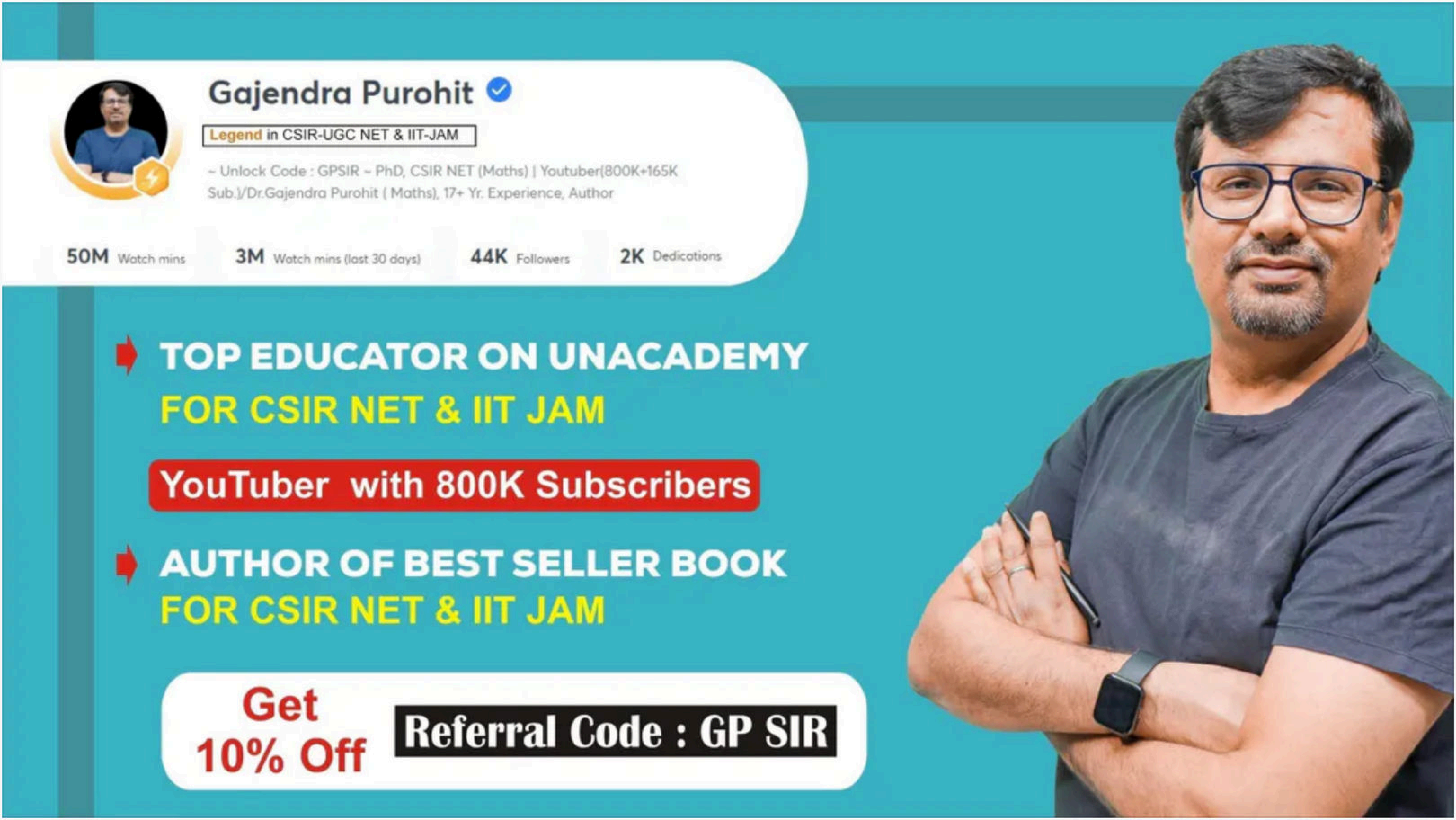
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