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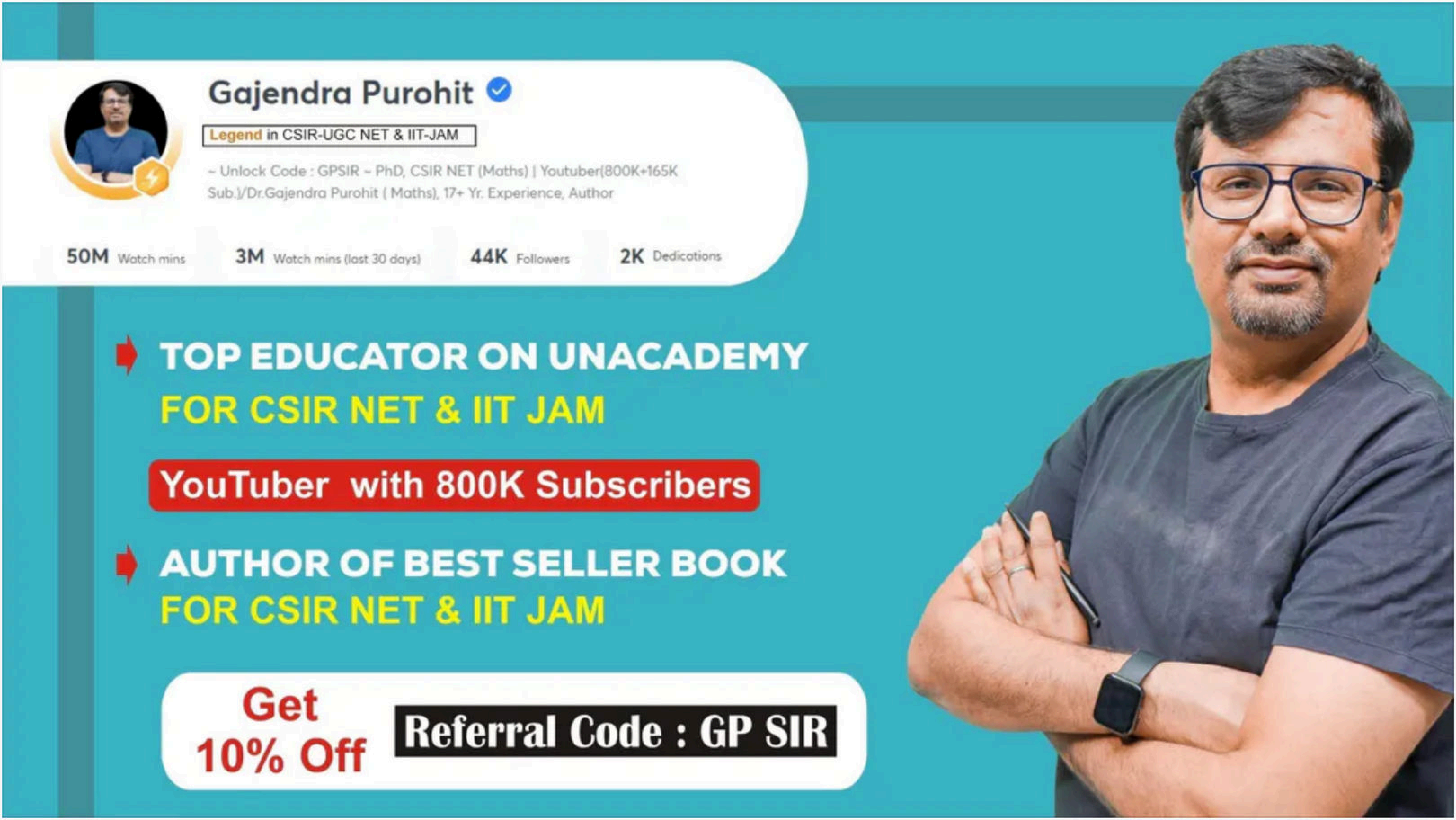
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Case 7: When Q is any other function of x (General Method)

