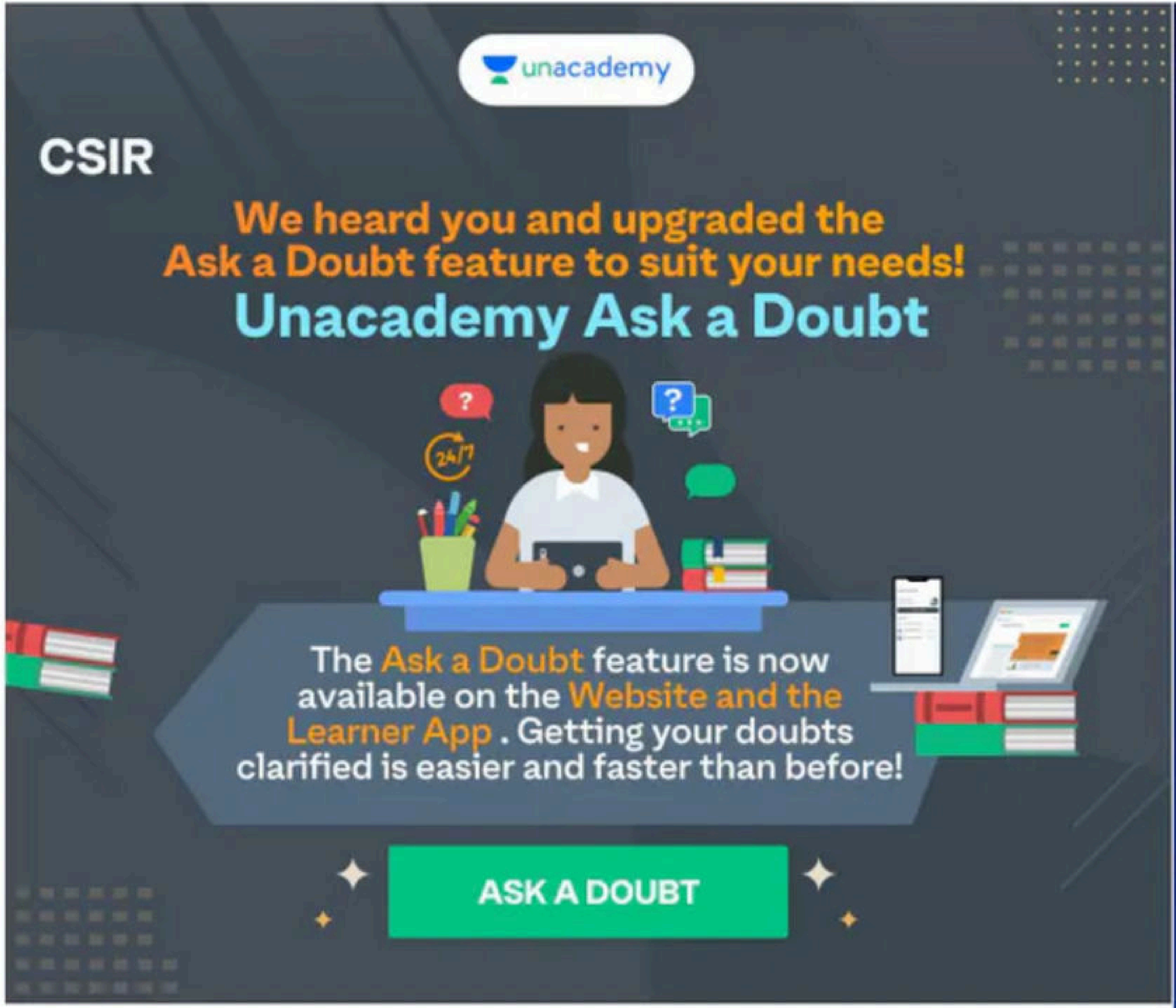
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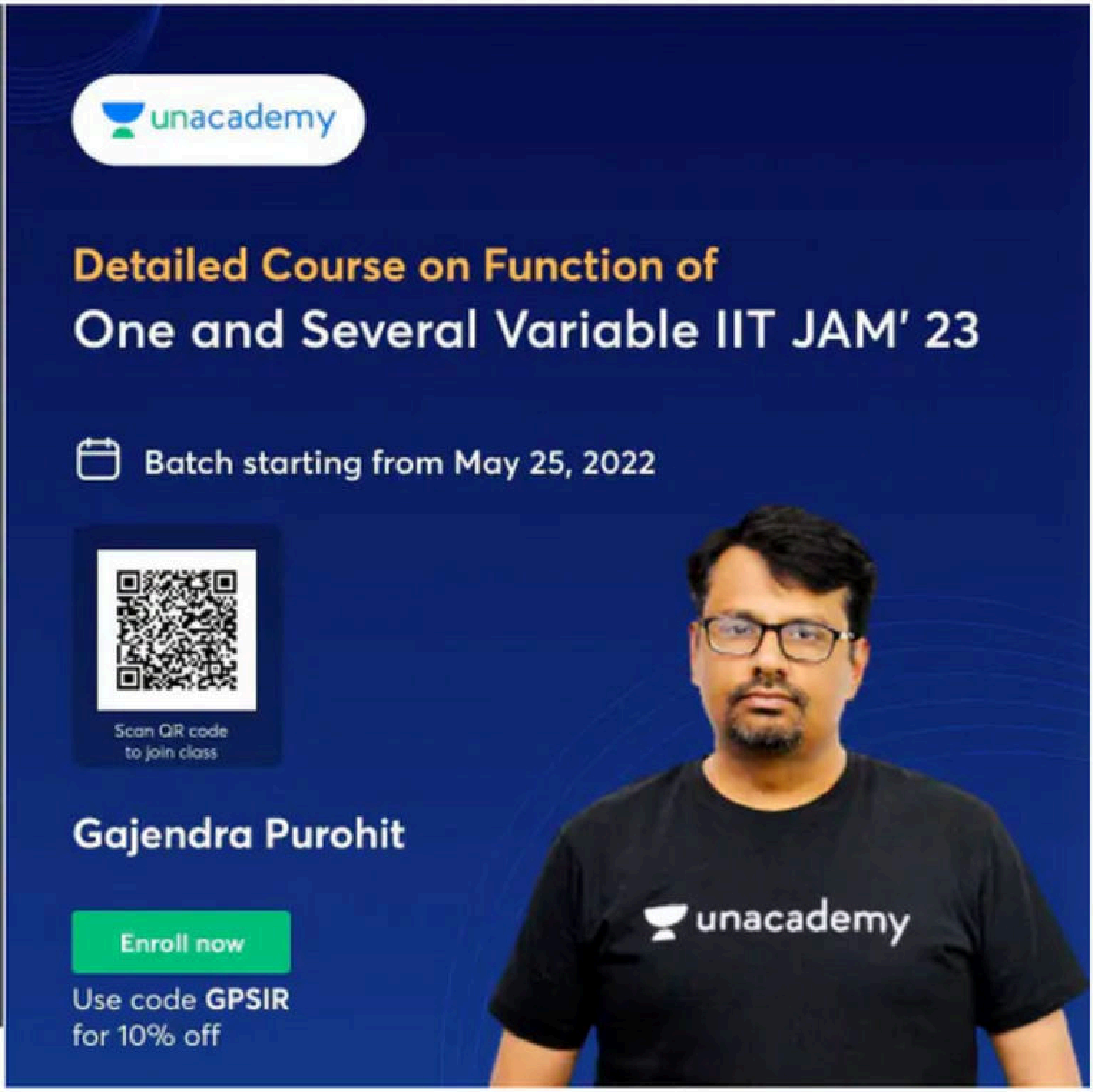
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