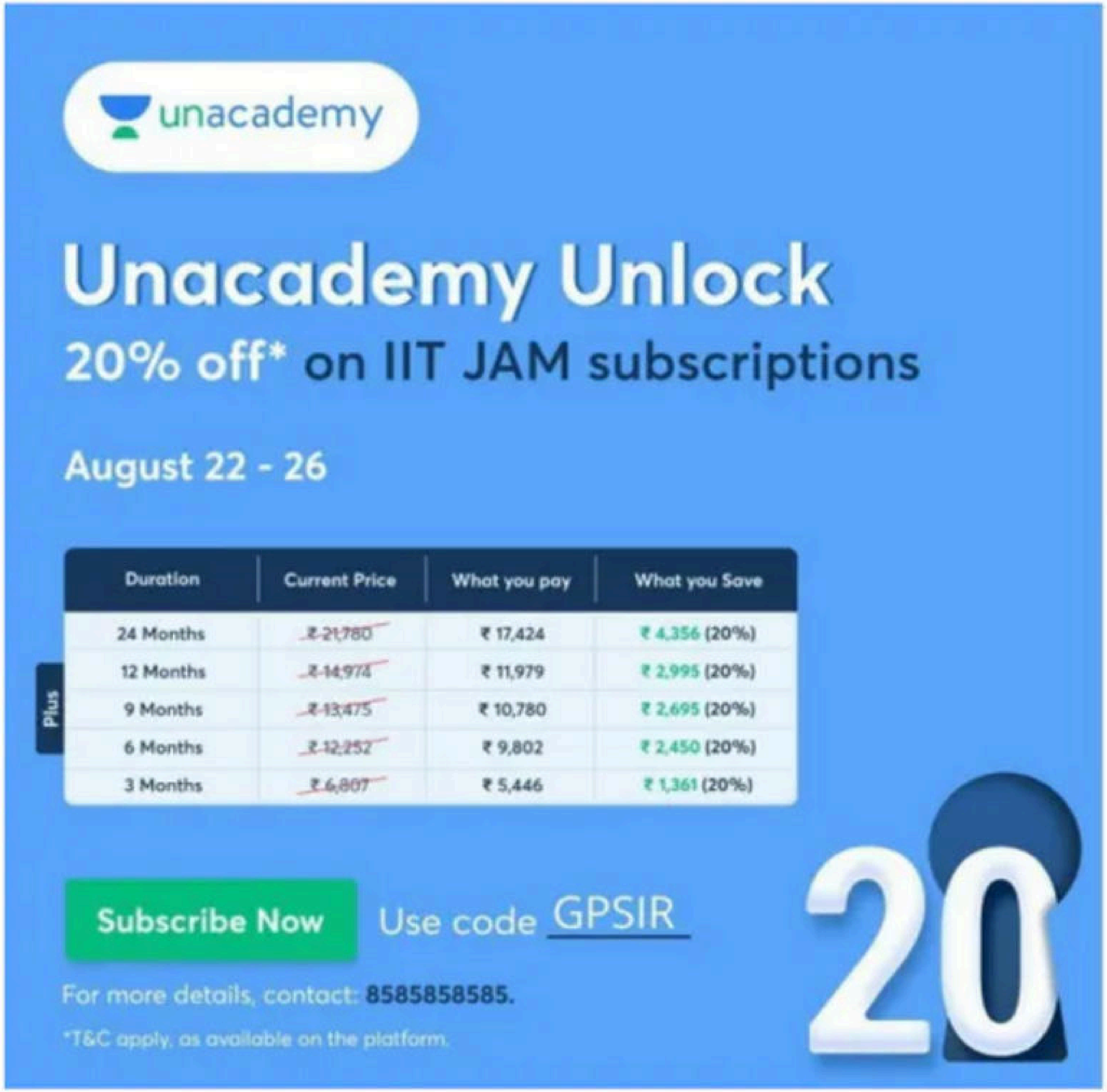
Variation of Parameter Method

Detailed Course on Differential Equation for IIT JAM' 23 - II

Gajendra Purohit • Lesson 15 • Aug 25, 2022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