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GATE CHEMICAL ENGINEERING

Assignment of Differential Equations

Ankur Bansal

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Q1. $y = e^{-2x}$ is a solution of the differential equation $y'' + y' - 2y = 0$

(a) True

(b) False

Q2. A differential equation of the form $\frac{dy}{dx} = f(x, y)$ is homogeneous if the function $f(x, y)$ depends only on the ratio $\frac{y}{x}$ (or) $\frac{x}{y}$

(a) True

(b) False

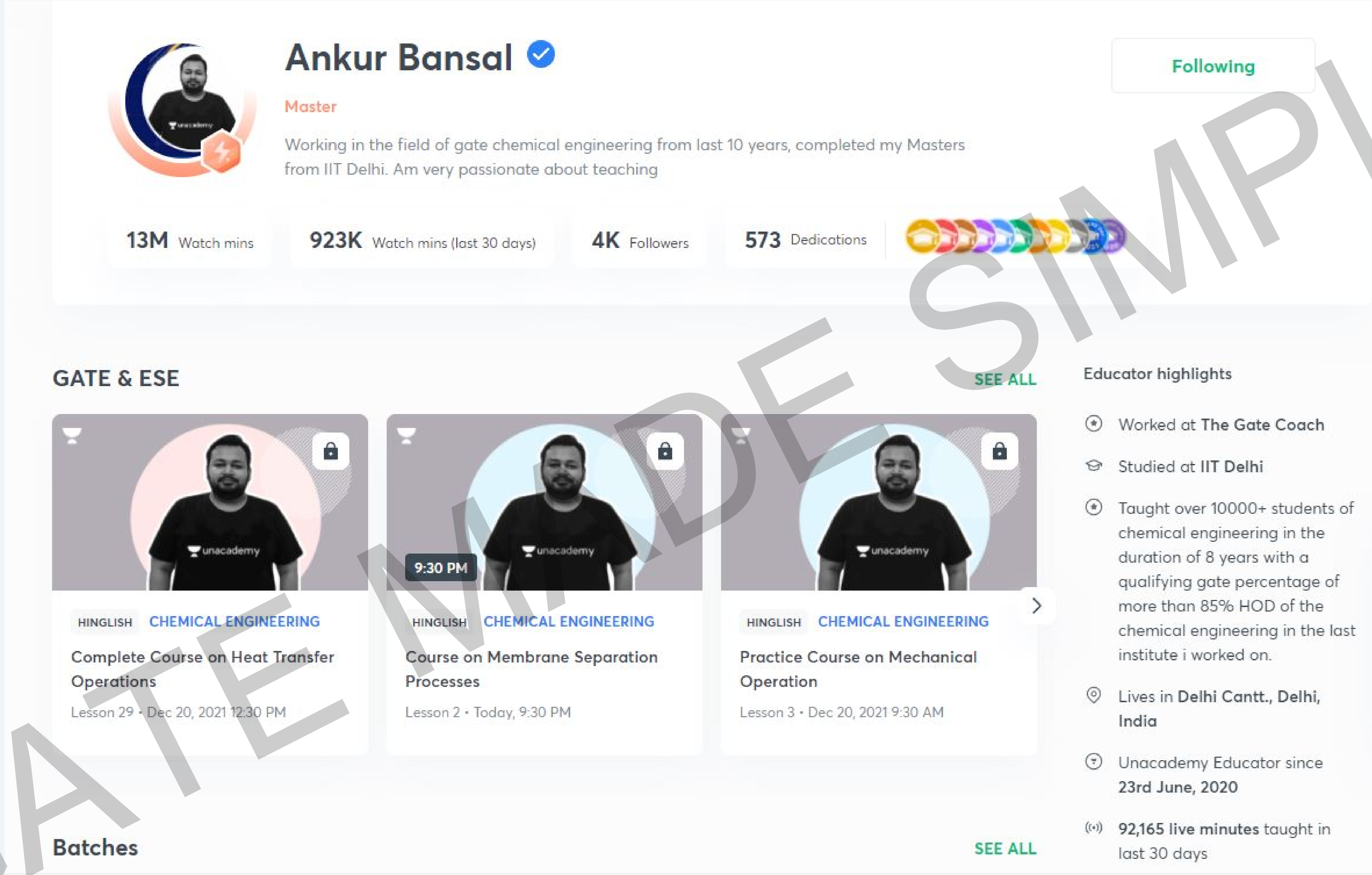
Q3. For the differential equation $f(x,y)\frac{dy}{dx} + g(x,y) = 0$ to be exact is

(a) $\frac{\partial f}{\partial y} = \frac{\partial g}{\partial x}$

(b) $\frac{\partial f}{\partial x} = \frac{\partial g}{\partial y}$

(c) $f = g$

(d) $\frac{\partial^2 f}{\partial x^2} = \frac{\partial^2 g}{\partial y^2}$



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Q4.The radial displacement in a rotating disc is governed by the differential equation $\frac{d^2u}{dx^2}+\frac{1}{x}\frac{du}{dx}-\frac{u}{x^2}=8x$ where u is the displacement and x is the radius if $u=0$ at $x=0$ and $\mathrm{u}=2$ at $\mathrm{x}=1$, calculate the displacement at $\mathrm{x}=1/2$

$$y=Ax+Bx\log x$$

Q5. The equation $\frac{d^2y}{dx^2} + (x^2 + 4x)\frac{dy}{dx} + y = x^8 - 8$ is a

