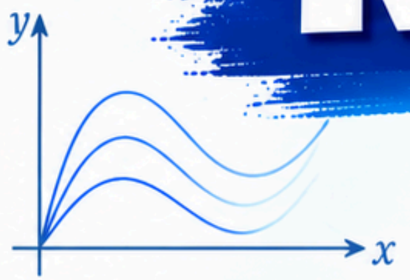
$\frac{dy}{dx} = f(x, y)$

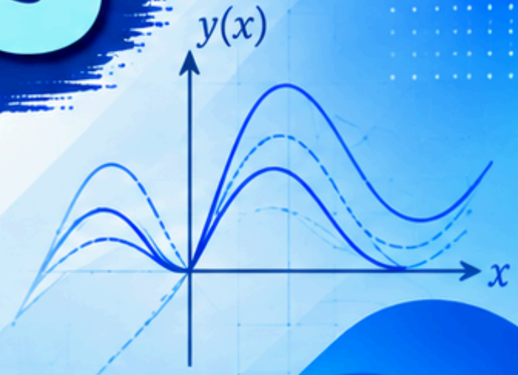
CSIR NET DEC 2026

REAL ANALYSIS

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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Real analysis



01	Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum.
02	Sequences and series, convergence, limsup, liminf.
03	Bolzano Weierstrass theorem, Heine Borel theorem.
04	Continuity, uniform continuity, differentiability, mean value theorem.
05	Sequences and series of functions, uniform convergence.
06	Riemann sums and Riemann integral, Improper Integrals.
07	Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral.
08	Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.
09	Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.



Real Analysis

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Topics	YouTube Videos [Click on the LINK to watch the video]
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Point Set Topology	WATCH NOW
Sequences of Real Numbers	WATCH NOW

Real Analysis

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Topics	YouTube Videos [Click on the LINK to watch the video]
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Function and Their Properties	WATCH NOW
Limit and Continuity	WATCH NOW

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Reimann Integral and Function of Bounded Variation	WATCH NOW
Sequence and Series of Function	WATCH NOW
Function of Several Variables	WATCH NOW

PREVIOUS YEARS WEIGHTAGE

ANALYSIS OF CSIR - NET / JRF PREVIOUS YEAR PAPER															
SUBJECTS	DEC.2018			JUNE.2019			DEC.2019			26-Nov-20			30-NOV-20		
	JRF | LS			JRF | LS			JRF | LS			JRF | LS			JRF | LS		
	MARKS			MARKS			MARKS			MARKS			MARKS		
SECTIONS	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL
UNIT-I	36	85.5	121.5	36	76	112	36	76	112	36	85.25	121.5	36	85.5	121.5
Real Analysis	18	47.5	65.5	18	38	56	15	42.75	57.75	18	52	70	18	52.25	70.25

ANALYSIS OF CSIR - NET / JRF PREVIOUS YEAR PAPER												
SUBJECTS	16 FEB,2022			JUNE.2023			DEC.2023			JUNE.2024		
	JRF | LS			JRF | LS			JRF | LS			JRF | LS		
	MARKS			MARKS			MARKS			MARKS		
SECTIONS	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL	PART-B	PART-C	TOTAL
UNIT-I	39	76	115	36	76	112	36	76	112	36	85.5	121.5
Real Analysis	21	42.75	63.75	18	47.5	65.5	21	42.75	63.75	27	38	65

REAL ANALYSIS - JULY 2026

TOPIC	NO. OF QUESTIONS
Point Set Topology	1
Sequence & Series	1
LCD + Function	1
Function of Two Variables	3
Improper Integral	1
Sequence & Series of Function	2
Power Series	1
Uniform Continuity	1
Bounded Variation	1
Riemann Integration	1
Metric Space	1
Measure Theory	2

TOTAL QUESTIONS	16	TOTAL MARKS	65.5

Real Analysis - December 2025

Topic	No. of Question
Uniform Continuity	2
Limit , Continuity , Differentiability	2
Sequence and Series of Function	2
Bounded Variation and Reimann Integral	1
Sequence	1
Series	1
Function of Two Variable	2
Measure Theory	1

Total Question - 12 , Total Marks - 50

Real Analysis - June 2025

Topic	No. of Question
Uniform Continuity	1
Limit , Continuity , Differentiability + Function	1+1+1
Sequence and Series of Function	2
Bounded Variation	1
Reimann Integral	1
Sequence & Series	2
Function of Two Variable	1
Measure Theory	1

Total Question - 12 , Total Marks - 50

SHORT NOTES

Sequence of real number

A sequence on a set R is a rule which assigns to each natural number, a unique element of R. a sequence is usually denoted by $\{a_n\}$ or $<a_n>$

Limit Point of a sequence

A real number l is said to be a cluster point of a sequence $\langle a_n \rangle$ iff neighbourhood of l contains infinitely many terms of the sequence.

Limit of a sequence

A real number l is said to be a limit of a sequence $\langle a_n \rangle$ iff neighbourhood of l contains infinitely many terms of the sequence and only finite terms lies in outside of neighbourhood of l.

Convergent Sequence

A sequence is called a convergent sequence iff limit of this sequence exist.

Note : If $\lim_{n\to\infty} a_n = l$ then we say that this sequence converge to l.

Divergent Sequence

A monotonic and unbounded sequence is called a divergent sequence.

Oscillatory Sequences

If a sequence $\{a_n\}$ neither converges to a finite number nor diverges to $+\infty$ or $-\infty$, then it is called an oscillatory sequence.

Subsequence

Let $\langle a_n \rangle$ be a given sequence. If $\langle n_k \rangle$ is a strictly increasing sequence of natural numbers (i.e., $n_1 < n_2 < n_3 \ldots$), then $\langle a_{n_k} \rangle$ is called a subsequence of $\langle a_n \rangle$

Limit Superior and limit Inferior of sequence

(1) Convergent sequence $\Rightarrow$ let $a_n \to l$ be a convergent sequence then $\underline{\lim} a_n = \overline{\lim} a_n = l$

(2) Divergent sequence $\Rightarrow$ let a_n be divergent sequence which diverge to ∞ then

$\underline{\lim} a_n = \overline{\lim}\, a_n = \infty$ and if a_n be divergent sequence which diverge to $-\infty$ then

$\underline{\lim} a_n = \overline{\lim}\, a_n = -\infty$

(3) Oscillatory sequence $\Rightarrow$ let a_n be a oscillatory sequence then $\underline{\lim} a_n \neq \overline{\lim} a_n$

Series

Let $\{a_n\}$ be a sequence of real numbers, the expression $a_1 + a_2 + ... + a_n + ...$, is called an infinite series and is denoted by $\sum_{n=0}^{\infty} a_n$ or simply $\sum a_n$ and a_n is called n^{th} term.

Necessary condition

A series $\sum_{n=0}^{\infty} a_n$ is convergent then $\lim_{n\to\infty} a_n = 0$ but converses need not be true.

