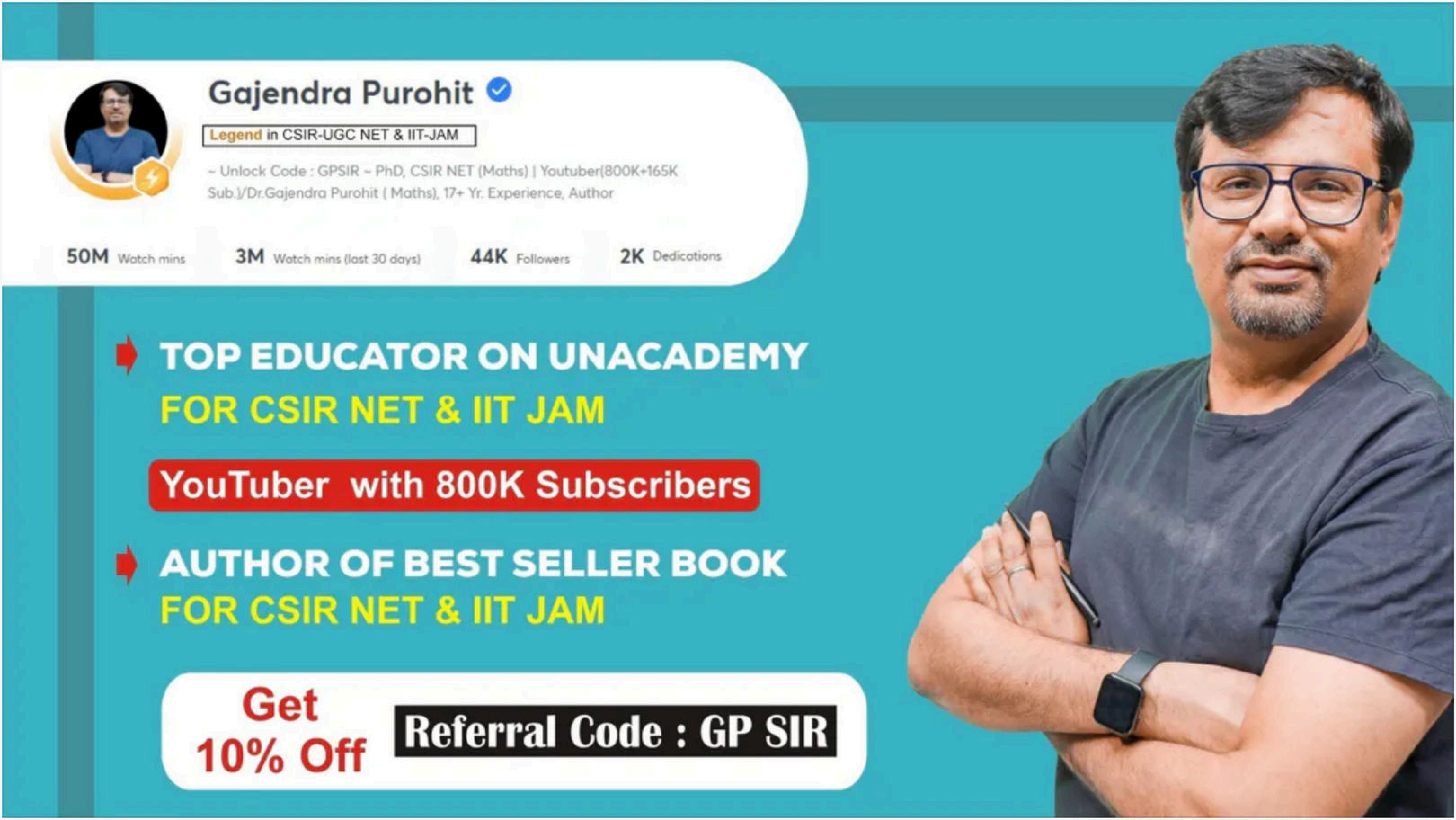
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