

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

Q.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

Q.3(a) 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

Q.4(a) Describe the geometrical significance of the derivative of the radius vector with respect to the polar angle. 8

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

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. 8

(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  $\pi ab$ , 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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