MATHS

BOOKS - KC SINHA ENGLISH

DIFFERENTIAL EQUATIONS - FOR BOARDS

Solved Examples

1. Find the order and degree of the following differential equation: $\left(\frac{d^3y}{dx^3}\right)^2 - x\left(\frac{dy}{dx}\right)^3$.

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2. Determine the order and degree of the differential equation $\frac{d^2y}{dx^2} = \sqrt{1 + \left(\frac{dy}{dx}\right)^2}$

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3. Determine the order and degree of each of the following differential equation. State also whether they are linear or non-linear: $y = px + \sqrt{a^2p^2 + b^2},\ where\ p = \frac{dy}{dx}$

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4. Find the order and degree of the differential equation $\frac{dy}{dx} + \sin\left(\frac{dy}{dx}\right) = 0$

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5. Find the order and degree of the differential equation $\log_e\left(1+\frac{d^2y}{dx^2}\right)=x$

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6. The differential equation representing the family of curves $y^2=2c\left(x+\sqrt{c}\right)$, where c is a positive parameter, is of (a) order 1 (b) order 2 (c) degree 3 (d) degree 4

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7. Obtain the differential equation of the family of curves represented by $y=Ae^x+Be^{-x}+x^2$, where A and B are arbitrary constants.

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8. From the differential equation of the family of curves $y = a\sin(x + b)$, where a and b are arbitrary constants.

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9. Form the differential equation representing the family of curves $y = A\cos(x + B)$ where AS and B are parameters.

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10. Find the differential equation of the family of curves $y = Ae^{x} + Be^{-x}$, where A and B are arbitrary constants.

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11. Form the differential equation corresponding to $y^2 = a(b - x)(b + x)$ by eliminating parameters $aandb$.

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12. Show that the differential equation of all parabolas $y^2 = 4a(x - b)$ is given by

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13. Form the differential equation corresponding to $y^2 = a(b - x)^2$,where a and b are arbitrary constant.

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14. Find the differential equation of the family of curves given by $x^2 + y^2 = 2ax$

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15. Form the differential equation representing the family of curves $y^2 - 2ay + x^2 = a^2$, where a is an arbitrary constant.

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16. Show that the differential equation representing one parameter family of curves $(x^2 - y^2) = c(x^2 + y^2)^2 is\ (x^3 - 3xy^2)dx = (y^3 - 3x^2y)dy$

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17. Form the differential equation of all concentric circles at the origin.


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18. Find the differential equation of family of all straight lines passing through the origin .


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19. Form the differential equation representing the family of parabolas having vertex at origin and axis along positive direction of x-axis.

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20. Form the differential equation of the family of circles touching the x-axis at origin.

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21. Form the differential equation of the family of circles in the second quadrant and touching the coordinate axes.

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22. Show that $y = ae^{2x} + be^{-x}$ is a solution of the differential equation $\frac{d^2y}{dx^2} - 2y = 0$.

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23. Show that the function $y = (A + Bx)e^{3x}$ is a solution of the equation $\frac{d^2y}{dx^2} - 6\frac{dy}{dx} + 9y = 0.$

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24. Verify that $y = ae^{3x} + be^{-x}$ is a solution of differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} - 3y = 0$

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25. Show that $y = Ax + \frac{B}{x}, x \neq 0$ is a solution of the differential equation $x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} - y = 0$

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26. Show that, $v = \frac{A}{r} + B$ satisfies the differential equation $\frac{d^2v}{dr^2} + \frac{2}{r} \cdot \frac{dv}{dr} = 0$

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27. solve the differential equation $\frac{dy}{dx} = e^{x+y} + x^2 e^y$

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28. Solve the differential equation $\frac{dy}{dx} = \sqrt{4 - y^2}, \ -2 < y < 2$

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29. Solve the differential equation $(\sqrt{a+x})\dfrac{dy}{dx}+x=0$

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30. Solve the differential equation $\dfrac{dy}{dx}=\dfrac{1+y^2}{1+x^2}$

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31. Solve the differential equation $\dfrac{dy}{dx}=\sin^{-1}x$

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32. Solve the following differential equation:

$(1+e^{2x})dy+(1+y^2)e^x dx=0$

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33. Solve the following differential equation:

$\cos x(1+\cos y)dx - \sin y(1+\sin x)dy = 0$

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34. Solve the differential eqaution

$x\left(1+y^2\right)dx - y\left(1+x^2\right)dy = 0,$ given that y=0 when x=1

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35. Solve the following differential equation :

$x\cos y\,dy = (xe^x \log x + e^x)dx$

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36. Solve the differential equation $\frac{dy}{dx} = \log(x+1)$

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37. Solve the differential equation

$$\frac{dy}{dx} = \frac{e^x\left(\sin^2 x + \sin 2x\right)}{y(2\log y + 1)}$$

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38. Solve the differential equation: $\left(1+y^2\right)(1+\log x)dx + xdy = 0$ given that when $x = 1,\ y = 1.$

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39. Solve: $(x+y)^2 \frac{dy}{dx} = a^2$

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40. Solve the differential equation:

$\sin^{-1}\left(\frac{dy}{dx}\right) = x + y.$

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41. Solve the following differential equation

$(x^2 + xy)dy = (x^2 + y^2)dx$

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42. Solve the following differential equation:

$2xydx + \left(x^2 + 2y^2\right)dy = 0$

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43. Solve the following differential equation:

$\left(x^3 + y^3\right)dy - x^2ydx = 0\right)$

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44. Solve the following differential equation:

$x^2\frac{dy}{dx} = x^2 - 2y^2 + xy$

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45. solve the differential equation $(y+x)\frac{dy}{dx}=y-x$

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46. Solve :

$$\left\{x\cos\left(\frac{y}{x}\right)+y\sin\left(\frac{y}{x}\right)\right\}ydx=\left\{y\sin\left(\frac{y}{x}\right)-x\cos\left(\frac{y}{x}\right)\right\}xdy$$

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47. Solve $\left(1+2e^{x/y}\right)dx+2e^{x/y}(1-x/y)dy=0.$

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48. Solve the following differential equation:

$$y\,dx + x\log\left(\frac{y}{x}\right)dy = 2x\,dy$$

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49. Solve each of the following initial value problem:

$$2xy + y^2 - 2x^2\frac{dy}{dx} = 0,\ y(1) = 2$$

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50. Solve the differential equation $x\frac{dy}{dx} - y = x\tan\left(\frac{y}{x}\right)$, given $y = \frac{\pi}{2}$ when $x = 1$.

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51. Solve the following differential equation:

$$\frac{dy}{dx} + \sec x \cdot y = \tan x \left(0 \leq x < \frac{\pi}{2}\right)$$

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52. Solve the following differential equation:

$\frac{dy}{dx} + 2\tan x \cdot y = \sin x$ Also find the particular solution if $y = 0$ when $x = \frac{\pi}{3}$

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53. Solve: $x \log x \frac{dy}{dx} + y = 2\log x$

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54. Solve the following differential equation :

$$(x^2 - 1)\frac{dy}{dx} + 2xy = \frac{2}{(x^2 - 1)}$$

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55. Solve the following differential equations:

$$(1 + x^2)\frac{dy}{dx} - 2xy = (x^2 + 2)(x^2 + 1)$$

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56. Solve the differential equation

$$\left[\frac{e^{-2\sqrt{x}}}{\sqrt{x}} - \frac{y}{\sqrt{x}}\right]\frac{dx}{dy} = 1(x \neq 0)$$

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57. Solve the differential equation :

$$x\frac{dy}{dx} + y - x + xy\cot x = 0, x \neq 0.$$

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58. Solve the differential equation: $\frac{dy}{dx} + \frac{y}{x} = e^x, x > 0$

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59. Solve: $\frac{dy}{dx} - 2y = \cos 3x$

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60. Find the general solution of the differential equations:

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

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61. Find the particular solution of the differential equation

$$\frac{dy}{dx} + y \cot x = 2x + x^2 \cot x (x \neq 0) \text{given that } y = 0 \text{when } x = \frac{\pi}{2}.$$

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62. Solve the following differential equation, given that $y = 1$ when $x = 2$: $x \frac{dy}{dx} + y = x^3$

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63. Solve the differential equation $\frac{dy}{dx} - 3y \cot x = \sin 2x$ given $y = 2$ when $x = \frac{\pi}{2}$.