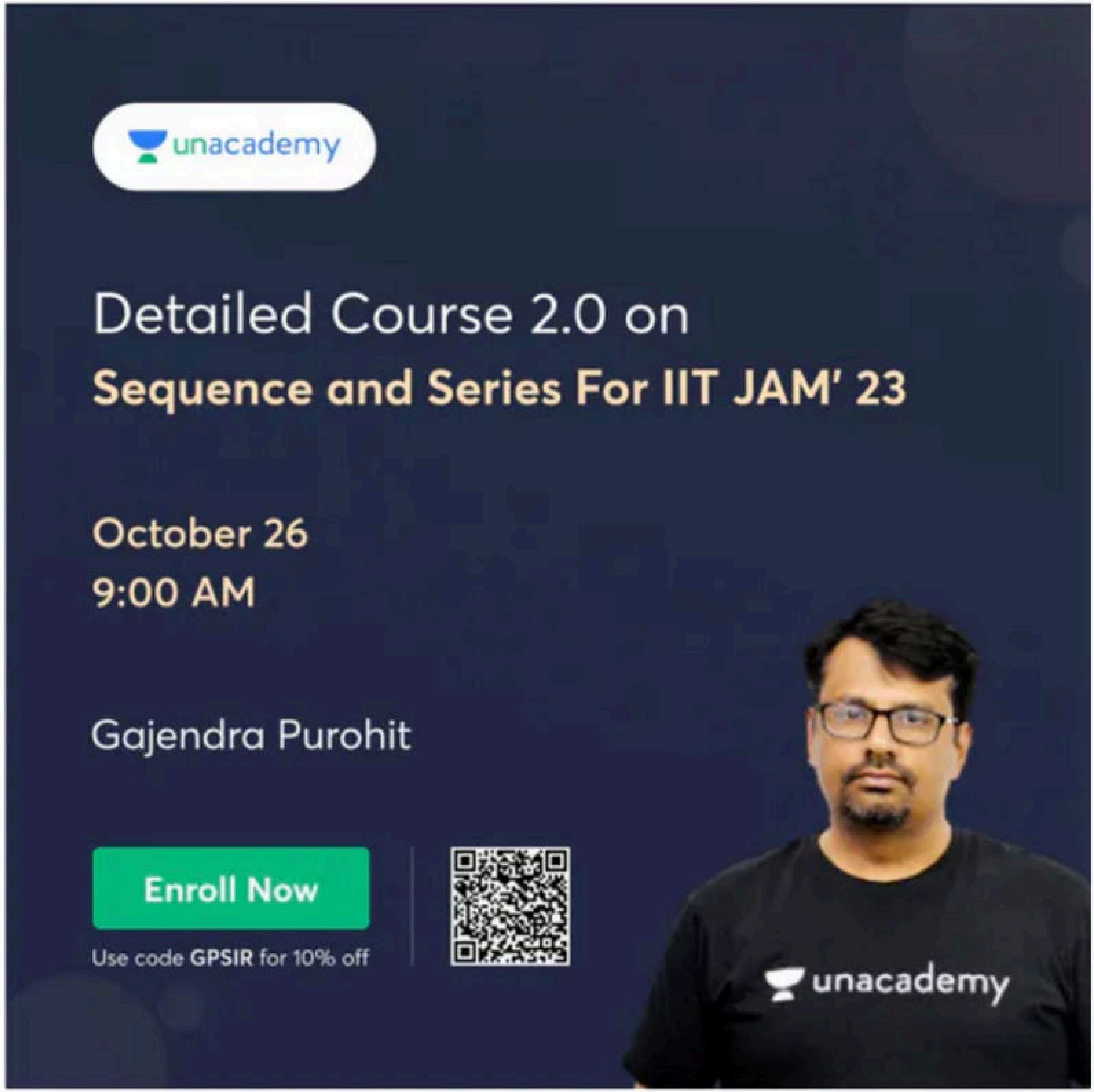
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