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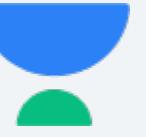
GATE CHEMICAL ENGINEERING

Assignment of Differential Equations

Ankur Bansal



- 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



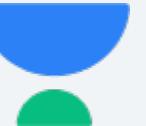
Q3. For the differential equation $f(x,y) \frac{dy}{dx} + g(x,y) = 0$ to be exact is

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



Ankur Bansal

 Master

Working in the field of gate chemical engineering from last 10 years, completed my Masters from IIT Delhi. Am very passionate about teaching

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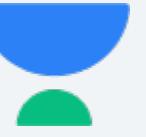
- Worked at The Gate Coach
- Studied at IIT Delhi
- Taught over 10000+ students of chemical engineering in the duration of 8 years with a qualifying gate percentage of more than 85% HOD of the chemical engineering in the last institute i worked on.
- Lives in Delhi Cantt., Delhi, India
- Unacademy Educator since 23rd June, 2020
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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 $u = 2$ at $x = 1$, calculate the displacement at $x = 1/2$

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



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 $t \rightarrow \infty$

- (a) 0
- (b) $5/2$
- (c) 5
- (d) 10



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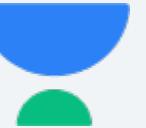
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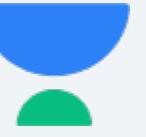
Q7. Transformation to linear form by substituting $v = y^{1-n}$ of the equation $\frac{dy}{dt} + p(t)y = q(t)y^n, n > 0$ will be

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



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 $y = C_1 e^{-x} + C_2 e^{-3x}$ 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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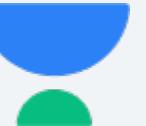
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In a certain exchanger, both the fluid has identical mass flow rate specific heat product. The hot fluid enters at 76°C and leaves at 97°C and cold fluid entering at 26°C leaves at 55°C. The effectiveness of heat exchanger is
a) 0.16
b) 0.58
c) 0.72
d) 1.0
Answer: (b)
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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 $x = a$

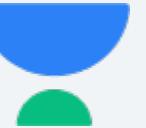
The form of non-zero solution of y (where m varies over all integers) are

- (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) $y = \sum_m A_m x^{\frac{m}{3}}$
- (d) $y = \sum_m A_m e^{-\frac{m\pi x}{a}}$



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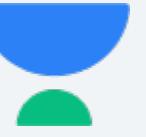
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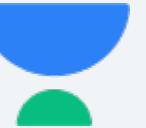
Q13. A system described by a linear, constant coefficient, ordinary, first order differential equation has an exact solution given by $y(t)$ for $t > 0$, when the forcing function is $x(t)$ and the initial condition is $y(0)$. If one wishes to modify the system so that the solution becomes $-2y(t)$ for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

- (a) Change the initial condition to $-y(0)$ and the forcing function to $2x(t)$
- (b) Change the initial condition to $2y(0)$ and the forcing function to $-x(t)$
- (c) Change the initial condition to $j\sqrt{2}y(0)$ and the forcing function to $j\sqrt{2}x(t)$
- (d) Change the initial condition to $-2y(0)$ and the forcing function to $-2x(t)$