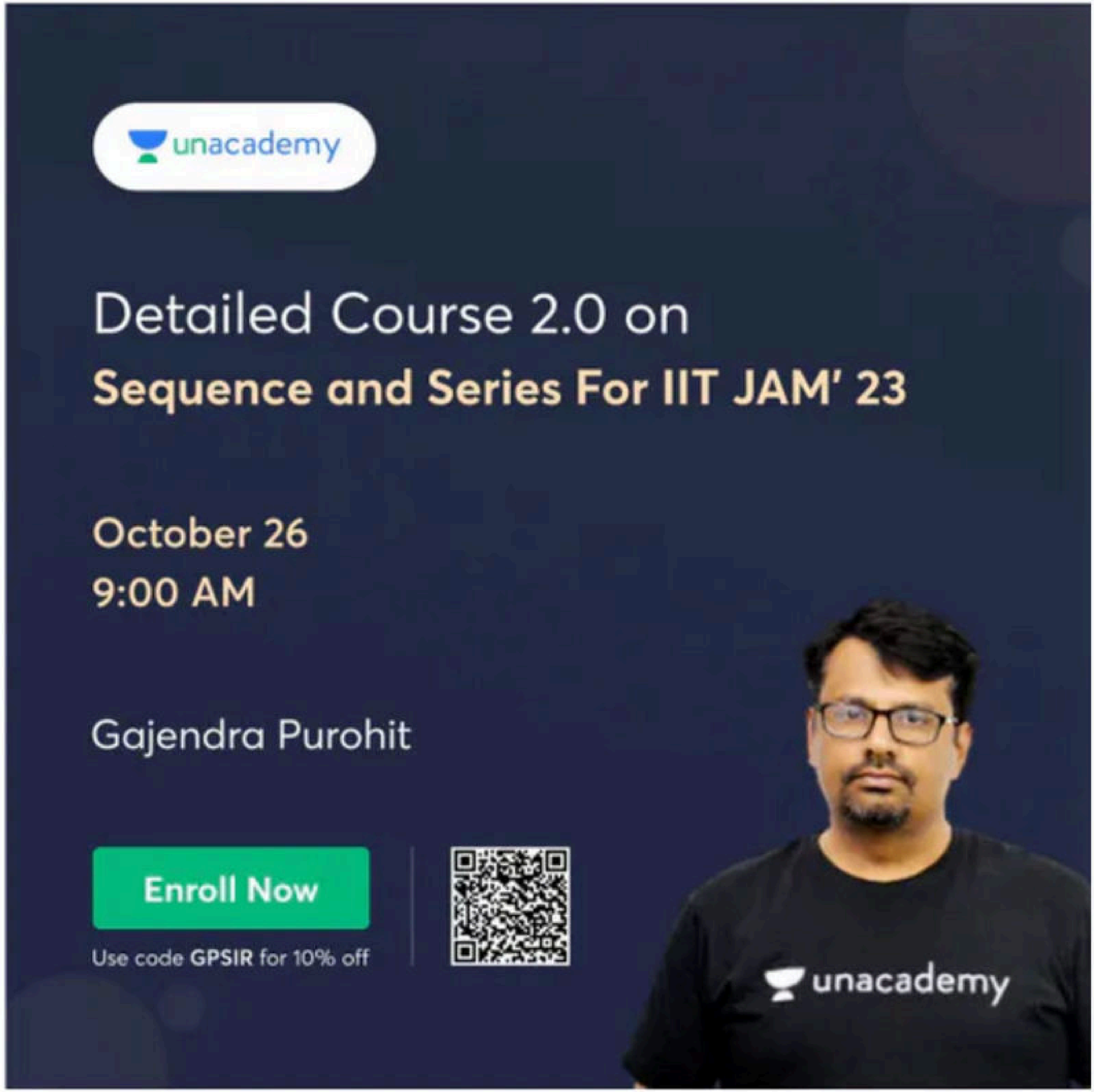
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Function of one variable