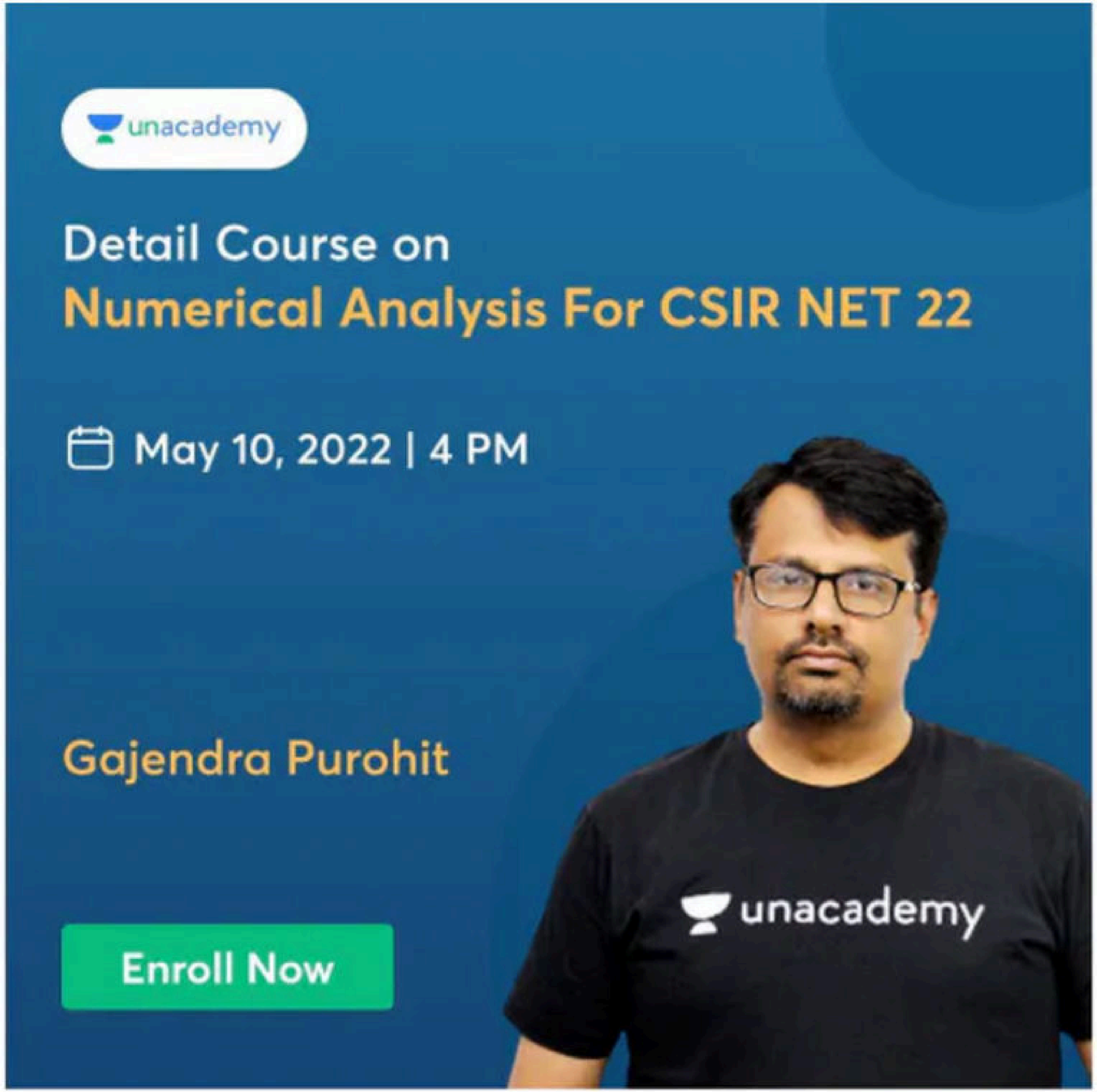
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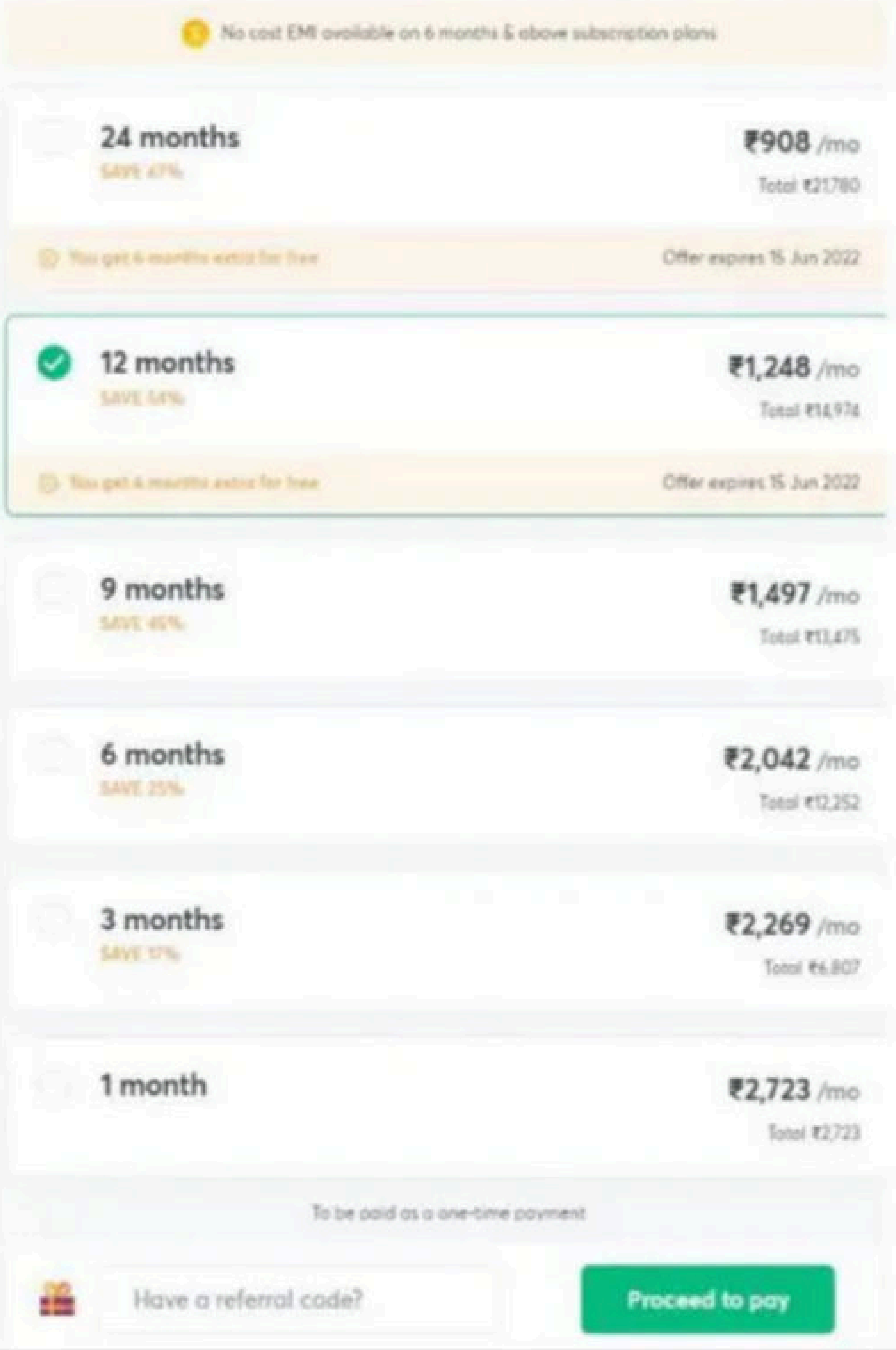

