

Answer all questions in the answer booklet provided. Please start each question on a new page. Full marks are not necessarily awarded for a correct answer with no working. Answers must be supported by working and/or explanations. Solutions found from a graphic display calculator should be supported by suitable working. For example, if graphs are used to find a solution, you should sketch them as part of your answer. Where an answer is incorrect, some marks may be given for a correct method, provided this is shown by written working. You are therefore advised to show all working.

1. [Maximum mark: 25]

This question will investigate the patterns in a sequence of sine functions using the identities in trigonometry and determine the sum of trigonometric ratios with large angles.

Consider the sequence of sine functions $\{f_n\}$ where $f_n(x) = \sin(2^{n-1} \cdot x)$ for $n \in \mathbb{N}^*$ and $x \in \mathbb{R}$.

(a) Find an expression of $f_2(x)$ in terms of $f_1(x)$ and $f_3(x)$. [4]

(b) Find an expression of $f_4(x)$ in terms of $f_2(x)$ and $f_6(x)$. [2]

(c) Hence show that $f_n(x) = 2\left(1 - 2(f_{n-1}(x))^2\right)f_{n-1}(x)$. [3]

(d) Prove by induction that $\cos\left(\frac{2^n\pi}{3}\right) = -\frac{1}{2}$ for all $n \in \mathbb{N}^*$. [4]

(e) Hence show that the sequence $f_1\left(\frac{2\pi}{3}\right), f_3\left(\frac{2\pi}{3}\right), f_5\left(\frac{2\pi}{3}\right), \dots$ is geometric by identifying the first term and the common ratio. [4]

(f) Determine if the geometric series $S = \sum_{n=1}^{\infty} f_n\left(\frac{2\pi}{3}\right)$ is convergent. [2]

(g) Hence or otherwise, find the exact value of the sum. [4]

$$\sin\left(\frac{\pi}{3}\right) = \sin\left(\frac{2\pi}{3}\right) + \sin\left(\frac{4\pi}{3}\right) + \sin\left(\frac{8\pi}{3}\right) + \dots + \sin\left(\frac{4096\pi}{3}\right).$$

Math Ib Hl Paper3 2013 Questions

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Table of Contents Math Ib Hl Paper3 2013 Questions

1. Understanding the eBook Math Ib Hl Paper3 2013 Questions
 - The Rise of Digital Reading Math Ib Hl Paper3 2013 Questions
 - Advantages of eBooks Over Traditional Books
2. Identifying Math Ib Hl Paper3 2013 Questions
 - 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 Math Ib Hl Paper3 2013 Questions
 - User-Friendly Interface
4. Exploring eBook Recommendations from Math Ib Hl Paper3 2013 Questions
 - Personalized Recommendations
 - Math Ib Hl Paper3 2013 Questions User Reviews and Ratings
 - Math Ib Hl Paper3 2013 Questions and Bestseller Lists
5. Accessing Math Ib Hl Paper3 2013 Questions Free and Paid eBooks
 - Math Ib Hl Paper3 2013 Questions Public Domain eBooks
 - Math Ib Hl Paper3 2013 Questions eBook Subscription Services
 - Math Ib Hl Paper3 2013 Questions Budget-Friendly Options
6. Navigating Math Ib Hl Paper3 2013 Questions eBook Formats

- ePub, PDF, MOBI, and More
- Math Ib Hl Paper3 2013 Questions Compatibility with Devices
- Math Ib Hl Paper3 2013 Questions Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Math Ib Hl Paper3 2013 Questions
 - Highlighting and Note-Taking Math Ib Hl Paper3 2013 Questions
 - Interactive Elements Math Ib Hl Paper3 2013 Questions
- 8. Staying Engaged with Math Ib Hl Paper3 2013 Questions
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Math Ib Hl Paper3 2013 Questions
- 9. Balancing eBooks and Physical Books Math Ib Hl Paper3 2013 Questions
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Math Ib Hl Paper3 2013 Questions
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Math Ib Hl Paper3 2013 Questions
 - Setting Reading Goals Math Ib Hl Paper3 2013 Questions
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Math Ib Hl Paper3 2013 Questions
 - Fact-Checking eBook Content of Math Ib Hl Paper3 2013 Questions
 - 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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