Function : A mapping $f : A \rightarrow B$ is said to be a function if every element of A assign to unique element of B.

Domain and range of function :

(i) Domain of function : Let $f : D \to R$ is a real value function then D is called domain of function

Another definition : Let $f : D \to R$ is a real valued function. Then the set of all points of R at which the function is well define then this set is called as domain of function.

(ii) Range of function : Let $f : A \to B$ is a function. then the set of all images of distinct elements of A is called range of function.

Bounded and Monotonic function :

(i)Bounded function : A function $f : D \to R$ is called bounded function if range of this function is bounded.

(ii) Monotonic function :

(1) Monotonic increasing function :

Let $f : D \to R$ be a function, then f is called monotonic increasing function is for

$x_1 < x_2 \Rightarrow f(x_1) \le f(x_2)$; for all $x_1, x_2 \in D$

(2) Monotonic decreasing function :

A function $f : D \rightarrow R$ is called monotonic decreasing if for $x_1 < x_2 \Rightarrow f(x_1) \geq f(x_2)$ for all $x_1, x_2 \in D$

One-One function : A real valued function $f : D \to R$ is called one-one function if $x_1 \neq x_2 \Rightarrow f(x_1) \neq f(x_2)$

Conclusion :

(1) If function is non-monotonic then this function is not one-one function.

(2) If function is strictly monotonic then this function is one-one function.

Another trick for one-one function :

(1) If graph of function intersect each line which parallel to x-axis at atmost one point.

(2) If $f'(x) > 0$ or $f'(x) < 0$ i.e. $f(x)$ is strictly monotonic function then $f(x)$ is one – one

Q.1. Let $f : R \to R$ is one-one function, then which of the following is/are true?

(a) f(x) is strictly increasing function.

(b) f(x) is strictly decreasing function.

(c) f(x) is strictly monotonic function.

(d) f(x) is monotonic function.

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Onto Function : A function $f : A \to R$ is said to be onto if $f(A) = R$.

Note : A function which is onto or not onto it is totally depend on co-domain.

Check onto function by graph :

If graph of function intersect each line which parallel to x-axis and contain in co-domain, then this function is onto function.

Q.2. Ler $f : R \to R^{+}$ is a non-monotonic function, then which of the following is true?

(a) A function is always one-one.

(b) A function may be one-one.

(c) A function is always onto

(d) A function may be onto

Composition of Function :

Let $f : A \rightarrow B$ and $g : B \rightarrow C$ are two real valued function then gof(x) is composition of function, where $gof(x) = g[f(x)]$.

Result : If gof(x) is one-one and onto, then f(x) is one-one and g(x) is onto.

$f(x) = x$

gof – one-one onto

$f : X \longrightarrow X$

Q.3. Let $f : X \to X$ such that $f(f(x)) = x$ for all $x \in X$. Then

(a) f is one-to-one and onto.

(b) f is one-to-one, but not onto

(c) f is onto but not one-to-one

(d) f need not be either one-to-one or onto

$f \circ f$

one-one

onto

Limit of function : Let f be a function defined for all points in some neighbourhood of a point a.

We say that f tends to the limit l as x tends to a.

i.e. $\lim_{x \to a} f(x) = l$

$$\lim_{x \to 1} (x^2+x+1) = 1^2+1+1=3$$

Then l is called limit of function.

$\frac{0}{0}$

$$\lim_{x \to a} \frac{x^2-a^2}{x-a}$$

$$\lim_{x \to a} \frac{\cancel{(x-a)}(x+a)}{\cancel{(x-a)}} = 2a$$

$$\lim_{x \to a} \frac{2x}{1} = 2a$$

Right hand limit : Let f(x) be a function, $\lim_{x\to a+0} f(x) = f(a+0) = l$ then is called right hand limit.

Left hand limit : Let f(x) be a function, then $\lim_{x\to a-0} f(x) = f(a-0) = l$ is called left hand limit of f(x) at 'a'.