Test for convergence

p-series Test : A positive term series $\sum \frac{1}{n^p}$ is convergent iff p>1 and $\sum \frac{1}{n^p}$ is called p-series.

Comparison test: Let $\sum a_n$, be a positive term series.

(a) If $a_n \le c_n$, for $n \le N_0$, where N_0 is some fixed integer and if $\sum c_n$ converges, then $\sum a_n$ converges.

(b) If $a_n \le c_n$ for $n \le N_0$ and if $\sum a_n$ diverges, then $\sum c_n$ diverges.

Limit form test: If $\sum a_n$ and $\sum b_n$ are two positive term series such that $\lim_{n\to\infty}\left(\frac{a_n}{b_n}\right) = l$ [finite and non-zero], then both the series behaves alike, i.e., both converge and diverge together.

Cauchy's root Test: Let $\sum a_n$ be a positive terms series and $\alpha = \lim_{n\to\infty} \sup \sqrt[n]{a_n}$. Then

(a) $\sum a_n$ converges, for $\alpha < 1$, (b) $\sum a_n$ diverges for $\alpha > 1$ and

(c) Test fails for $\alpha = 1$

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D'Alembert's ratio Test: The positive terms series $\sum a_n$ is

(a) Converges if $\limsup_{n\to\infty}\left(\frac{a_{n+1}}{a_n}\right)<1$, (b) Diverges if $\limsup_{n\to\infty}\left(\frac{a_{n+1}}{a_n}\right)>1$

Cauchy's Condensation Test: If $\langle a_n \rangle$ is a decreasing sequence of positive real numbers, then the two series $\sum a_n$ and $\sum a_{2^n} 2^n$ converge or diverge together.

Alternating series

A series of the form $\sum(-1)^{n-1} a_n$, where a_n are all positive, is called alternating series.

Leibnitz test or Alternating Series Test: Suppose $\sum a_n$ is an infinite series such that

(a) $|a_1| \geq |a_2| \geq |a_3| \geq \ldots$ (b) $\lim_{n\to\infty} a_n = 0$

Then $\sum a_n$ is converges.

Absolutely convergent series: $\sum u_n$ is absolutely convergent if $\sum |u_n|$ is convergent.

Conditionally convergent series: Let $\sum a_n$ is a convergent series but $\sum |a_n|$ is divergent, then $\sum a_n$ is said to be conditionally convergent series or A series which is convergent but not absolutely is called conditionally convergent series.

Countability

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Finite set : Let $N_m = \{1, 2, 3, \ldots. m\}$. A set which is either empty or equivalent to N_m is said to be a finite set.

Infinite set : A set which is not finite is called infinite set or we can say that A set which is not equivalent to $N_m = \{1, 2, \ldots., m\}$ for any $m \in N$.

Countably infinite set : A set S is said to be countably infinite if it is similar to the set of natural numbers.

Uncountable set : A set which is not countable is called uncountable set.

Results :

(1) Cardinality of countably infinite set is χ_0.

(2) Cardinality of every uncountable set is c.

(3) Countable union of countable set is countable.

(4) A finite cartesian product of countable set is countable.

(5) Infinite cartesian product of countable set A is uncountable set if $|A| > 1$

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Point Set Topology

Upper bound of set : $\alpha \in R$ is called upper bound of S if all the elements of S are less than to α.

Lower bound : $\beta \in R$ is called lower bound of S if all the elements of S are greater to β.

Neighbourhood of a point : Let $S \subseteq R$ and $a \in R$. We say S is a neighbourhood of a point 'a' if $\exists$ an open interval I s.t. $a \in I \subseteq S$.

Interior point : If $S \subseteq R$ is neighbourhood of a real number α, then α is interior point of S.

Open Set: Let $S \subseteq R$, if every elements of S is interior point of S, then S is called open set.

Limit point : A point p is a limit point of a set S iff every neighbourhood of p contain infinitely many points of S.

Compact set : A set which is closed and bounded is called compact set.

Connected set : A non-empty set $S \subset R$ is said to be connected if it is an interval or it is singleton.

Limit of function

One-side limit :

Right hand limit (RHL) : A function f(x) is said to approach L as $x \to a$ from the right or from above if $\lim_{h \to 0} f(a+h) = L$.

Left hand limit (LHL) : A function f(x) is said to approach L as $x \to a$ from the left or from below if $\lim_{h \to 0} f(a-h) = L$.

Note : Limit of f(x) exist at x = a, iff RHL = LHL at x = a.

Continuity

A function $f : A \to R$ is said to be continuous at point $x = a \in A'$ (where a is a limit point of A), if $\lim_{x \to a^+} f(x) = \lim_{x \to a^-} f(x) = f(a)$

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Uniform continuity

(1) If a function f is uniformly continuous on an interval I, then it is continuous on I

(2) If a function f is continuous on closed interval [a, b], then it is uniformly continuous on [a, b]

(3) If a function f is continuous on open interval (a, b), then f is uniformly continuous on (a, b) iff $\lim_{x\to a^+} f(x)$ and $\lim_{x\to b^-} f(x)$ both exists

Differentiablity

Let f : [a, b] $\to$ R be a function and $c \in (a,b)$, then 'f' is said to be derivable or differentiable at 'c', if $\lim_{x\to c} \frac{f(x)-f(c)}{x-c}$ exists.

Applications of derivative

(1) Rolle's Theorem: Let f be continuous function on $[a,b]$ and differentiable on (a,b) and $f(a)=f(b)$ then $\exists c \in (a,b)$ such that $f'(c)=0$.

(2) Lagrange's Mean Value Theorem [L.M.V.T]:

If f is a function defined on $[a,b]$ such that f continuous on closed interval $[a,b]$ and derivable on open interval (a,b), then there exists atleast one real numbers $c \in (a,b)$ such that $\frac{f(b)-f(a)}{b-a} = f'(c)$

Fixed point

A real number α is called fixed point of a real valued function iff $f(\alpha) = \alpha$

Riemann Integration

Riemann integrable: A bounded real valued function f defined on $[a,b]$ is said to be Riemann integrableiff $\int_{\underline{a}}^{b} f(x)\,dx = \int_{a}^{\overline{b}} f(x)\,dx$.

The common value is denoted by $\int_a^b f(x)\,dx$

Sequence of function

Let D be a subset of R and for each n $\in$ N, let $f_n : D \to R$ be a function, then $\langle f_n \rangle$ is called sequence of function i.e.$\langle f_n \rangle = \langle f_1, f_2, f_3, \ldots, f_n, f_{n+1} \ldots \rangle$

M_n – test : Let $f_n(x)$ is a sequence of function and f(x) is pointwise limit on S.

We define $\sup_{x\in S} |f_n(x) - f(x)|$. Then $f_n(x)$ converge uniformly to f(x) on S

iff $M_n \to 0$ as $n \to \infty$.