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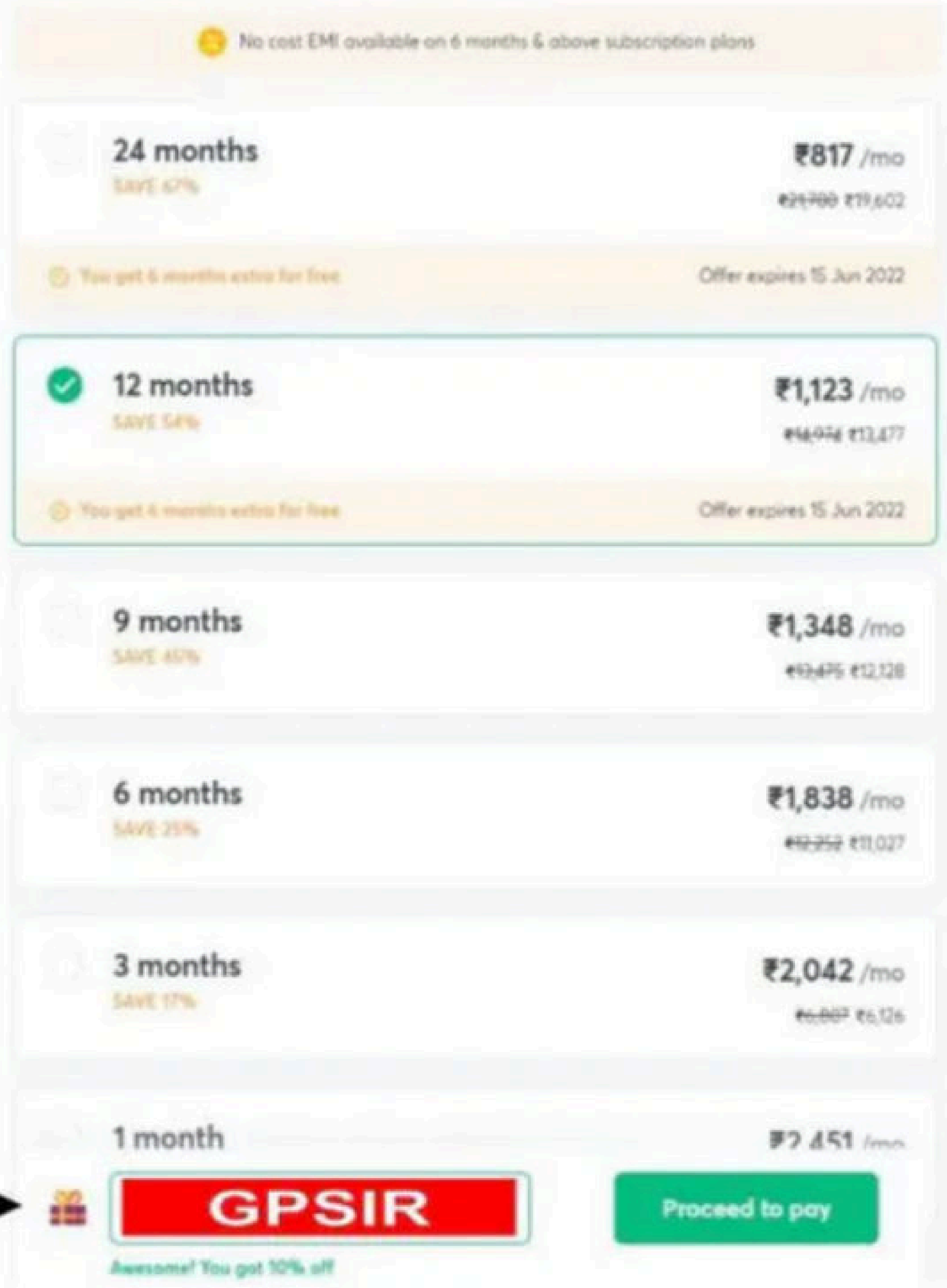