Note : Let f(x) be a function then $\lim_{x\to a} f(x) = f(a+0) = f(a-0)$.

$$f(x) = \begin{cases} x^2+1 & x<0 \\ 2x+1 & x \geq 0 \end{cases}$$

L.H.L $\quad \lim_{x \to 0^-} (x^2+1) = 1$

RHL $\quad \lim_{x \to 0^+} (2x+1) = 1$

$$f(x) = \begin{cases} x^2+1 & x<1 \\ 2x+1 & x \geq 1 \end{cases}$$

LHL

$\lim_{x \to 1^-} (x^2+1) = 2$

RHL

$\lim_{x \to 1^+} (2x+1) = 3$

$$\lim_{x \to 0} \frac{x - |x|}{x}$$

$$f(x) = \begin{cases} \frac{x+x}{x} \; 2 & x < 0 \\ \frac{x-x}{x} & x \geq 0 \end{cases}$$

Q.4. Let $f : (-1,1) \to R$ and $g : (-1,1) \to R$ be thrice continuously differential function such that $f(x) \neq g(x)$ for every non – zero $x \in (-1,1)$. Suppose $f(0) = \log 2$, $f'(0) = \pi$, $f''(0) = \pi^2$, $f'''(0) = \pi^9$ and $g(0) = \log 2$, $g'(0) = \pi$, $g''(0) = \pi^2$, $g'''(0) = \pi^3$ then the value of limit $\lim\limits_{x\to 0}\dfrac{e^{f(x)} - e^{g(x)}}{f(x) - g(x)}$ is **IIT JAM 2022**

(a) 1 (b) 2

(c) 3 (d) 4

$f(0) = \log 2 = g(0)$

$f'(0) = \pi = g'(0)$

$f''(0) = \pi^2 = g''(0)$

$f'''(0) = \pi^9, \quad g'''(0) = \pi^3$

$$\lim_{x\to 0} \frac{\cancel{e^{f(x)} f'(x)\left[(f'(x))^2 + f''(x)\right]} + e^{f(x)}\left[\cancel{2f'f''} + f'''\right] - \cancel{e^{g(x)} g'\left[(g')^2 + g''\right]} + e^{g}\left[\cancel{2gg''} + g'''\right]}{f''' - g'''}$$

$$\lim_{x\to 0} \frac{e^{f(x)}\left[f'''\right] - e^{g(x)} g'''}{f''' - g'''} = \lim_{x\to 0} \frac{e^{\log 2}\pi^9 - e^{\log 2}\pi^3}{\pi^9 - \pi^3}$$

$$= e^{\log 2}$$

$$= 2$$

Q sim

$$1^{\infty}$$

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

$$y=\left(1+\frac{1}{n}\right)^{n}$$

$$\log y = n\log\left(1+\frac{1}{n}\right)$$

$$\lim_{n\to\infty}\log y = \lim_{n\to\infty}\frac{\log\left(1+\frac{1}{n}\right)}{\frac{1}{n}}$$

$$\log \lim_{n\to\infty} y = \lim_{n\to\infty}\frac{\frac{1}{1+\frac{1}{n}}\cancel{\left(-\frac{1}{n^2}\right)}}{\cancel{\left(-\frac{1}{n^2}\right)}}$$

$$\log \lim_{n\to\infty} y = 1$$

$$\lim_{n\to\infty} y = e$$

Q $\lim_{x\to a}\left[\frac{f(x)}{f(a)}\right]^{\frac{1}{\log x-\log a}}$

(a) $\frac{a f'(a)}{f(a)}$

(b) $e^{\frac{a f'(a)}{f(a)}}$

(c) $\frac{a f(a)}{f'(a)}$

(d) $e^{\frac{a f(a)}{f'(a)}}$

$\log y=\frac{1}{\log x-\log a}\left(\frac{f(x)}{f(a)}\right)$

$\lim_{x\to a}\log y=\lim_{x\to a}\frac{1}{\log x-\log a}\cdot\log\left(\frac{f(x)}{f(a)}\right)$

$\lim_{x\to a}\log y=\lim_{x\to a}\frac{\log f(x)-\log f(a)}{\log x-\log a}$

$\lim_{x\to a}\log y=\lim_{x\to a}\frac{\frac{1}{f(x)}f'(x)-0}{\frac{1}{x}}=\frac{a f'(a)}{f(a)}$