(a) Partial differential equation

(b) Non linear differential equation

(c) Non homogeneous differential equation

(d) Ordinary differential equation

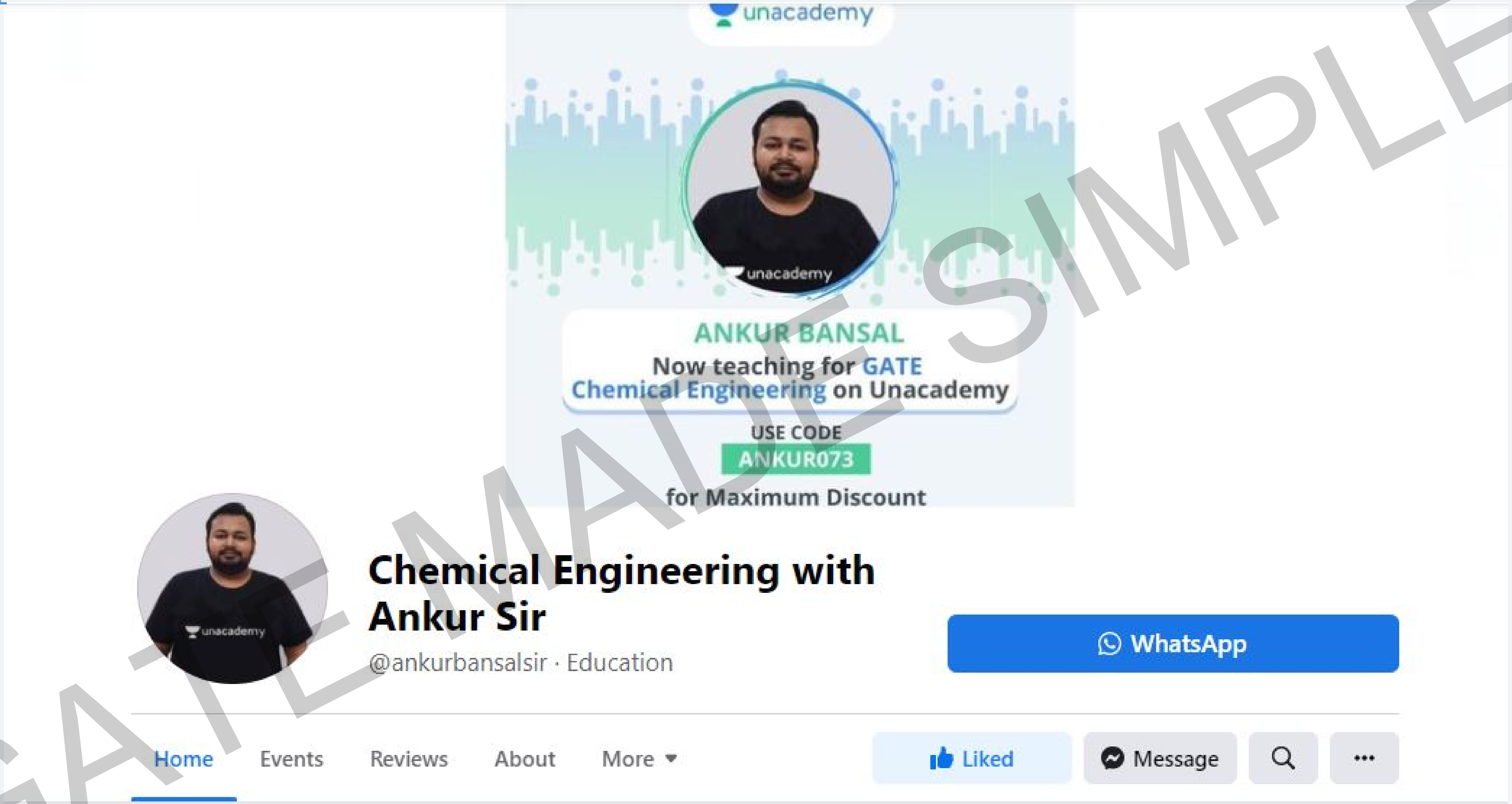
Q6. For the equation $\ddot{x}(t)x + 3\dot{x}(t) + 2x(t) = 5$, the solution $x(t)$ approaches the following values as $t \to \infty$

(a) 0

(b) 5/2

(c) 5

(d) 10



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Q7. Transformation to linear form by substituting $v = y^{1-n}$ of the equation $\frac{dy}{dt} + p(t)y = q(t)y^n, n > 0$ will be

(a) $\frac{\mathrm{dv}}{\mathrm{dt}} + (1 - \mathrm{n})\mathrm{pv} = (1 - \mathrm{n})\mathrm{q}$

(b) $\frac{\mathrm{dv}}{\mathrm{dt}} + (1 + \mathrm{n})\mathrm{pv} = (1 + \mathrm{n})\mathrm{q}$

(c) $\frac{\mathrm{dv}}{\mathrm{dt}} + (1 + \mathrm{n})\mathrm{pv} = (1 - \mathrm{n})\mathrm{q}$

(d) $\frac{\mathrm{dv}}{\mathrm{dt}} + (1 + \mathrm{n})\mathrm{pv} = (1 + \mathrm{n})\mathrm{q}$

Q8. If $x^2\left(\frac{dy}{dx}\right)+2xy=\frac{2\ln x}{x}$ and $y(1)=0$ then what is $y(e)$?

(a) e

(b) 1

(c) $\frac{1}{e}$

(d) $\frac{1}{e^2}$

Q9. The complete solution of the ordinary differential equation $\frac{d^2y}{dx^2} + p\frac{dy}{dx} + qy = 0$ is $y = C_1e^{-x} + C_2e^{-3x}$ then P and q are

(a) $p = 3, q = 3$
(b) $P = 3, q = 4$
(c) $p = 4, q = 3$
(d) $P = 4, q = 4$

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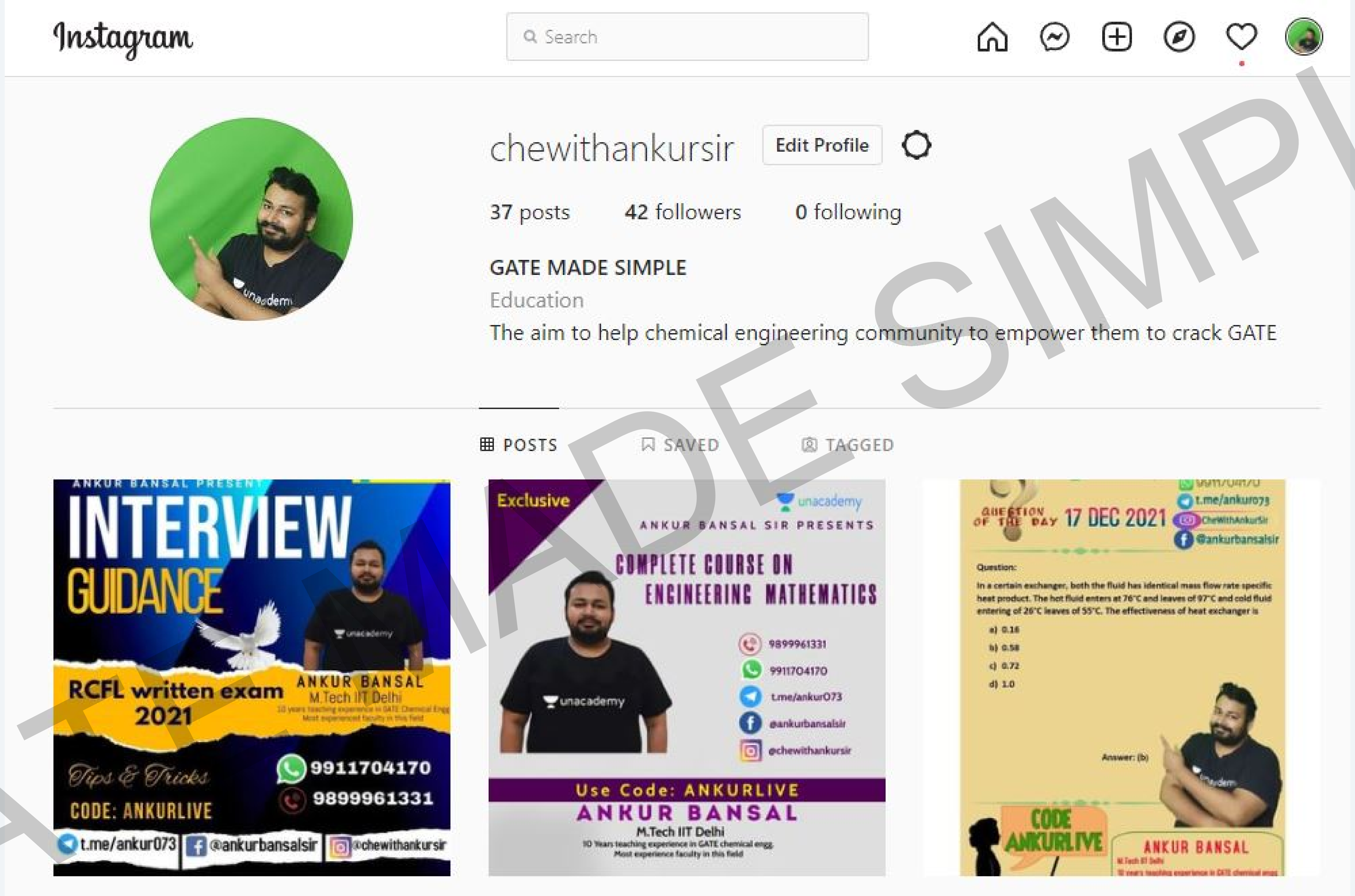

