Gajendra Purohit

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Methods of solving differential equation

Variable separable method

The equation of this type can be put in the form $f(x)dx + g(y)dy = 0$

Integrating both sides, we get the solution

$$\int f(x)dx + \int g(y)dy = C$$

$$x^2 y y' = e^y$$

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

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

$$\int y e^{-y} dy = -\frac{1}{x} + C$$

$$y \int e^{-y} dy - \int \left(\frac{d(y)}{dx} \int e^{-y} dy\right) dx = -\frac{1}{x} + C$$

~~$-ye^{-y} - e^{-y} = -\frac{1}{x} + C$~~

$$x(y+1) = \frac{1}{x} + C$$

$$x(y+1) = (1 + Cx)e^y$$

$y(0) = 0$

$$0(0+1) = (1 + C \cdot 0)e^0$$

$0 = 1$

$0 = 0 \cdot C$

$$\frac{dy}{dx} = \frac{y}{x}$$

$$\frac{dy}{y} = \frac{dx}{x}$$

$\log y = \log x + \log c$

$y = xc$

$1 = c$

$y = x$

unique

$y(1) = 1$

No solution

$y(0) = 1$

$1 \neq 0$

$0 = 0 \cdot c$

$y(0) = 0$

Infinite

$y = 2x$

$y = 3x$

$y = 4x$

$y = 5x$

Q.1. The DE $2x\frac{dy}{dx}=3(2y-1), y(0)=\frac{1}{2}$ has

(a) No solution

(b) Infinite many solution

(c) A unique solution

(d) More than one but only finitely many solutions

$\frac{dy}{2y-1} = \frac{3dx}{2x}$

$\frac{1}{2}\log(2y-1) = \frac{3}{2}\log x + \log c$

$\log(2y-1) = \log x^3 + \log c$

$\log(2y-1) = \log cx^3$

$2y-1 = cx^3$

$= c \cdot 0$

$2\frac{1}{2} - 1$

$0 = 0 \cdot c$

Q.2. The differential equation $y - x\frac{dy}{dx} = 3\left(1 + x^2\frac{dy}{dx}\right)$ s.t

$y(0) = 3$ has

(a) Unique solution

(b) Infinite solution

(c) Two solution

(d) More than two but finite solution

$\frac{1}{x(3x+1)} = \frac{A}{x} + \frac{B}{3x+1}$

$= \frac{1}{x} - \frac{3}{3x+1}$

$y - x\frac{dy}{dx} = 3 + 3x^2\frac{dy}{dx}$

$x^2\frac{dy}{dx} + x\frac{dy}{dx} = y - 3$

$x(3x+1)\frac{dy}{dx} = y - 3$

$\int \frac{dy}{y-3} = \int \frac{dx}{x(3x+1)} + \log c$

$\log(y-3) = \log x - \log(3x+1) + \log c$

$y - 3 = \frac{xc}{3x+1}$

$(y-3)(3x+1) = xc$

$0 = 0 \cdot c$

Q.3. Consider the equation $y' = \frac{-t}{y}$ then which of the following is correct.

(below c_1 is a constant and $y' = \frac{dy}{dt}$)

(a) There exist a solution for $|t| \leq |c_1|$

(b) Solution is not defined for $|t| \geq |c_1|$

(c) Both (a) and (b) are true

(d) Neither (a) nor (b) is true.

$$\frac{dy}{dt} = -\frac{t}{y}$$

$$y\,dy = -t\,dt$$

$$\frac{y^2}{2} = -\frac{t^2}{2} + C$$

$$y^2 + t^2 = 2C$$

$$y^2 = 2C - t^2$$

$$y = \pm\sqrt{2C - t^2}$$

$$C^2 - t^2 \geq 0$$

$$C^2 \geq t^2$$

Q.4. $y(t)$ be the solution of ODE $y'(t) = 1 - y^2(t)$,

$t \in R$. $y : R \to R$, $y(0) = 0$

(a) $y(t) = 1$ for some $t_1 \in R$

(b) $y(t)$ is strictly increasing in R

(c) $y(t) > -1$ for all $t \in R$

(d) $y(t)$ is increasing in $(0, 1)$ and decreasing in $(1, \infty)$

$$\frac{1+y}{1-y} = e^{2t} \Rightarrow 1+y = (1-y)e^{2t}$$

$$1+y = e^{2t} - ye^{2t}$$

$$(1+e^{2t})y = e^{2t} - 1$$

$$y = \frac{e^{2t}-1}{e^{2t}+1}$$

$$y' = \frac{(e^{2t}+1)2e^{2t} - (e^{2t}-1)2e^{2t}}{(1+e^{2t})^2}$$

$$y'(t) = \frac{2e^{2t}}{(1+e^{2t})^2} > 0$$

$$\frac{e^{2t}-1}{e^{2t}+1} > -1$$

$$e^{2t} - 1 > -e^{2t} - 1$$

$$e^{2t} + e^{2t} > 0$$

$$2e^{2t} > 0$$

$$\frac{1}{2}\ln 1 = c = 0$$

$$\frac{1}{2}\ln\frac{(1+y)}{1-y} = t$$

$$\ln\frac{1+y}{1-y} = 2t$$

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Reducible to seperation of variable