Series of function

Let $\langle f_n(x) \rangle$ is a sequence of function then we define $\sum f_n(x)$ is called series of function.

Weierstrass test for uniformly convergence

A series $\sum f_n$ will converge uniformly in [a, b] if there exist a convergent series $\sum M_n$ s.t. $|f_n(x)| \le M_n$.

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Function of several variables

Let $S \subseteq R^n$, then $f : S \to R$ is called a real- valued function of n variables

Limit of a function of two variables:

Let $S \subseteq R^2$ and $f : S \to R$ be a real valued function and $(a, b) \in R^2$ be a limit point of S. then

$f(x,y) \to l$, as $(x,y) \to (a,b)$, or $\lim_{(x,y)\to(a,b)} f(x,y) = l$

Continuity of a function at a point

Let $S \subseteq R^2$ and $(a,b) \in S$ and $f : S \to R$ be a real valued function of two variables, then f is said to be continuous at point $(a,b) \in S$, if $\lim_{(x,y)\to(a,b)} f(x,y) = f(a,b)$

Directional Derivative

Directional derivative of $f(x,y)$ at a point α in the direction $u(u_1,u_2)$ then

$$D_u(\alpha) = \lim_{h\to 0} \frac{f(\alpha + hu) - f(\alpha)}{h}$$

Partial derivative

(i) **Partial derivative w.r.t. x :** Directional derivative of f(x, y) at point P(a, b) in the direction of u = (1, 0). It is denoted by $f_x(a, b)$.

i.e., $f_x(a,b) = \lim_{h\to 0} \frac{f(a+h,b) - f(a,b)}{h}$

(ii) **Partial derivative w.r.t. y :** Directional derivative of f(x, y) at point P(a, b) in the direction of u = (0, 1). It is denoted by $f_y(a, b)$.

i.e., $f_y(a,b) = \lim_{h\to 0} \frac{f(a,b+h) - f(a,b)}{h}$

Differentiability of function of several variables

A function $f(x,y)$ is said to be differentiable at any point (a,b) if

$f(a+h,b+k) - f(a,b) = Ah + Bk + g(h,k)\sqrt{h^2+k^2}$ ... (1), and $\lim_{(h,k)\to(0,0)} g(h,k) = 0$ where A & B are partial derivative w.r.t. x & y.

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-:Previous Year Questions :-

NOTE:- click on abovetextyoucanrefertolinkofvideosolution of questions

1. Let A, B be non-empty subsets of $\mathbb{N}$ with cardinality $|A| \geq 2$.

Let $S_1 = \{f: A \to B \mid f \text{ is one-to-one}\}$ and $S_2 = \{g: B \to A \mid g \text{ is onto}\}$.

Which of the following statements is true? **CSIR NET JULY – 2025**

Q2. If the function $s: [0,4] \to \mathbb{R}$ defined by

$$s(x) = \begin{cases} a(x-2)^2 + b(x-1)^2, & 0 \leq x \leq 1 \\ (x-2)^2 & 1 < x \leq 3 \\ 2c(x-2)^2 + (x-3)^3, & 3 < x \leq 4 \end{cases}$$

is a cubic spline, then the value of $2a + b + 2c$ is **CSIR NET JULY 2025**

Q3. Let

$$A = \left\{\frac{p}{q} \in (0,1): p \in \mathbb{N}, q = 2^n \text{ for some } n \in \mathbb{N} \cup \{0\}, \gcd(p,q) = 1\right\}$$

$$B = \left\{\frac{p}{q} \in (0,1): p \in \mathbb{N}, q = 2^n 5^m \text{ for some } n, m \in \mathbb{N} \cup \{0\}, \gcd(p,q) = 1\right\}$$

$$C = \left\{\frac{p}{q} \in (0,1): \frac{p}{q} \text{ has terminating decimal expansion}\right\}$$

be subsets of $(0,1)$. Which of the following statements is true?

(a) $A \subsetneq C$ and $B \subsetneq C$ (b) $A \subsetneq C \subsetneq B$ (c) $A \subsetneq B \subsetneq C$

(d) $A \subsetneq B = C$ **CSIR NET JULY – 2025**

Q4. For each $n \geq 1$, let $f_n: [0, 1] \to R$ be defined as

$$f_n(x) = \{nx \text{ if } x \in \left[0, \frac{1}{n}\right] 2 - nx \text{ if } x \in (\frac{1}{n}, \frac{2}{n}] \, 0 \text{ if } x \in (\frac{2}{n}, 1]$$

Which of the following statements is true? **CSIR NET JULY – 2025**

1. $(f_n)_{n \geq 1}$ converges uniformly on $[0, 1]$ to a continuous function f.
2. $(f_n)_{n \geq 1}$ converges pointwise on $[0, 1]$ to a discontinuous function f.
3. $(f_n)_{n \geq 1}$ converges pointwise on $[0, 1]$ to a continuous function f.
4. $(f_n)_{n \geq 1}$ does not converge pointwise on $[0, 1]$.

Q5. : Let $f(x) = x\log_e\left(1 + \frac{1}{x}\right)$

for $x \in (0, \infty)$. Which of the following statements is true? **CSIR NET JULY – 2025**

1. f is unbounded.
2. f is increasing.
3. $\lim_{x\to\infty} f(x) = 2$.
4. f is decreasing.

Q7. Let $p: R \longrightarrow R$ be a nonconstant polynomial. Which of the following statements are true? **CSIR NET JULY – 2025**

1. The preimage of a compact set under p is a compact set.
2. The preimage of a connected set under p is a connected set.
3. Every point $x \in R$ has an open neighbourhood U_x such that the restriction $p|_{U_x}$ is a homeomorphism onto an open set in R.
4. The image of a bounded set under p is a bounded set.

Q 6: For each $n \geq 1$, let $f_n : R \to R$ be a function defined by

$$f_n(x) = \frac{e^{-n^2x^2}}{n}$$

Which of the following statements are true? **CSIR NET JULY – 2025**

1. $(f_n)_{n\geq1}$ converges uniformly to 0 on R, and $(f_n')_{n\geq1}$ converges uniformly to 0 on the interval (-M, M) for some positive real number M.
2. $(f_n)_{n\geq1}$ converges uniformly to 0 on R, and $(f_n')_{n\geq1}$ converges pointwise to 0 on R.
3. $(f_n)_{n\geq1}$ converges uniformly to 0 on R and $(f_n')_{n\geq1}$ does not converge pointwise to 0 on R.
4. $(f_n)_{n\geq1}$ converges pointwise to 0 on R but not uniformly on R.

Q8. Let $(f_n)_{n\geq1}$ be a sequence of real-valued functions on R. Which of the following statements are true? **CSIR NET JULY – 2025**

1. If each f_n is uniformly continuous and $(f_n)_{n\geq1}$ converges to f uniformly, then f is uniformly continuous.
2. If each f_n is bounded and $(f_n)_{n\geq1}$ converges to f pointwise, then f is bounded.
3. If each f_n is bounded and continuous, $(f_n)_{n\geq1}$ converges pointwise to a bounded and continuous function f, then the convergence is uniform.
4. If each f_n is differentiable and $(f_n)_{n\geq1}$ converges to f uniformly, then f is differentiable.