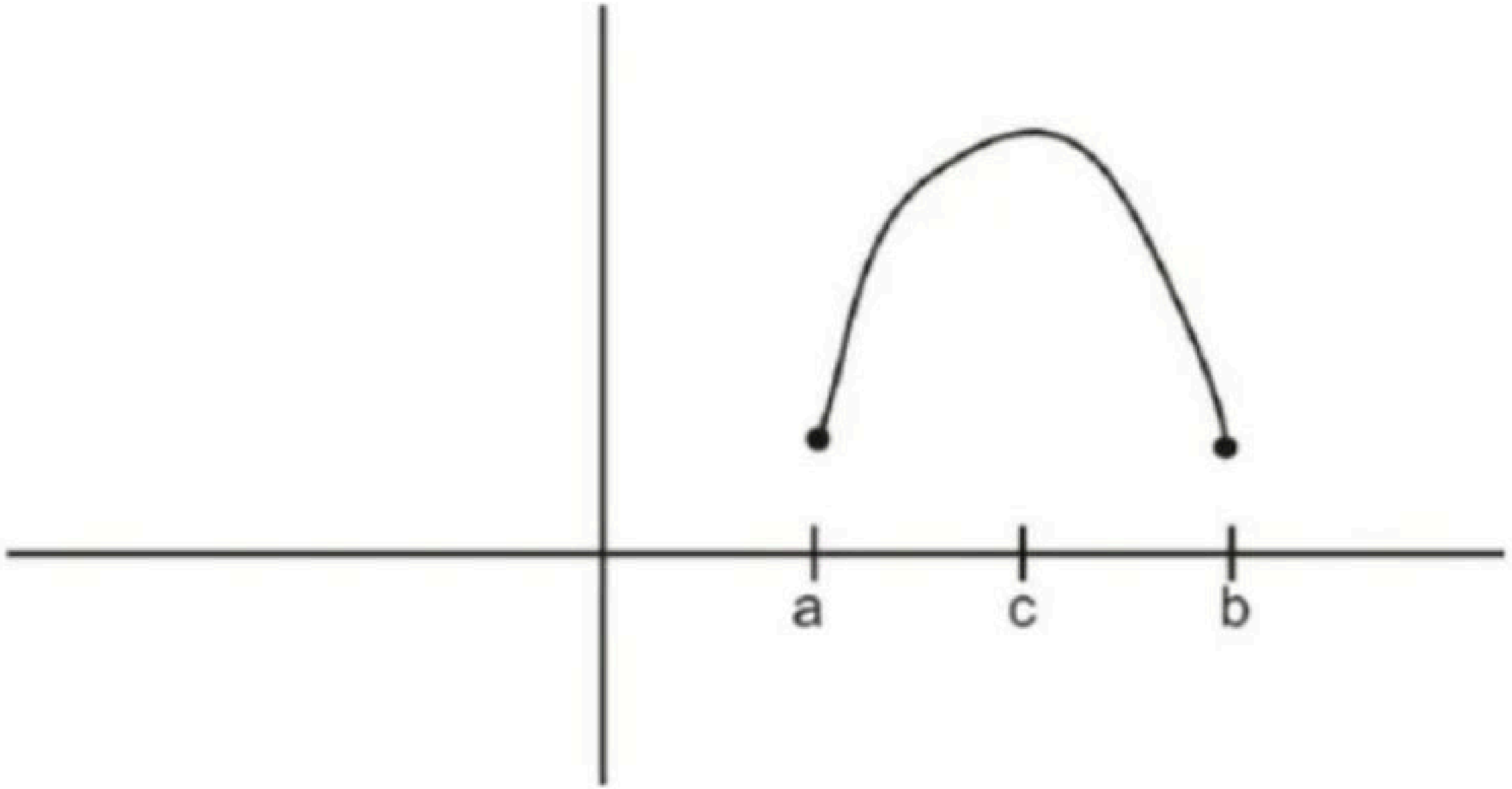
Mean Value Theorem :