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Q10. For the differential equation $\frac{d^2y}{dx^2} + k^2y = 0$, the boundary conditions are

(i) $y = 0$ for $x = 0$ and

(ii) $y = 0$ for $x = a$

The form of non-zero solution of y (where m varies over all integers) are

(a) $y = \sum_m A_m \sin\left(\frac{m\pi x}{a}\right)$

(b) $y = \sum_m A_m \cos\left(\frac{m\pi x}{a}\right)$

(c) $y = \sum_m A_m x^{\frac{mx}{3}}$

(d) $y = \sum_m A_m e^{-\frac{m\pi x}{a}}$

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Q11. The solution of the differential equation $k^2 \frac{d^2y}{dx^2} = y - y_2$ under the boundary conditions
(i) $y = y_1$ at $x = 0$ and (ii) $y = y_2$ at $x = \infty$ where k, y_1 and y_2 are constant is

(a) $y = (y_1 - y_2)e^{-x/k^2} + y_2$

(b) $y = (y_2 - y_1)e^{\frac{-x}{k}} + y_1$

(c) $y = (y_1 - y_2)\sinh\left(\frac{x}{k}\right) + y_1$

(d) $y = (y_1 - y_2)e^{-x/x} + y_2$

Q12. Which one of the following differential equations has a solution given by the function

$y = 5\sin\left(3x + \frac{\pi}{3}\right)$(a) $\frac{dy}{dx} - \frac{5}{3}\cos(3x) = 0$

(b) $\frac{dy}{dx} + \frac{5}{3}(\cos 3x) = 0$

(c) $\frac{d^2y}{dx^2} + 9y = 0$

(d) $\frac{d^2y}{dx^2} - 9y = 0$

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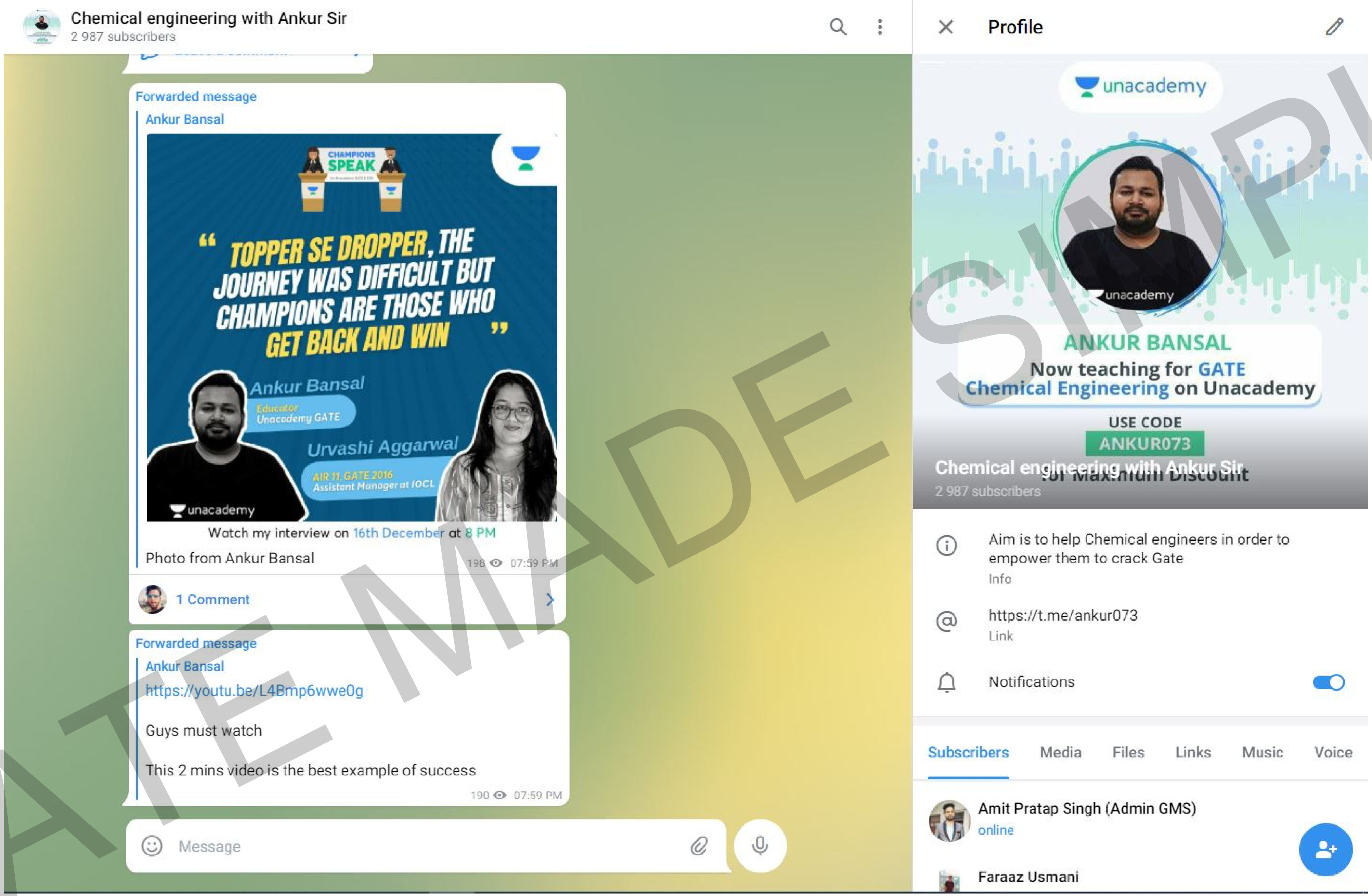