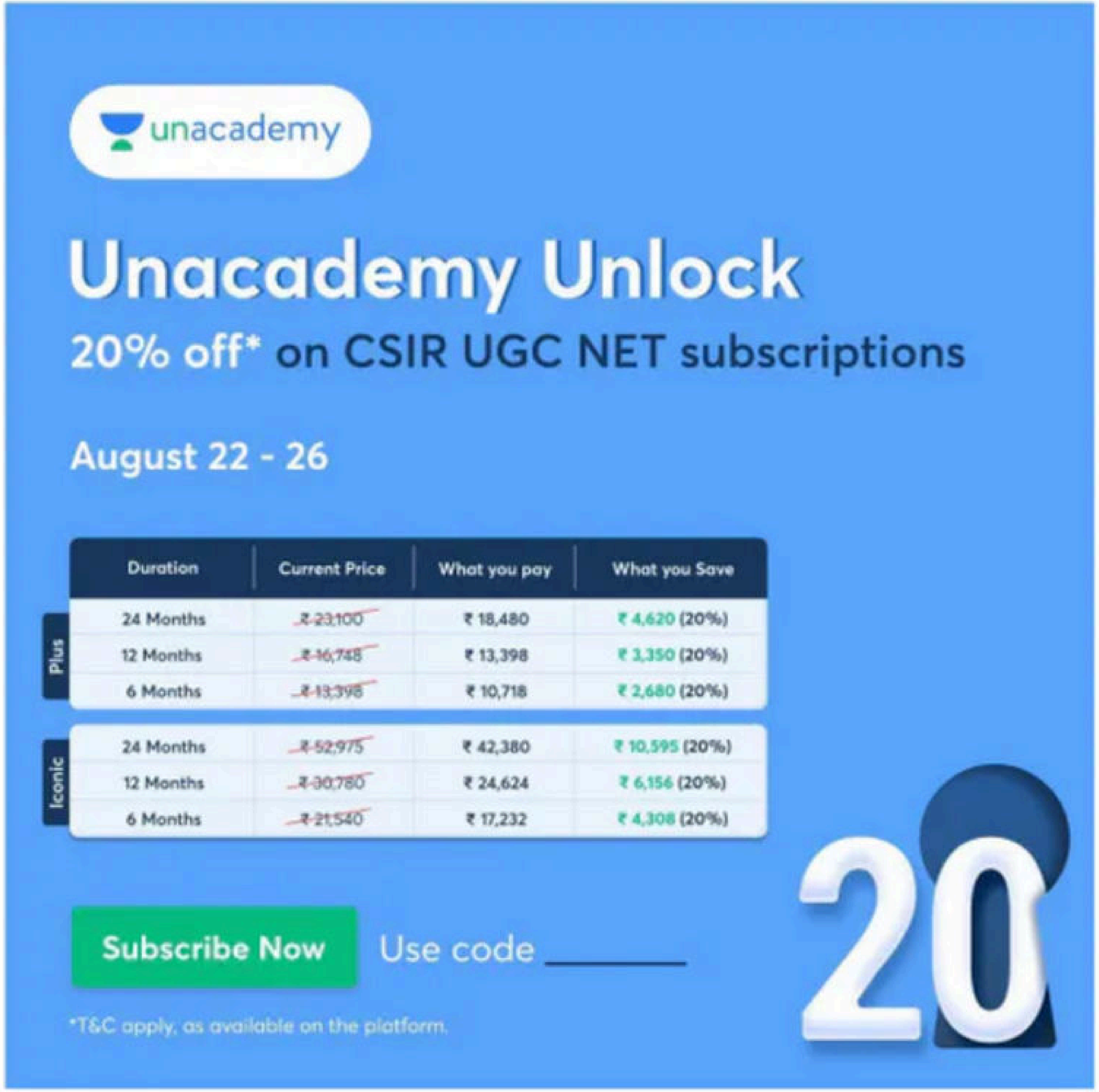
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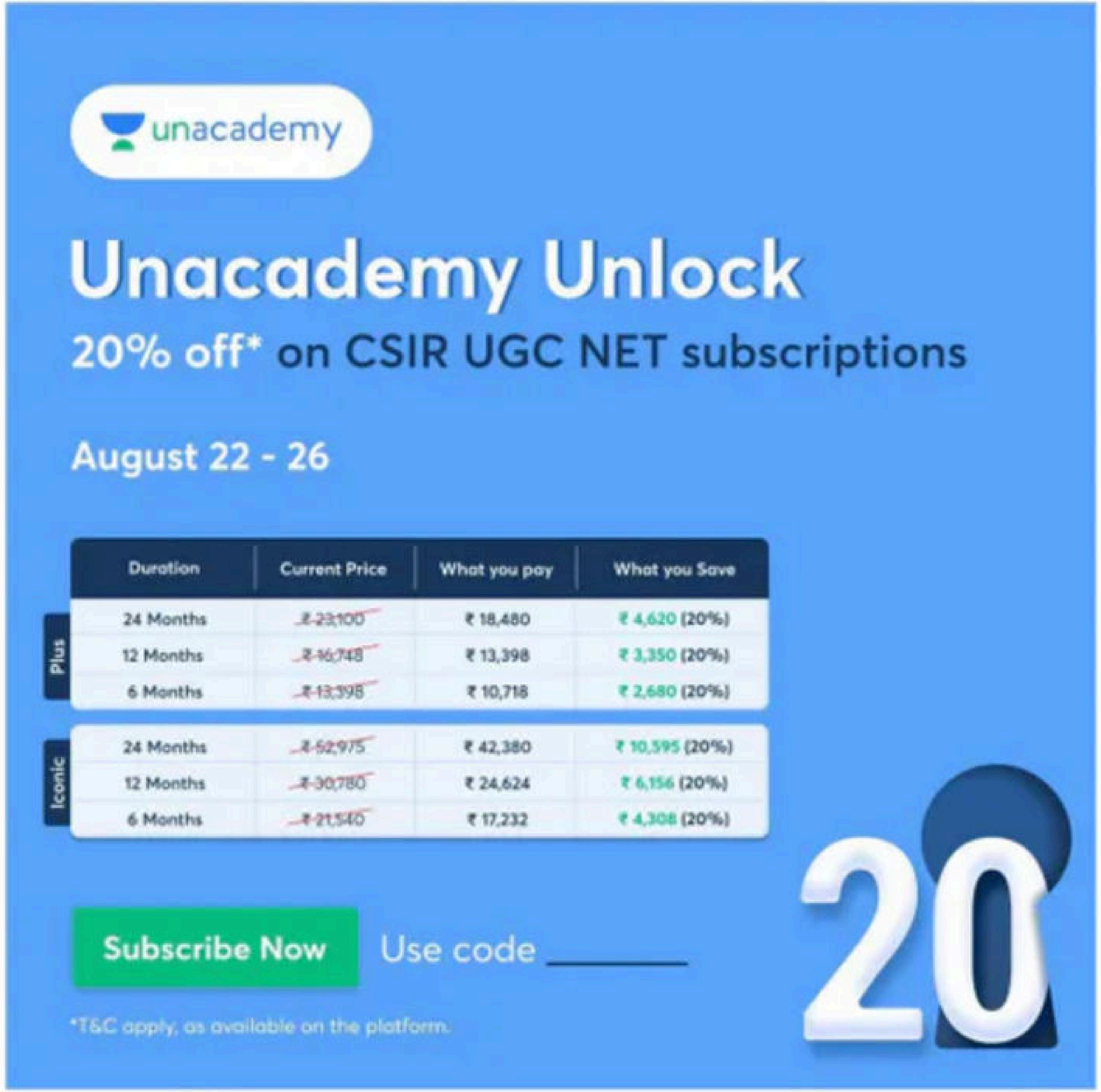
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Homogeneous Differential Equation