(1) Rolle's Theorem : Let f be a function defined on [a, b] s.t.

(a) f is continuous on [a, b]

(b) f is differentiable on (a, b)

(c) f(a) = f(b) then $\exists$ c $\in$ (a, b) s.t. $f'(c) = 0$



Q.1. If $f(x)=\begin{cases} 1+x & if\ x<0 \\ (1-x)(px+q) & if\ x\ge 0 \end{cases}$ satisfies the assumption of Rolle's theorem in the interval [-1, 1] then the order pair (p, q) is **IIT JAM 2017**

(a) (2, -1) (b) (-2, -1)

(c) (-2, 1) (d) (2, 1)

Q.3. Using Rolle's theorem ,the equation $a_0x^n + a_1x^{n-1} + a_2x^{n-2} + \ldots + a_n = 0$ has atleast one root between 0 and 1 , If

(a) $\frac{a_0}{n} + \frac{a_1}{n-1} + \ldots\ldots a_{n-1} = 0$

(b) $\frac{a_0}{n-1} + \frac{a_1}{n-2} + \ldots\ldots a_{n-2} = 0$

(c) $\frac{a_0}{n+1} + \frac{a_1}{n} + \ldots\ldots a_n = 0$

(d) $a_0 n + a_1(n-1) + \ldots\ldots a_{n-1} = 0$

Lagrange's mean value theorem (LMVT) :

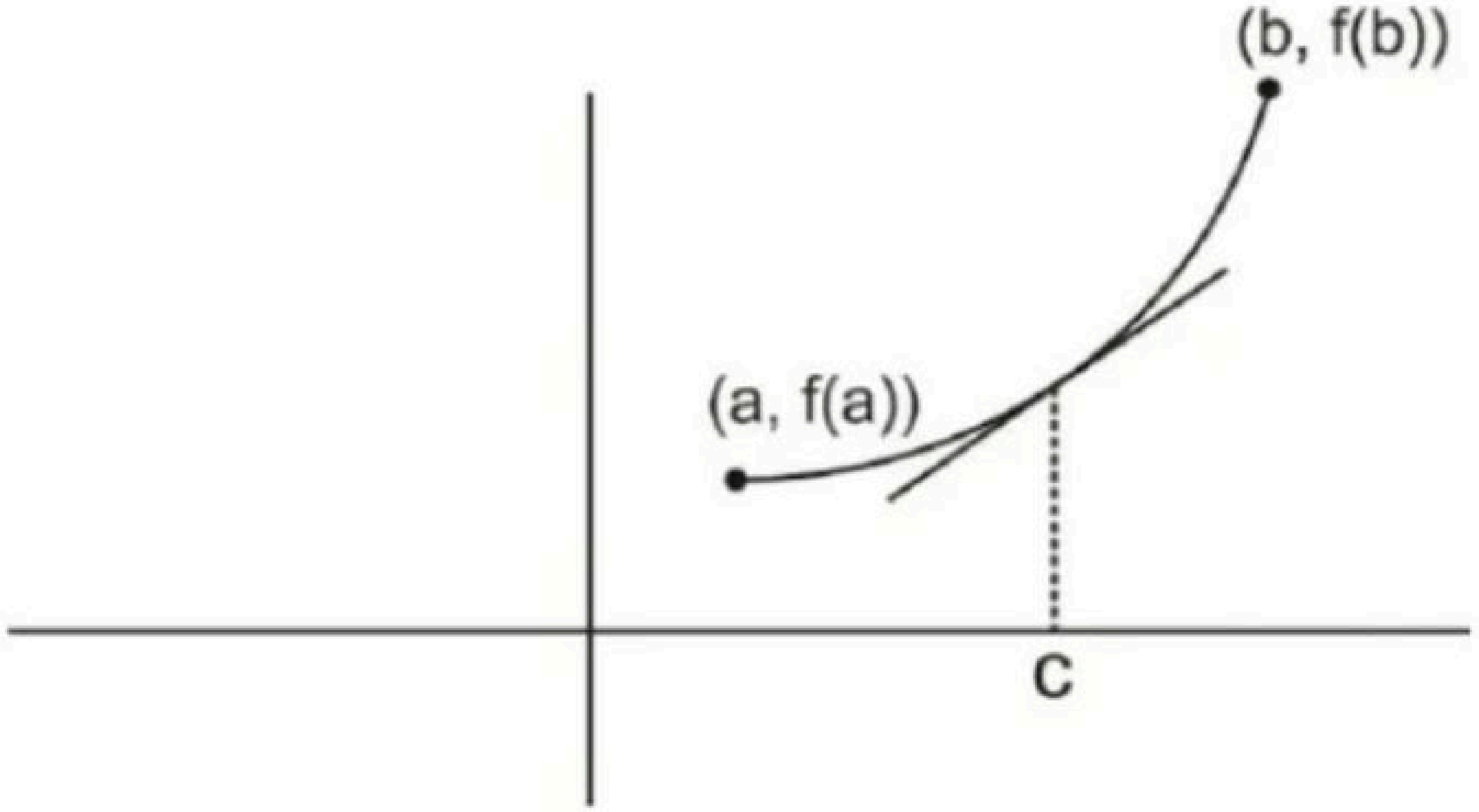
Let f be a function defined on [a, b] s.t.