Q 9: What is the value of the limit **(CSIR NET JULY – 2025)**

$$\lim_{n\to\infty} \frac{1}{n}[(n+1)(n+2)\cdots(n+n)]^{1/n}?$$

(a) $\frac{2}{e}$

(b) $\frac{4}{e}$

(c) $log_e 2 - 1$

(d) $2log_e 2 - 1$

Q 10: Let f and g be real-valued Riemann integrable functions on $[a, b]$ such that $g([a, b]) \subseteq [a, b]$. Which of the following statements are necessarily true? **(CSIR NET JULY – 2025)**

(a) The composition $f \circ g$ is Riemann integrable.

(b) If $g(x) \neq 0$ for each $x \in [a, b]$, then $\frac{f}{g}$ is Riemann integrable.

(c) The positive square root $\sqrt{f^2 + g^2}$ is Riemann integrable.

(d) The composition $f \circ g$ is Riemann integrable, if both f and g are continuous.

Q 11: Let f be a bounded, twice continuously differentiable real-valued function on $(0, \infty)$ such that $f''(x) \geq 0$ for all $x \in (0, \infty)$. Which of the following statements are true? **(CSIR NET JULY – 2025)**

1. $f'(x) \leq 0$ for all $x > 0$.
2. $lim_{x\to\infty} f'(x) = 0$.
3. $lim_{x\to\infty} xf'(x)$ need not exist.
4. $lim_{x\to\infty} xf'(x) = 0$.

12. What is the number of injective function from {1, 2, ….., 7} to {1, 2, ….., 10}? **(CSIR NET FEB – 2025)**

(a) 10^7 (b) $\frac{10!}{7!}$ (c) $\frac{10!}{3!}$ (d) 7^{10}

13. Let f : [0, 1] → R be defined by f(x) = sin(x²). Let $A = \lim_{n\to\infty}\left(\sum_{k=1}^{n} f\left(\frac{k}{n}\right) - n\int_0^1 f(x)dx\right)$.

Which of the following statement is true? **(CSIR NET FEB – 2025)**

(a) A = 0 (b) A = 1 (c) $A = \frac{\sin(1)}{2}$ (d) $A = \sin\left(\frac{1}{4}\right)$

14. Let f : R → R be such that $\sup_{x\neq y}\frac{|f(x)-f(y)|}{|x-y|} = L$, where 1 < L < ∞. Put h : R → R be a differentiable function satisfying |h'(x)| ≤ 3/4 for all x ∈ R for α > 0. Define g(x) = αf(x) + h(x) for x ∈ R. Consider the sequence $\{x_n\}_{k=0}^{\infty}$ defined by $x_{n+1} = g(x_k)$, k = 0, 1, ….

Where x ∈ R. The sequence $\{x_k\}_{k=0}^{\infty}$ converges to the solution of the equation x = g(x) if **(CSIR NET FEB – 2025)**

(a) $\alpha < \frac{2}{3L}$ (b) $\alpha < \frac{3}{2L}$ (c) $\alpha < 4L$ (d) $\alpha < \frac{1}{4L}$

15. Let A, B and C be sets. Which of the following sets is equal to A/(B/C)?

(CSIR NET FEB – 2025)

(a) A/B (b) (A/B)∪C (c) A/(B∪C) (d) (A/B)∪ A ∩ C

16. Consider the power series $\sum_{n=1}^{\infty}\frac{n^{n^2}}{(n+1)^{n^2}}x^n$ with coefficient in real number R. Which of the following statement is true? **(CSIR NET FEB – 2025)**

(a) The radius of convergence of the series is 1/e

(b) The series converges at x = 5

(c) The series converges at x = 3

(d) The series converges for all x with |x| < 1/2.

17. For integer $n \geq 0$, let $f_n : [-1, 0] \to R$ be defined by $f_n(x) = \frac{x}{(1-x)^n}$.

Which of the following statements is true about the series $\sum_{n=0}^{\infty} f_n$?
(CSIR NET FEB – 2025)

(a) The series is neither absolutely convergent nor uniformly convergent.

(b) The series is both absolutely convergent and uniformly convergent.

(c) The series is absolutely convergent but not uniformly convergent.

(d) The series is uniformly convergent but not absolutely convergent.

19. Consider the function $f : R^2 \to R$ defined by $f(x,y) = \begin{cases} \frac{x^2 y}{x^4 + y^2} + e^{xy}, & (x,y) \neq (0,0) \\ 1, & (x,y) = (0,0) \end{cases}$

Which of the following statements are True? **(CSIR NET FEB – 2025)**

(a) f is differentiable on $R^2 \setminus \{(0, 0)\}$

(b) All the directional derivatives of f exist at (0, 0)

(c) f is differentiable on R^2

(d) f is not continuous at (0, 0)

18. Consider the sequence $(a_n)_{n\geq 1}$ and $(b_n)_{n\geq 1}$ defined by $a_n = \frac{e^n + e^{-n}}{2}$ & $b_n = \frac{a_{n+1}}{a_n}$.

Which of the following statement is true? **(CSIR NET FEB – 2025)**

(a) For each $x \in R$, there exist an n such that $a_n > x$

(b) For each $x \in R$, there exist an n such that $a_n < x$

(c) For each $x \in R$, there exist an n such that $b_n > x$

(d) For each $x \in R$, there exist an n such that $b_n < x$

20. For a positive real number a, $\sqrt{a}$ denotes the positive square root of a. Consider the function $f : R^2 \to R$ defined by $f(x,y) = \begin{cases} \frac{x}{|x|}\sqrt{x^2+y^2}, & x \neq 0 \\ 0 & x = 0 \end{cases}$.

