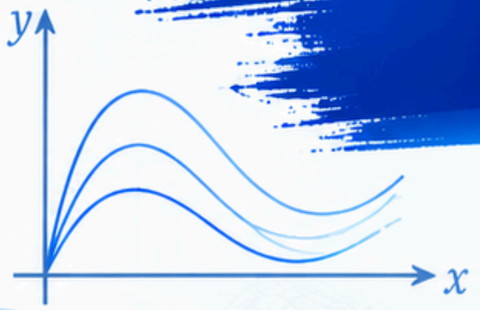
$\frac{dy}{dx} = f(x, y)$

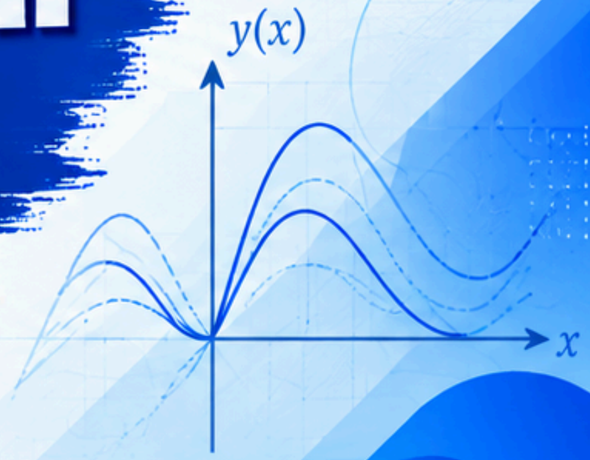
CSIR NET DEC 2026

Ordinary Differential Equations (ODE)

TO-DO LIST

$y'' + p(x)y' + q(x)y = 0$





- Exam Weightage
- YouTube Video Links
- Short Notes
- Previous Year Questions (PYQs)
- Practice Plan
- Important Formulas & Key Concepts

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Ordinary Differential Equations (ODEs)

$$\frac{dy}{dx} = f(x, y)$$

- Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs.

- General theory of homogeneous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.



$$y'' + p(x)y' + q(x)y = 0$$

$$y(x) = \int_a^b G(x,t)f(t)\,dt$$

Ordinary Differential Equations

Topics	YouTube Videos [Click on the LINK to watch the video]
Existence and uniqueness of solutions of initial value problems	WATCH NOW
Singular solutions of first-order ODEs	WATCH NOW
System of first-order ODEs	WATCH NOW
General theory of homogeneous and non-homogeneous linear ODEs	WATCH NOW

Ordinary Differential Equations

Topics	YouTube Videos [Click on the LINK to watch the video]
Variation of parameters	WATCH NOW
Cauchy-Euler Equations	WATCH NOW
Sturm-Liouville boundary value problems	WATCH NOW
Green's Function	WATCH NOW

PREVIOUS YEARS WEIGHTAGE

ANALYSIS OF CSIR-NET / JRF PREVIOUS YEAR PAPER

SUBJECTS	DEC. 2018			SUBJECTS	JUNE. 2019			SUBJECTS	DEC. 2019			SUBJECTS	26 NOV. 2020		
	JRF		LS		JRF		LS		JRF		LS		JRF		LS
	MARKS				MARKS				MARKS				MARKS		
SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL
UNIT - III	24	56	80	UNIT - III	25	57	82	UNIT - III	24	57	81	UNIT - III	24	56	80
ODE	6	9.5	15.5	ODE	6	14.25	20.25	ODE	6	14.25	20.25	ODE	6	14.25	20.25

SUBJECTS	30 NOV. 2020			SUBJECTS	16-Feb-22			SUBJECTS	JUNE. 23			SUBJECTS	DEC. 2023		
	JRF		LS		JRF		LS		JRF		LS		JRF		LS
	MARKS				MARKS				MARKS				MARKS		
SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL
UNIT - III	27	48	75	UNIT - III	24	52	76	UNIT - III	23	52	75	UNIT - III	22	51	83
ODE	9	14.25	23.25	ODE	6	14.25	20.25	ODE	6	12	18	ODE	7	14	21

SUBJECTS	JULY. 2024			SUBJECTS	FEB. 2025			SUBJECTS	JULY. 2025			SUBJECTS	DEC. 2025		
	JRF		LS		JRF		LS		JRF		LS		JRF		LS
	MARKS				MARKS				MARKS				MARKS		
SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL	SECTIONS	PART B	PART C	TOTAL
UNIT - III	24	55	79	UNIT - III	24	52.25	76.25	UNIT - III	21	52.25	73.25	UNIT - III	21	47.5	68.5
ODE	6	14	20	ODE	6	14.25	20.25	ODE	6	14.25	20.25	ODE	6	14.25	20.25

Weightage of Ordinary Differential Equation in CSIR NET

MARKS	NO. OF QUESTIONS
16 - 19	4 - 5

CSIR NET JULY 2026

	Topic	Marks	No. of Questions
1	Second order Constant coefficient	4.75	1
2	Initial value problem	3	1
3	Boundary value problem	4.75	1
4	Second order ODE (Normal form)	4.75	1

CSIR NET DEC. 2025

	Topic	Marks	No. of Questions
1	Wronskian	3	1
2	Initial value problem	3	1
3	Zero of solution	4.75	1
4	Series solution	4.75	1

CSIR NET JULY 2025

	Topic	Marks	No. of Questions
1	Second order ODE	4.75 + 3	2
2	General theory of ODE	4.75	1
3	Initial value problem	3	1
4	Boundary value problem	3	1

SHORT NOTES

Differential equation

An equation which contains independent variables, dependent variables and their derivatives w.r.t. independent variables is called differential equation.

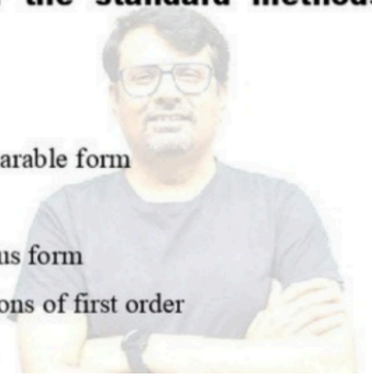
Equations of first order and first degree

A General differential equation of first order and first degree is of the form

$\frac{dy}{dx} = f(x,y)$ or $Mdx + Ndy$ where M, N are functions of x and y both.