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64. The differential equations, find a particular solution satisfying the given condition:

$(1 + x^2)\frac{dy}{dx} + 2xy = \frac{1}{1 + x^2}; y = 0$when $x = 1$

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65. Find the particular solution of the differential equation. $\frac{dy}{dx} + y \cot x = 4x \ \cos ec\, x, \ (x \neq 0),$ given that $y = 0$ when $x = \frac{\pi}{2}$.

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66. Solve: $\left(x+2y^3\right)\frac{dy}{dx}=y.$

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67. Solve the following differential equation:

$\left(1+y^2\right)dx=\left(\tan^{-1}y-x\right)dy$

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68. Solve the following differential equation: $\frac{dy}{dx}+\frac{y}{x}=x^3$

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69. Solve the following differential equation:

$$\tan y \cdot \frac{dy}{dx} + \tan x = \cos y \cos^2 x$$

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70. The Integrating Factor of the differential equation

$$\left(1 - y^2\right) \frac{dx}{dy} + yx = ay$$

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Exercise

1. Find the order and degree of $\frac{d^2y}{dx^2} + 4x = 0$ and also state whether its linear or non-linear.

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2. $a = \dfrac{\left[1 + \left(\dfrac{dy}{dx}\right)^2\right]^{3/2}}{\dfrac{d^2y}{dx^2}}$, where a is constant.

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3. Find the order and degree of $\dfrac{d^3y}{dx^3} + 3\dfrac{d^2y}{dx^2} + 3\dfrac{dy}{dx} + y = 0$ and also state whether its linear or non-linear.

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4. Find the order and degree of $x^2\left(\dfrac{d^2y}{dx^2}\right)^3 + y\left(\dfrac{dy}{dx}\right)^4 + y^4 = 0$ and also state whether its

linear or non-linear.

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5. The order of the differential equation $2x^2\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + y = 0$ is

(A) 2 (B) 1 (C) 0 (D) not defined

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6. Determine order and degree (if defined) of differential equations given $y' + y = e^x$

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7. Determine order and degree (if defined) of differential equations given $y'' + 2y' + \sin y = 0$

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8. Find the order and degree of $\frac{dy}{dx} = e^x$

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9. Find the order and degree of $(x + y - 3)dx + (x^2 + 3x + y)dy = 0$ and also state whether they are linear or non-linear.

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10. Find the order and degree of $\frac{d^3y}{dx^3} + \left(\frac{d^2y}{dx^2}\right)^3 + \frac{dy}{dx} + 4y = \sin x$ and also state whether they are linear or non-linear.

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11. Find the order and degree of $5\frac{d^2y}{dx^2} = \left[1 + \left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}$ and also state whether they are linear or non-linear.

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12. Determine order and degree (if defined) of differential equations given $\left(\frac{ds}{dt}\right)^4 + 3s\frac{d^2s}{dt^2} = 0$

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13. Find the order and degree of $y''' + y^2 + e^{y'} = 0$

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14. Find the order and degree of $\frac{d^2y}{dx^2} + 3\frac{dy}{dx} = y\sin\left(\frac{d^2y}{dx^2}\right)$

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15. Find the order and degree of $\frac{d^3y}{dx^3} - 2\sin\left(\frac{d^3y}{dx^3}\right) = 0$

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16. Form a differential equation for the family of curves represented by $ax^2 + by^2 = 1$, where a and b are arbitrary constants.

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17. The differential equation satisfying all the curves $y = ae^{2x} + be^{-3x}$, where a and b are arbitrary constants, is

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18. If a is arbitrary constant, find the differential equation of $x^2 + y^2 = a^2$

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19. Form a differential equation representing the given family of curves by eliminating arbitrary constants a and b.

$y = ae^{3x} + be^{-2x}$

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20. Form a differential equation representing the given family of curves by eliminating arbitrary constants a and b.

$\frac{x}{a} + \frac{y}{b} = 1$

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21. Form a differential equation representing the given family of curves by eliminating arbitrary constants a and b.

$y = e^{2x}(a + bx)$

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22. if a, b are arbitrary constants, find the differential equation of $y = a\cos nx + b\sin nx$

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23. Find the differential equation of the family of curves $y = A\cos x + B\sin x$, where A, B are parameters.