$\underline{y=e^{\frac{a f'(a)}{f(a)}}}$

Q

$$\lim_{x\to\infty} x\left[\log\left(1+\frac{x}{2}\right)-\log\frac{x}{2}\right]$$

(a) 0 (b) ∞

(c) 1 (d) 2

$$\lim_{x\to\infty} (x)\log\left(\frac{1+\frac{x}{2}}{x/2}\right)$$

$$\lim_{x\to\infty} \frac{\log\left(\frac{2}{x}+1\right)}{1/x}$$

$$\lim_{x\to\infty} \frac{\frac{1}{\frac{2}{x}+1}\left(-\frac{2}{\cancel{x^2}}\right)}{-\cancel{1/x^2}}$$

$$= 2$$

$$\lim_{x\to 0}\left(\frac{\sin 3x}{x^3}+\frac{a}{x^2}+b\right)=0 \quad \text{then} \quad \frac{a^2}{2}+b$$

$$\frac{9}{2}+\frac{9}{2}$$

(a) $9/2$ (b) $9/4$

(c) 0 (d) $9/8$

$$\lim_{x\to 0}\frac{\sin 3x+ax+bx^3}{x^3}$$

$$\lim_{x\to 0}\frac{3\cos 3x+a+3bx^2}{3x^2}$$

$$3\times 1+a=0$$

$$a=-3$$

$$\lim_{x\to 0}\frac{-9\sin 3x+0+6bx}{6x}$$

$$\lim_{x\to 0}\frac{-27\cos 3x+6b}{6}=\frac{-27+6b}{6}=0$$

$$6b=27$$

$$b=9/2$$

Q.5. Which of the following is false

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T (a) $\lim\limits_{x\to\infty}\frac{x}{e^x}=0$

T (b) $\lim\limits_{x\to 0^+}\frac{\sin x}{1+2x}=0$

T (c) $\lim\limits_{x\to 0^+}\frac{1}{xe^{\frac{1}{x}}}=0$

(d) $\lim\limits_{x\to 0^+}\frac{\cos x}{1+2x}=0$

$\frac{1}{e^n}$

$\frac{e^{-1/x}}{x}$

$\frac{1}{1}$

Q.6. The value of $\lim_{x\to 0} \frac{|x|-x}{2x}$ is

(a) 0 (b) 2

(c) 1 (d) does not exist

$$\begin{cases} \dfrac{-2x}{2x} \quad -1 & x<0 \\[2ex] \dfrac{x-x}{2x} & \underline{x \geq 0} \end{cases}$$

Q.7. The value of $\lim\limits_{x \to 0} \dfrac{x}{\sqrt{1-\cos x}}$

(a) $\sqrt{2}$ (b) $-\sqrt{2}$

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

$$\lim_{x \to 0} \frac{x}{\sqrt{2}\sin x/2}$$

$$\lim_{x \to 0} \frac{1}{\sqrt{2}\cos x/2 \cdot 1/2}$$

$$\frac{1}{\sqrt{2}\,\frac{1}{2}} = \underline{\sqrt{2}}$$

Q.8. Let f be a monotone non-decreasing real-valued function on R. Then

(a) $\lim_{x \to a} f(x)$ exists at each point a.

(b) If a < b, then $\lim_{x \to a^+} f(x) \le \lim_{x \to b^-} f(x)$.

(c) f is an unbounded function

(d) The function $g(x) = e^{-f(x)}$ is a bounded function.

Q.9. Let p be a real polynomial of the real variable x of the form $p(x) = x^n + a_{n-1}x^{n-1} + ... + a_1 x + 1$. Suppose that p has no roots in the open unit disc and $p(-1) = 0$. Then

(a) $p(1) = 0$

(b) $\lim_{x \to \infty} p(x) = \infty$

(c) $p(2) > 0$

(d) $p(3) = 0$

Continuity

Continuous function at a point 'a' :

Let f : A $\rightarrow$ R be a real valued function. This function is continuous at x = $\alpha \in$ A

if $\lim_{x \to \alpha} f(x) = f(\alpha)$.