Following are some of the standard methods to solve differential equations

1. Variable separable form
2. Reducible to variable separable form
3. Homogeneous equation
4. Reducible to homogeneous form
5. Linear differential equations of first order
6. Reducible to linear form



Case I: Variable separable: An equation whose variables are separable and can be put in the form $g(x)dx+h(y)dy=0$ is called an equation of variable separable form. Integrating, $\int g(x)dx + \int h(y)dy = c$, where c is an arbitrary constant. This is the general solution of the differential equation.

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Case II: Equations reducible to variable separable:

To solve the equation $\frac{dy}{dx} = f(ax+by+c)$ ..... (1)

Method to solve:

Put $ax + by + c = z$ so that $a + b\frac{dy}{dx} = \frac{dz}{dx}$ *i.e.* $\frac{dy}{dx} = \frac{1}{b}\left(\frac{dz}{dx} - a\right)$

Putting in (1) $\frac{1}{b}\left(\frac{dz}{dx} - a\right) = f(z) \Rightarrow \frac{dz}{dx} = a + bf(z)$ which is of the type "Variable Separable" and hence can be solved.

Case III: Homogeneous Equations :

To solve the equation $\frac{dy}{dx} = \frac{f(x,y)}{\phi(x,y)}$ where $f(x,y)$ and $\phi(x,y)$ are both homogeneous functions of the same degree in x and y.

(i) Put y = vx so that $\frac{dy}{dx} = v + x\frac{dv}{dx}$ (ii) Proceed as in Case I.

Case IV: Equations reducible to homogeneous equations

To solve the equation $\frac{dy}{dx} = \frac{a_1x + b_1y + c_1}{a_2x + b_2y + c_2}$

(1) For, $\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$ we have

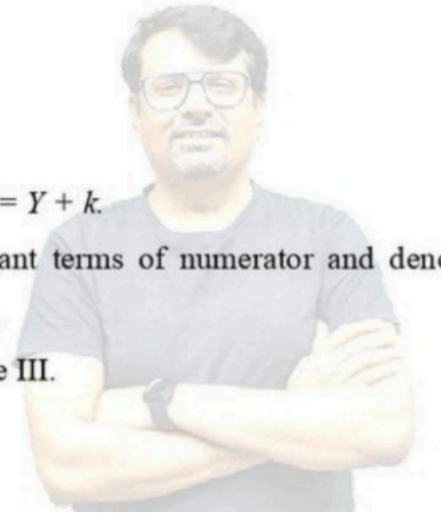
Method to solve:

(i) Put $x = X + h$, $y = Y + k$.

(ii) Equate the constant terms of numerator and denominator to zero and find the values of h and k.

(iii) Proceed as in case III.

(2) For, $\frac{a_1}{a_2} = \frac{b_1}{b_2}$ we have



Method to solve:

(i) Put $a_1x + b_1y = v$

(ii) The equation gets reduced to variable separable form in v and x.

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Case V: Linear differential equations of first order

The solution of $\frac{dy}{dx} + P(x)y = Q(x)$ where P and Q are functions of x only, is given by

$y.e^{\int Pdx} = \int e^{\int Pdx} Qdx + C$ where C is a constant and integrating factor = $e^{\int Pdx}$.

Case VI: Equations reducible to linear differential equation

To Solve the equation $\frac{dy}{dx} + Py = Qy^n$ where P and Q are functions of x.

Method to solve

(i) Dividing throughout by y^n.

(ii) Putting $y^{1-n} = z$ and get the linear equation in z.

(iii) Proceed as in Case V.

Case VII: Exact Differential Equation

Definition: The equation Mdx + Ndy = 0 is exact if $\frac{\partial M}{\partial y} = \frac{\partial N}{\partial x}$ and its solution is

$$\int_{\text{treating } y \text{ as constant}} Mdx + \int (\text{terms of } N \text{ not containing } x)dy = c$$ where c is constant.

The Wronskian : The Wronskian of n functions $y_1(x)$, $y_2(x)$ ..... $y_n(x)$ is denoted by

$$w(x) \text{ or } w(y_1, y_2, \ldots, y_n) = \begin{vmatrix} y_1 & y_2 & \cdots & y_n \\ y_1' & y_2' & \cdots & y_n' \\ \vdots & \vdots & \vdots & \vdots \\ y_1^{(n-1)} & y_2^{(n-1)} & \cdots & y_n^{(n-1)} \end{vmatrix}$$

Let $a_0(x)\, y'' + a_1(x)\, y' + a_2(x)\, y = 0$

Where $a_0(x)$, $a_1(x)$, $a_2(x)$ are continuous and $a_0(x) \neq 0 \ \forall\, x$

If $y_1(x)$ and $y_2(x)$ are solution

Then $W(y_1, y_2) = \begin{vmatrix} y_1 & y_2 \\ y_1' & y_2' \end{vmatrix} = y_1 y_2' - y_2 y_1'$

Able's Formula:

$W(y_1, y_2) = Ae^{-\int \frac{a_1(x)}{a_0(x)} dx}$ is called Able's formula.

Linear differential equation with constant coefficients

A linear differential equation with constant coefficients is one in which the dependent variable and its differential coefficients occur only in the first degree and are not multiplied together.

$$P_0 \frac{d^n y}{dx^n} + P_1 \frac{d^{n-1} y}{dx^{n-1}} + \ldots\ldots + P_n y = Q$$

Auxiliary Equation (A.E.): Auxiliary equation is obtained by equating to zero the symbolic coefficients of y. Thus, $D^n + a_1 D^{n-1} + \ldots\ldots + a_n = 0$ is the auxiliary equation.

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Method to solve the equation: $P_0\frac{d^n y}{dx^n} + P_1\frac{d^{n-1}y}{dx^{n-1}} + \ldots\ldots + P_n y = 0$, where $P_0, P_1, P_2, \ldots. P_n$ are constants.