Which of the following statement are true? **(CSIR NET FEB – 2025)**

(a) f is continuous at (0, 0)

(b) The partial derivative $\frac{\partial f}{\partial x}$ and $\frac{\partial f}{\partial y}$ exist at (0,0)

(c) f is differentiable at (0, 0)

(d) f is not differentiable at (0, 0)

21. For each positive integer n, define $f_n : [0, 1] \to R$ by $f_n(x) = nx(1 - x)^n$, which of the following statement are true? **(CSIR NET FEB – 2025)**

(a) $(f_n)_{n\geq 1}$ does not converges point wise on [0, 1]

(b) $(f_n)_{n\geq 1}$ converges point wise to a continuous function on [0, 3]

(c) $(f_n)_{n\geq 1}$ converges point wise to a discontinuous function on [0, 2]

(d) $(f_n)_{n\geq 1}$ does not converges uniformly on [0, 1]

23. Let $f : [0, 1] \to R$ be a monotonic function. Which of the following statement are true?

(a) f is Riemann integrable on [0, 1]

(b) The set of discontinuities of f cannot contain a non-empty open set

(c) f is a lebesque measurable function

(d) f is a Borel measurable function

(CSIR NET FEB – 2025)

22. Consider the function $f : R \to R$ defined by

$$f(x) = \begin{cases} x^2 \sin\left(\frac{1}{x}\right), & \text{if } x \neq 0 \\ 0, & \text{if } x = 0 \end{cases}$$

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

(a) $\lim_{x\to 0} f(x)$ exists

(b) f is continuous at 0

(c) f is differentiable at 0

(d) $\lim_{x\to 0} f'(x)$ does not exist

24. Let $(a_n)_{n\geq 1}$, $(b_n)_{n\geq 1}$ and $(c_n)_{n\geq 1}$ be sequence given by **(CSIR NET FEB – 2025)**

$$a_n = (-1)^n (1 + e^{-n})$$

$$b_n = \max\{a_1, \ldots a_n\}$$

and $c_n = \min\{a_1 \ldots a_n\}$

Which of the following statement are true?

(a) $(a_n)_{n\geq 1}$ does not converges

(b) $\limsup_{n\to\infty} a_n = \lim_{n\to\infty} b_n$

(c) $\liminf_{n\to\infty} a_n = \lim_{n\to\infty} c_n$

(d) $\lim_{n\to\infty} b_n = \lim_{n\to\infty} c_n$

25. Which of the following statements are true? **(CSIR NET FEB – 2025)**

(a) Let $x, y \in R$ with $x < y$. Then there exist $r \in Q$ such that $x < \frac{2^{2024} r}{e} < y$

(b) Let $(a_n)_{n\geq 2}$ be a sequence of positive real numbers. If there exists a positive realnumber L such that $\lim_{x\to\infty} \text{Sup} \frac{\sin}{\log gx} = L$, then $\lim_{x\to\infty} \text{Sup} a_n < \infty$.

(c) The set of all finite subsets of Q is countably infinite.

(d) The set of continuous function from R to the set {0, 1} is infinite.

27. Let $f : R \to R$ be a continuous function such that $f(x) = 0$ for all $x \leq 0$ and for all $x \geq 1$. Define $F(x) = \sum_{n=-\infty}^{\infty} f(x+n),\ x \in R$.

Which of the following statements are true? . **(CSIR NET FEB – 2025)**

(a) F is bounded

(b) F is continuous on R

(c) F is uniformly continuous on R

(d) F is not uniformly continuous on R

26. Let $g : R \to R$ be a continuous function. Define $f(x) = \int_0^x (x-t)g(t)dt,\ x \in R$

Which of the following statement are true? **(CSIR NET FEB – 2025)**

(a) $f(0) = 0$

(b) $f(0)$ exist and $f(0) = 0$

(c) $f'(0) =$ exist and $f''(0) = g(0)$

(d) $f'(0)$ exist and $f''(0) \neq g(0)$

Q28. A bounded sequence contains a convergence subsequence.

Then which of the following statement is true? **(CSIR NET JULY – 2024)**

(a) Finitelly many subsequence

(b) Only one subsequence

(c) Atmost two subsequence

(d) Countably infinite subsequence

Q29. If $\{a_n\}$ is a bounded sequence of real number and $\lim_{n\to\infty} a_n$ does not exist

Let $S = \{l \in R : \exists$ a subsequence of $\{a_n\}$ which is converges to $'l'\}$

Then which of the following is necessarily true **(CSIR NET JULY – 2024)**

(a) S is empty set

(b) S has exactly one element

(c) S has atleast two

(d) S has to be finite set

Q31. Suppose $\{a_n\}$ be positive sequence of real numbers. Define $b_n = \frac{a_n}{\max\{a_1, a_2, \ldots, a_n\}}$.

Then which of the following statements is/are correct? **(CSIR NET JULY – 2024)**

(a) If $\lim_{n\to\infty} b_n$ exist then $\{a_n\}$ is bounded

(b) If $\lim_{n\to\infty} b_n = 1$, then $\lim a_n$ exist in R

(c) If $\lim_{n\to\infty} b_n = \frac{1}{2}$ then $\lim a_n$ exist

(d) If $\lim_{n\to\infty} b_n = 0$ then $\lim a_n = 0$

Q30. Let $\{a_n\}$ be a bounded sequence. Then which of the following is false?

(CSIR NET JULY – 2024)

(a) $\limsup(a_n) = \liminf(a_n) \Rightarrow a_n$ is convergent

(b) $\text{Inf}(a_n) = \limsup(a_n) \Rightarrow a_n$ is convergent

(c) $\sup(a_n) = \liminf(a_n) \Rightarrow a_n$ is constant

(d) $\sup(a_n) = \inf(a_n) \Rightarrow a_n$ is constant

Q32. What is the cardinality of the set of real solutions of $e^x + x = 1$

(CSIR NET JULY – 2024)

(a) 0 (b) 1 (c) countably infinite (d) uncountable

Q33. Let $\sum_{n=1}^{\infty} a_n$ be a convergent series of real numbers.

For $n \geq 1$. Define $A_n = \begin{cases} a_n, & \text{if } a_n > 0 \\ 0, & \text{otherwise} \end{cases}$ & $B_n = \begin{cases} a_n, & \text{if } a_n < 0 \\ 0, & \text{otherwise} \end{cases}$

Which of the following statements are necessarily true? **(CSIR NET JULY – 2024)**

(a) $A_n \to 0$ and $B_n \to 0$ as $n \to \infty$

(b) $\sum_{n=1}^{\infty} a_n$ is absolultely convergent, then $\sum_{n=1}^{\infty} A_n$ and $\sum_{n=1}^{\infty} B_n$ are absolutely convergent.

(c) Both $\sum_{n=1}^{\infty} A_n$ and $\sum_{n=1}^{\infty} B_n$ are convergent

(d) If $\sum_{n=1}^{\infty} a_n$ is not absolutely convergent, then both $\sum_{n=1}^{\infty} A_n$ and $\sum_{n=1}^{\infty} B_n$ are divergent

Q34. Consider the improper integrals $I = \int_{\pi/2}^{\pi} \frac{1}{\sqrt{\sin x}} dx$ and for $n \geq 0$ $I_a = \int_{a}^{\infty} \frac{1}{x\sqrt{1+x^2}} dx$

(CSIR NET JULY – 2024)

(a) The integral I is convergent

(b) The integral I is not convergent

(c) The integral I_a converges for $a = 1/2$ but not for $a = 0$

(d) The integral I_a converges for all $a \geq 0$

35. For each $n \geq 1$ define $f_n : R \to R$ by $f_n(x) = \frac{x^2}{\sqrt{x^2 + \frac{1}{n}}}, x \in R$. Where $\sqrt{\ }$ denotes the non-negative square root. Wherever $\lim_{n\to\infty} f_n(x)$ exists, denote it by f(x). Which of the following statements is true? **(CSIR NET JULY – 2024)**

(a) There exists $x \in R$ such that f(x) is not defined

(b) $f(x) = 0$ for all $x \in R$ (c) $f(x) = x$ for all $x \in R$ (d) $f(x) = |x|$ for all $x \in R$

36. Let $f : [0, 1) \to [1, \infty)$ be defined by

$f(x) = \frac{1}{1-x}$. For $n \geq 1$, let $p_n(x) = 1 + x + x^2 + \ldots\ldots + x^n$.