Continuity of some important function :

(1) **Polynomial function :** Let $f(x) = a_n x^n + ... a_1 x + a_0$ then $\lim_{x\to\alpha} f(x) = f(\alpha) .\Rightarrow$ f(x) is continuous at any point.

(2) **Constant function :** Let $f(x) = \alpha$.

Here $\lim_{x\to a} f(x) = f(\alpha) = \alpha$.

Constant function is always continuous at a.

(3) **Rational function :**

Let p(x) and q(x) are polynomial, then $f(x) = \dfrac{p(x)}{q(x)}$ is called rational function.

Hence f(x) is continuous at c, if $q(c) \neq 0$

(4) Trigonometry function :

(a) $f(x) = \sin x$

(5) Exponential function :

(6) Logarithmic function :

Sequential definition : Let $f : A \to R$ be a function and f is continuous at 'c' iff for every sequence $\langle x_n \rangle$ converging to c, then $\langle f(x_n) \rangle$ converging to f(c).

i.e. if $\exists$ two sequence $\langle x_n \rangle$ and $\langle y_n \rangle$ s.t. $\langle x_n \rangle \to c$ and $\langle y_n \rangle \to c$.

but if $\langle f(x_n) \rangle$ and $\langle f(y_n) \rangle$ converging to distinct limit then f(x) is not continuous at c.

Result :

Let f : R → R is a function defined by

$$f(x) = \begin{cases} g(x), & x \in Q \\ h(x), & x \in Q^C \end{cases}$$

Then f(x) is continuous at all zeros of g(x) – h(x) = 0.

Q.1. Let $f : R \rightarrow R$ be defined by $f(x) = \begin{cases} x^6 - 1 & x \in Q \\ 1 - x^6 & x \in Q^C \end{cases}$.

The number of points at which f(x) is continuous is

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(a) 1 (b) 2

(c) 3 (d) 4

Result : Let f : [0 ,1] → R is a function such that

$$f(x) = \begin{cases} x^{\alpha} \sin\frac{1}{x} & x \neq 0 \\ 0 & x = 0 \end{cases}$$

Then f(x) is continuous iff $\alpha > 0$

Q.2. Which of the follwing values of α , the function

$$f(x)=\begin{cases} x^{\alpha}\sin\frac{1}{x} & x\neq 0 \\ 0 & x=0 \end{cases}$$ is continuous

(a) 1/2

(b) 1

(c) 2

(d) -1/3

Q.3. Let the function f(x) be defined by $f(x)=\begin{cases} e^x & x \text{ is rational} \\ e^{1-x} & x \text{ is irrational} \end{cases}$ for x in (0,1) then

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(a) f is continuous at every point in (0,1)

(b) f is discontinuous at every point in (0,1)

(c) f is discontinuous at only one point in (0,1)

(d) f is continuous at only one point in (0,1)