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

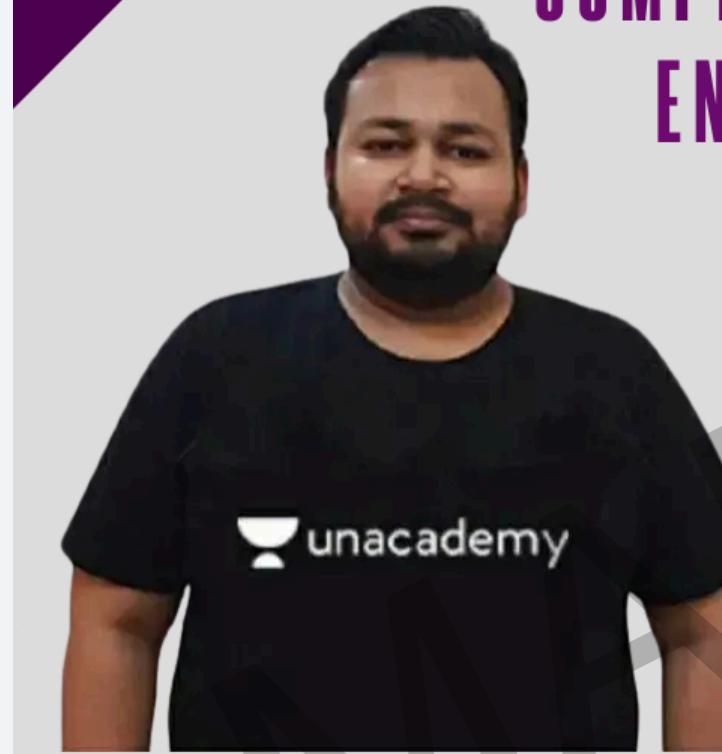
- (a) $u = u \frac{x}{L}$
- (b) $u = u \left(\frac{1-e^{kx}}{1-e^{kL}} \right)$
- (c) $u = u \left(\frac{1-e^{-kx}}{1-e^{-kL}} \right)$
- (d) $u = u \left(\frac{1+e^{kx}}{1+e^{kL}} \right)$

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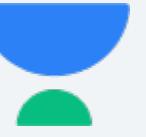
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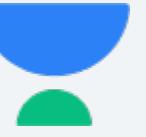


Q16. If the characteristic equation of the differential equation $\frac{d^2y}{dx^2} + 2\alpha \frac{dy}{dx} + y = 0$ has two equal roots, then the values of α are

- (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) $\frac{dy}{dx} + xy = 0$
- (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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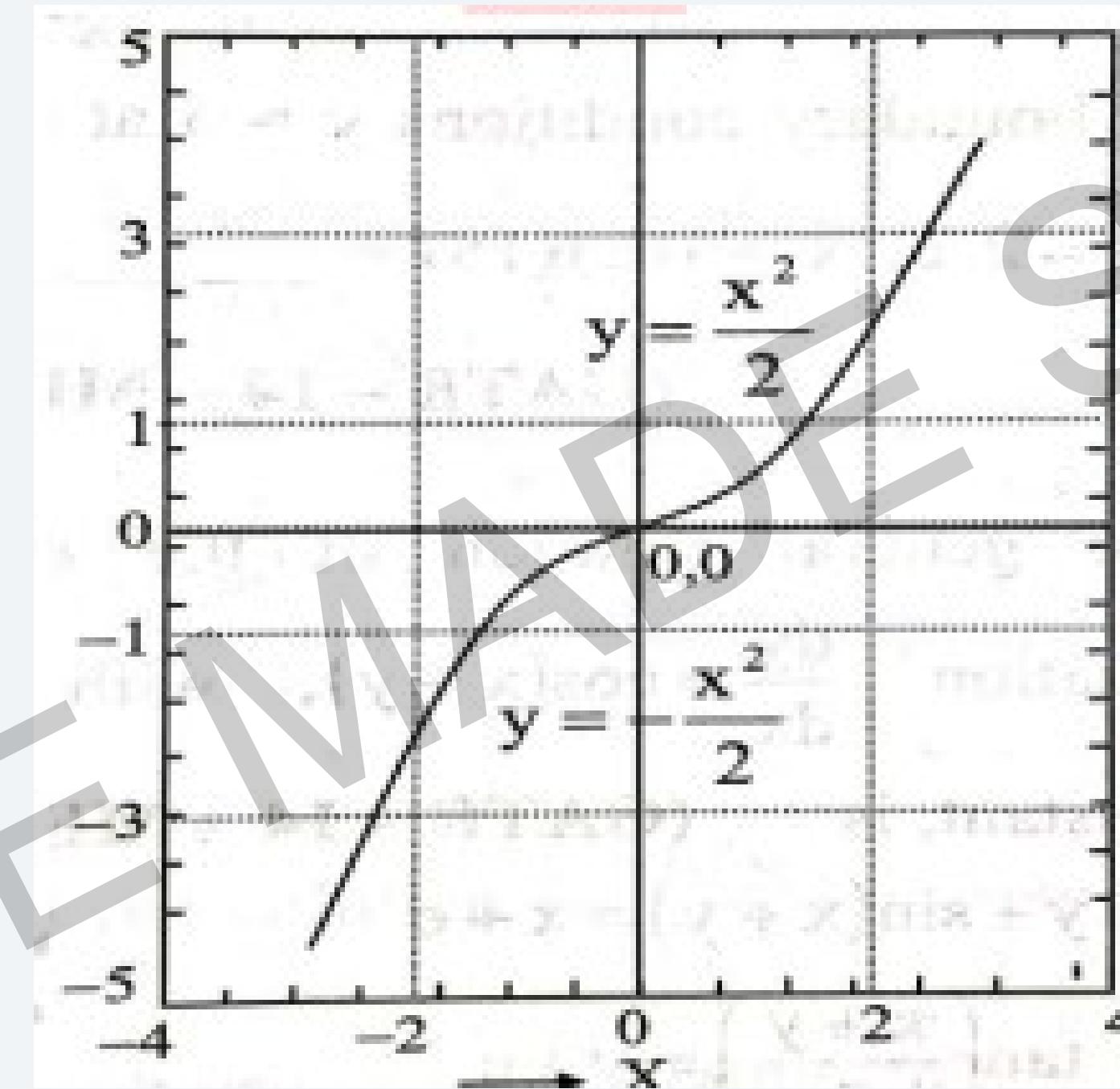
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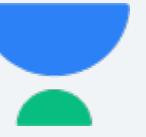
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Q19. The figure shows the plot of y as a function of x





