Subject: A Course of Mathematics
Paper: A
Note: Attempt Six questions in all by selecting Three questions from each section.

## SECTION-I

(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+6/3**

- Define least upper bound and prove that the set $S = \{x : x^2 < 2\}$ has least upper bound $= \sqrt{2}$. **2+6/1**

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 $y^{(n)}(x)$. **8/8**

2.3(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: $\displaystyle\lim_{x \to 1} \dfrac{(1 - x^{n+1})(1 - x^{n+2})(1 - x^{n+3})\ldots(1 - x^{n+4})}{(1 - x)(1 - x^2)(1 - x^3)\ldots(1 - x^4)}$. **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 **2/9**
$(1 - x^2) y^{(n-1)}(x) + (2n + 1) x y^{(n-1)}(x) + (n^2 - m^2) y^{(n)}(x) = 0$. **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 $\displaystyle\int_0^\infty \dfrac{\ln(1 + x^2)}{1 + x^2} dx = \pi \ln 2$.

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+7/9**

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

Q.9(a) Evaluate $\displaystyle\int \dfrac{x + \sin x}{1 + \cos x} dx$. **8/2**

(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. **4/1**

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

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 $\pi ab$, 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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**Mark Steyvers**

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