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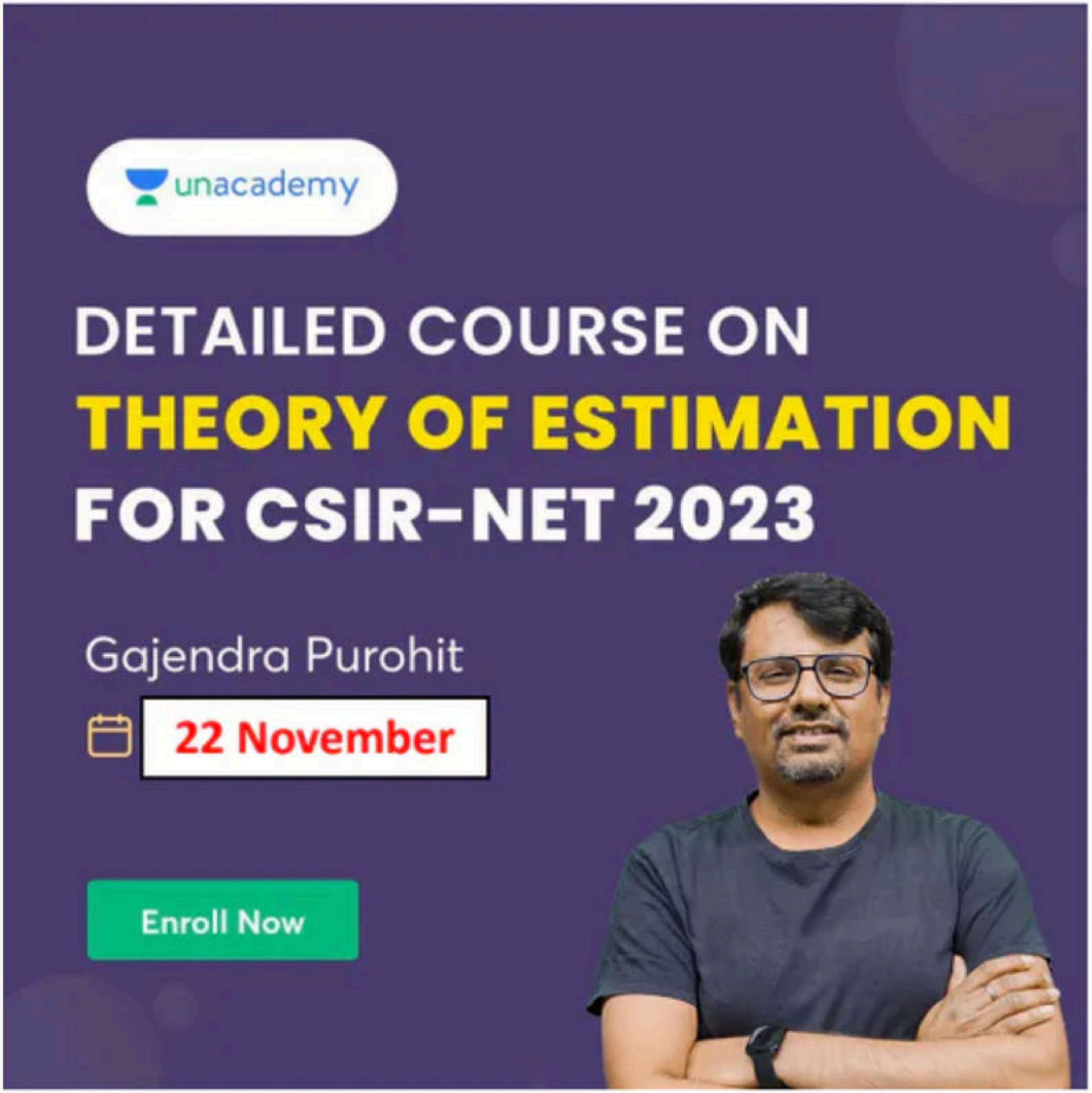
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Directional Derivative :