Then which of the following statements are true? (**CSIR NET JULY – 2024**)

(a) f(x) is not uniformly continuous on [0, 1)

(b) The sequence $(P_n(x))$ converges to f(x) pointwise on [0, 1)

(c) The sequence $(P_n(x))$ converges to f(x) uniformly on [0, 1)

(d) The sequence $(P_n(x))$ converges to f(x) uniformly on [0, c) for every $0 < c < 1$

37. Define $f : R^2 \to R$ $f(x,y) = \begin{cases} \frac{y\sqrt{x^2+y^2}}{x} & \text{if } x \neq 0 \\ 0 & \text{if } x = 0 \end{cases}$,

Which of the following statements are true? (**CSIR NET JULY – 2024**)

(a) $\frac{\partial f}{\partial x}(0,0)$ exists

(b) $\frac{\partial f}{\partial y}(0,0)$ exists

(c) f is not continuous at (0, 0)

(d) f is not differentiable at (0, 0)

38. Consider the set $A = \{x \in Q : 0 < (\sqrt{2}-1)x < \sqrt{2}+1\}$ as a subset of R.

Which of the following statements is true? (**CSIR NET JULY – 2024**)

(a) $\sup A = 2 + 2\sqrt{3}$

(b) $\sup A = 3 + 2\sqrt{2}$

(c) $\inf A = 2 + 2\sqrt{3}$

(d) $\inf A = 3 + 2\sqrt{2}$

39. Let C be the collection of all sets S such that the power set of S is countably infinite. Which of the following statements is true? (**CSIR NET JULY – 2024**)

(a) There exists a non-empty finite set in C

(b) There exists a countably infinite set in C

(c) There exists an uncountable set in C

(d) C is empty

40. Let $f: R \to R$ by $f(x) = x|x|$. which of the following statements are true?

(CSIR NET JULY – 2024)

(a) f is continuous on R

(b) f is differentiable on R

(c) f is differentiable only at 0

(d) f is not differentiable at 0

41. $f: R \to R$ be a continuous and function and one- to-one function. which of the following statements are necessarily true? **(CSIR NET JULY – 2024)**

(a) f is strictly increasing

(b) f is strictly decreasing

(c) f is either strictly increasing or decreasing

(d) f is onto

42. Let $K \subseteq R$ be non-empty and $f: K \to K$ be continuous such that

$$|x-y| \leq |f(x)-f(y)| \ \forall x, y \in K$$

Which of the following statements are true? **(CSIR NET JULY – 2024)**

(a) f need not be surjective

(b) f must be surjective if K = [0, 1]

(c) f is injective and $f^{-1}: f(K) \to K$ is continuous

(d) f is injective, but $f^{-1}: f(K) \to K$ need not be continuous

43. Let X be a non-empty finite set and $Y = \{f^{-1}(0): f \text{ is a real-values function on } X\}$. Which one of the following statements is true? **(CSIR NET DEC – 2023)**

(a) Y is an infinite set.

(b) Y has $2^{\{X\}}$ elements.

(c) There is a bijective function from X to Y.

(d) There is a surjective function from X to Y.

44. Let $f : R \to R$ be a differentiable function such that f and its derivative f' have no common zeros in [0, 1]. Which one of the following statements is true?

(CSIR NET DEC – 2023)

(a) f never vanishes in [0, 1].

(b) f has at most finitely many zeros in [0, 1].

(c) f has infinitely many zeros in [0, 1].

(d) $f(1/2) = 0$.

45. Consider the following infinite series : **(CSIR NET DEC – 2023)**

A. $\sum_{n=1}^{\infty} \frac{\sin(n\pi/2)}{\sqrt{n}}$

B. $\sum_{n=1}^{\infty} \log\left(1+\frac{1}{n^2}\right)$

Which one of the following statements is true?

(a) A is convergent, but B is not convergent

(b) A is not convergent, but B is convergent

(c) Both A and B are convergent

(d) Neither A nor B is convergent.

46. Consider the following subset of R : $U = \{x \in R : x^2 - 9x + 18 \leq 0, x^2 - 7x + 12 \leq 0\}$. Which one of the following statements is true? **(CSIR NET DEC – 2023)**

(a) inf U = 5

(b) inf U = 4

(c) inf U = 3

(d) inf U = 2

47. Let f(x) be a cubic polynomial with real coefficients. Suppose that f(x) has exactly one real root and that this root is simple. Which one of the following statements holds for ALL antiderivatives F(x) of f(x)? **(CSIR NET DEC – 2023)**

(a) F(x) has exactly one real root

(b) F(x) has exactly four real roots

(c) F(x) has at most two real roots

(d) F(x) has at most one real root.

48. Let $f : [0, \infty) \to R$ be the periodic function of period 1 given by $f(x) = 1 - |2x - 1|$ for $x \in [0, 1]$. Further, define $g: [0, \infty) \to R$ by $g(x) = f(x^2)$.

Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) f is continuous on $[0, \infty)$.

(b) f is uniformly continuous on $[0, \infty)$.

(c) g is continuous on $[0, \infty)$.

(d) g is uniformly continuous on $[0, \infty)$.

50. For a real number λ consider the improper integrals $I_\lambda = \int_0^1 \frac{dx}{(1-x)^\lambda}, K_\lambda = \int_1^\infty \frac{dx}{x^\lambda}$

Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) There exists λ such that I_λ converges, but K_λ does not converge.

(b) There exists λ such that K_λ converges, but I_λ does not converge.

(c) There exists λ such that I_λ, K_λ both converge.

(d) There exists λ such that neither I_λ nor K_λ converges.

49. Let x be a real number. Which of the following statements are true?

(CSIR NET DEC – 2023)

(a) There exist an integer $n \geq 1$ such that $n^2 \sin\frac{1}{n} \geq x$.

(b) There exist an integer $n \geq 1$ such that $n\cos\frac{1}{n} \geq x$.

(c) There exist an integer $n \geq 1$ such that $ne^{-n} \geq x$.

(d) There exist an integer $n \geq 1$ such that $n(\log n)^{-1} \geq x$.