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Q13. A system described by a linear, constant coefficient, ordinary, first order differential equation has an exact solution given by $y(t)$ for $t > 0$, when the forcing function is $x(t)$ and the initial condition is $y(0)$. If one wishes to modify the system so that the solution becomes $-2y(t)$ for $t > 0$, we need to

(a) Change the initial condition to $-y(0)$ and the forcing function to $2 \times (t)$

(b) Change the initial condition to $2y(o)$ and the forcing function to $-x(t)$

(c) Change the initial condition to $j\sqrt{2}y(0)$ and the forcing function to $j\sqrt{2} \times (t)$

(d) Change the initial condition to $-2y(0)$ and the forcing function to $-2x(t)$

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Q14. The maximum value of the solution $y(t)$ of the differential equation $y(t) + \ddot{y}(t) = 0$ with initial conditions $\dot{y}(0) = 1$ and $y(0) = 1$, for $t \geq 0$ is

(a) 1

(b) 2

(c) π

(d) $\sqrt{2}$

Q15. The solution to the differential equation $\frac{d^2u}{dx^2} - k\frac{du}{dx} = 0$ where ' k ' is a constant, subjected to the boundary conditions $u(0) = 0$ and $u(L) = U$, is

(a) $u = u\frac{x}{L}$

(b) $u = u\left(\frac{1-e^{kx}}{1-e^{kL}}\right)$

(c) $u = u\left(\frac{1-e^{-kx}}{1-e^{-kL}}\right)$

(d) $u = u\left(\frac{1+e^{\mathrm{kx}}}{1+e^{\mathrm{kL}}}\right)$

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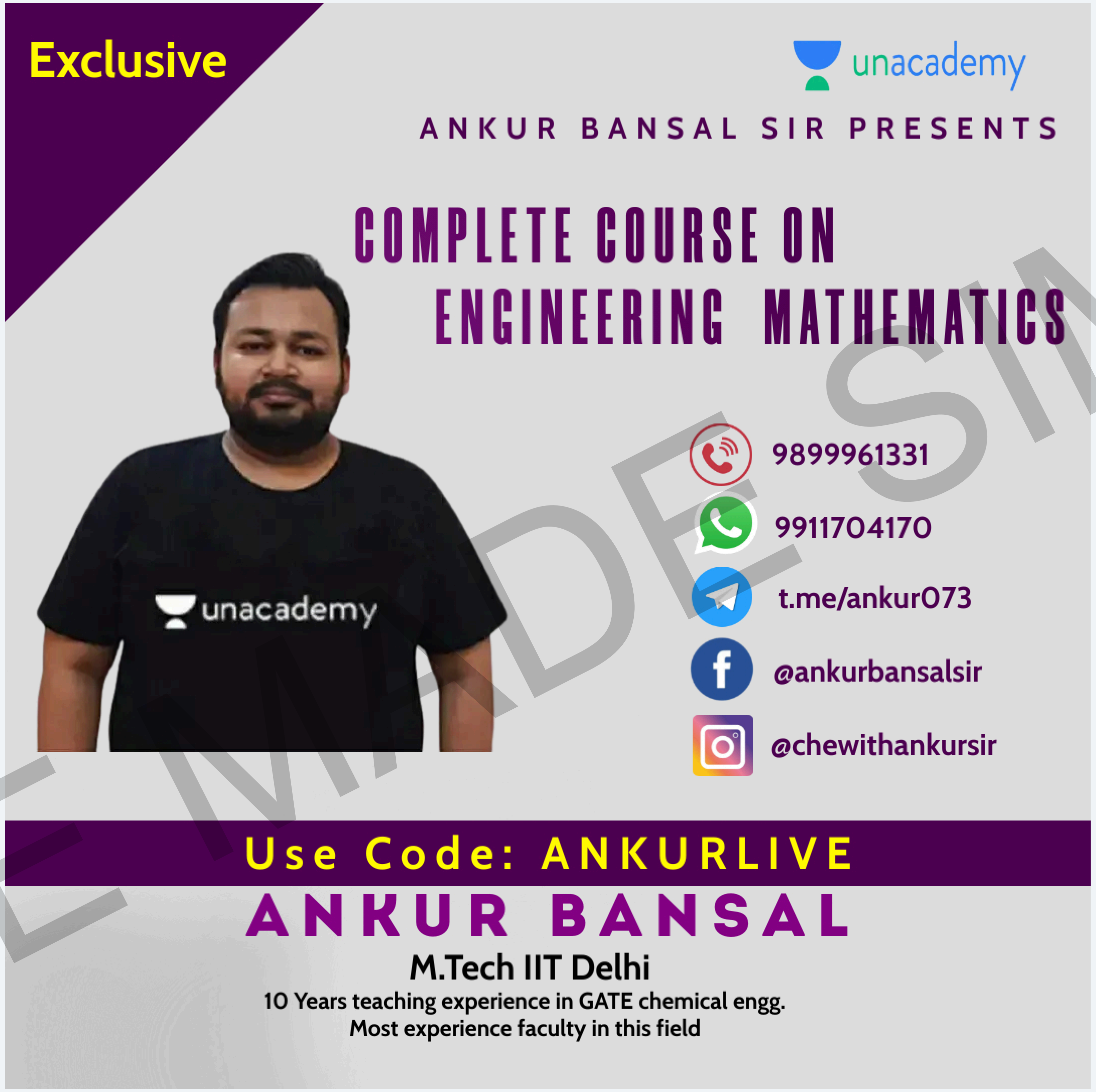

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Q16. If the characteristic equation of the differential equation $\frac{d^2y}{dx^2} + 2\alpha\frac{dy}{dx} + y = 0$ has two equal roots, then the values of α are

(a) ± 1

(b) 0,0

(c) $\pm$j

(d) $\pm 1/2$

Q17. Which ONE of the following is a linear non - homogeneous differential equations, where x and y are the independent and dependent variables respectively

(a) $\frac{dy}{dx} + xy = e^{-x}$

(b) $\frac{\mathrm{dy}}{\mathrm{dx}} + \mathrm{xy} = 0$

(c) $\frac{dy}{dx} + xy = e^{-y}$

(d) $\frac{dy}{dx} + e^{-y} = 0$

Q18. If a and b are constants, the most general solution of the differential equation $\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 0$ is