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24. Form the differential equation of the family of curves represented by the equation (a being the parameter):

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

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

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

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25. Find the differential equation of the family of curves $(x + a)^2 - 2y^2 = a^2$, where a is an arbitrary constant.

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26. Form the differential equation representing the family of curves given by $(x - a)^2 + 2y^2 = a^2$, where a is an arbitrary constant.

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27. Show that the differential equation of which $y = 2(x^2 - 1) + ce^{-x}$ ^ 2 is a solution, is $\frac{dy}{dx} + 2xy = 4x^3$.

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28. Form the differential equation of simple harmonic motion given by $x = A\cos(nt + \alpha)$, where n is fixed and A, α are parameters.

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29. Form the differential equation of the family of circles having centre on y-axis and radius 3 units.

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30. Form the differential equation of the family of hyperbolas having foci on x-axis and centre at origin.

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31. Find the differential equation of all the circles which pass thorough the origin and whose centres lie on x-axis.

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33. Verify that the function $y = e^{-3x}$ is a solution of the differential equation $\frac{d^2y}{dx^2} + \frac{dy}{dx} - 6y = 0$

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34. Verify that the given functions (explicit or implicit) is a solution of the corresponding differential equation: $y = e^x + 1 : y'' - y' = 0$

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35. Verify that the given functions (explicit or implicit) is a solution of the corresponding differential equation :

$y = Ax : xy' = y (x \neq 0)$

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36. Verify that the given functions (explicit or implicit) is a solution of the corresponding differential equation: $y = \cos x + C : y' + \sin x = 0$

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37. In each of the following verify that the given function (explicit or implicit) is a solution of the corresponding differentia equation: $y = x \sin x$ ii. $y = \sqrt{a^2 - x^2}$

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38. Verify that the given functions (explicit or implicit) is a solution of the corresponding differential equation: $xy = \log y + C : y' = \frac{y^2}{1 - xy} (xy \neq 1)$

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39. Verify that the given functions (explicit or implicit) is a solution of the corresponding differential equation: $x + y = \tan^{-1} y : y^2 y' + y^2 + 1 = 0$

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40. Verify that $y = 4 \sin 3x$ is a solution of the differential equation $\frac{d^2 y}{dx^2} + 9y = 0.$

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41. Show that the function $y = A\cos 2x + B\sin 2x$ is a solution of the differential equation $\frac{d^2y}{dx^2} + 4y = 0$

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42. Verify that the function $y = a \cos x + b \; s \in x$, where, a, $b \in R$ is a solution of the differential equation $\frac{d^2y}{dx^2} + y = 0$.

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43. Show that the differential equation of which $y = 2(x^2 - 1) + ce^{-x} \hat{} 2$ is a solution, is

$\frac{dy}{dx} + 2xy = 4x^3.$

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44. Verify the solution problems: Show that $y = e^{-x} + ax + b$ is solution of the differential equation $e^x \frac{d^y}{dx^2} = 1$

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45. Show that $y = e^x(A\cos x + B\sin x)$ is the solution of the differential equation $\frac{d^2y}{dx^2} - 2\frac{dy}{dx} + 2y = 0.$

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46. Verify that $y = ce^{tan-1_x}$ is a solution of differential equation $\left(1+x^2\right)\frac{d^2y}{dx^2}+x\frac{dy}{dx}=0.$

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47. Verify that the function $y = C_1e^{ax}\cos bx + C2ax\sin bx,\ C_1, C_2,$ are arbitrary constants is a solution of the differentia equation $\frac{d^2y}{dx^2}-2a\frac{dy}{dx}+\left(a^2+b^2\right)y=0$

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48. Solve the following differential equation: $\frac{dy}{dx}=(e^x+1)y$

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49. Solve the equation: $\left(1+x^2\right)\tan^{-1}x\cdot\frac{dy}{dx}+y=0$

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50. Solve the equation: $\sec^2 x\tan y\,dx+\sec^2 y\tan x\,dy=0$

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51. Solve the following differential equation: $\tan y\,dx+\sec^2 y\tan x\,dy=0$

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52. Solve : $\left(x^2-yx^2\right)dy+\left(y^2+x^2y^2\right)dx=0$