51. Suppose that $f : [-1, 1] \to R$ is continuous. Which of the following imply that f is identically zero on $[-1, 1]$? **(CSIR NET DEC – 2023)**

(a) $\int_{-1}^{1} f(x)x^n dx = 0$ for all $n \geq 0$

(b) $\int_{-1}^{1} f(x)p(x)dx = 0$ for all real polynomials p(x)

52. Let $(f_n)_{n\geq 1}$ be the sequence of function defined on [0, 1] by $f_n(x) = x^n \log\left(\frac{1+\sqrt{x}}{2}\right)$

Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) (f_n) converges pointwise on [0, 1]

(b) (f_n) converges uniformly on compact subsets of [0, 1) but not on [0, 1)

(c) (f_n) converges uniformly on [0, 1) but not on [0, 1)

(d) (f_n) converges uniformly on [0, 1]

54. For every n ≥ 1, consider the entire function $p_n(z) = \sum_{k=0}^{n} \frac{z^k}{k!}$. Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) The sequence of functions $(p_n)_{n\geq 1}$ converges to an entire function uniformly on compact subsets of C.

(b) For all n ≥ 1, p_n has a zero in the set $\{z \in C : |z| \leq 2023\}$

(c) There exists a sequence (z_n) of complex numbers such that $\lim_{n\to\infty} |z_n| = \infty$ and $p_n(z_n)$ for all n ≥ 1

(d) Let S denote the set of all the zeros of p_n. If $a_n = \min_{z\in S_n} |z|$, then $a_n \to \infty$ as $n \to \infty$.

53. Let f : R → R be a continuous function such that $|f(x) - f(y)| \geq \log(1 + |x - y|)$, for all x, y ∈ R. Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) f is necessarily one-one

(b) f need not be one-one

(c) f is necessarily onto

(d) f need not be onto

55. Which of the following statements are true? **(CSIR NET DEC – 2023)**

(a) The function f : R → R defined by $f(x) = \begin{cases} [x]\sin\frac{1}{x} & for\ x \neq 0 \\ 0 & for\ x = 0 \end{cases}$ has a discontinuity at 0 which is removable.

(b) The function f : [0, ∞) → R defined by $f(x) = \begin{cases} [x]\sin\frac{1}{x} & for\ x \neq 0 \\ 0 & for\ x = 0 \end{cases}$ has a discontinuity at 0 which is NOT removable.

(c) The function f : R → R defined by $f(x) = \begin{cases} e^{1/x} & x < 0 \\ e^{1/x+1} & x \geq 0 \end{cases}$ has a jump discontinuity at 0.

(d) Let f, g : [0, 1] → R be two functions of bounded variation. Then the product fg has atmost countably many discontinuities.

56. Consider the sequence $(a_n)_{n\geq 1}$ where $a_n = \cos\left((-1)^n \frac{n\pi}{2} + \frac{n\pi}{3}\right)$.

Which of the following is true? **(CSIR NET DEC – 2023)**

(a) $\limsup_{n\to\infty} a_n = \frac{\sqrt{3}}{2}$

(b) $\limsup_{n\to\infty} a_{2n} = 1$

(c) $\limsup_{n\to\infty} a_{2n} = \frac{1}{2}$

(d) $\limsup_{n\to\infty} a_{3n} = 0$

57. Let $\{A_n\}_{n\geq 1}$ be a collection of non-empty subsets of Z such that $A_n \cap A_m = \emptyset$ for $m \neq n$. If $Z = \cup_{n\geq 1} A_n$, then which of the following statements are necessarily true?

(CSIR NET DEC – 2023)

(a) A_n in finite for every integer $n \geq 1$

(b) A_n is finite for some integer $n \geq 1$

(c) A_n is infinite for some integer $n \geq 1$

(d) A_n is countable (finite or infinite) for every integer $n \geq 1$

58. For real number a, b, c, d, e, f, consider the function $F : R^2 \to R^2$ given by $F(x, y) = (ax + by + c, dx + dy + f)$, for $x, y \in R$. Which of the following statements are true?

(CSIR NET DEC – 2023)

(a) F is continuous

(b) F is uniformly continuous

(c) F is differentiable

(d) F has partial derivatives of all orders

59. $\lim_{n\to\infty} \frac{1}{n}(1 + \sqrt{2} + 3\sqrt{3} + \ldots\ldots + n\sqrt{n}) = ?$ **(CSIR NET NOV – 2022)**

(a) 0 (b) 1 (c) 2 (d) does not exist

60. If f.g : R → R, $f(x) = x^2$, $g(x) = \sin x$ then which of the following is uniformal continuous? **(CSIR NET NOV – 2022)**

(a) $g(f(x)) \to \sin x^2$ – Not u.c.

(b) $f(x)\, g(x) \to x^2 \sin x$

(c) $f(g(x)) \to \sin^2 x \to \sin x \to$ u.c.

(d) $f(x) + g(x) \to x^2 + \sin x \to$ not u.c.

61. Sequence $\langle a_n \rangle = 3 + 5\left(-\frac{1}{2}\right)^n + (-1)^n\left(\frac{1}{4} + (-1)^n \frac{2}{n}\right)$ then Lim inf & Lim sup is exist in interval **(CSIR NET NOV – 2022)**

(a) (11/4, 13/4) (b) (15/4, 12/4) (c) (11/2, 13/4) (d) None

62. $A = \{1, 1/2, 1/3, 1/4, ...\}$ & $B = A \cup \{0\}$. Then

(CSIR NET NOV – 2022)

(a) AB closed (b) B is closed (c) AB homeomorphic to Z

(d) BB homeomorphic to Z.

63. Which of the following continuous function with onto function? **(CSIR NET NOV – 2022)**

(a) (0, 1) to (0, 1] (b) [0, 1] to (0, 1] (c) (0, 1) to {1, 1} (d) (0, 1) to R

64. Let a_n & b_n be two sequence of real number and E & F be two subsets of R.

Let E + F = {a + b : a ∈ E, b ∈ F). Assume that the right hand side B well defined in each of the following statements. Which of the following statements are true?

(CSIR NET NOV – 2022)

(a) $\limsup_{n\to\infty}(a_n + b_n) \le \limsup_{n\to\infty} b_n$.

(b) lim sup (E + F) ≤ lim sup E + lim sup F

(c) $\liminf_{n\to\infty}(a_n + b_n)$

(d) lim inf (E + F) = lim inf E + lim sup F

65. If $S_1 = \frac{1}{3} - \frac{1}{2}\times\frac{1}{3^2} + \frac{1}{3}\times\frac{1}{3^2} - \frac{1}{4}\times\frac{1}{3^4}\ldots..$

& $S_2 = \frac{1}{4} + \frac{1}{2}\times\frac{1}{4^2} + \frac{1}{3}\times\frac{1}{4^3} + \frac{1}{4}\times\frac{1}{4^4} + \ldots.$

Then which of the following is true? **(CSIR NET NOV – 2022)**

(a) $3S_1 = 4S_2$ (b) $4S_1 = 3S_2$ (c) $S_1 + S_2 = 0$ (d) $S_1 = S_2$

66. Which of the following sets are countable? **(CSIR NET NOV – 2022)**

(a) The set of all polynomials with rational coefficient.