Let f be a function of n-variables defined on D and let u = $(u_1, u_2, \ldots, u_n)$ be a unit vector then the directional derivative of f at $\alpha = (x_1, x_2, \ldots, x_n)$ in the direction of u denoted by $D_u f(x_1, x_2, \ldots, x_n)$ is defined by

$$D_u f(\alpha) = \lim_{h \to 0} \frac{f(\alpha + hu) - f(\alpha)}{h} \text{ if limit exist,}$$

Where $\alpha = (x_1, x_2, \ldots, x_n)$, $u = (u_1, u_2, \ldots, u_n)$

$$\alpha + hu = (x_1 + hu_1, x_2 + hu_2 \ldots x_n + hu_n)$$

Note :

(1) If direction is not unit vector, then firstly we convert into unit vector.

(2) If direction is not mention in question then we take arbitrary direction as

$$u = \cos\theta\ \hat{i} + \sin\theta\ \hat{j}$$

‘Some important result :

(1) If f(x, y) is differentiable at (a, b) then all directional derivative exist at (a, b) but converse need not be true.

(2) If f(x, y) is continuous at (a, b) then all directional derivative of f at (a, b) but converse need not be true.

(3) If partial derivative exist and continuous at (a,b) then f is differentiable at (a, b)

Q1. Let f : $R^2 \rightarrow R$ be a function. Then which of the following statements is/are TRUE? **IIT-JAM 2017**

(a) If f is differentiable at (0, 0), then all directional derivatives of f exists at (0, 0)

(b) If all directional of f exists at (0, 0), then f is differentiable at (0, 0)

(c) If all directional derivative of f exists at (0, 0), then f is continuous at (0, 0)

(d) If the partial derivatives $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$ exists and are continuous in a disc centred at (0,0) then f is differentiable at (0,0)

Q2. Let $f(x,y)=\begin{cases}\dfrac{x^3+y^3}{x^2-y^2}, & x^2-y^2\neq 0\\ 0, & x^2-y^2=0\end{cases}$.

Then the directional derivative of f at (0, 0) in the direction of $\frac{4}{5}\hat{i}+\frac{3}{5}\hat{j}$ is **IIT-JAM 2019**

(a) 2.5 to 2.7 (b) 2.4 to 2.8

(c) 2.6 to 2.6 (d) 2.8 to 2.9

Q3. Let f : $R^2 \to R$ be defined by $f(x,y)=\begin{cases}\left(1+\dfrac{x}{y}\right)^2, & y\neq 0\\ 0, & y=0\end{cases}$. If the directional derivative of f at (0, 0) exists along the direction $\cos\alpha\,\hat{i}+\sin\alpha\,\hat{j}$, where $\sin\alpha \neq 0$, then the value of cot α is **IIT-JAM 2015**

(a) 1

(b) -1

(c) 2

(d) 0

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Maxima and minima of two variables function

1. Maxima of function :

Let (a, b) be a point in the domain of $f(x, y)$, then $f(x, y)$ has a maxima at (a, b) iff $(a, b) \geq f(x, y)$; for all $(x, y) \in$ domain

2. **Minima of function :**

Let (a, b) be a point in the domain of $f(x, y)$, then $f(x, y)$ has a minima at (a, b) iff $f(a, b) \leq f(x, y)$; for all $(x, y) \in$ domain

3. Extremum point :

f(x, y) is said to have an extremum at a point (a, b) if it has either a maximum and minimum at (a, b).

4. Critical point :

A point (a, b) is said to be a critical point for the function f(x, y) if $f_x(a, b) = 0$ &$f_y(a, b) = 0$

Note : A critical point is an extremum point of function but converse may not true.

Procedure of finding maxima & minima

Let $f(x, y)$ be a function of two variables and $r = f_{xx}(a, b)$, $s = f_{xy}(a, b)$, $t = f_{yy}(a, b)$, then

(i) f has a minima at (a, b) if $rt - s^2 > 0$ & $r > 0$

(ii) f has a maxima at (a, b) if $rt - s^2 > 0$ & $r < 0$

(iii) f has neither maxima nor minima at (a, b) if $rt - s^2 < 0$

(iv) f may or may not have an extrema if $rt - s^2 = 0$

Saddle Point :

A point (a, b) is said to be saddle point if it is neither maxima nor minima.

Q.1. Consider the function $f(x, y) = 5 - 4\sin x + y^2$ for $0 < x < 2\pi$ and $y \in R$. The set of critical points of $f(x, y)$ consists of **IIT JAM – 2017**

(a) a point of local maxima and a point of local minima

(b) a point of local maxima and a saddle point

(c) a point of local maxima, a point of local minima and a saddle point

(d) a point of local minima and a saddle point.

Q.2 $f(x, y) = x^3 - y^3 - 3x^2 + 3y^2 + 7, (x, y) \in R^2$. Then the local minimum(m) and local Maximum (M) of f are given by **IIT JAM – 2017**

(a) $m = 3, M = 7$ (b) $m = 4, M = 11$

(c) $m = 7, M = 11$ (d) $m = 3, M = 11$

Q3. Let f given by $f(x, y) = x^2 + xy + y^2 - x - 100$. Find the points of local maxima and local minima (if any) of f. **IIT JAM – 2011**

(a) Only $\left(\frac{2}{3}, -\frac{1}{3}\right)$ (b) Only $\left(-\frac{2}{3}, -\frac{1}{3}\right)$

(c) $\left(\frac{2}{3}, \frac{1}{3}\right)$ (d) None of these

Q4. Let $f(x, y) = x^3 + y^3 + 3xy$ is a function of two variables. Which of the following is true?

IIT – JAM 2012

(a) maxima at (-1, -1)
(b) minima at (-1, -1)

(c) maxima at (0, 0)

(d) saddle point at (-1, -1)

Q5. Let $f(x, y) = x^4 - 2x^2y^2 + y^4 + x^2 - 6xy + 9y^2$

then which of the following is true

(a) f has a minima (global) at $(0,1)$

(b) f has a minima (global) at $(0,0)$

(c) f has a minima (global) at $(2,0)$

(d) None of these

Q6. The critical point of $f(x, y) = x^3 + y^2 - 12x - 6y + 40$ are **IIT JAM – 2006**

(a) saddle point (b) maxima

(c) minima (d) none of thes

Q7. Let $f(x, y) = 4xy - x^3y - xy^3$ for $(x, y) \in R^2$. The value of f at local minimum in the rectangular region $R = \left\{(x, y) \in R^2 \mid |x| < \frac{3}{2}, |y| < \frac{3}{2}\right\}$ is