(i) Write the equation in the symbolic form as : $(P_0D^n + P_1D^{n-1} + P_2D^{n-2} + \ldots + P_n)y=0$.

(ii) Write down the auxiliary equation (A.E.) as: $P_0m^n + P_1m^{n-1} + \ldots + P_n = 0$. Solve it for m

(iii) From the roots of A.E. write down the corresponding part of the complete solution (C.S.) as follows:

Roots of A.E.	**Corresponding parts of C.S.**
One real root m_1.	$c_1e^{m_1x}$
Two real and distinct roots m_1, m_2	$c_1e^{m_1x} + c_2e^{m_2x}$
Two real and equal roots m_1, m_1	$e^{m_1x}(c_1 + c_2x)$
Three real and equal roots m_1, m_1, m_1	$e^{m_1x}(c_1 + c_2x + c_3x^2)$
One pair of imaginary and different roots $\alpha \pm i\beta$	$e^{\alpha x}(c_1\cos\beta x + c_2\sin\beta x)$
Two pairs of imaginary and equal roots $\alpha \pm i\beta, \alpha \pm i\beta$	$e^{\alpha x}[(c_1 + c_2x)\cos\beta x + (c_3 + c_4x)\sin\beta x]$

Standard Cases of particular integral

* Determination of PI of $f(D)y = Q$

(1) General method for PI $\frac{1}{D-\alpha}Q = e^{\alpha x}\int Q.e^{-\alpha x}dx$

(2) $\frac{1}{f(D)}e^{\alpha x} = \frac{1}{f(\alpha)}e^{\alpha x}$;Provided $f(\alpha) \neq 0$

(3) $\frac{1}{(D-\alpha)^r\,\phi(D)}e^{\alpha x} = \frac{1}{\phi(\alpha)}\frac{x^r}{r!}e^{\alpha x}$

(4) $\frac{1}{\phi(D^2)}\sin ax = \frac{1}{\phi(-a^2)}\sin ax$ If $\phi(-a^2)$ is non-zero.

If $\phi(-a^2) = 0$ then $\frac{1}{\phi(D^2)}\sin ax = x\frac{1}{\frac{d}{dD}(D^2)}\sin ax$

Same for cosax

(5) $\frac{1}{f(D)}e^{\alpha x}V = e^{\alpha x}\frac{1}{f(D+\alpha)}V$

(6) $\frac{1}{f(D)}xV = x\frac{1}{f(D)}V + \left(\frac{d}{dD}\frac{1}{f(D)}\right)V$

(7) Method to evaluate $\frac{1}{f(D)}x^m$, where m is positive integer, is as follows :

(i) From f(D), take the lowest degree term outside. Then the remaining factor will be of the type $[1 \pm \phi(D)]$.

(ii) Take $[1 \pm \phi(D)]$ to the numerator and expand it by Binomial Theorem

(iii) Operate each term on x^m.

Linear differential equations with variable coefficients

Cauchy's Linear Equation :

A homogeneous linear equation is of the form $P_0x^n\frac{d^ny}{dx^n} + P_1x^{n-1}\frac{d^{n-1}y}{dx^{n-1}} + \ldots\ldots + P_ny = Q(x)$ where

$P_0, P_1, \ldots, P_n$ are all real constants and Q(x) is a function of x, is called Cauchy's linear equation.

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Method to solve

(i) Put $x = e^z$, i.e., $z = \log x$, $x > 0$

(ii) Put $\frac{d}{dz} = D$ so that $xD = D, x^2D^2 = D(D-1), x^nD^n = D(D-1)\ldots.(D-n+1)$

Putting these in the given equation, we get

$[P_0D(D-1)\ldots.(D-n+1) + P_1D(D-1)\ldots(D-n+2) + \ldots\ldots + P_n]y = Q(e^z)$,

which is linear equation with constant coefficients and solve for y in terms of z.

(iii) Put z = log x, and we get the required solution.

Method of variation of parameter

Working rule for $\frac{d^2y}{dx^2} + P(x)\frac{dy}{dx} + Q(x)y = f(x)$

I. Take f(x) = 0, which gives $\frac{d^2y}{dx^2} + P(x)\frac{dy}{dx} + Q(x)y = 0$ … (2)

Let $y = c_1y_1 + c_2y_2$ be the CF of (2)

II. General solution of (1) is y = CF + PI

$$PI = u_1y_1 + u_2y_2 \text{ Where } u_1 = -\int \frac{y_2 f(x)}{W}dx \text{ and } u_2 = \int \frac{y_1 f(x)}{W}dx$$

Where W is the wronskian of the two functions y_1 and y_2.

$$W = \begin{vmatrix} y_1 & y_2 \\ y'_1 & y'_2 \end{vmatrix}$$

The Lipschitz Condition

Let f(x, y) be a function defined for (x, y) in a set S then f is said to satisfy Lipschitz condition on S if ∃ k ∈ Z^+ s.t. $|f(x, y_1) - f(x, y_2)| \le k|y_1 - y_2|$ ∀ $(x, y_1), (x, y_2)$ ∈ S.

Then constant k is called Lipschitz constant.

Existence and Uniqueness theorem

If the Initial Value Problem $y' = f(x, y), y(x_0) = y_0$

Then function is continuous in a rectangle R R : $|x - x_0| \le a, |y - y_0| \le b$

And satisfying lipschitz condition in R then ∃ a unique solution y = y(x) on an interval I : $|x - x_0| \le h$ of the IVP, where $h = \min\left\{a, \frac{b}{M}\right\}$ & M = max |f(x, y)| in R

System of ODE

A pair of linear differential equations $\frac{dy}{dx} = f(x, y)$ and $\frac{dy}{dx} = g(x, y)$ is called system of linear differential equation and it is denoted by Y' = AY Where A is Auxiliary matrix of this system, where $A = \begin{bmatrix} f_x & f_y \\ g_x & g_y \end{bmatrix}_{(a,b)}$ and (a ,b) is critical point

