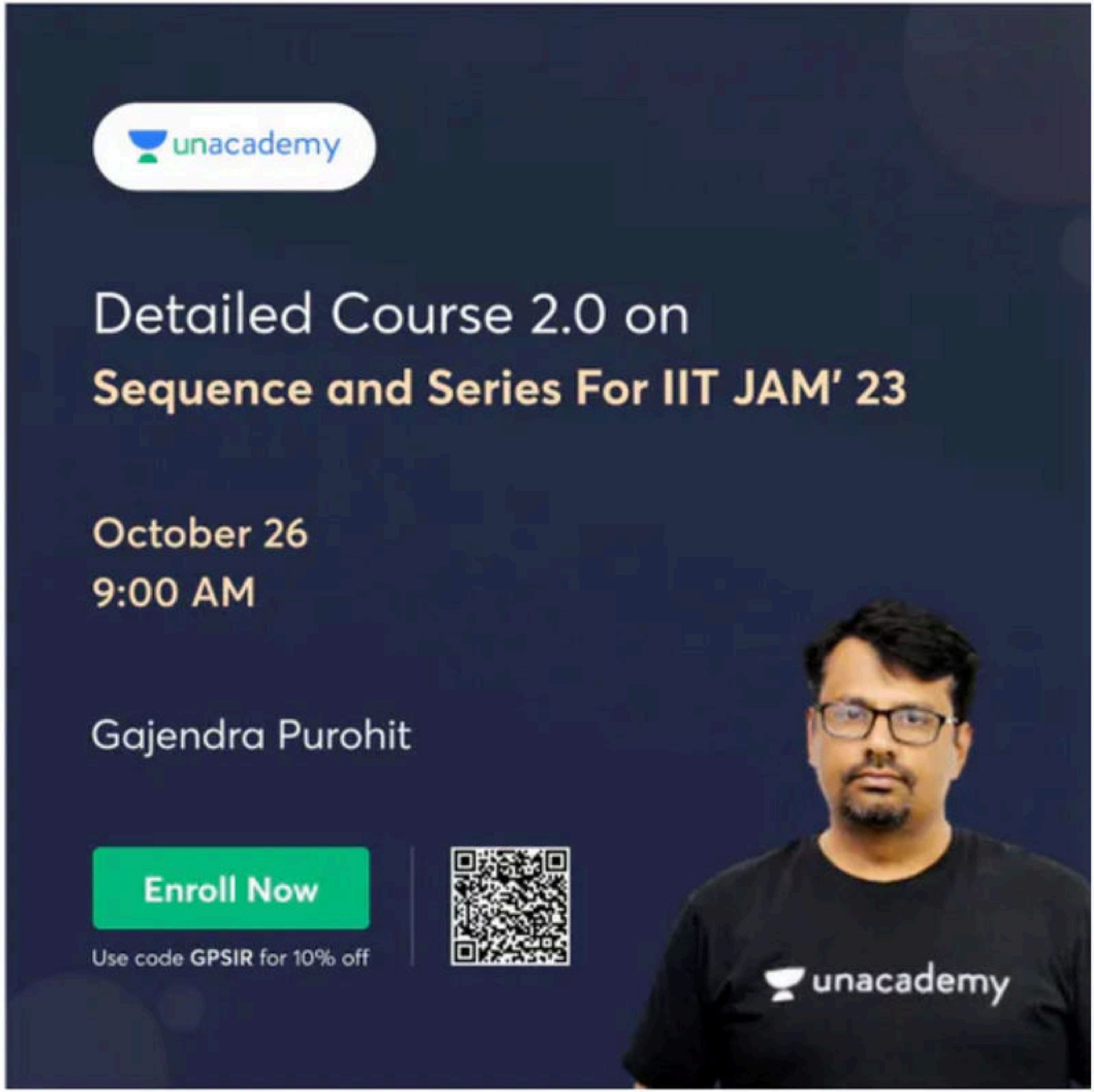
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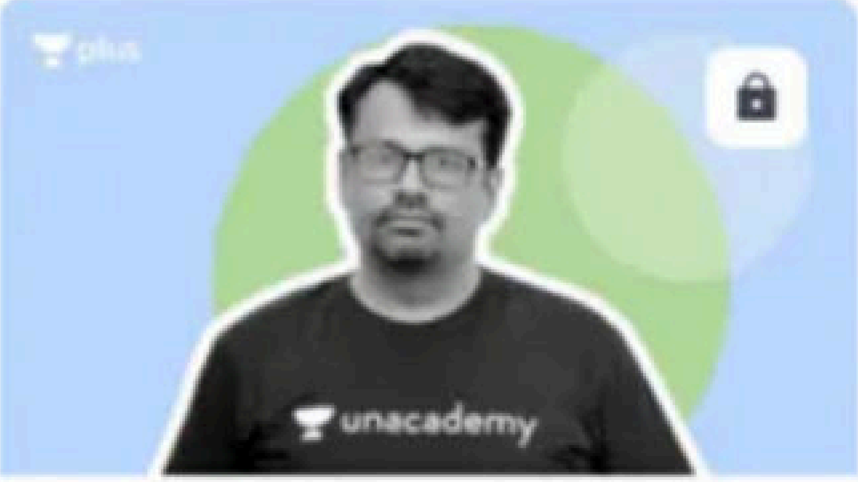

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- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
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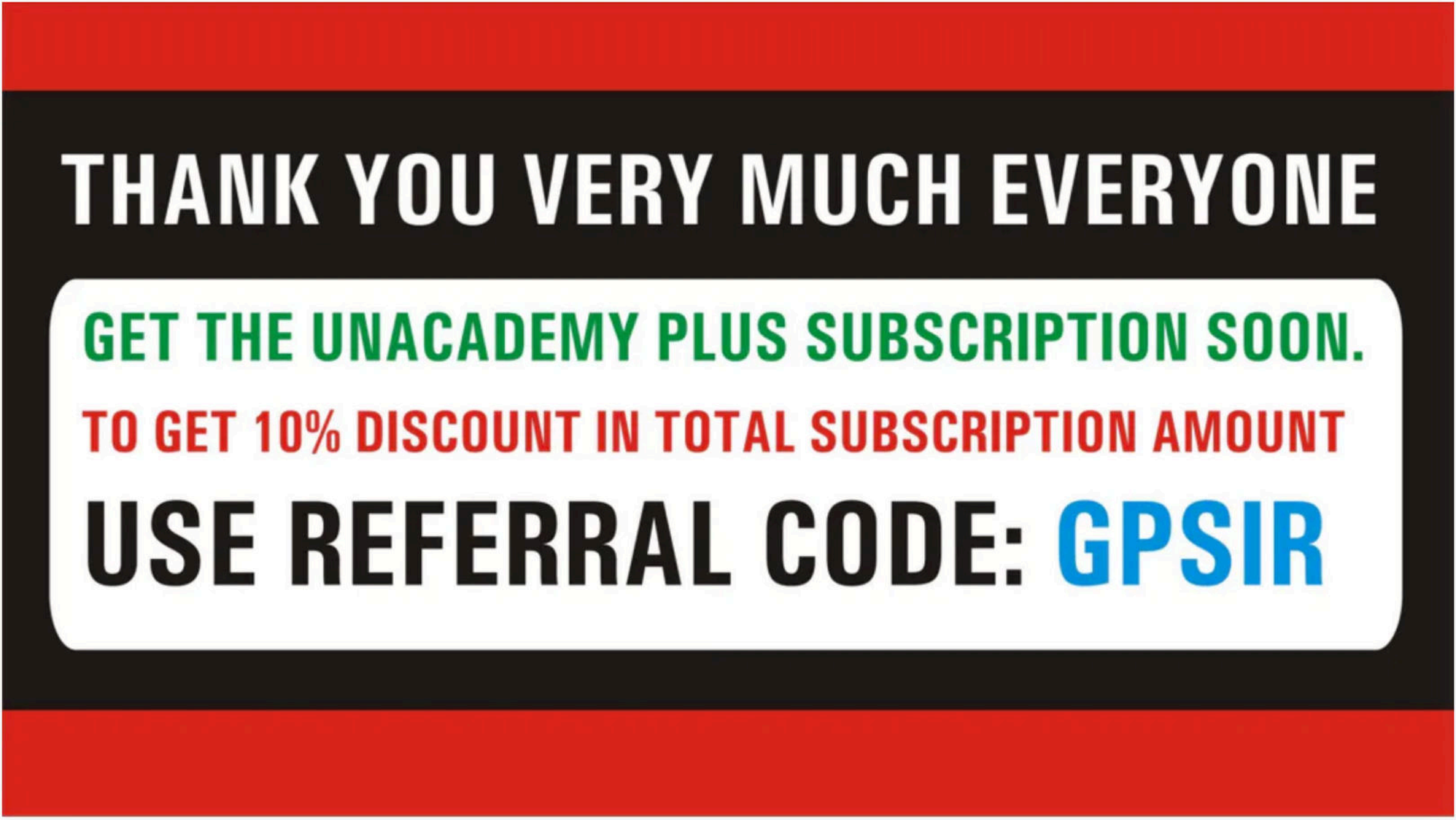
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