(a) -2 (b) -3

(c) -7/8 (d) 0

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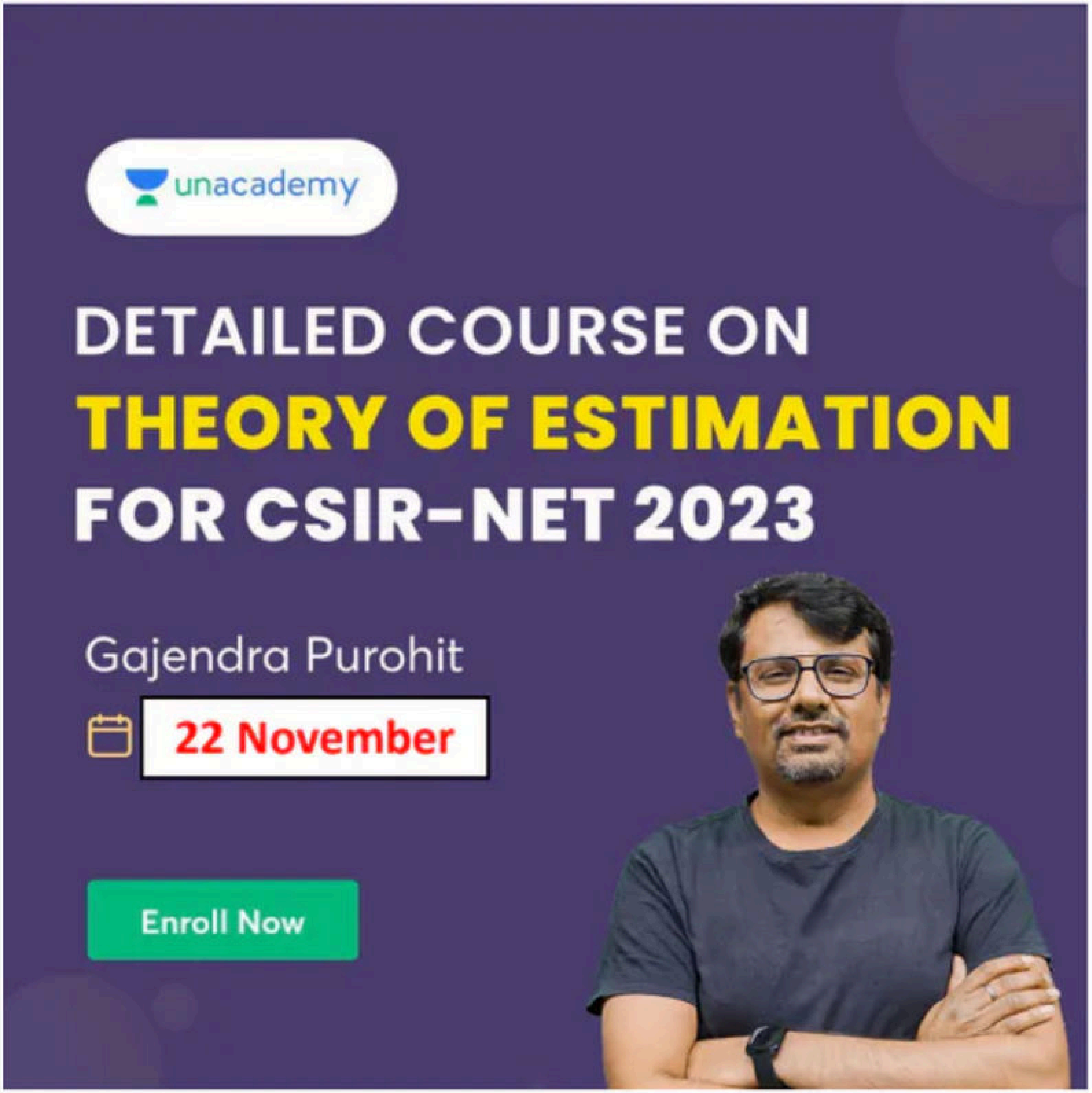
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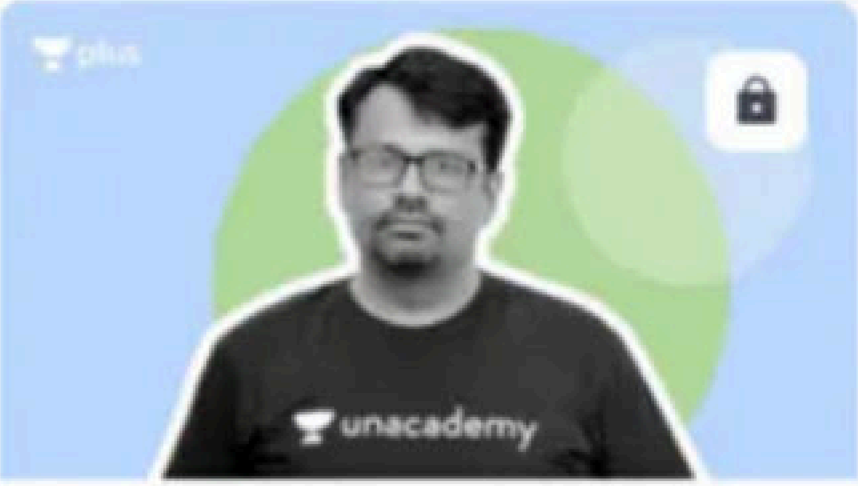