Class of Critical point

λ_1&λ_2 are eigen value of A	
(1) $\lambda_1 \neq \lambda_2$ are real with same sign	Node
(2) $\lambda_1 \neq \lambda_2$ and real with opposite sign	Saddle point
(3) $\lambda_1 = \lambda_2 = \lambda \in R$	Node
(4) $\lambda_1 = \alpha + i\beta$&$\lambda_2 = \alpha - i\beta$ $\beta \neq 0$ (a) $\alpha \neq 0$ (b) $\alpha = 0$	 Spiral point Centre point

Stability of Critical point

1	$\lambda_1 \neq \lambda_2$ with same sign	(a) $\lambda_1 > 0$ &$\lambda_2 > 0$ (b) $\lambda_1 < 0$ &$\lambda_2 < 0$	Unstable Asymptotic stable
2.	$\lambda_1\lambda_2 < 0$ $\lambda_1, \lambda_2 \in R$		Unstable
3.	$\lambda_1 = \lambda_2 = \lambda = R$	(a) $\lambda > 0$ (b) $\lambda < 0$	Unstable Asymptotic stable
4.	$\lambda = \alpha \pm i\beta$		
5.	$\alpha \neq 0$	(i) $\alpha > 0$ (ii) $\alpha < 0$	Unstable Asymptotic stable
	$\alpha = 0$		Stable but not Asymptotic stable

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Boundary Value Problem

The most general second order ordinary linear differential equation is

$$P(x)y'' + Q(x)y' + R(x)\,y = S(x)$$

Now consider the following types of boundary condition at two point $x = a$ and $x = b$

(1) $a_0y(a) + a_1y'(a) = c_1$; $b_0y(b) + b_1y'(b) = c_2$ is called regular condition.

(2) $y(a) = y(b)$; $y'(a) = y'(b)$ is called periodic condition.

The bounded condition are said to be homogeneous if both c_1 & c_2 are zero.

-:Previous Year Questions :-

NOTE:- click on above text you can refer to link of video solution of questions

1. For a continuous function q defined on R, consider the ordinary differential equation (ODE) $\frac{d^2y}{dx^2} + q(x)y = 0, x \in R$. Then which of the following statements are false?

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(a) There exists a q such that cos(x) and $e^x\cos(x)$ are solutions of ODE

(b) There exists a q such that sin(x) and cos(x) are solutions of ODE

(c) There exists a q such that $e^x\sin(x)$ and $e^x\cos(2x)$ are solutions of ODE

(d) There exists a q such that xe^x and $x(x-1)e^x$ are solutions of ODE.

2. Consider the ordinary differential equation (ODE)

CSIR NET JUNE 2025 $\frac{d^2y}{dx^2} + (\cos(x))\frac{dy}{dx} + (\sin(x))y = 0$

Let $\varphi_1(x)$, $\varphi_2(x)$ be solutions of the ODE, satisfying $\varphi_1(0) = 1, \frac{d\varphi_1}{dx}(0) = 0$ and $\varphi_2(0) = 0, \frac{d\varphi_2}{dx}(0) = 1$. Then which of the following statements are true?

(a) $\varphi_1(x + 2\pi)$ is also a solution of ODE.

(b) $\varphi_2(x + 4\pi)$ is also a solution of ODE.

(c) There is NO constants a, b such that $\varphi_2(x + 4\pi) = a\varphi_1(x) + b\varphi_2(x)$

(d) There exists a, b $\in$ R such that $\varphi_1(x + 2\pi) = a\varphi_1(x) + b\varphi_2(x)$

3. Let $D = \{(x, y) \in R^2 : -1 \le x \le 1, -1 \le y \le 1\}$, and $f : D \to R$ be the function defined by $f(x, y) = 1 + \sqrt{y_+}$, where $y_+ = \max\{y, 0\}$.

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Consider the initial value problem (IVP) $\frac{dy}{dx} = f(x, y), y(0) = 0$.

Then which of the following statements are true?

(a) f is a Lipschitz continuous function on D

(b) f is NOT a Lipschitz continuous function on D

(c) IVP has at least one solution

(d) IVP has NO solution

4. Let $(\lambda_n)_{n\in N}$ be the sequence of eigenvalues of the Strum-Liouville problem $\frac{d}{dx}\left(x\frac{dy}{dx}\right) + \frac{\lambda}{x}y = 0, 1 < x < e^{2\pi}$, $y(1) = 0, y(e^{2\pi}) = 0$. Then $\sum_{n=1}^{\infty}\frac{1}{\lambda_n}$ is equal to

CSIR NET JUNE 2025

(a) $\frac{\pi^2}{12}$ (b) $\frac{2\pi^2}{3}$ (c) $\frac{\pi^2}{4}$ (d) $\frac{\pi^2}{16}$

5. If $\varphi(x) = x$ is a solution of the ordinary differential equation (ODE) $y'' - \left(\frac{2}{x} + 1\right)\frac{dy}{dx} + \left(\frac{2}{x^2} + \frac{1}{x}\right)y = 0$. Then the general solution of the ODE is given by **CSIR NET JUNE 2025**

(a) $(a + be^{-2x})x$; $a, b \in R$ (b) $(a + be^{2x})x$; $a, b \in R$

(c) $ae^x + bx$; $a, b \in R$ (d) $(a + be^x)x$; $a, b \in R$

6. Let $u = u(x, t)$ be the solution of **CSIR NET JUNE 2025**

$$\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0, x \in R, t > 0$$

$u(x, 0) = 1 + x^2$, $x \in R$

$$\frac{\partial u}{\partial t}(x, 0) = x + 1, x \in R$$

Then the value of $u(1, 1)$ is

(a) 2 (b) 3 (c) 4 (d) 5

7. Consider the Cauchy problem $x\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}=1,\ u(0,y)=e^{y}, y\in R$

Then which of the following statements are true?

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(a) There is NO neighbourhood of the origin on which (CP) has a solution.

(b) (CP) has a unique solution defined on some neighbourhood of the origin

(c) (CP) has a unique solution defined on some neighbourhood of the point (0, 1) in the xy-plane.

(d) (CP) has an infinite number of solutions, each of which is defined on some neighbourhood of the origin.