(a) ae^{-t}

(b) $ae^{-t} + bte^{-t}$

(c) $ae^{t} + bte^{-t}$

(d) ae^{-2t}

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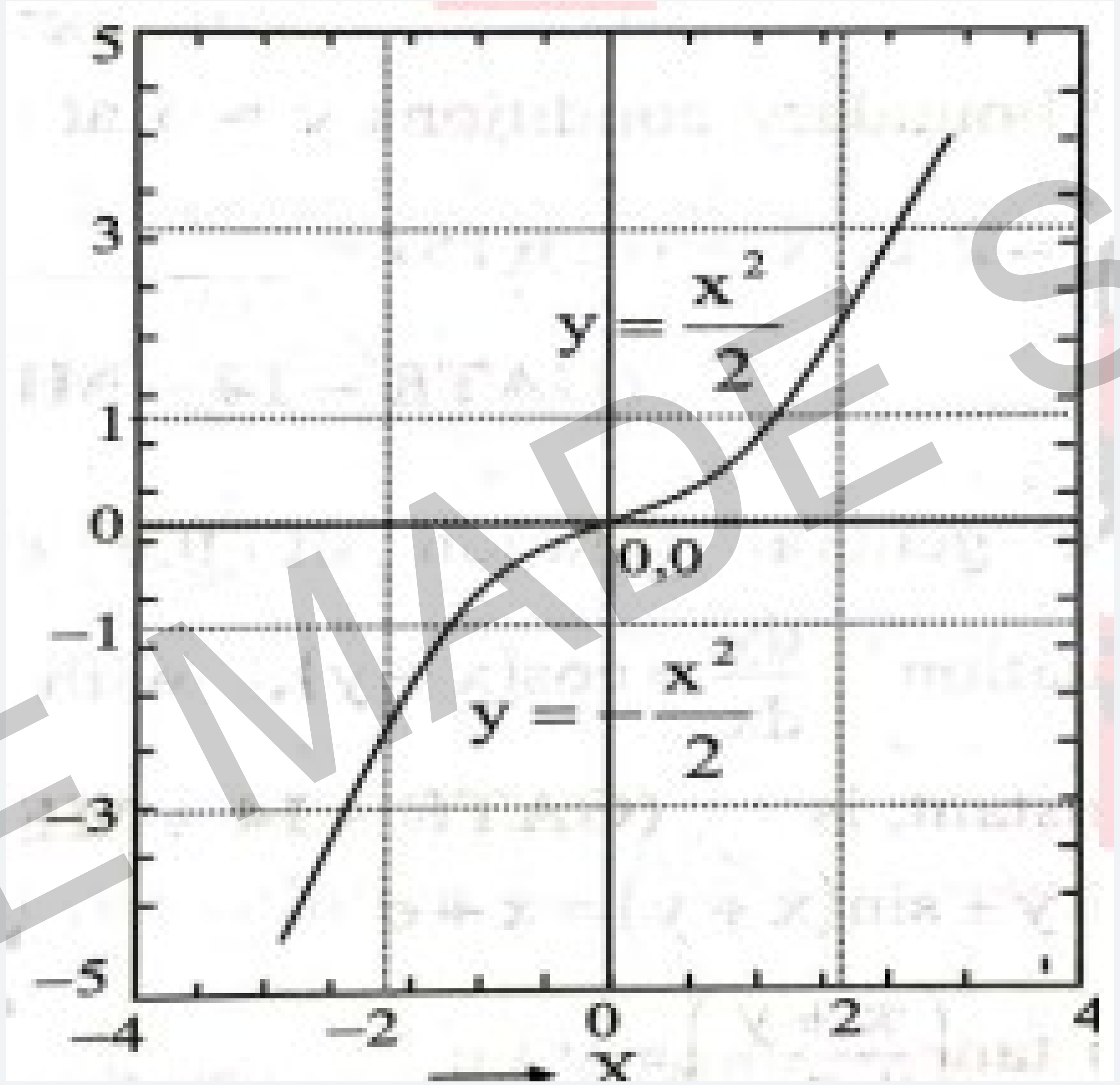
Q19. The figure shows the plot of y as a function of x



The function shown in the solution of the differential equation (assuming all initial conditions to be zero) is

(a) $\frac{d^2y}{dx^2} = 1$

(b) $\frac{dy}{dx} = -x$

(c) $\frac{\mathrm{dy}}{\mathrm{dx}} = \mathrm{x}$

(d) $\frac{\mathrm{d}y}{\mathrm{dx}} = |x|$

Q20. The matrix form of the linear system $\frac{dx}{dt} = 3x - 5y$ and $\frac{dy}{dt} = 4x + 8y$ is

(a) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & -5 \\ 4 & 8 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

(b) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 3 & 8 \\ 4 & -5 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

(c) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 4 & -5 \\ 3 & 8 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

(d) $\frac{d}{dt}\begin{Bmatrix} x \\ y \end{Bmatrix} = \begin{bmatrix} 4 & 8 \\ 3 & -5 \end{bmatrix}\begin{Bmatrix} x \\ y \end{Bmatrix}$

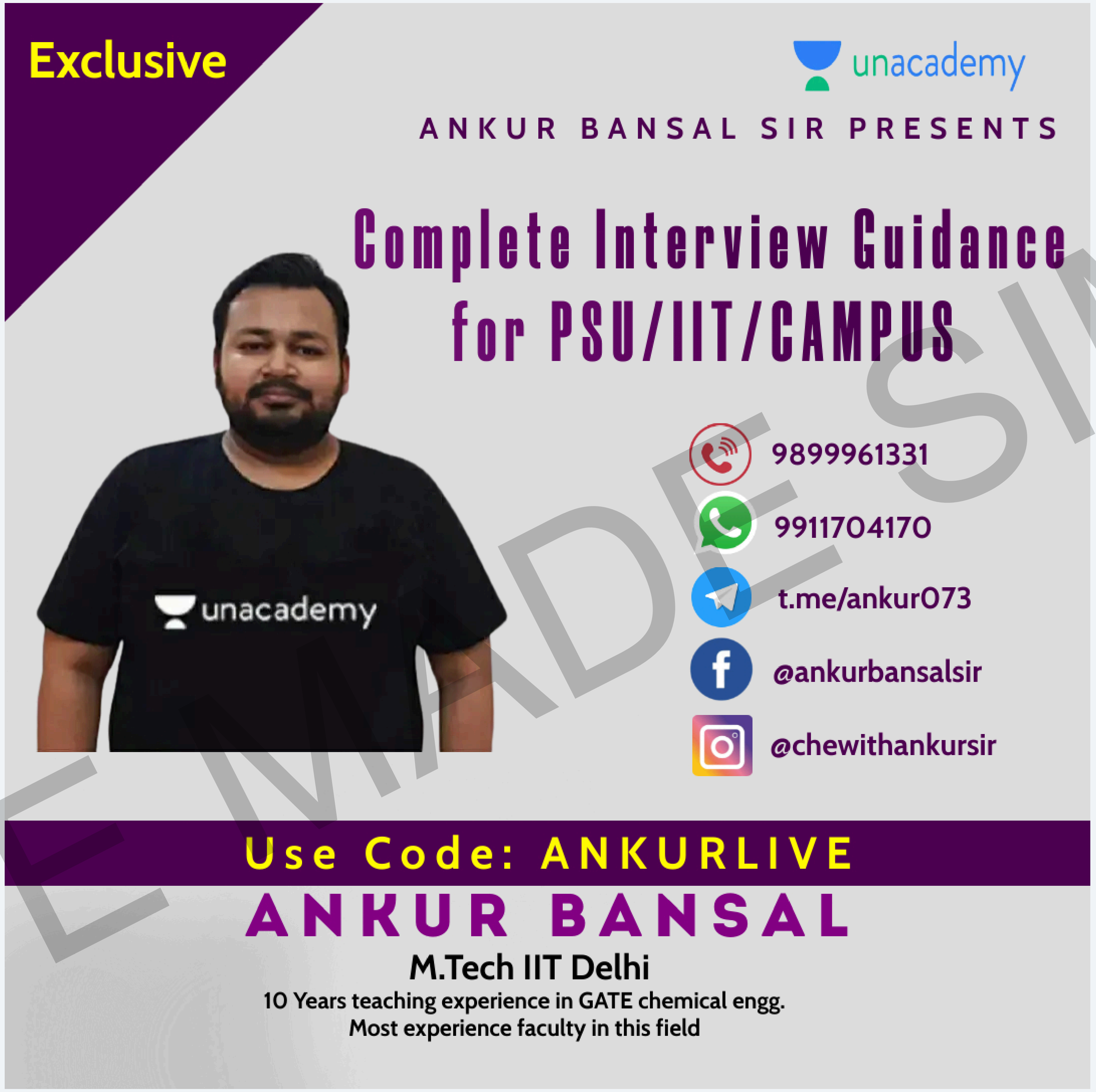
Q21. The general solution of the differential equation $\frac{dy}{dx} = \cos(x + y)$, with c as a constant, is