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53. Solve the equation: $2\sin 3ydx + 3x\cos 3ydy = 0$

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54. Solve the following differential equations:

$(x+2)\frac{dy}{dx} - x^2 + 4x - 9, x \neq -2$

$\frac{dy}{dx} = \sin^3 x\cos^2 x + xe^x$

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55. Solve the following differential equation:

$\frac{dy}{dx} = \sin^3 x\cos^2 x + xe^x 2$

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56. Solve the differential equation: $\frac{dy}{dx} = \frac{1 - \cos x}{1 + \cos x}$

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57. Solve: $\frac{dy}{dx} + y = 1$

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58. Solve the equation: $(x + 1)\frac{dy}{dx} = 2xy$

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59. Solve: $e^x \sqrt{1-y^2}dx + \frac{y}{x}dy = 0$

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60. Solve the following differential equation:

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

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61. Solve $\frac{dy}{dx} = xy + x + y + 1$

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62. Solve the following differential equations.

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

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63. Solve the initial value problem

$$y' = y \cot 2x, y\left(\frac{\pi}{4}\right) = 2.$$

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64. Solve the following differential equation:

$$xy(y+1)dy = \left(x^2 = 1\right)dx$$

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65. Solve the following differential equation: $5\frac{dy}{dx} = e^x y^4$

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66. Solve: $\frac{dy}{dx} = \frac{1}{\sin^4 x + \cos^4 x}$ (ii) $\frac{dy}{dx} = \frac{3e^{2x} + 3e^{4x}}{e^x + e^{-x}}$

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67. $\sqrt{1+x^2}dy + \sqrt{1+y^2}dx = 0$

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68. $\frac{dy}{dx}\tan y = \sin(x+y) + \sin(x-y)$

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69. Solve the differential equation $x\left(x^2-1\right)\frac{dy}{dx}=1$, given that when $x=2, y=0$.

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70. Find the solution of the differential equation $\cos y dy+\cos x \sin y dx=0$ given that $y=\pi/2$, when $x=\pi/2$.

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71. Solve the differential equation $(x-1)\frac{dy}{dx}=2xy$, given that $y(2)=1$

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72. The differential equations, find a particular solution satisfying the given condition:

$\cos\left(\frac{dy}{dx}\right) = a(a \in R); y = 2$ when x=0

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73. Find the equation of the curve passing through the point (1, 1) whose differential equation is $xdy = \left(2x^2 + 1\right)dx(x \neq 0)$.

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74. The volume of spherical balloon being inflated changes at a constant rate. If initially its radius is 3 units and after 3

seconds it is 6 units. Find the radius of balloon after t seconds.

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75. Solve: $(x-y)^2 \frac{dy}{dx} = 1$

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76. Solve: $\frac{dy}{dx} = \cos(x+y)$

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77. Solve the equation $(x+y+1)\left(\frac{dy}{dx}\right) = 1$

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78. Solve the differential equation $\frac{dy}{dx} + 1 = e^{x+y}$

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79. Solve $\frac{dy}{dx} = \cos(x+y) + \sin(x+y)$

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80. Solve: $\left(x^2 + 2xy + y^2 + 1\right)\frac{dy}{dx} = 2(x+y)$

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81. Solve: $(x-y)^2\frac{dy}{dx} = a^2$

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82. Solve the following differential equations: $(x+y)^2 \frac{dy}{dx} = 1$

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83. Solve the differential equation $x^2 dy + y(x+y)dx = 0$, given that $y = 1 \, when \, x = 1$.

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84. Solve the following differential equations: $\frac{dy}{dx} - \frac{y-x}{y+x}$

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85. Solve: $2xy\frac{dy}{dx} = x^2 + y^2$

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86. Solve: $xy\frac{dy}{dx} = x^2 - y^2$

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87. Solve the differential equation $(x + y)dy = (x - y)dx$

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88. Show that the differential equation $2xy\frac{dy}{dx} = x^2 + 3y^2$ is homogeneousand solve it.