8. Let u = u(x, y) be the solution to the Cauchy problem

$(y+u)\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}=x-y, x\in R, y>0$
$u(x,1)=1+x, \qquad x\in R$

. Then which of the following statements is true? **CSIR NET JUNE 2025**

(a) u(1, 1) = 2

(b) u(2, 2) = 4

(c) u(3, 3) = 3/2

(d) u(4, 4) = 2/3

9. Given that $y_1(x)=e^{2x}$ is a solution of the ordinary differential equation (ODE)

$$x\frac{d^2y}{dx^2}-(3+4x)\frac{dy}{dx}+(4x+6)y=0,\ x>0$$

Let $y_2=y_2(x)$ be the solution of the ODE satisfying the conditions

$$y_2(1)=\frac{e^2}{4}, y_2'(1)=\frac{3}{2}e^2$$

Then which of the following statement is true? **CSIR-NET-DEC (2024)**

(a) y_2 is a strictly increasing function on $(0, \infty)$

(b) $e^{-2x}y_2(x)\to 1$ as $x\to\infty$

(c) y_2 is a strictly decreasing function on $(0, \infty)$

(d) $e^{-2x}y_2(x)\to 0$ as $x\to\infty$

10. Let $u=c_1(x, y)$ be the solution of the Cauchy problem

$$x\frac{\partial u}{\partial x}+y\frac{\partial u}{\partial y}=u, \qquad (x,y)\neq(0,0)$$

$$u(x,1)=\sqrt{1+x^2}, x\in 1R$$

Then which of the following statement is true?
CSIR-NET-DEC (2024)

(a) u(1, 0) = 0

(b) $u(x_1, y_1)=u(x_2, y_2)$ whenever $x_1^2+y_1^2=x_2^2+y_2^2$

(c) $u(1, y)=\sqrt{2}$ for all $y\in R$

(d) $u(x_1, y_1)=u(x_2, y_2)$ whenever $x_1+y_1=x_2+y_2$

11. Suppose that the differential equation $\frac{d^2y}{dx^2}+p(x)\frac{dy}{dx}+e^{2x}y=0,\ x\in R$ transform into a second order differential equation with constant coefficients under the change of independent variable given by S = s(x) satisfying $\frac{ds}{dx}(0)=1$. Then which of the following statement is true? **CSIR-NET-DEC (2024)**

(a) $e^{-x}p(x)$ is a constant function on R

(b) $e^{-2x}p(x)$ is a constant function on R

(c) $s(x)=\frac{e^{2x}}{2}, x\in R$

(d) $p(x)\to 1$ as $x\to\infty$

12. Let $u = u(x, t)$ be a solution of the wave equation $\frac{\partial^2 u}{\partial t^2}-\frac{\partial^2 u}{\partial x^2}=0,\ x\in R,\ t>0,$ satisfying the condition $u(0, t) = 0,\ \forall\ t\geq 0.$

Then which of the following statements is true? **CSIR-NET-DEC (2024)**

(a) $u(x, t) = 0$, whenever $x = t$

(b) $u(x, t) = 0$ whenever $x = -t$

(c) $u(-x, t) = u(x, t)$, whenever $x > 0, t > 0$

(d) $u(-x, t) = -u(x, t)$, whenever $0 < x \leq t$

13. Consider the non-homogeneous ordinary differential equation

$$\frac{d^2y}{dx^2}+5\frac{dy}{dx}+6y=\sin\left(e^{-5x}\right),\ x>0$$

Then which of the following statement are true?
CSIR-NET-DEC (2024)

(a) Every solution of the DE is bounded on $(0, \infty)$

(b) There exist a solution of the ODE which is unbounded on $(0, \infty)$

(c) Every solution of the ODE is unbounded on $(0, \infty)$

(d) Every solution of the ODE tends to zero as $x\to\infty$

14. If $x = x(t), y = y(t)$ is the solution of the initial value problem

$$\frac{dx}{dt}=x-4e^{-2t}y$$

$$\frac{dy}{dt}=e^{2t}x-y$$

$x(0) = 1, y(0) = 1$

Then which of the following statement are true?
CSIR-NET-DEC (2024)

(a) $\lim_{x\to\infty} t^{-2}x(t)y(t)=0$

(b) $x(1)=0, y\left(\frac{1}{2}\right)=0$

(c) $x\left(\frac{1}{2}\right)=0, y(1)=0$

(d) $\lim_{x\to\infty} t^{2}x(t)y(t)=2$

15. Let $u = u(x, t)$ be the solution of the initial boundary value problem

$$\frac{\partial u}{\partial t} = \frac{\partial^2 u}{dx^2}, (x,t) \in (0,1) \times (0,\infty)$$

$$u(x,0) = 4x(1-x), x \in [0,2]$$

$$u(0,t) = u(1,t) = 0,\ t \geq 0$$

Then which of the following statement are true?

CSIR-NET-DEC (2024)

(a) $\lim_{t \to \infty} u(x,t) = 0$ for all, $x \in (0,1)$

(b) $u(x,t) = u(1-x,t)$ for all $x \in (0,1), t > 0$

(c) $\int_0^1 u(x,t)^2 dx$ is a non-increasing function of t

(d) $\int_0^1 u(x,t)^2 dx$ is a non-decreasing function of t

16. For $b \in R$, let $y_b = y_b(x)$ be the unique solution of the initial value problem.

$$\frac{dy}{dx} = y^5 + y^4 + y^3 + y^2 + y + 1,\ y(0) = b$$

Defined on its maximal interval of existence I_b. Then which of the following statement are true? **CSIR-NET-DEC (2024)**

(a) These exists an $a \in (0, \infty)$, such that for every $b \in R$ with $b > \alpha$, the solution y_b is bounded above on I_b.

(b) There exist an $a \in (0, \infty)$ such that for every $b \in R$ with $b > \alpha$ the solution y_b is bounded below on I_b.

(c) There exists an $\alpha \in (-\infty, 0)$ such that for every $b \in R$ with $b < \alpha$ the solution y_b is bounded above on I_b.

(d) The exists an $\alpha \in (-\infty, 0)$ such that for every $b \in R$ with $b < \alpha$, the solution y_b is bounded below on I_b.