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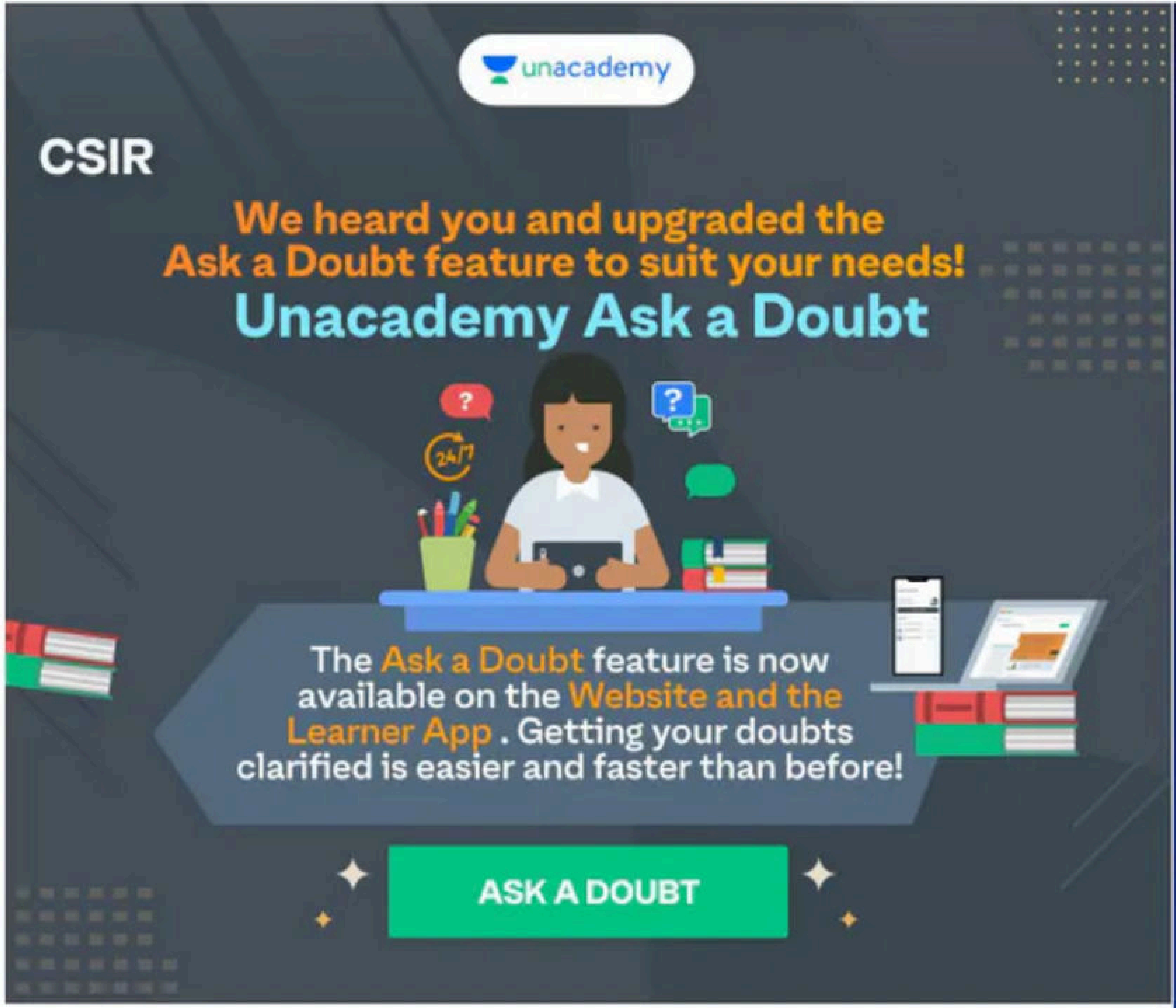
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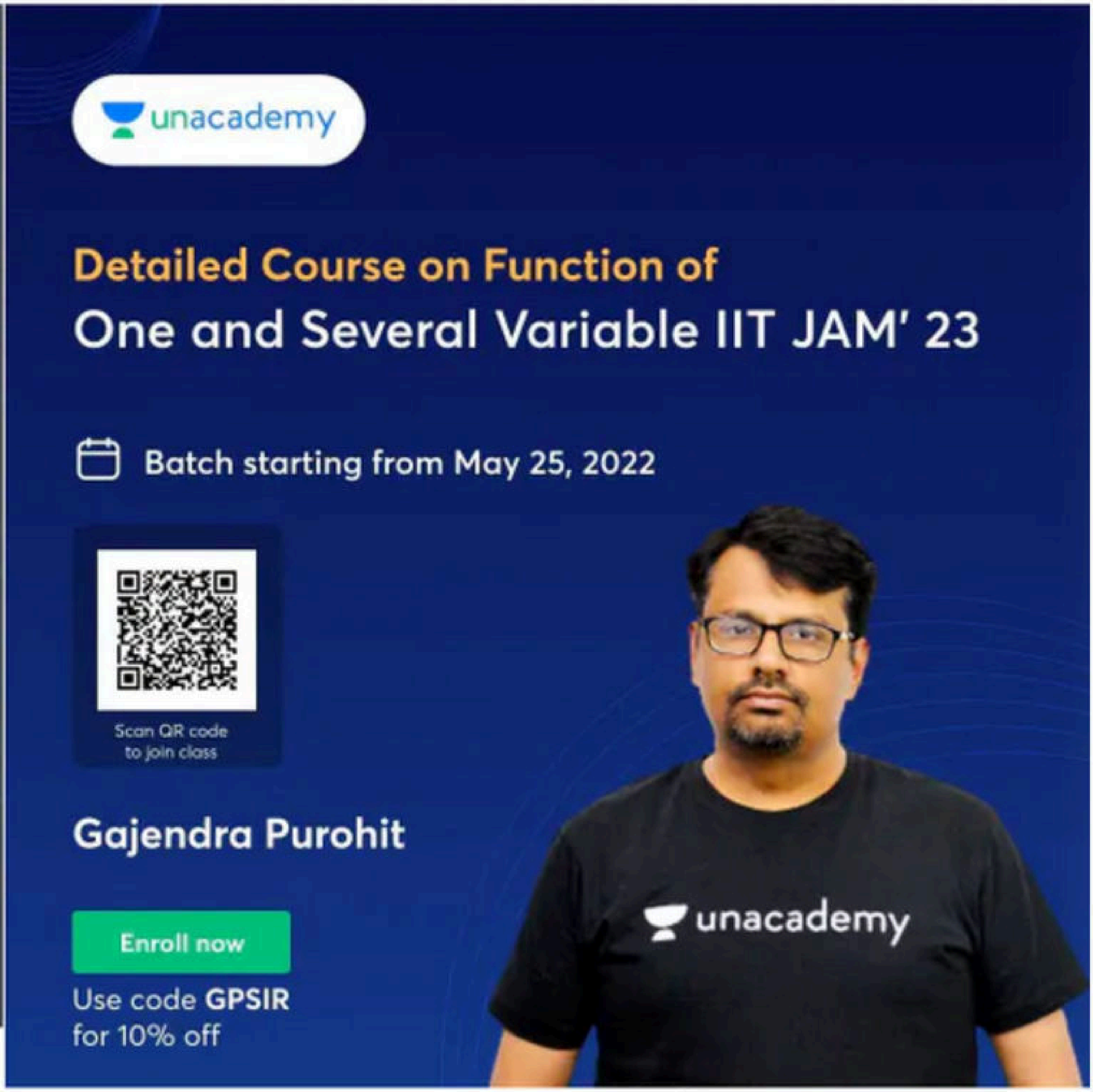
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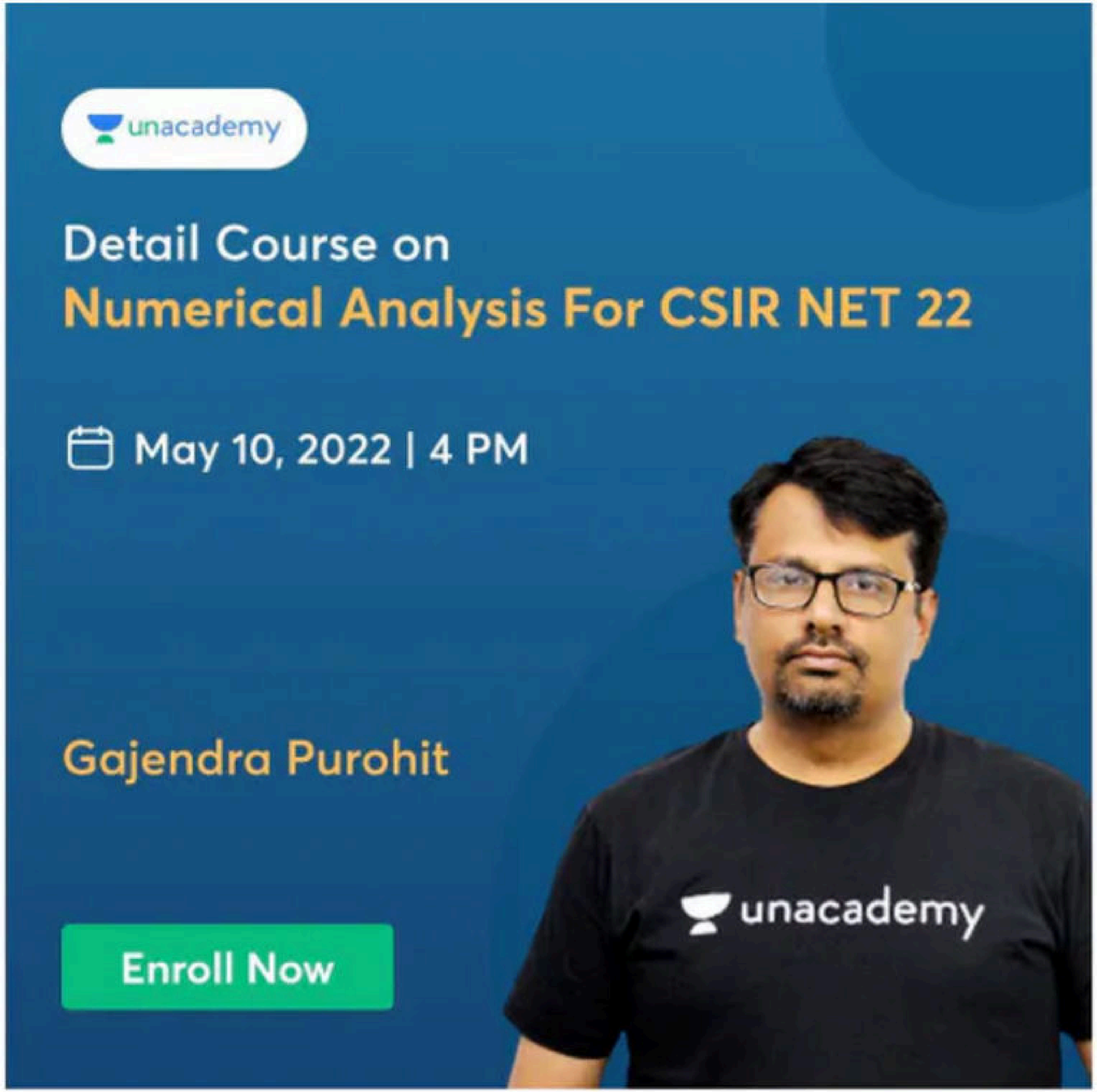
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You get 6 months extra for free — Offer expires 15 Jun 2022

