

Subject: A Course of Mathematics
Paper: A
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 $f(x) = x - [x]$, $x \in \mathbb{R}$, for integral values of $\mathbb{R}$. 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 $\frac{du}{dx} = \frac{du}{dv} \cdot \frac{dv}{dx}$. 9

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

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

(b) Evaluate the following limit: $\lim_{x \rightarrow 1} \frac{(1-x^{n+1})(1-x^{n+2})(1-x^{n+3}) \dots (1-x^{n+k})}{(1-x)(1-x^2)(1-x^3) \dots (1-x^k)}$. 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 $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is $\frac{1}{p^2} = \frac{1}{a^2} + \frac{1}{b^2} - \frac{r^2}{a^2 b^2}$. 8

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

(b) If $y(x) = (x + \sqrt{1+x^2})^n$, prove that $(1+x^2)y''(x) + xy'(x) - n^2 y(x) = 0$ and $(1-x^2)y^{(n-2)}(x) + (2n+1)xy^{(n-1)}(x) + (n^2 - n^2)y^{(n)}(x) = 0$. 9/10

Q.6(a) Find the centre of curvature of the astroid $x^{2/3} + y^{2/3} = a^{2/3}$. 9
(b) The normal to a given curve is a tangent to its evolute. 8

SECTION-II

Q.7(a) State and prove the fundamental theorem of the integral calculus. 9

(b) Prove that $\int_0^{\pi} \frac{\ln(1+x^2)}{1+x^2} dx = \pi \ln 2$. 8

Q.8(a) Define improper integral and determine the convergence or divergence of the following improper integral and evaluate. The convergent integral $\int_0^{\infty} e^{-x} x^5 dx$. 2+7/9

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

Q.9(a) Evaluate $\int \frac{x + \sin x}{1 + \cos x} dx$. 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 $\int \frac{\sqrt{9x^2-1}}{x} dx$. 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 $27S = 8a(\sec^2 \psi - 1)$. 8

(b) Find the area of the region included between the cardioid $r = 2a(1 + \cos \theta)$ 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 $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$. 8

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

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

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

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Table of Contents Maths Past Papers O Level 21

1. Understanding the eBook Maths Past Papers O Level 21
 - The Rise of Digital Reading Maths Past Papers O Level 21
 - Advantages of eBooks Over Traditional Books
2. Identifying Maths Past Papers O Level 21
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Maths Past Papers O Level 21
 - User-Friendly Interface
4. Exploring eBook Recommendations from Maths Past Papers O Level 21
 - Personalized Recommendations
 - Maths Past Papers O Level 21 User Reviews and Ratings
 - Maths Past Papers O Level 21 and Bestseller Lists
5. Accessing Maths Past Papers O Level 21 Free and Paid eBooks
 - Maths Past Papers O Level 21 Public Domain eBooks
 - Maths Past Papers O Level 21 eBook Subscription Services

- Maths Past Papers O Level 21 Budget-Friendly Options
- 6. Navigating Maths Past Papers O Level 21 eBook Formats
 - ePub, PDF, MOBI, and More
 - Maths Past Papers O Level 21 Compatibility with Devices
 - Maths Past Papers O Level 21 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Maths Past Papers O Level 21
 - Highlighting and Note-Taking Maths Past Papers O Level 21
 - Interactive Elements Maths Past Papers O Level 21
- 8. Staying Engaged with Maths Past Papers O Level 21
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Maths Past Papers O Level 21
- 9. Balancing eBooks and Physical Books Maths Past Papers O Level 21
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Maths Past Papers O Level 21
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Maths Past Papers O Level 21
 - Setting Reading Goals Maths Past Papers O Level 21
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Maths Past Papers O Level 21
 - Fact-Checking eBook Content of Maths Past Papers O Level 21
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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