17. If $x_1 = x_1(t), x_2 = x_2(t)$ is the solution of the initial value problem.

$$e^{-t}\frac{dx_1}{dt} = -x_1 + x_2$$

$$e^{-t}\frac{dx_2}{dt} = -x_1 - x_2$$

$x_1(0) = 1, x_2(0) = 0$ and $r(t) = \sqrt{x_1^2(t) + x_2^2(t)}$.

Then which of the following statements are true? **CSIR-NET JUNE (2024)**

(a) $x(t) \to 0$ as $t \to +\infty$ (b) $r(\ln 2) = e^{-1}$

(c) $x(\ln 2) = 2e^{-1}$ (d) $r(t)\, e^t \to 0$ as $t \to +\infty$

18. Let φ denote the solution to the boundary value problem (BVP)

$$\begin{cases} (xy')' - 2y' + \dfrac{y}{x} = 1, & 1 < x < e^4 \\ y(1) = 0, \quad y(e^4) = 4e^4 \end{cases}$$

. Then the value of $y(e)$ is

CSIR-NET JUNE (2024)

(a) $-e/2$ (b) $-e/3$ (c) $e/3$ (d) e

19. Consider the initial value problem (IVP) $y'(x) = \dfrac{\sin(y(x))}{1 + y^4(x)}, x \in R; y(0) = y_0$.

Then which of the following statements are true?
CSIR-NET JUNE (2024)

(a) There is a positive y_0 such that the solution of the IVP is unbounded

(b) There is a negative y_0 such that the solution of the IVP is bounded

(c) For every $y_0 \in R$, every solution of the IVP is bounded.

(d) For every $y_0 \in R$, there is a solution to the IVP for all $x \in R$

20. Consider the initial value problem (IVP) $\begin{cases} y'(x) = \sqrt{|y(x) + \varepsilon|}, x \in R \\ y(0) = y_0 \end{cases}$.

Consider the following statements : **CSIR-NET JUNE (2024)**

S_1 : There is an $\varepsilon > 0$ such that for all $y_0 \in R$, the IVP has more than one solution.

S_2 : There is a $y_0 \in R$ such that for all $\varepsilon > 0$, the IVP has more than one solution.

Then

(a) both S_1 and S_2 are true (b) S_1 is true but S_2 is false

(c) S_1 is false but S_2 is true (d) both S_1 and S_2 are false.

21. Given that $y_1(x) = e^{2x}$ is a solution of the ordinary differential equation (ODE)

$$x\frac{d^2y}{dx^2}-(3+4x)\frac{dy}{dx}+(4x+6)y=0,\ x>0$$

Let $y_2 = y_2(x)$ be the solution of the ODE satisfying the conditions

$$y_2(1)=\frac{e^2}{4}, y_2'(1)=\frac{3}{2}e^2$$

Then which of the following statement is true? **CSIR-NET-FEB (2025)**

(a) y_2 is a strictly increasing function on $(0, \infty)$

(b) $e^{-2x}y_2(x)\to 1$ as $x\to\infty$

(c) y_2 is a strictly decreasing function on $(0, \infty)$

(d) $e^{-2x}y_2(x)\to 0$ as $x\to\infty$

22. Suppose that the differential equation $\frac{d^2y}{dx^2}+p(x)\frac{dy}{dx}+e^{2x}y=0,\ x\in R$

transform into a second order differential equation with constant coefficients under the change of independent variable given by S = s(x) satisfying $\frac{ds}{dx}(0)=1$. Then which of the following statement is true? **CSIR-NET-FEB (2025)**

(a) $e^{-x}p(x)$ is a constant function on R

(b) $e^{-2x}p(x)$ is a constant function on R

(c) $s(x)=\frac{e^{2x}}{2}, x\in R$

(d) $p(x)\to 1$ as $x\to\infty$

23. Consider the non-homogeneous ordinary differential equation

$$\frac{d^2y}{dx^2}+5\frac{dy}{dx}+6y=\sin\left(e^{-5x}\right),\ x>0$$

Then which of the following statement are true?

(a) Every solution of the DE is bounded on (0, ∞)

(b) There exist a solution of the ODE which is unbounded on (0, ∞)

(c) Every solution of the ODE is unbounded on (0, ∞)

24. If x = x (t), y = y(t) is the solution of the initial value problem

$$\frac{dx}{dt}=x-4e^{-2t}y$$

$$\frac{dy}{dt}=e^{2t}x-y$$

x (0) = 1, y(0) = 1

Then which of the following statement are true? **CSIR-NET-FEB (2025)**

(a) $\lim_{x\to\infty} t^{-2}x(t)y(t)=0$

(b) $x(1)=0, y\left(\frac{1}{2}\right)=0$

(c) $x\left(\frac{1}{2}\right)=0, y(1)=0$

(d) $\lim_{x\to\infty} t^{2}x(t)y(t)=2$

25. For $b \in R$, let $y_b = y_b(x)$ be the unique solution of the initial value problem.

$$\frac{dy}{dx} = y^5 + y^4 + y^3 + y^2 + y + 1,\ y(0) = b$$

Defined on its maximal interval of existence I_b. Then which of the following statement are true?

(a) These existsan $a \in (0, \infty)$, such that for every $b \in R$ with $b > \alpha$, the solution y_b is bounded above onI_b.

(b) There exist an $a \in (0, \infty)$ such that for every $b \in R$ with$b > \alpha$ the solution y_b is bounded below on I_b.

(c) There exists an $\alpha \in (-\infty, 0)$such that for every $b \in R$ with $b < \alpha$ the solution y_b is bounded above on I_b.

(d) The exists an $\alpha \in (-\infty, 0)$ such that for every $b \in R$ with $b < \alpha$, the solution y_b is bounded below on I_b.

26. For a continuous function q defined on R, consider the ordinary differential equation (ODE) $\frac{d^2y}{dx^2} + q(x)y = 0, x \in R$. Then which of the following statements are false?

CSIR NET JUNE 2025

(a) There exists a q such that cos(x) and $e^x\cos(x)$ are solutions of ODE

(b) There exists a q such that sin(x) and cos(x) are solutions of ODE

(c) There exists a q such that $e^x\sin(x)$ and $e^x\cos(2x)$ are solutions of ODE

(d) There exists a q such that xe^x and $x(x-1)e^x$ are solutions of ODE.