Resolve $f(D)$ into linear factors. Let $f(D)=(D-m_1)(D-m_2)\ldots(D-m_n)$

Then for P.I. use

$$\frac{Q}{D-\alpha}=e^{\alpha x}\int e^{-\alpha x}Q\,dx \quad \& \quad \frac{Q}{D+\alpha}=e^{-\alpha x}\int e^{\alpha x}Q\,dx$$

$$(D+\alpha)y = \varphi \quad \Big| \quad y = \frac{\varphi}{D+\alpha}$$

$$\frac{dy}{dx} + \alpha y = \varphi$$

$$If = e^{\int \alpha\, dx} = e^{\alpha x}$$

$$y \cdot If = \int If\, \varphi\, dx$$

$$y e^{\alpha x} = \int e^{\alpha x} \varphi\, dx$$

$$y = e^{-\alpha x} \int e^{\alpha x} \varphi\, dx$$

$$(D-\alpha)y = \varphi \quad \Big| \quad y = \frac{\varphi}{D-\alpha}$$

$$y = e^{\alpha x} \int e^{-\alpha x} \varphi\, dx$$

$$\frac{dy}{dx} - \alpha y = \varphi$$

$$If = e^{-\alpha x}$$

$$y \cdot If = \int If\, \varphi\, dx$$

$$y e^{-\alpha x} = \int e^{-\alpha x} \varphi\, dx$$

$$y = e^{\alpha x} \int e^{-\alpha x} \varphi\, dx$$

$$(D^2+1)y = \operatorname{cosec} x$$

$$\frac{1}{(D+i)(D-i)} = \frac{A}{D-i} + \frac{B}{D+i} = \frac{1}{2i(D-i)} - \frac{1}{2i}\frac{1}{(D+i)}$$

$$(D+\alpha)y = \phi \qquad y = \frac{\phi}{D+\alpha}$$

$$y = \frac{\operatorname{cosec} x}{D^2+1} = \frac{\operatorname{cosec} x}{(D+i)(D-i)}$$

$$y = \frac{1}{2i}\left[\boxed{\frac{\operatorname{cosec} x}{D-i}} - \frac{\operatorname{cosec} x}{D+i}\right]$$

$$\frac{\operatorname{cosec} x}{D-i} = e^{ix}\int e^{-ix}\operatorname{cosec} x\,dx$$

$$= e^{ix}\int(\cos x - i\sin x)\operatorname{cosec} x\,dx$$

$$= e^{ix}\int\left(\frac{\cos x}{\sin x} - i\right)dx = e^{ix}\int(\cot x - i)\,dx$$

$$= e^{ix}(\log\sin x - ix)$$

$$\frac{\operatorname{cosec} x}{D+i} = e^{-ix}[\log\sin x + ix]$$

$$y = \frac{1}{2i}\left[e^{ix}(\log\sin x - ix) - e^{-ix}(\log\sin x + ix)\right]$$

$$y = \left(\left(\frac{e^{ix}-e^{-ix}}{2i}\right)\log\sin x - \cancel{i}x\left[\frac{e^{ix}+e^{-ix}}{2\cancel{i}}\right]\right)$$

$$y = (\sin x\log\sin x - x\cos x)$$

$$\frac{d^2y}{dx^2} + \alpha^2 y = \tan\alpha x$$

$$(D^2+\alpha^2)y = \tan\alpha x$$

$$y = \frac{\tan\alpha x}{D^2+\alpha^2} = \frac{\tan\alpha x}{(D+i\alpha)(D-i\alpha)}$$

$$y = \frac{1}{2i\alpha}\left(\frac{\tan\alpha x}{D-i\alpha} - \frac{\tan\alpha x}{D+\alpha i}\right)$$

$$\frac{1}{(D-\alpha i)(D+i\alpha)} = \frac{A}{D-i\alpha} + \frac{B}{D+i\alpha}$$

$$= \frac{1}{2i\alpha}\frac{1}{D-i\alpha} - \frac{1}{2i\alpha}\frac{1}{D+i\alpha}$$

$$\frac{\tan\alpha x}{D-i\alpha} = e^{i\alpha x}\int e^{-i\alpha x}\tan\alpha x\,dx$$

$$= e^{i\alpha x}\int(\cos\alpha x - i\sin\alpha x)\tan\alpha x\,dx$$

$$= e^{i\alpha x}\int\left(\sin\alpha x - i\frac{\sin^2\alpha x}{\cos\alpha x}\right)dx$$

$$= e^{i\alpha x}\left(-\frac{\cos\alpha x}{\alpha} - i\int\left(\frac{1-\cos^2\alpha x}{\cos\alpha x}\right)dx\right)$$

$$= -e^{i\alpha x}\left(\frac{\cos\alpha x}{\alpha} + i\int\sec\alpha x\,dx - i\int\cos\alpha x\,dx\right)$$

$$= -e^{i\alpha x}\left(\frac{\cos\alpha x}{\alpha} + i\frac{\log}{\alpha}(\sec\alpha x+\tan\alpha x) - i\frac{\sin\alpha x}{\alpha}\right)$$