Cauchy's Homogeneous Differential Linear Equations

A linear differential equation of the form

$$x^n \frac{d^n y}{dx^n} + a_1 x^{n-1} \frac{dy^{n-1}}{dx^{n-1}} + \ldots\ldots\ldots\ldots + a_{n-1} x\left(\frac{dy}{dx}\right) + a_n y = Q$$

Or $\quad \left(x^n D^n + a_1 x^{n-1} D^{n-1} + \ldots.. + a_{n-1} xD + a_n\right) y = Q$

Where $a_1, a_2, \ldots.., a_{n-1}, a_n$ are constants, and Q is either a constant or function of x only is called homogeneous linear differential equation.

Put $x = e^z \Rightarrow z = \log x$, Let $D_1 = \frac{d}{dz}$ Then we have,

$$x\frac{dy}{dx} = D_1 y, x^2 \frac{d^2 y}{dx^2} = D_1(D_1 - 1)y, x^3 \frac{d^3 y}{dx^3} = D_1(D_1 - 1)(D_1 - 2)y$$

$$\ldots x^n \frac{d^n y}{dx^n} = D_1(D_1 - 1)(D_1 - 2)\ldots(D_1 - n + 1)y$$

Substituting the values of $x\frac{dy}{dx}, x^2\frac{d^2y}{dx^2}$... in above equation and changing independent variable from x to z. So

$$\left[D_1(D_1-1)(D_1-2).....(D_1-n+1)+......+a_{n-2}D_1(D_1-1)+a_{n-1}D_1+a_n\right]y = f(z)$$

Which is of the form linear differential equation with constant coefficients, and hence solve using the methods defined earlier, then replacing z with log x, we got the required solution.