(i) f is continuous on [a, b]

(ii) f is differentiable on (a, b),

then $\exists$ c $\in$ (a, b)

s.t. $$\frac{f(b)-f(a)}{b-a} = f`(c)$$



Q.3. Let $f : [a, b] \rightarrow R$ be a differentiable function. there exist point $c_1, c_2 \in (a, b)$ then which of the following is true **IIT JAM 2005**

(a) $3f(c_1)\, f'(c_1) = f'(c_2)\, [f(a) - f(b)]$

(b) $4f(c_1)\, f'(c_1) = f''(c_2)\, [f(a) + f(b)]$

(c) $5f(c_1)\, f''(c_1) = f'(c_2)\, [f(a) + f(b)]$

(d) $2f(c_1)\, f'(c_1) = f'(c_2)\, [f(a) + f(b)]$

Q.4. For a, b $\in$ R with $a < b$, let $f : [a, b] \to R$ be continuous on [a, b] and twice differentiable on (a, b). Further, assume that the graph of f intersects the straight line segment joining the points (a, f(a)) and (b, f(b)) at point (c, f(c)) for $a < c < b$. Then which of the following is always true **IIT JAM 2012**

(a) There exists a real number $\xi \in (a, b)$ such that $f``(\xi) = 0$

(b) For all real number $\xi \in (a, b)$ such that $f``(\xi) \neq 0$

(c) we can't say

(d) None of these

Cauchy's Mean Value Theorem :

Let f & g be two function defined on [a, b] s.t.

(i) f and g are continuous in [a, b]

(ii) f & g are differentiable in (a, b)

(iii) g`(x) ≠ 0 for each x ∈ (a, b) and g(a) ≠ g(b).

Then ∃ at least one point c ∈ (a, b) s.t.

$$\frac{f(b)-f(a)}{g(b)-g(a)}=\frac{f'(c)}{g'(c)}$$

Q.5. The value of ξ in the mean value theorem of $f(b) - f(a) = (b-a)f'(\xi)$ for $f(x) = Ax^2 + Bx + C$ in (a, b) is

(a) $b + a$ (b) $b - a$

(c) $\frac{(b+a)}{2}$ (d) $\frac{(b-a)}{2}$

Q.6 A function $f(x) = 1 - x^2 + x^3$ is defined in the closed interval [-1, 1]. The value of x, in the open interval (-1, 1) for which the mean value theorem is satisfied is

(a) -1/2 (b) -1/3

(c) 1/3 (d) 1/2

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Taylor's infinite series :

$a = \pi/4$

$f(x) = \sin x$, $x - \pi/4$

$f(\pi/4) = 1/\sqrt{2}$

$f'(x) = \cos x$ | $f'(\pi/4) = 1/\sqrt{2}$

$f''(x) = -\sin x$ | $f''(\pi/4) = -1/\sqrt{2}$

$f'''(x) = -\cos x$ $f'''(\pi/4) = -1/\sqrt{2}$

Let n ∈ N , I = [a,b] and f : I → R be a function f , f' , f''….$f^{(n)}$ are continouous on I and that $f^{(n+1)}$ exist on (a , b). then

$(x-\pi/4)^5$

$$f(x) = f(a) + (x-a)f`(a) + \ldots\ldots \frac{(x-a)^{n-1}}{(n-1)!} f^{(n-1)}(a) + \frac{(x-a)^n}{(n)!} f^{(n)}(a) + ..$$

$\sin x = f(\pi/4) + (x-\pi/4)\, f'(\pi/4) + \frac{(x-\pi/4)^2}{2!} f''(\pi/4) + \cdots$

This is called Taylor's infinite series about x = a.

Maclaurin's infinite series :

$\sin x = \frac{1}{\sqrt{2}} + (x-\pi/4)\frac{1}{\sqrt{2}} + \frac{(x-\pi/4)^2}{2!}(-1/\sqrt{2}) + \cdots$ $f^{iv} = \sin x$

$f^{v} = \cos x$

In Taylor's series put a = 0.