(a) $Y + \sin(x + y) = x + c$

(b) $\tan\left(\frac{x+y}{2}\right) = y + c$

(c) $\cos\left(\frac{x+y}{2}\right) = x + c$

(d) $\tan\left(\frac{x+y}{2}\right) = x + c$



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Q22. Consider two solutions $x(t) = x_1(t)$ and $x(t) = x_2(t)$ of the differential equation

$$\frac{d^2x(t)}{dt^2} + x(t) = 0, t > 0, \text{ such that } x_1(0) = \left.\frac{dx_1(t)}{dt}\right|_{t=0} = 0,$$

$$x_2(0) = \left.\frac{dx_2(t)}{dt}\right|_{t=0} = 1$$

$$\text{The Wronskian } w(t) = \begin{vmatrix} x_1(t) & x_2(t) \\ \dfrac{dx_1(t)}{dt} & \dfrac{dx_2(t)}{dt} \end{vmatrix} \text{ at } t = \pi/2 \text{ is}$$

(a) 1

(b) -1

(c) 0

(d) $\pi/2$

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Q23. Water is flowing at a steady rate through a homogeneous and saturated horizontal soil strip of 10 m length. The strip is being subjected to a constant water head (H) of 5 m at the beginning and 1 m at the end. If the governing equation of flow in the soil strip is $\frac{d^2H}{dx^2} = 0$ where x is the distance along the soil strip), the value of H (in m) at the middle of the strip is

____

Q24. The degree and order of the differential equation

$$\frac{d^4y}{dx^4} + 5\sqrt{\left(\frac{dy}{dx}\right)^4 + y^3} = 0$$ are respectively

(a) 2 and 4

(b) 4 and 2

(c) 2 and 3

(d) 3 and 2

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Q25. Given differential equation $y''' - 3(y'')^2 + 4y' + 6y = 0$ is