27. Consider the ordinary differential equation (ODE) **CSIR NET JUNE 2025**

$$\frac{d^2y}{dx^2}+(\cos(x))\frac{dy}{dx}+(\sin(x))y=0$$

Let $\varphi_1(x)$, $\varphi_2(x)$ be solutions of the ODE, satisfying $\varphi_1(0)=1, \frac{d\varphi_1}{dx}(0)=0$ and $\varphi_2(0)=0, \frac{d\varphi_2}{dx}(0)=1$. Then which of the following statements are true?

(a) $\varphi_1(x + 2\pi)$ is also a solution of ODE.

(b) $\varphi_2(x + 4\pi)$ is also a solution of ODE.

(c) There is NO constants a, b such that $\varphi_2(x + 4\pi) = a\varphi_1(x) + b\varphi_2(x)$

(d) There exists a, b $\in$ R such that $\varphi_1(x + 2\pi) = a\varphi_1(x) + b\varphi_2(x)$

28. Let $D = \{(x, y) \in R^2 : -1 \le x \le 1, -1 \le y \le 1\}$, and $f : D \to R$ be the function defined by $f(x,y)=1+\sqrt{y_+}$, where $y_+ = \max\{y, 0\}$. **CSIR NET JUNE 2025**

Consider the initial value problem (IVP) $\frac{dy}{dx}=f(x,y), y(0)=0$.

Then which of the following statements are true?

(a) f is a Lipschitz continuous function on D

(b) f is NOT a Lipschitz continuous function on D

(c) IVP has at least one solution

(d) IVP has NO solution

29. Let $(\lambda_n)_{n\in N}$ be the sequence of eigenvalues of the Strum-Liouville problem

$$\frac{d}{dx}\left(x\frac{dy}{dx}\right)+\frac{\lambda}{x}y=0, 1<x<e^{2\pi},$$
$$y(1)=0, y(e^{2\pi})=0$$

Then $\sum_{n=1}^{\infty}\frac{1}{\lambda_n}$ is equal to **CSIR NET JUNE 2025**

(a) $\frac{\pi^2}{12}$ (b) $\frac{2\pi^2}{3}$ (c) $\frac{\pi^2}{4}$ (d) $\frac{\pi^2}{16}$

30. If $\varphi(x) = x$ is a solution of the ordinary differential equation (ODE)

$$y''-\left(\frac{2}{x}+1\right)\frac{dy}{dx}+\left(\frac{2}{x^2}+\frac{1}{x}\right)y=0$$

Then the general solution of the ODE is given by **CSIR NET JUNE 2025**

(a) $(a + be^{-2x})x$; $a, b \in R$ (b) $(a + be^{2x})x$; $a, b \in R$

(c) $ae^x + bx$; $a, b \in R$ (d) $(a + be^x)x$; $a, b \in R$

31. $y''+(e^{x^2}+\cos x)y=0$, $y_1(0)=3$, $y_2(0)=-5$, $y_1'(0)=-1$ & $y_2'(0)=\alpha$ and $w(1/2)=4$, then what is the value of α? CSIR NET DEC 2025

(a) 2 (b) 3 (c) -3 (d) 4

Q32 Let $y(x) = xe^x$ be a solution of the differential equation

$y'' + \alpha y' + \beta y = 0$, where α and β are real numbers. If $p = p(x)$ is the solution of $p'' + \alpha p' + \beta p = \frac{e^x}{x}; x > 0,\ p(1) = p'(1) = e,$

then which of the following statements is/are true?

CSIR NET JULY 2026

(a) $(\alpha + \beta)^2 = 1$

(b) $(\alpha + \beta)^2 = 2$

(c) $p(e) = 2e^e$

(d) $p(e) = e^{(e+1)}$

Q33Consider the following three statements: **CSIR NET JULY 2026**

- **S1:** The initial value problem: $2(y')^2 + 7y^2 + 10 = 0,\ y(0) = 1$ has a unique solution in $\mathbb{R}$.
- **S2:** Let $D = \{(x, y) \in \mathbb{R}^2 : |x - 1| \leq 1, |y - 2| \leq 2\}$. Then the initial value problem

  $y' = x^2 + y^4,\ y(1) = 2$ defined on D has a unique solution for $x \in \left(\frac{129}{130}, \frac{131}{130}\right)$.
- **S3:** On $\mathbb{R}$, the functions x^3 and $x^2|x|$ are linearly dependent solutions of $x^2y'' - 4xy' + 6y = 0$.

Then

(a) S1 is true but S2 is FALSE

(b) Both S1 and S3 are FALSE

(c) S2 is true but S3 is FALSE

(d) S3 is true but S2 is FALSE

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Q34 For $n \in \mathbb{N}$, let y_n be the eigenfunction corresponding to the eigenvalue λ_n for the Sturm–Liouville problem

$$x(xy')' + \lambda y = 0; \quad y'(1) = 0, \quad y(e) = 0,$$

where e is the base of natural logarithm. Then which of the following statements is/are true?

(a) $\lambda_n = \frac{(2n-1)^2\pi^2}{e^2}$

(b) $\lambda_n = \frac{(2n-1)^2\pi^2}{4}$

(c) $y_n = \cos\left(\frac{(2n-1)\pi x}{e}\right)$

(d) $y_n = \cos\left(\frac{(2n-1)\pi \log_e x}{2}\right)$

Q35 Let $y_1 = y_1(x)$ and $y_2 = y_2(x)$ be two linearly independent solutions of the differential equation $y'' - 4xy' + (4x^2 - 1)y = 0$, $x \in \mathbb{R}$. Which of the following statements is/are true for all $x \in \mathbb{R}$?