$\frac{(x-\pi/4)^5}{5!} f^{v}(\pi/4)$

So, $f(x) = f(0) + xf`(0) + \ldots\ldots \frac{x^n}{n!} f^{(n)}(0)$

$f^{v}(\pi/4)/5! = \frac{1}{\sqrt{2}} \frac{1}{120}$

which is called Maclaurin's infinite series

$$f(x) = 2x^3 + 7x^2 + x - 1$$

$$(x-2)$$

$$f(x) = f(2) + (x-2) f'(2) + \frac{(x-2)^2}{2!} f''(2) + \frac{(x-2)^3}{3!} f'''(2)$$

$$= 45 + (x-2)\,53 + \frac{(x-2)^2}{2}(38) + \frac{(x-2)^3}{6}(12)$$

$$= 45 + 53(x-2) + 19(x-2)^2 + 2(x-2)^3$$

$$f(2) = 16 + 28 + 2 - 1 = 45$$

$$f'(x) = 6x^2 + 14x + 1$$

$$f'(2) = 24 + 28 + 1 = 53$$

$$f''(x) = 12x + 14$$

$$f''(2) = 24 + 14 = 38$$

$$f'''(x) = 12$$

$$f'''(2) = 12$$

$f(x) = \sin x$

$x + \pi/4$

coeff of $(x+\pi/4)^4$

$\frac{f^{iv}(\pi/4)}{4!}$

(a) $\frac{1}{\sqrt{2}}\frac{1}{4!}$ (b) $-\frac{1}{\sqrt{2}}\frac{1}{4!}$

(c) $\frac{1}{\sqrt{2}}\frac{1}{4}$ (d) $-\frac{1}{\sqrt{2}}\frac{1}{4}$

$f(x) = \sin x$

$f'(x) = \cos x$

$f''(x) = -\sin x$

$f'''(x) = -\cos x$

$f^{iv}(x) = \sin x$

$f^{iv}(-\pi/4) = -1/\sqrt{2}$

$-\frac{1}{\sqrt{2}}\frac{1}{4!}$

Tricks : If f(x) is continuous function and it is vanishes at countably infinte numbers then it will

be identically zero

$f(x) = 0$

$f(0) = 0$

$f(1) = 0$

$f(2) = 0$

$f(3) = 0$

$f(4) = 0$

Q.7. Let S be the set of all continuous function f : [-1,1] → R satisfying the following three conditions

(i) f is infinitely differentiable on the open interval (-1,1)

(ii) The Taylor's series

$$f(0)+f'(0)x+\frac{f''(0)}{2!}x^2+\ldots\ldots \text{ of f at 0}$$

converges to f(x) for each x ∈ (-1,1)

(iii) $f\left(\frac{1}{n}\right)=0$ for all n ∈ N

Which of the following is true **IIT JAM 2022**

(a) f(0) = 0 for all f ∈ S

(b) $f'\left(\frac{1}{2}\right)=0$ for all f ∈ S

(c) ∃ f ∈ S such that $f'\left(\frac{1}{2}\right)\neq 0$

(d) ∃ f ∈ S such that f(x) ≠ 0 for some x ∈ [-1,1]

f(x) = 0

Q.8. Let α be the real number such that the coefficient of x^{125} in Maclaurin's series of $(x + \alpha^3)e^x$ is $\dfrac{28}{(124)!}$, then α **IIT JAM 2020**

(a) 15 (b) 20

(c) 25 (d) 30

$f(x) = (x+\alpha^3)e^x$

$f'(x) = e^x + (x+\alpha^3)e^x$

$f'(0) = \alpha^3 + 1$

$f''(x) = e^x + e^x + (x+\alpha^3)e^x$

$f''(0) = 2 + \alpha^3$

$f^{125}(0) = 125 + \alpha^3$

$\dfrac{f^{125}(0)}{125!}$

$\dfrac{125+\alpha^3}{125!} = \dfrac{28}{(124)!}$

$\dfrac{125+\alpha^3}{125 \times \cancel{(124)!}} = \dfrac{28}{\cancel{(124)!}}$

$125 + \alpha^3 = 28 \times 125$

$\alpha^3 = 28 \times 125 - 125$

$\alpha^3 = 125(28-1)$

$\alpha^3 = 125 \times 27$

$\alpha^3 = 5^3 \cdot 3^3$

$\alpha = 5 \times 3$

Q.9. Let $f(x) = \sqrt{x} + \alpha x$, x > 0 and g(x) = $a_0 + a_1(x-1) + a_2(x-1)^2$ be the sum of the first three terms of the taylor series of f(x) around x = 1. If g(3) = 3, then α is? **IIT JAM 2019**