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



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

$$\frac{dy}{dx} = \cos(x + y), \text{ with } c \text{ as a constant, is}$$

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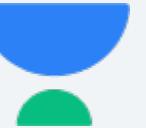
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Q22. Consider two solutions $x(t) = x_1(t)$ and $x(t) = x_2(t)$ of the differential equation

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

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

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

- (a) 1
- (b) -1
- (c) 0
- (d) $\pi/2$



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

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

- (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



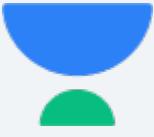
Q26. $(y'') + \sin(y') = 0$ given differential equation is

- (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 _____



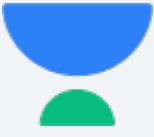
Q29. $5y''' + 6y'' + xy' + \ln y = 0$ given differential equation is

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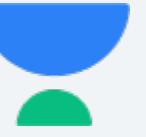
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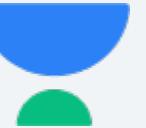
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Q34. Solve $y \ln y dx - x dt = 0$

- (a) $y = \ln x$
- (b) $\ln y = x$
- (c) $x = e^y$
- (d) None



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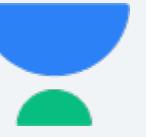
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Q37. The volume of spherical balloon being inflated changes at a constant rate. If initially its radius is 3 units and after 3 second it is 6 units. Find the radius of the balloon after ' t ' seconds

- (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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PYQs



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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
- (iii) Second order and third degree



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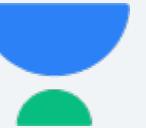
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Q43. Solve the following differential equations:

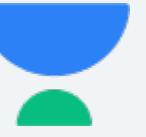
(i) $\frac{dx}{x} = \tan y \cdot dy$

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



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

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

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

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

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



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

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

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

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

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



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

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

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

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

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

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

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

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

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

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



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

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

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

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

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



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

$$(xxx\text{ii}) (D^2 - 4D + 3)y = x^3$$

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

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

$$\text{and } \frac{dx}{dt} = 0$$

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

when $x = 0$



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

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

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

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

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