Subject: A Course of Mathematics
Paper: A

Attempt Six questions in all by selecting Three questions from each section.

SECTION-I

Q.1 (a) Define continuous function in term of $(\delta - \varepsilon)$ form and discuss the continuity of $f(x) = x - [x]$, $x \in R$, for integral values of R. 3+6

(b) Define least upper bound and prove that the set $S = \{x : x^2 < 2\}$ has least upper bound $= \sqrt{2}$. 2+6

Q.2 (a) If u is a derivable function of v and v is a derivable function of x, then prove that $\dfrac{du}{dx} = \dfrac{du}{dv} \cdot \dfrac{dv}{dx}$. 9

(b) If $y(x) = e^{ax} x^2$, find a formula for $y^{(n)}(x)$. 8

Q.3 (a) If f is differentiable on $[a, b]$ and f' decreases strictly on $[a, b]$, prove that $f'(b) < \dfrac{f(b) - f(a)}{b - a} < f'(a)$. How is this result modified if f' increases strictly on $[a, b]$? Hence show that if $f(x) = \sin x$, $a = \dfrac{\pi}{3}$, $b = \dfrac{61\pi}{180}$ then $\sin 61° - \sin 60° < 0.0088$. 9

(b) Evaluate the following limit: $\lim\limits_{x \to 1} \dfrac{(1 - x^{n+1})(1 - x^{n+2})(1 - x^{n+3})...(1 - x^{n+4})}{(1 - x)(1 - x^2)(1 - x^3)...(1 - x^4)}$. 8

Q.4 (a) Describe the geometrical significance of the derivative of the radius vector with respect to the polar angle. 9

(b) Show that Pedal equation of the ellipse $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} = 1$ is $\dfrac{1}{p^2} = \dfrac{1}{a^2} + \dfrac{1}{b^2} - \dfrac{r^2}{a^2 b^2}$. 8

Q.5 (a) Show that the maximum value of $\left(\dfrac{1}{x}\right)^x$ is $(e)^{1/e}$. 8

(b) If $y(x) = \{x + \sqrt{1 + x^2}\}^m$, prove that $(1 + x^2) y''(x) + x y'(x) - m^2 y(x) = 0$ and $(1 - x^2) y^{(n+2)}(x) + (2n + 1) x y^{(n+1)}(x) + (n^2 - m^2) y^{(n)}(x) = 0$. 9

Q.6 (a) Find the centre of curvature of the astroid $x^{2/3} + y^{2/3} = a^{2/3}$. 8

(b) The normal to a given curve is a tangent to its evolute. 9

SECTION-II

Q.7 (a) State and prove the fundamental theorem of the integral calculus. 8

(b) Prove that $\displaystyle\int_0^\infty \dfrac{\ln(1 + x^2)}{1 + x^2} dx = \pi \ln 2$. 9

Q.8 (a) Define improper integral and determine the convergence or divergence of the following improper integral and evaluate. The convergent integral $\displaystyle\int_0^\infty e^{-x} x^5 dx$. 2+7

(b) Evaluate $\displaystyle\int \dfrac{x^2}{(1 + x^2)^3} dx$. 8

Q.9 (a) Evaluate $\displaystyle\int \dfrac{x + \sin x}{1 + \cos x} dx$. 8

(b) (i) If $f(x)$ and $g(x)$ are two antiderivatives of $\phi(x)$ then $f(x)$ and $g(x)$ must differ by a constant. 4

(ii) Evaluate $\displaystyle\int \dfrac{\sqrt{9x^2 - 1}}{x} dx$. 4

Q.10 (a) Show that the intrinsic equation of the semicubical parabola $ay^2 = x^3$, taking the cusp as the fixed point is $27S = 8a(\sec^3 \psi - 1)$. 8

(b) Find the area of the region included between the cardiod $r = 2a(1 + \cos \theta)$ and the circle $r = 6a\cos\theta$. 8

Q.11 (a) Assuming that the area of an ellipse with semi axes a and b is πab, compute the volume of the ellipsoid $\dfrac{x^2}{a^2} + \dfrac{y^2}{b^2} + \dfrac{z^2}{c^2} = 1$. 8

(b) Find the Fourier series representing the function $f(x) = |x|$, $-\pi \le x \le \pi$. 8

Q.12 (a) Determine whether the series $\displaystyle\sum_{n=1}^\infty \dfrac{\arctan n}{1 + n^2}$ converges or diverges. 8

(b) Apply any appropriate test to determine the convergence or divergence of the series $\displaystyle\sum_{n=1}^\infty \dfrac{(2n + 1)!}{n^2(n + 1)!}$. 8

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