$$\frac{\tan\alpha x}{D+i\alpha} =$$

$$\frac{1}{D-\alpha}\varphi = e^{\alpha x}\int e^{-\alpha x}\varphi\, dx$$

$$e^{ix} = \cos x + i \sin x$$

$$e^{-ix} = \cos x - i \sin x$$

$$\cos x = \frac{e^{ix} + e^{-ix}}{2}$$

$$\sin x = \frac{e^{ix} - e^{-ix}}{2i}$$

Note: We can find particular integral by this following method

$$f(D) = Q \Rightarrow (D - m_1)(D - m_2)y = Q \quad ...(1)$$

Step – 1 : Put $(D - m_2)y = u \quad ...(2)$

then (1) becomes $(D - m_1)u = Q$

find value of u by FOFD linear DE

Step – 2 : Put value of u in (2)

then we get value of y

which is particular integral

Q1. A particular integral of the differential equation $y''+3y'+2y=e^{e^x}$ is

$e^x = t$

$e^x dx = dt$

(a) $e^{e^x}e^{-x}$ (b) $e^{e^x}e^{-2x}$

(c) $e^{e^x}e^{2x}$ (d) $e^{e^x}e^{x}$

$(D^2+3D+2)y = e^{e^x}$

$(D+1)(D+2)y = e^{e^x}$

$(D+2)y = \frac{e^{e^x}}{D+1} = e^{-x}\int e^x e^{e^x}\,dx$

$(D+2)y = e^{-x}\int e^t\,dt = e^{-x}e^{e^x}$

$y = \frac{e^{-x}e^{e^x}}{D+2} = e^{-2x}\int e^{2x-x}e^{e^x} = e^{-2x}\int e^x e^{e^x}\,dx$

$= e^{-2x}e^{e^x}$

$(D^2-2D+1)y = e^x \log x$

(a) $x^2 e^x \left[\log x + 3/2\right]$

(b) $\frac{x^2 e^x}{2}\left(\log x + 3/2\right)$

(c) $x^2 e^x \left[\log x - 3/2\right)$

(d) $\frac{x^2 e^x}{2}\left(\log x - 3/2\right)$

$$y = e^x\left(\frac{x^2}{2}\log x - \frac{x^2}{4} - \frac{x^2}{2}\right)$$

$$y = e^x\left(\frac{x^2}{2}\log x - \frac{3}{4}x^2\right)$$

$$= e^x \frac{x^2}{2}\left(\log x - 3/2\right)$$

$(D-1)^2 y = e^x \log x$

$(D-1)y = \frac{e^x \log x}{D-1}$

$(D-1)y = e^x \int \cancel{e^{-x}}\left(\cancel{e^x}\log x\right)dx$

$= e^x\left(x\log x - x\right)$

$$y = \frac{e^x\left(x\log x - x\right)}{D-1}$$

$$y = e^x \int \cancel{e^{-x}}\cdot\cancel{e^x}\left(x\log x - x\right)dx$$

$$= e^x\left(\int x\log x\,dx - \int x\,dx\right)$$

Q2. Solve $(D^2-3D+2)y=\sin(e^{-x})$

(a) $y=c_1e^x+c_2e^{2x}-e^x\sin(e^{-x})$

(b) $y=c_1e^x+c_2e^{2x}-e^{-2x}\sin(e^{-x})$

(c) $y=c_1e^x+c_2e^{2x}+e^{-2x}\sec(e^{-x})$

(d) $y=c_1e^x+c_2e^{2x}-e^{-2x}\sin(e^{2x})$

$e^{-x}=t$

$-e^{-x}dx=dt$

$(D-1)(D-2)y=\sin e^{-x}$

$(D-2)y=\dfrac{\sin e^{-x}}{D-1}$

$(D-2)y=e^{x}\int e^{-x}\sin e^{-x}dx$

$(D-2)y=-e^{x}\int \sin t\,dt$

$(D-2)y=e^{x}\cos(e^{-x})$

$y=\dfrac{e^{x}\cos(e^{-x})}{D-2}=e^{2x}\int e^{-2x}e^{x}\cos(e^{-x})dx$

$=e^{2x}\int e^{-x}\cos(e^{-x})dx$

$=-e^{2x}\int\cos t\,dt$

$=\underline{-e^{2x}\sin(e^{-x})}$

Q3. The solution of differential equation $\frac{d^2y}{dx^2} - y = e^x$ satisfying $y(0) = 0$ & $\frac{dy}{dx}(0) = \frac{3}{2}$ is

