Unit I: Relations, Functions, and Inverse Trigonometry

General Instructions

1. Total Questions: **20**
2. Duration: **60 Minutes**
3. All questions are compulsory.
4. Read each question carefully before answering.
5. Choose the most appropriate answer from the given options.
6. Use of calculator or electronic devices is strictly prohibited.

1. Let R be a relation on the set of integers $\mathbb{Z}$ defined by xRy if and only if $x^2 + y^2$ is even. Prove whether R is an equivalence relation.

2. Determine the number of onto functions from a set A containing 6 elements to a set B containing 2 elements.

3. Let $f : \mathbb{R} \setminus \{3\} \to \mathbb{R} \setminus \{1\}$ be defined by $f(x) = \frac{x-2}{x-3}$. Find the inverse function $f^{-1}(x)$.

4. If the relation $R = \{(a, b) : 1 + ab > 0\}$ is defined on the set of real numbers, check if it is transitive. Provide a counterexample if it is not.

5. Find the domain of the function $f(x) = \sqrt{\log_{10}\left(\frac{5x-x^2}{4}\right)}$.

6. Let $f : \mathbb{R} \to \mathbb{R}$ be defined as $f(x) = x^3 + (a + 2)x^2 + 3ax + 5$. Find the set of values of a for which $f(x)$ is a one-one function.

7. Solve for x: $\tan^{-1}(2x) + \tan^{-1}(3x) = \frac{\pi}{4}$.

8. Find the value of $\cos\left(2\cos^{-1} x + \sin^{-1} x\right)$ at $x = \frac{1}{5}$.

9. If $f(x) = \frac{4^x}{4^x+2}$, calculate the sum $f(1/100) + f(2/100) + \cdots + f(99/100)$.

10. Prove that the function $f : \mathbb{R} \to \mathbb{R}$ defined by $f(x) = \cos(x + \phi)$ is neither one-one nor onto.

11. Find the principal value of $\sin^{-1}\left(\sin\frac{2\pi}{3}\right) + \cos^{-1}\left(\cos\frac{4\pi}{3}\right)$.

12. Let $S = \{1, 2, 3, 4\}$. Find the number of subsets of $S \times S$ that represent a reflexive relation on S.

13. If $\sin^{-1} x + \sin^{-1} y + \sin^{-1} z = \frac{3\pi}{2}$, find the value of $x^{100} + y^{100} + z^{100} - \frac{9}{x^{101}+y^{101}+z^{101}}$.

14. Determine the range of the function $f(x) = \tan^{-1}\sqrt{x^2 + x}$.

15. Let R be a relation on $\mathbb{R}$ defined by $aRb \Leftrightarrow |a| \leq b$. Examine the symmetry and transitivity of R.

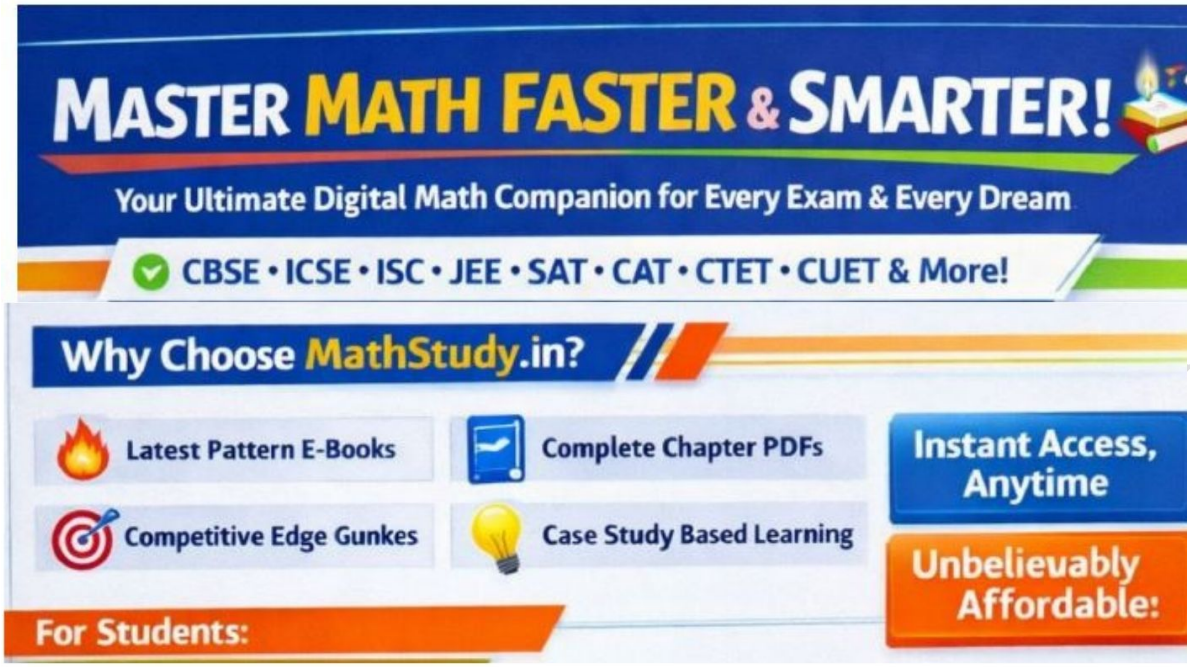
16. Find the value of $\tan\left(\frac{1}{2}\cos^{-1}\frac{\sqrt{5}}{3}\right)$.

17. If $f(x) = \sin^{-1}\left(\frac{2x}{1+x^2}\right)$, find the interval of x for which $f(x) = 2\tan^{-1} x$.

18. Evaluate: $\sum_{n=1}^{\infty} \tan^{-1}\left(\frac{1}{1+n+n^2}\right)$.

19. Let $A = \{1, 2, 3, \ldots, n\}$. How many functions $f : A \to A$ can be formed such that $f(1) \neq 1$?

20. Simplify the expression: $\tan^{-1}\left(\frac{x}{y}\right) - \tan^{-1}\left(\frac{x-y}{x+y}\right)$.



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