(a) 1 (b) 1/2

(c) 1/4 (d) 3/4

$a_n = \frac{f^n(1)}{n!}$

$x^{-1/2}$

$g(x) = a_0 + a_1(x-1) + a_2(x-1)^2$

$g(x) = \boxed{f(1)} + \boxed{\frac{f'(1)}{1!}}(x-1) + \boxed{\frac{f''(1)}{2!}(x-1)^2}$

$g(x) = (1+\alpha) + \left[\frac{1}{2}+\alpha\right](x-1) + \left[-\frac{1}{4}\right]\frac{(x-1)^2}{2}$

$3 = (1+\alpha) + \left(\frac{1}{2}+\alpha\right)2 - \frac{4}{8}$

$3 = 1+\alpha + 1 + 2\alpha - \frac{1}{2}$

$3\alpha = 1 + \frac{1}{2}$

$3\alpha = \frac{3}{2}$ $\quad \alpha = \frac{1}{2}$

$f'(x) = \frac{1}{2\sqrt{x}} + \alpha$

$f''(x) = -\frac{1}{4}\frac{1}{x^{3/2}}$

$f(x) = e^x + \sin x$ coff. $(x-\pi)^2$ in Taylor series exp.

(a) e^{π} (b) $0.5\, e^{\pi}$

(c) $e^{\pi}+1$ (d) $e^{\pi}-1$

$$\frac{f''(\pi)}{2!}$$

$f'(x) = e^x + \cos x$

$f''(x) = e^x - \sin x$

$= \frac{e^{\pi}}{2}$

$f''(\pi) = e^{\pi}$

Taylor Series expansion of $f(x) = \int_0^x e^{-t^2/2}\,dt$ around $x=0$ has form

$f(x) = a_0 + a_1 x + a_2 x^2 + \cdots$

coeff of a_2 is

(a) 0 (b) 1

(c) -1 (d) 2

$a_2 = \frac{f''(0)}{2!} = 0$

$f'(x) = e^{-x^2/2}$

$f''(x) = e^{-x^2/2}(-x)$

$f''(0) = 0$

Taylor series expansion of $\frac{\sin x}{x-\pi}$ at $x=\pi$ is given by

(a) $1+\frac{(x-\pi)^2}{3!}$

(b) $-1-\frac{(x-\pi)^2}{3!}+$

(c) $1-\frac{(x-\pi)^2}{3!}+$

(d) $-1+\frac{(x-\pi)^2}{3!}+\cdots$

$$\frac{\sin(x+\pi-\pi)}{(x-\pi)}$$

$$\frac{\sin(\pi+(x-\pi))}{(x-\pi)}=\frac{-\sin(x-\pi)}{x-\pi}$$

$$-\frac{1}{x-\pi}\left((x-\pi)-\frac{(x-\pi)^3}{3!}+\cdots\right.$$

$$-1+\frac{(x-\pi)^2}{3!}-\cdots$$

Q.10. The coefficient of x^2 in the Maclaurin's series expansion of the function $f(x) = xe^x$.