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89. $\frac{dy}{dx} + \frac{x - 2y}{2x - y} = 0$

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90. $y^2 + x^2 \frac{dy}{dx} = xy \frac{dy}{dx}$

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91. Solve $x\left(\frac{dy}{dx}\right) = y(\log y - \log x + 1)$

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92. Solve: $(x-y)\dfrac{dy}{dx}=x+3y$

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93. $\left(x^3+3xy^2\right)dx+\left(y^3+3x^2y\right)dy=0$

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94. Solve: $\left(x-\sqrt{xy}\right)dy=ydx$

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95. Solve the following differential equation:

$$x\frac{dy}{dx}-y=2\sqrt{y^2-x^2}$$

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96. Solve: $y^2dx + \left(x^2 + xy + y^2\right)dy = 0$

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97. Solve the following differential equation:

$$x\frac{dy}{dx}\sin\left(\frac{y}{x}\right) + x - y\sin\left(\frac{y}{x}\right) = 0$$

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98. Solve the differential equation $x^2dy + y(x + y)dx = 0$, given that $y = 1\, when\, x = 1$.

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99. Solve the differential equation $(x+y)dy+(x-y)dx=0$; given that y = 1 when x = 1.

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100. Solve the differential equation : $\left(x\sin^2\left(\frac{y}{x}\right)-y\right)dx+xdy=0$ given $y=\frac{\pi}{4}$ when $x=1$.

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101. Find the particular solution of the differential equation $x\frac{dy}{dx}-y+x\cos ec\left(\frac{y}{x}\right)=0;$ given that $y=0$ when $x=1$.

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103. Solve the differential equation : $\left(1-x^2\right)\frac{dy}{dx}-xy=x$

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104. Solve $\left(x^2+1\right)\frac{dy}{dx}+2xy=\sqrt{x^2+4}$

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105. Solve: $\frac{dy}{dx}+2y=e^{-x}$

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106. Solve the following differential equation:

$$4\frac{dy}{dx} + 8y = 5\,e^{-3x}$$

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107. Solve the following differential equation :

$$\frac{dy}{dx} + 2y = 6e^{x}$$

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108. Solve the following differential equation:

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

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109. Solve the following differential equations: $x\frac{dy}{dx} = x + y$

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110. Solve $\frac{dy}{dx} + 3y = e^{-2x}$

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111. Solve the each of the following differential equation: $x\frac{dy}{dx} + 2y = x^2,\ x \neq 0$

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112. Solve: $\frac{dy}{dx} + y = \cos x$

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113. Solve: $\frac{dy}{dx} + y = e^x$

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114. Solve: $x\frac{dy}{dx} - y = x + 1$

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115. Solve: $\frac{dy}{dx} + y = \cos x = \sin x$

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116. Solve: $\frac{dy}{dx} + \frac{y}{x} = x^n$

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117. Solve the following differential equation:

$\frac{dy}{dx} - y \tan x = e^x \sec x$

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118. Solve: $\left(1 + x^2\right) \frac{dy}{dx} + 2xy = \cos x$

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119. Solve: $(\sec x) \frac{dy}{dx} = y + \sin x$

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120. Solve the following differential equations:

$$\frac{dy}{dx} + y\cos x = \sin x \cos x$$

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121. Solve: $\frac{dy}{dx} + 2y\cot x = 3x^2 \cos ec^2 x$

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122. Solve: $\frac{dy}{dx} + y\tan x = 2x + x^2 \tan x.$

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123. Solve: $x\frac{dy}{dx} = y(\log y - \log x - 1)$

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124. $\left(1 - x^2\right)\frac{dy}{dx} + xy = ax$

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125. Find the particular solution of the differential equation $\frac{dy}{dx} + y\cot x = 2x + x^2\cot x (x \neq 0)$ given that $y = 0$ when $x = \frac{\pi}{2}$.

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126. Solve $ydx + \left(x - y^2\right)dy = 0$

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127. Solve the each of the following differential equation: $(x + 3y^2)\frac{dy}{dx} = y$

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128. Solve: $(x - y^3)\frac{dy}{dx} + y = 0$

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129. Solve: $\frac{dy}{dx} + x \sin 2y = x^3 \cos^2 y = \sin x$

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130. Solve $x\dfrac{dy}{dx} + y = y^2 \ln x.$

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131. $\dfrac{dy}{dx} = x^3y^3 - xy$

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