Q1. Consider the differential equation $x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} - 4y = 0$ with the boundary condition of $y(0) = 0$ and $y(1) = 1$. The complete solution of differential equation is

(a) x^2

(b) $\sin\left(\frac{\pi x}{2}\right)$

(c) $e^x \sin\left(\frac{\pi x}{2}\right)$

(d) $e^{-x} \sin\left(\frac{\pi x}{2}\right)$

Q2. The general solution of $x^2\frac{d^2y}{dx^2}-5x\frac{dy}{dx}+9y=0$ is

(a) $(c_1 + c_2x)e^{3x}$

(b) $(c_1 + c_2 \ln x)x^3$

(c) $(c_1 + c_2x)x^3$

(d) $(c_1 + c_2 \ln x)\ e^{x^3}$

Q3 The general solution of differential equation $4x^2y'' - 8xy' + 9y = 0$ is

(a) $c_1e^{5x/2} + c_2e^{-3x/2}$ (b) $c_1e^{3x/2} + c_2e^{-3x/2}$

(c) $(c_1 + c_2 \log x)x^{3/2}$ (d) $c_1x^{3/2} + c_2x^{-3/2}$

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Q4. If $\frac{(c_1 + c_2 \ln x)}{x}$ is the general solution of the differential equation $x^2 \frac{d^2 y}{dx^2} + kx \frac{dy}{dx} + y = 0$, x > 0 the k equals

(a) 3

(b) -3

(c) 2

(d) -1

Q5. A solution of the differential equation

$2x^2\frac{d^2y}{dx^2}+3x\frac{dy}{dx}-y=0, x>0$ that passes through the point $(1,1)$ is

(a) $y=\frac{1}{x}$

(b) $y=\frac{1}{x^2}$

(c) $y=\frac{1}{\sqrt{x}}$

(d) $y=\frac{1}{x^{3/2}}$

Q6. Let $y(x); x>0$ be the solution of differential equation $x^2\frac{d^2y}{dx^2}+5x\frac{dy}{dx}+4y=0$ satisfying the conditions $y(1)=1$ & $y'(1)=0$ Then the value of $e^2y(e)$ is

(a) 3 (b) 1

(c) 2 (d) -1

Q7. Let y(x) be the solution of $x^2y''(x)-2y(x)=0;\ y(1)=1, y(2)=1$

Then the value of y(3) is

(a) $\frac{11}{21}$ (b) 1

(c) $\frac{17}{21}$ (d) $\frac{11}{7}$

Q8 A particular solution of $x^2\frac{d^2y}{dx^2}+2x\frac{dy}{dx}+\frac{y}{4}=\frac{1}{\sqrt{x}}$ is

(a) $\frac{1}{2\sqrt{x}}$ (b) $\frac{\log x}{2\sqrt{x}}$

(c) $\frac{(\log x)^2}{2\sqrt{x}}$ (d) $\frac{(\log x)\sqrt{x}}{2}$

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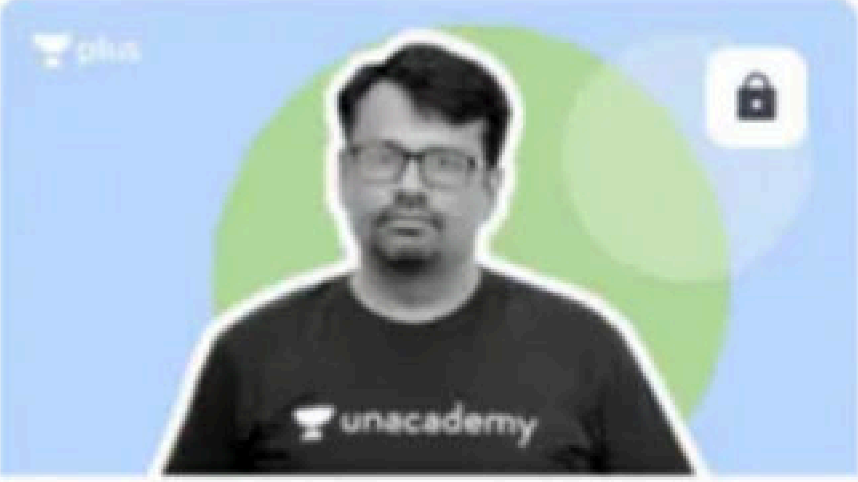

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- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
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- Lives in **Udaipur, Rajasthan, India**
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