(a) $y(x) = \sinh x + \frac{x}{2}e^x$ (b) $y(x) = x\cosh x + \frac{x}{2}e^x$

(c) $y(x) = \sinh x - \frac{x}{2}e^x$ (d) $y(x) = 2x\cosh x - \frac{x}{2}e^x$

$\frac{xe^x}{2D}$ $\frac{e^x}{D^2-1}$

$m^2-1=0$

$m=\pm 1$

$y = c_1\cosh x + c_2\sinh x + \frac{xe^x}{2}$

$0 = c_1$

$y = c_2\sinh x + \frac{xe^x}{2}$

$\frac{dy}{dx} = c_2\cosh x + \frac{e^x}{2} + \frac{xe^x}{2}$

$\frac{3}{2} = c_2 + \frac{1}{2}$ $c_2 = 1$

$y = \sinh x + \frac{xe^x}{2}$

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Q.4. A particular integral of $\frac{d^2y}{dx^2}-(a+b)\frac{dy}{dx}+aby=Q(x)$ is

(a) $e^{ax}\{\int e^{(a-b)x}\int Qe^{bx}dx\}dx$

(b) $e^{ax}\{\int e^{(b-a)x}\int Qe^{-bx}dx\}dx$

(c) $e^{-ax}\{\int e^{(b-a)x}\int Qe^{bx}dx\}dx$

(d) None of these

$(D-a)(D-b)y = Q(x)$

$(D-a)y = \frac{Q(x)}{D-b}$

$(D-a)y = e^{bx}\int e^{-bx}Q(x)dx$

$y = \frac{\boxed{e^{bx}\int e^{-bx}Q(x)dx}}{D-a}$

$y = e^{ax}\int e^{-ax}\left(e^{bx}\int e^{-bx}Q(x)dx\right)dx$

$y = e^{ax}\int\left(e^{(b-a)x}\int e^{-bx}Q(x)dx\right)dx$

Q.5. Consider the differential equation

$$y'' + ay' + y = \sin x \ \text{ for } x \in R \qquad (**).$$

Then which one of the following is true ?**IIT JAM 2022**

(a) If $a = 0$, then all the solutions of (**) are unbounded over R.

(b) If $a = 1$, then all the solutions of (**) are unbounded over $(0, \infty)$.

(c) If $a = 1$, then all the solutions of (**) tend to zero as $x \to \infty$

(d) If $a = 2$, then all the solutions of (**) are bounded over $(-\infty, 0)$

Q.6. The real valued function $y(x)$ defined on R is said to be periodic if there exists a real number $T > 0$ such that $y(x+T) = y(x)$ for all $x \in R$. Consider the differential equation $\frac{d^2y}{dx^2} + 4y = \sin ax,\ x \in (R,)$ (*)**IIT JAM 2022**

where $a \in R$ is a constant. Then Which of the following is are true ?

(a) All solutions of (*) are periodic for every choice of a.

(b) All solutions of (*) are periodic for every choice of $a \in R - \{-2, 2\}$

(c) All solutions of (*) are periodic for every choice of $a \in Q - \{-2, 2\}$

(d) $a \in R - Q$ Then there is a unique periodic solution of (*)

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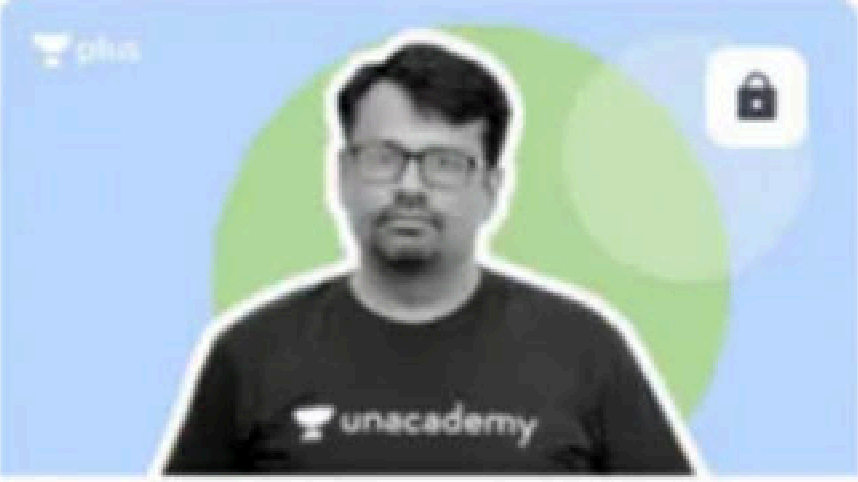

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- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
- PhD, NET | Plus Educator For CSIR NET | Youtuber (260K+Subs.) | Director Pacific Science College |
- Lives in **Udaipur, Rajasthan, India**
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