(a) Linear having second degree

(b) Non - linear having second degree

(c) Linear having third order

(d) None of these

Q26. $(y'') + \sin(y') = 0$ given differential equation is

(a) Linear because degree is one

(b) Linear because y and y^1 are not multiple together

(c) Non - linear because it is of second order

(d) None of these

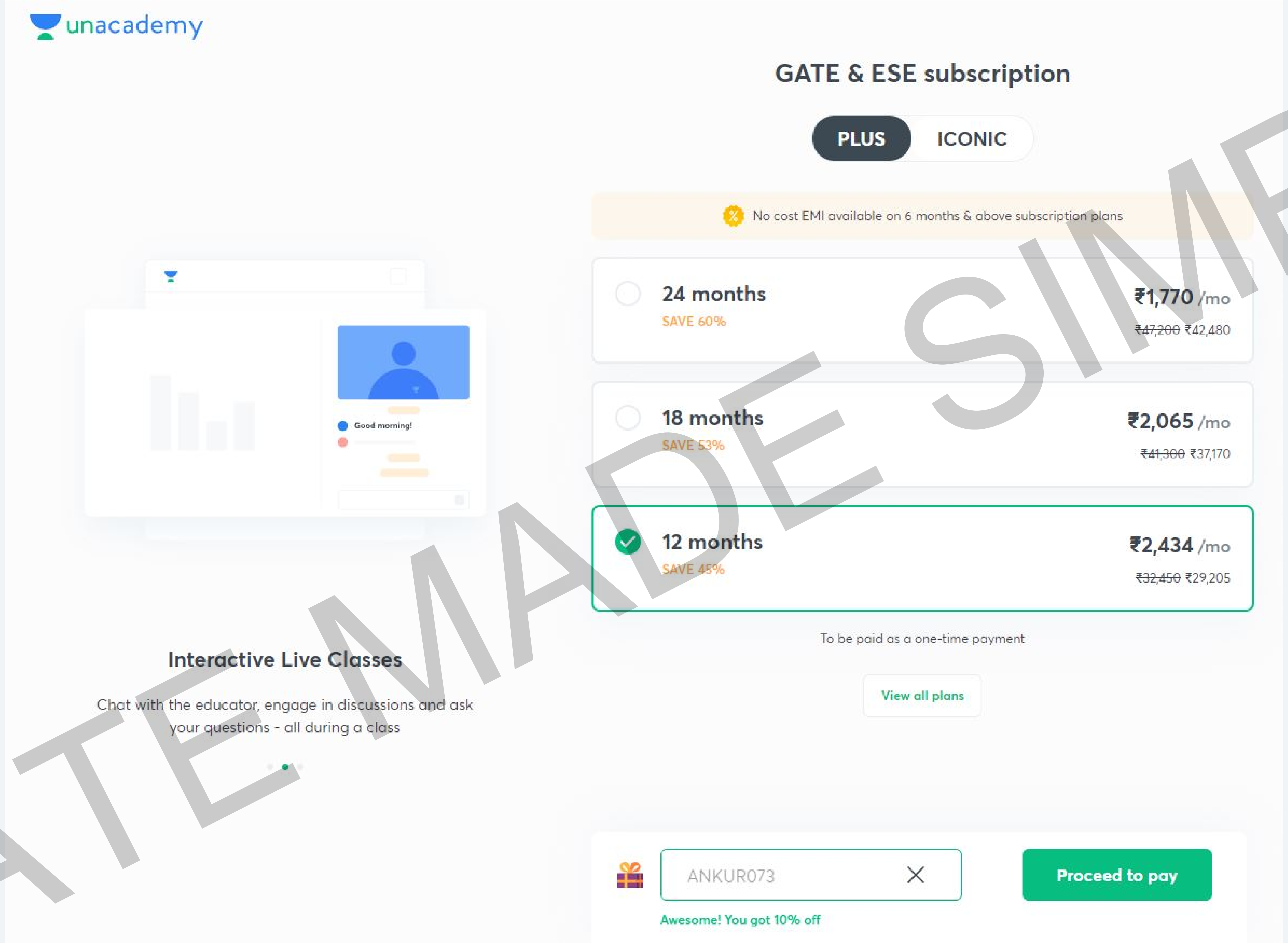
Q27. Order and degree of $y' + y = e^x$

(a) 1,1

(b) 1,2

(c) 1, not defined

(d) not a differential equation



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Q28. $y'' + 2y' + \sin y = 0$ given differential equation possess a degree of ________

Q29. $5y''' + 6y'' + xy' + \ln y = 0$ given differential equation is

(a) Linear, second order, second degree

(b) Linear, third order, first degree

(c) Non linear, third order, first degree

(d) Non-linear, third order, degree not defined

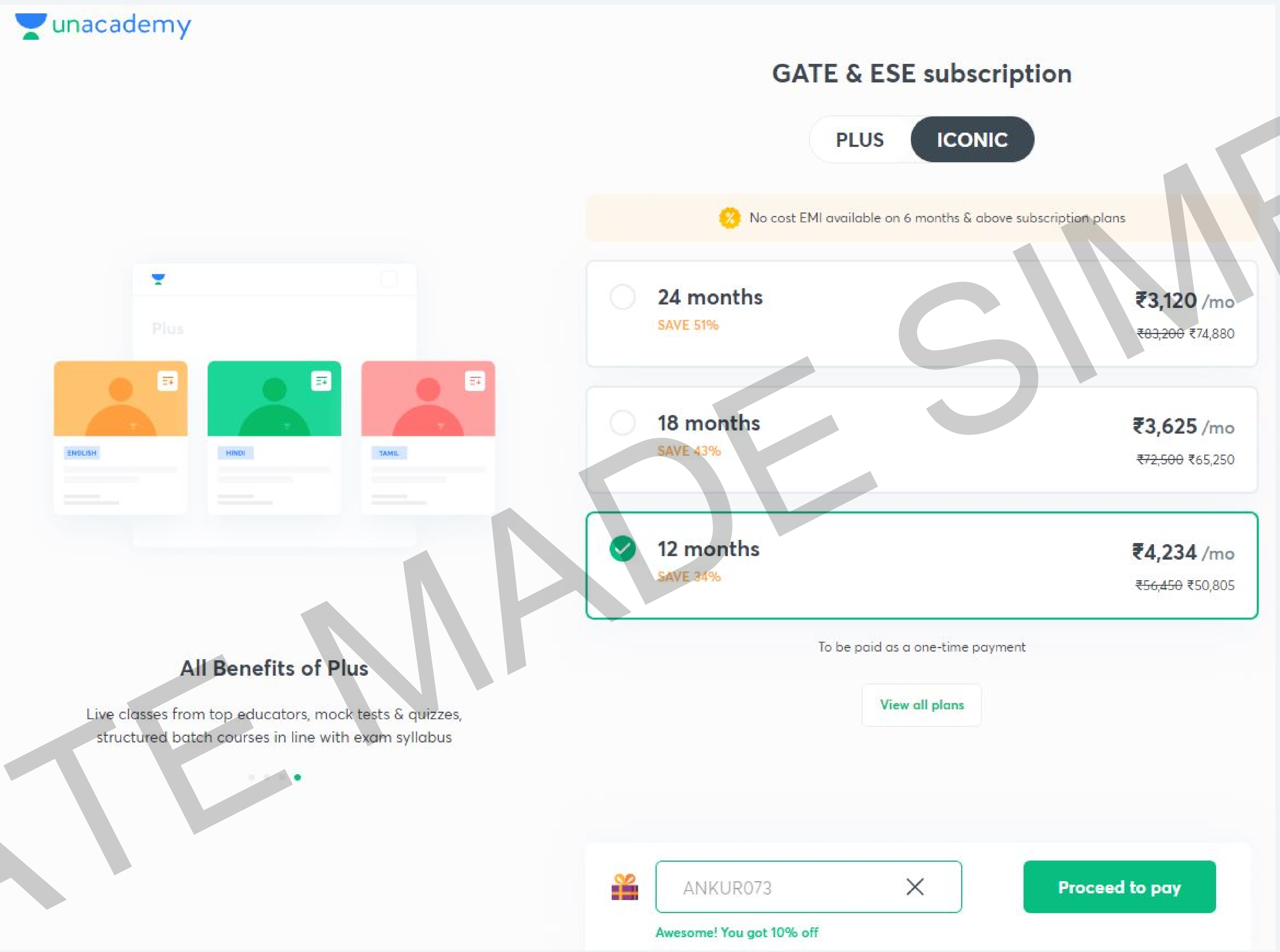
Q30. Form the differential equation of family of circles touching the y-axis at the origin.

(a) $2y = y^2 - x^2$

(b) $2xy = x^2 - y^2$

(c) $2xyy' = y^2 - x^2$

(d) $2xyy' = x^2 - y^2$



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Q31. Form the differential equation of the family of parabolas having vertex at origin and axis a long positive - y axis

(a) $xy' = 2x$

(b) $xy' = 2y$

(c) $xy'' = 2$

(d) $xy'' = 2y'$

Q32. Form the differential equation of ellipses having foci on y-axis and center at origin

(a) $xyy'' + xy' - yy' = 0$

(b) $xyy'' + x(y')^2 - yy' = 0$

(c) $xyy'' + x(y')^3 - yy' = 0$

(d) none

Q33. Which of the following differential equation has $y = C_1 e^{x} + C_2 e^{-x}$ as the general solution

(a) $y'' + y = 0$

(b) $y'' - y = 0$

(c) $y'' + 1 = 0$

(d) $y'' - 1 = 0$

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Q34. Solve $y\ln y dx - x dt = 0$

(a) $y = \ln x$

(b) $\ln \mathrm{y} = \mathrm{x}$

(c) $x = e^{y}$

(d) None

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Q35. Find the equation of the curve passing through the point (0,0) and whose differential equation is $y' = e^x \sin x$

