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SIXTH SEMESTER UG (CBCSS-UG) DEGREE EXAMINATION, MARCH 2024

Mathematics

MTS 6B 10—REAL ANALYSIS

(2019 Admissions onwards)

Time : Two Hours and a Half | Maximum Marks : 80

Section A

Questions 1—15. *Answer any number of questions.*
Each carry 2 *marks. Maximum marks* 20.

1. State discontinuity criterion. Hence show that the signum function is not continuous at $x = 0$.

2. State maximum-minimum theroem.

3. Show that $f(x) = \dfrac{1}{x}$ is uniformly continuous on $[a, \infty)$ where $a > 0$.

4. Define Riemann integral of a function f on an integral $[a, b]$.

5. If f and g are in $R[a, b]$ and if $f(x) \leq g(x)$ for all x in $[a, b]$ then show that $\int_a^b f \leq \int_a^b g$.

6. State Lebesgue's integrability criterion.

7. If f and g belong to $R[a, b]$ then the product fg belongs to $R[a, b]$.

8. Show that $\lim \dfrac{\sin(nx+n)}{n} = 0$ for $x \in \mathbb{R}$.

9. Discuss the uniform convergence of $f_n(x) = \dfrac{x}{n}$ on A = [0, 1].

10. Evaluate $\lim\left(e^{-nx}\right)$ for $x \in \mathbb{R}, x \geq 0$.

11. Define absolute convergence of series of functions.

12. Evaluate $\int_{-\infty}^{0} e^x \, dx$.

13. Find the principal value of $\int_{-\infty}^{\infty} \dfrac{dx}{x^2+1}$.

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14. Show that $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$.

15. Define Beta fucntion. St B (p, q) = B (q, p).

Section B

Questions 16—23. *Answer any number of questions.*
Each carry 5 *marks. Maximum marks* 35.

16. Let $A = \{x \in \mathbb{R} | x > 0\}$. Define h on A by $h(x) = 0$ if $x \in A$ is irrational and $h(x) = \frac{1}{n}$ if $x \in A$ is rational with $x = \frac{m}{n}, m, n \in \mathbb{N}$ have no common factor except 1. Then show that h is continuous at every irrational number in A and discontinuous at every rational number in A.

17. Let I be an interval and $f : I \to \mathbb{R}$ be a continuous function on I then show that f(I) is an interval.

18. If $f \in R\,[a, b]$ then show that f is bounded on $[a, b]$.

19. Show that if $\phi : [a, b] \to R$ is a step function then $\phi \in R[a, b]$.

20. Evaluate $\lim \frac{x^2 + nx}{n}, x \in R$. Is the convergence uniform on $\mathbb{R}$?

21. Let (f_n) be a sequence of bounded functions on $A \subseteq \mathbb{R}$. Then show that (f_n) converges uniformly on A to a bounded function f iff for each $\varepsilon > 0$ there is a number $H(\varepsilon)$ in $\mathbb{N}$ such that for all $m, n \geq H(\varepsilon)$ then $\|f_m - f_n\|_A \leq \varepsilon$.

22. Discuss the convergence of $\int_0^\infty \frac{\sin^2 x}{x^2}\,dx$.

23. Define Beta function and show that $\forall p > 0, q > 0, B(p, q) = 2\int_0^{\pi/2} \sin^{2p-1}\theta \cos^{2p-1}\theta\, d\theta$.

Section C

Questions 24—27. *Answer any* **two** *questions.*
Each carry 10 *marks.*

24. (a) Show that if f and g are uniformly continuous on $A \subseteq \mathbb{R}$ and they are bounded on A then their product fg is also uniformly continuous.

(b) Show that $f(x) = \sqrt{x}$ is uniformly continuous on $[a, \infty)$ where $a > 0$.

25. Suppose f and g are in R $[a, b]$. Then

(a) if $k \in \mathrm{R}$, show that $kf \in \mathcal{R}[a,b]$ and $\int_a^b kf = k\int_a^b f$.

(b) $f + g \in \mathcal{R}[a,b]$ and $\int_a^b f + g = \int_a^b f + \int_a^b g$.

26. Discuss the pointwise and uniform convergence of :

(a) $f_n(x) = \dfrac{\sin(nx + n)}{n}$ for $x \in \mathbb{R}$.

(b) $g_n(x) = \dfrac{x^2 + nx}{n}$ for $x \in \mathbb{R}$.

27. Show that $\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$.

(2 × 10 = 20 marks)