12 months — SAVE 54% — ₹1,248 /mo — Total ₹14,974

You get 6 months extra for free — Offer expires 15 Jun 2022

9 months — SAVE 45% — ₹1,497 /mo — Total ₹13,475

6 months — SAVE 25% — ₹2,042 /mo — Total ₹12,252

3 months — SAVE 17% — ₹2,269 /mo — Total ₹6,807

1 month — ₹2,723 /mo — Total ₹2,723

To be paid as a one-time payment

Have a referral code? — Proceed to pay

After Using Referral Code

No cost EMI available on 6 months & above subscription plans

24 months — SAVE 67% — ₹817 /mo — ~~₹21,780~~ ₹19,602

You get 6 months extra for free — Offer expires 15 Jun 2022

12 months — SAVE 54% — ₹1,123 /mo — ~~₹14,974~~ ₹13,477

You get 6 months extra for free — Offer expires 15 Jun 2022

9 months — SAVE 45% — ₹1,348 /mo — ~~₹13,475~~ ₹12,128

6 months — SAVE 25% — ₹1,838 /mo — ~~₹12,252~~ ₹11,027

3 months — SAVE 17% — ₹2,042 /mo — ~~₹6,807~~ ₹6,126

1 month — ₹2,451 /mo

GPSIR — Proceed to pay

Awesome! You got 10% off