(a) $y = 1 + e^x(\sin x - \cos x)$
(b) $y = 1 - e^x(\sin x - \cos x)$
(c) $y = [1 + e^x(\sin x - \cos x)]/2$
(d) $y = [1 - e^x(\sin x - \cos x)]/2$

Q36. At any point (x, y) of a curve, the slope of the tangent is twice the slope of the line segment joining the point of contact to the point $(-4, -3)$. Find the equation of the curve given that it passes through $(-2,1)$

(a) $y = (x + 4)^2$

(b) $y + 3 = (x + y)^2$

(c) $y = x + (x + 4)^2$

(d) none

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Q37. The volume of spherical balloon being inflated changes at a constant rate. If initially its radius is 3 units and after 3 second it is 6 units. Find the radius of the balloon after ' t ' seconds

(a) $(63t + 27)^{1/2}$

(b) $(63t + 27)^{1/3}$

(c) $(27t + 63)^{1/2}$

(d) none

Q38. In a bank, principal increases continuously at the rate of $r\%$ per year. Find the value of r if Rs. 100 doubles itself in 10 years ___________ $(\log_e 2 = 0.6931)$.

Q39. The solution of $\frac{dy}{dx} = -\frac{x}{y}$ at $x = 1$ and $y = \sqrt{3}$ is

(a) $x - y^2 = -2$

(b) $x + y^2 = 4$

(c) $x^2 - y^2 = -2$

(d) $x^2 + y^2 = 4$

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Q40. Solution of the differential equation $3y\frac{dy}{dx} + 2x = 0$ represents a family of

(a) ellipses

(b) circles

(c) parabolas

(d) hyperbolas

Q41. Write the order and degree of the following differential equations:

(i) $\frac{d^2y}{dx^2} + a^2x = 0$

(ii) $\left[1 + \left(\frac{dy}{dx}\right)^2\right]^{3/2} = \frac{d^2y}{dx^2}$

(iii) $x^2\left(\frac{d^2y}{dx^2}\right)^3 + y\left(\frac{dy}{dx}\right)^4 + y^4 = 0$

Q42. Give an example of each of the following type of differential equations.

(i) A linear-differential equation of second order and first degree

(ii) A non-linear differential equation of second order and second degree

(ii) Second order and third degree

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Q43. Solve the following differential equations:

(i) $\frac{dx}{x} = \tan \mathrm{y} \cdot \mathrm{dy}$

(ii) $y(1+x^2)^{1/2}dy + x\sqrt{1+y^2}dx = 0$

(iii) $\sec^2 x \tan y dx + \sec^2 y \tan x dy = 0$

(iv) $(1+x^2)dy - xydx = 0$

(v) $\frac{dy}{dx} = \mathrm{e}^{\mathrm{x}-\mathrm{y}} + \mathrm{x}^2\mathrm{e}^{-\mathrm{y}}$

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(vi) $x(y-x)\frac{dy}{dx} = y(y+x)$

(vii) $x(x-y)dy + y^2dx = 0$

(viii) $\frac{dy}{dx} + \frac{x-2y}{2x-y} = 0$

(ix) $\frac{dy}{dx} = \tan\frac{y}{x} + \frac{y}{x}$

(x) $\frac{dy}{dx} + \frac{3xy+y^2}{3x^2}$

(xi) $(2y - 3x)dx + xdy = 0$

(xii) $\frac{dy}{dx} + y\cot \mathrm{x} = \cos \mathrm{x}$

(xiii) $\cos^2 x \frac{dy}{dx} + y = \tan x$

(xiv) $x\cos x \frac{dy}{dx} + y(x\sin x + \cos x) = 1$

(xv) $x\log x \frac{dy}{dx} + y = 2\log x$

(xvi) $\frac{1}{y^2}\frac{dy}{dx} - \frac{1}{y} = 2\mathrm{x}\mathrm{e}^{-\mathrm{x}}$

(xvii) $\frac{dy}{dx} = \mathrm{y}\tan\mathrm{x} - \mathrm{y}^2\sec\mathrm{x}$

(xviii) $\frac{dy}{dx} = 2y\tan x + y^2\tan^2 x$, if $y = 1$ at $x = 0$

(xix) $\frac{dy}{dx} + \tan x \tan y = \cos x \sec y$

$(xx)(x^2y^2 + xy)ydx + (x^2y^2 - 1)xdy = 0$

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(xxi) $(2x - y)dx = (x - y)dy$

(xxii) $(y\sec^2 x + \sec x \tan x)dx + (\tan x + 2y)dy = 0$

(xxiii) $(x^4 - 2xy^2 + y^4)dx - (2x^2 y - 4xy^3 + \sin y)dy = 0$

(xxiv)$(x^2 + 2ye^{2x})dy + (2xy + 2y^2 e^{2x})dx = 0$

$$(xxv)\left[y\left(1 + \frac{1}{x}\right) + \cos y\right]dx + (x + \log x - x\sin y)dy = 0$$

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$(xxvi)(3x^2y^4 + 2xy)dx + (2x^3y^3 - x^2)dy = 0$

(xxvii) $(xy^3 + y)dx + 2(x^2y^2 + x + y^4)dy = 0$

(xxviii) $y(x^2y + e^x)dx - e^x dy = 0$

(xxix) $(2x^4y^4e^y + 2xy^3 + y)dx + (x^2y^4e^y - x^2y^2 - 3x)dy = 0$

$$(\mathrm{xxx})\mathrm{x}^2\frac{d^2y}{dx^2} - 2\mathrm{x}\frac{dy}{dx} + 2\mathrm{y} = \mathrm{x}^2 + \sin(5\log \mathrm{x})$$

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(xxxi) $x^2\frac{d^2y}{dx^2}-3x\frac{dy}{dx}+y=\log x\frac{\sin(\log x)+1}{1}$

(xxxii) $(D^2-4D+3)y=x^3$

(xxxiii) $5\frac{d^3y}{dx^3}-\frac{d^2y}{dx^2}-6\frac{dy}{dx}=1+x^2$

(xxxiv) $\frac{d^2x}{dt^2}+2\frac{dx}{dt}+5x=\sin 2t$, given that when $t=0, x=3$ and $\frac{dx}{dt}=0$

(xxxv) $\frac{d^2y}{dx^2}-7\frac{dy}{dx}+6y=2\sin 3x$, given that $y=1, \frac{dy}{dx}=0$ when $x=0$

(xxxvi) $\frac{d^2y}{dx^2} + \mathrm{a}^2\mathrm{y} = \sec \mathrm{ax}$

(xxxvii) $(D^2 - 4)y = x^2e^{3x}$

(xxxviii) $(D^2 - 3D + 2)y = 2x^2e^{4x} + 5e^{3x}$

(xxix) $\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = \mathrm{e}^{3x}$

$(xxxx)(D^3 + 2D^2 - D - 2)y = e^x$