(1) Both $e^{-x^2}y_1$ and $e^{-x^2}y_2$ are periodic

(2) Both y_1 and y_2 are bounded

(3) Both y_1 and y_2 are unbounded

(4) $e^{-x^2}y_1$ is NOT periodic and $e^{-x^2}y_2$ is periodic

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Answer Key

1	2	3	4	5	6	7	8	9	10
a,c,d	a,b,d	b	b	d	d	a	a	a	b
11	12	13	14	15	16	17	18	19	20
a	d	a,d	c,c	a,b,c	b,c	a,b,d	a	b,c,d	d
21	22	23	24	25	26	27	28	29	30
a	a	a, d	c, d	b, c	a, c, d	a, b, d	b	b	d
31	32	33	34	35					
b	a,c	c	b,d	a,c					

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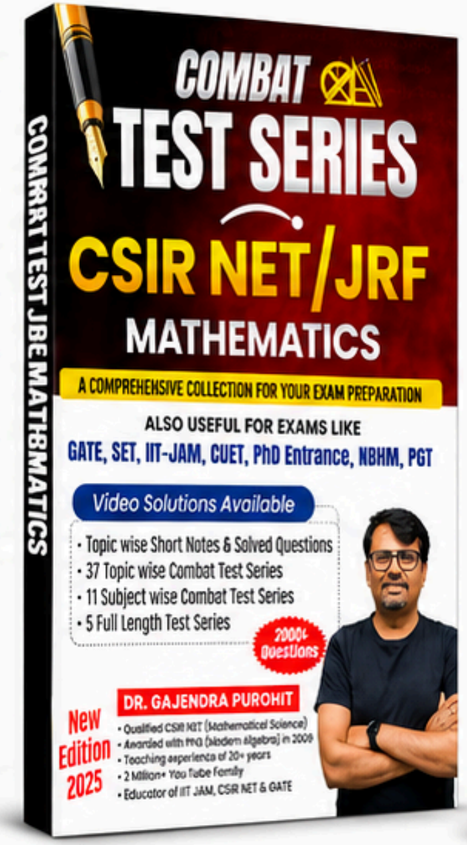
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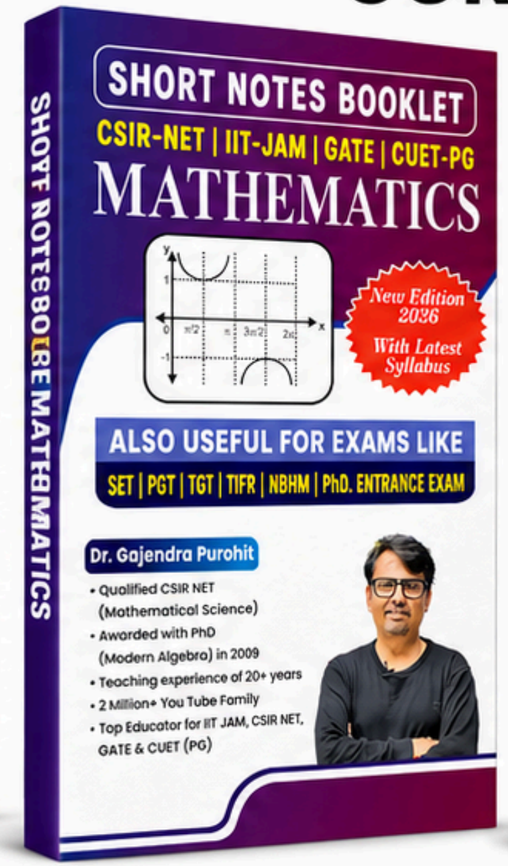
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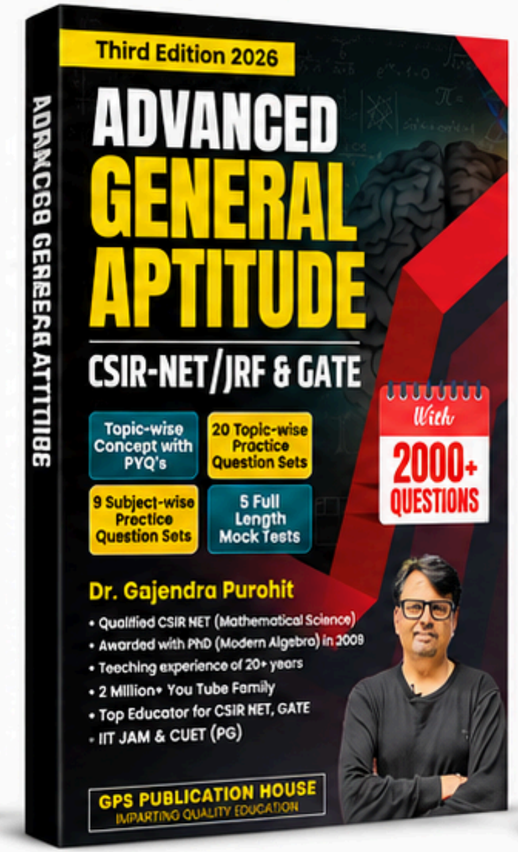
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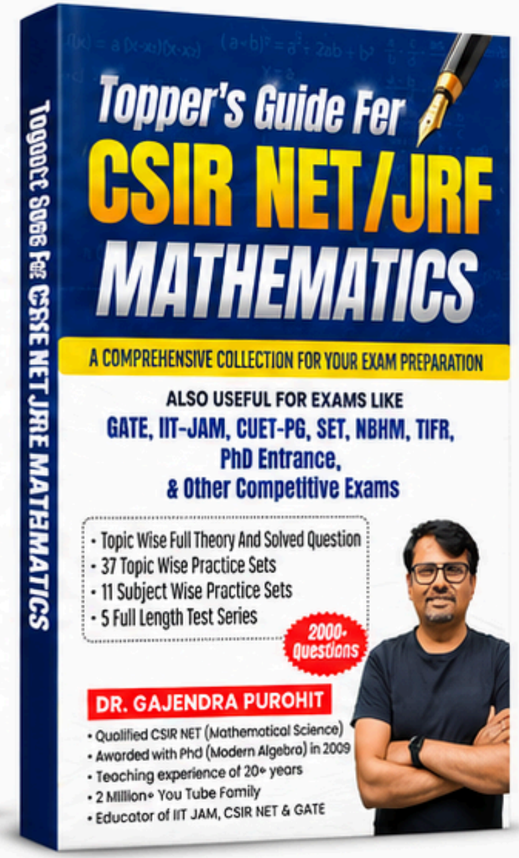
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