(a) 0 (b) 1

(c) 2 (d) 3

$x = 0$

$$\frac{f''(0)}{2!} = \frac{2}{2!} = 1$$

$f(x) = xe^x$

$f'(x) = e^x + xe^x$

$f''(x) = e^x + e^x + xe^x$

$f''(0) = 1 + 1 + 0 = 2$


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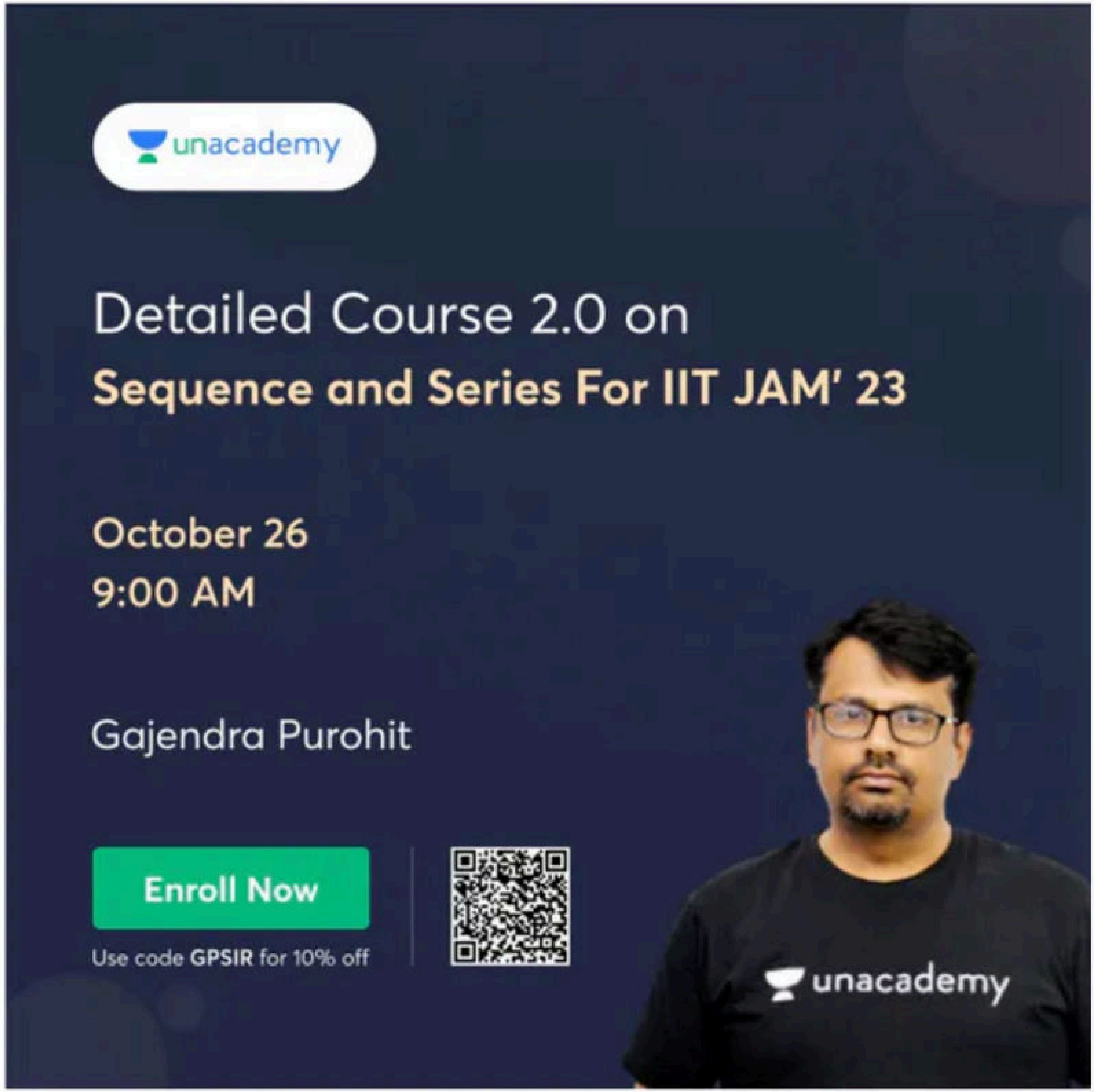
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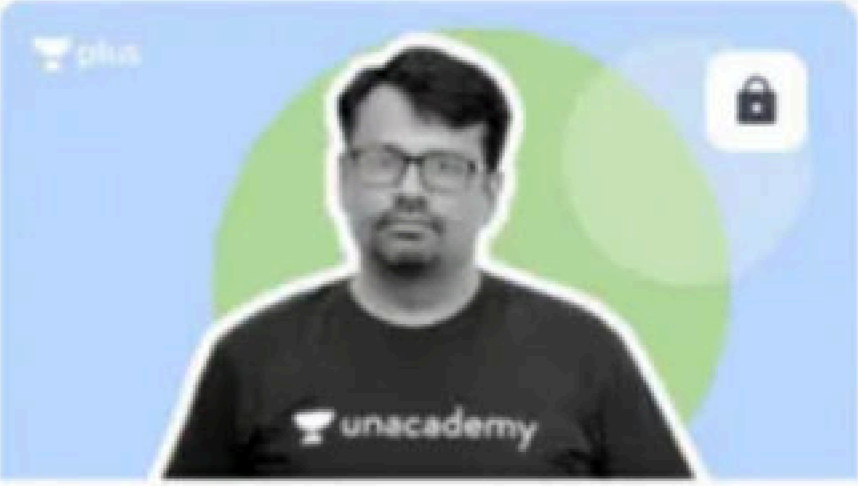

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Educator highlights

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