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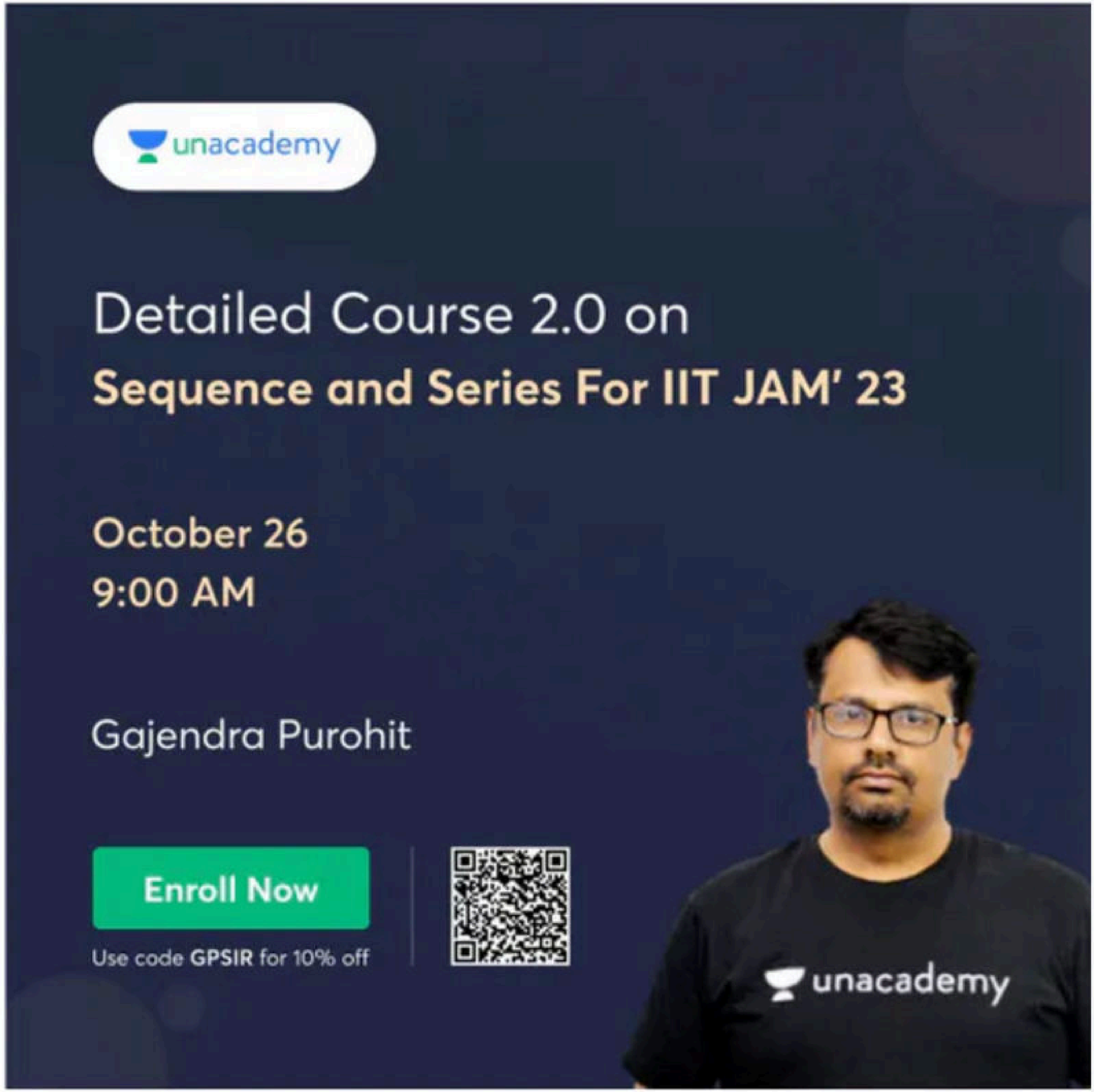
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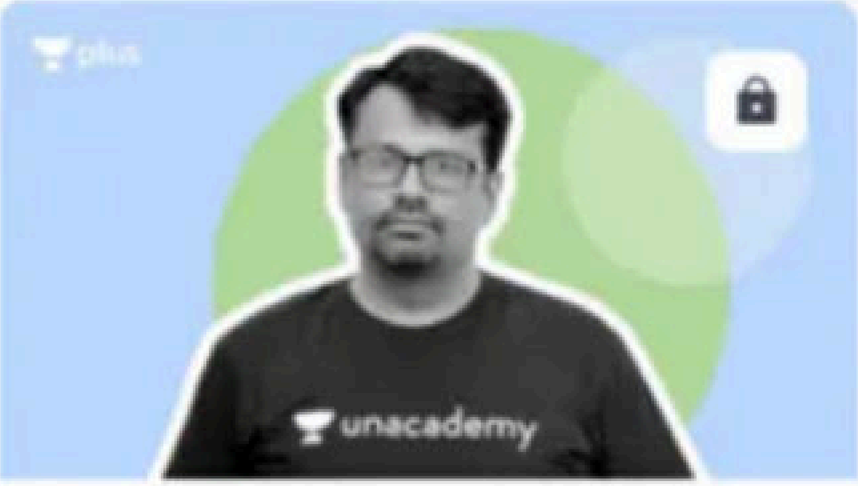

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- Works at **Pacific Science College**
- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
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