(b) The set of all polynomials with real coefficient.

(c) The set of all 2 × 2 real matrix with rational eigen-values.

(d) The set of all real matrices whose row Echelon form has rational entries.

Answer Key

1	2	3	4	5	6	7	8	9	10	11	12
c	b	d	c	b	b	a, d	a	d	c, d		c
13	14	15	16	17	18	19	20	21	22	23	24
c	d	d	d	c	a	a, d	a, b, d	b, d	a, b, c, d	a, b, c, d	a
25	26	27	28	29	30	31	32	33	34	35	36
a, c	a, b, c	a	d	c	c	c, d	b	a, b, d	a, c	d	a, b, d
37	38	39	40	41	42	43	44	45	46	47	48
a, b, d	b	d	a, b	c	a, b, c	b	c	c	c	c	a, b, c

Answer Key

49	50	51	52	53	54	55	56	57	58	59	60
d	a, b, d	a, b	d	a, c	a, c, d	b, c, d	b	d	a, b, c, d	b	c
61	62	63	64	65	66						
a	b, c	a, c	a	d	a						

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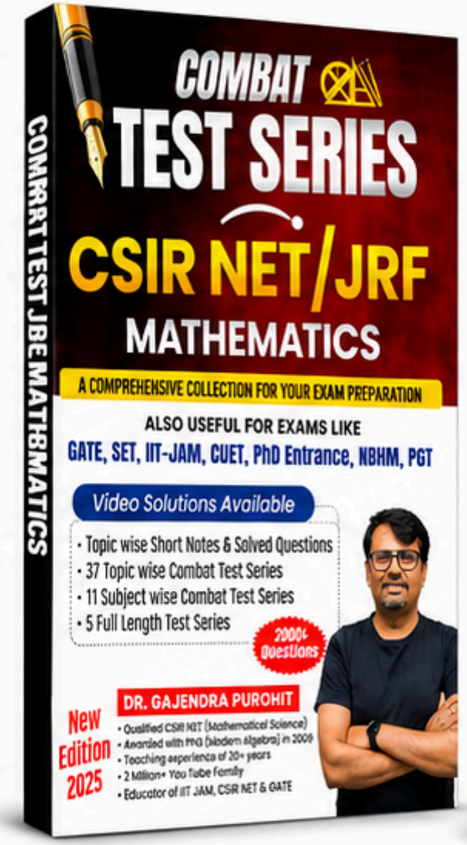
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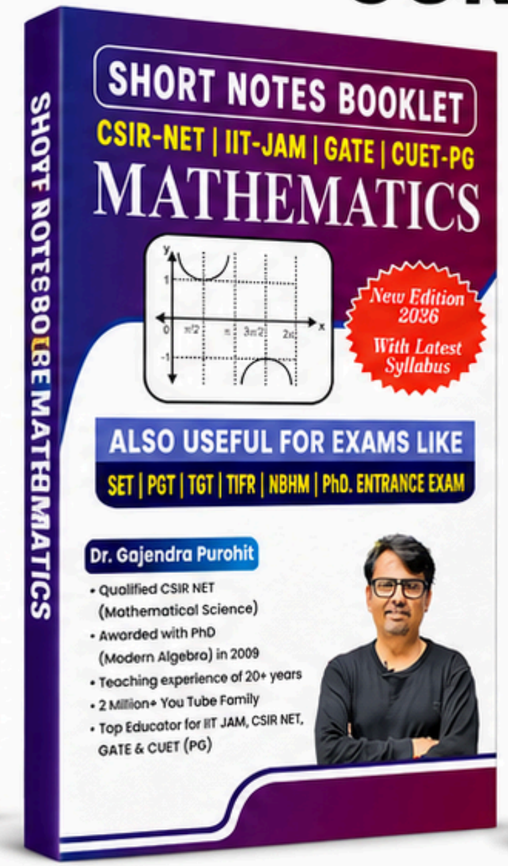
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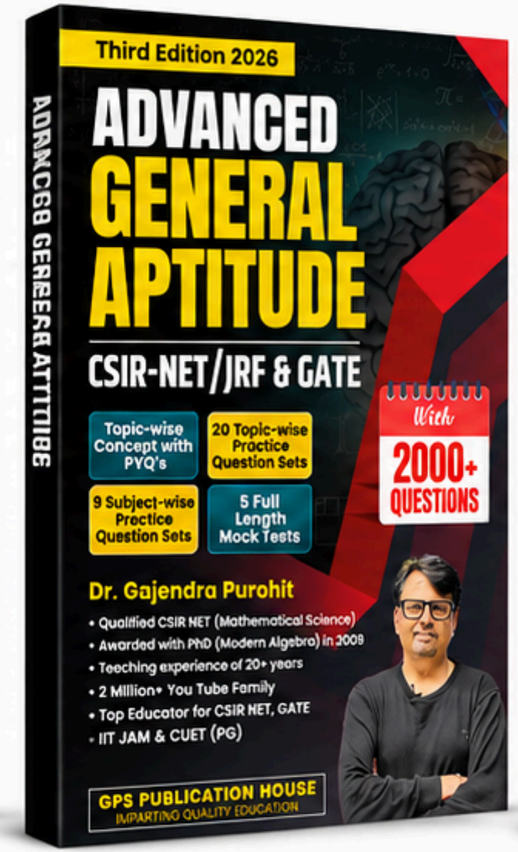
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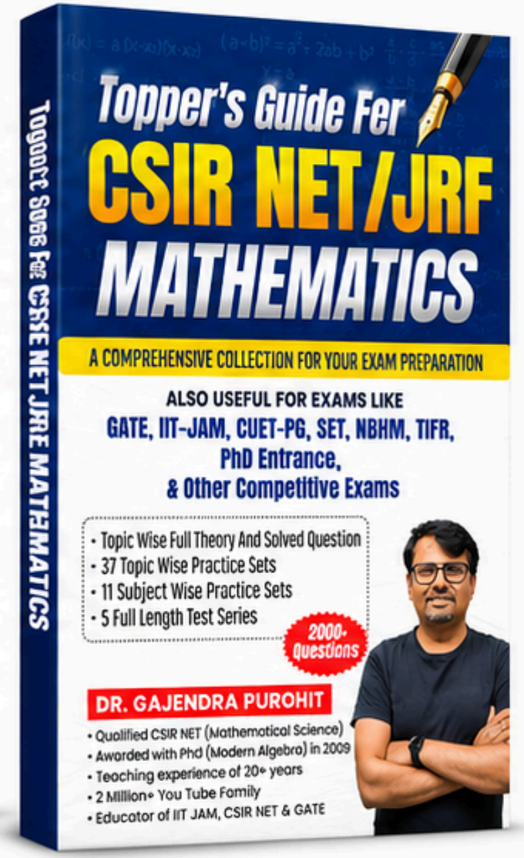
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