If equation of form $\frac{dy}{dx} = f(ax+by+c)$ or $\frac{dy}{dx} = f(ax+by)$ then we can be reduced to an equation in which variable can be separated for this purpose we use substitution

$ax + by + c = v$ or $ax + by = v$

$$\frac{dy}{dx} = \frac{x+2y+5}{2x+4y+7}$$

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

Let $x+y+1 = v$

$$1 + \frac{dy}{dx} = \frac{dv}{dx}$$

$$\frac{dy}{dx} = \frac{dv}{dx} - 1$$

$$\frac{dv}{dx} - 1 = v^2$$

$$\frac{dv}{dx} = v^2 + 1$$

$$\int \frac{dv}{v^2+1} = \int dx$$

$$\frac{1}{1}\tan^{-1}\frac{v}{1} = x + c$$

$$\tan^{-1}(x+y+1) = 2x + 2c$$

$(x+2y-1)dx = (x+2y+1)dy$

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

$x+2y = u$

$1+2\frac{dy}{dx} = \frac{du}{dx}$

$\frac{dy}{dx} = \frac{1}{2}\left(\frac{du}{dx}-1\right)$

$\frac{1}{2}\left(\frac{du}{dx}-1\right) = \frac{u-1}{u+1}$

$\frac{du}{dx} = \frac{2u-2}{u+1}+1$

$\frac{du}{dx} = \frac{3u-1}{u+1}$

$\frac{u+1}{3u-1}du = dx + c$

$\int\left(\frac{1}{3} + \frac{4}{3}\frac{1}{(3u-1)}\right)du = x+c$

$\frac{u}{3} + \frac{4}{9}\int\frac{1}{u-\frac{1}{3}}du = x+c$

$\frac{u}{3} + \frac{4}{9}\ln\left(u-\frac{1}{3}\right) = x+c$

$3u-1$

$u+1$

$u = \frac{1}{3}$

$\frac{4}{3}$

Q.5. Let $(x+y+1)\frac{dy}{dx}=1$ s.t. $y(1)=1$, then

(a) $x+y+2=4\,e^{y-1}$

(b) $x+y-3=-e^{y-1}$

(c) $x+y+1=3\,e^{y-1}$

(d) $x+y+3=5\,e^{y-1}$

Q.6. The general solution of the differential equation $(x + y - 3)dx - (2x + 2y + 1)\,dy = 0$ is

(a) $\ln|3x + 3y - 2| + 3x + 6y = k$

(b) $\ln|3x + 3y - 2| - 3x - 6y = k$

(c) $7\ln|3x + 3y - 2| + 3x + 6y = k$

(d) $7\ln|3x + 3y - 2| - 3x + 6y = k$

Q. 9. Match each differential equation in Group I to its family solution curves from Group II

Group I	**Group II**
A. $\frac{dy}{dx}=\frac{y}{x}$	1. Circles
B. $\frac{dy}{dx}=-\frac{y}{x}$	2. Straight lines
C. $\frac{dy}{dx}=\frac{x}{y}$	3. Hyperbola
D. $\frac{dy}{dx}=-\frac{x}{y}$	

(a) A-2 ,B-3 ,C-3 ,D-1

(b) A-1 ,B-3 ,C-2 ,D-1

(c) A-2 ,B-1 ,C-3 ,D-3

(d) A-3 ,B-2 ,C-1 ,D-2

Q10. Let y(x) be the solution of the differential equation

$$\frac{d}{dx}\left(x\frac{dy}{dx}\right)=x;\ y(1)=0,\ \left.\frac{dy}{dx}\right|_{x=1}=0.$$ Then y(2) is

[IIT-JAM: 2016]

(a) $\frac{3}{4}+\frac{1}{2}\ln 2$

(b) $\frac{3}{4}-\frac{1}{2}\ln 2$

(c) $\frac{3}{4}+\ln 2$

(d) $\frac{3}{4}-\ln 2$

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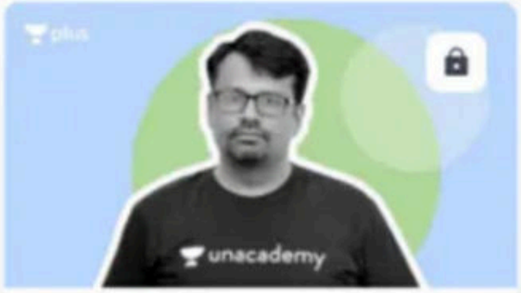

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Educator highlights

- Works at **Pacific Science College**
- 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**
- Unacademy Educator since

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