

8. [Maximum mark: 16]

Let  $y = \frac{\ln x}{x^2}$  for  $x > 0$ .

(a) Show that  $\frac{dy}{dx} = \frac{1-4 \ln x}{x^3}$ .

$$\begin{aligned} \frac{(2x)^1 x^1 - \ln(x^2) \cdot 2x^2}{(x^2)^2} &= \frac{\frac{1}{x} x^1 - \ln(x^2) \cdot 2x^2}{x^4} \\ &= \frac{x^0 - 2x^2 \ln(x^2)}{x^4} \quad [3] = \frac{x^0(1-4 \ln x)}{x^4} \\ &= \frac{1-4 \ln x}{x^3} \end{aligned}$$

Consider the function defined by  $f(x) = \frac{\ln x}{x^2}$  for  $x > 0$  and its graph  $y = f(x)$ .

(b) The graph of  $f$  has a horizontal tangent at point P. Find the coordinates of P. [5]



$$f'(x) = 0 \quad \frac{1-4 \ln x}{x^3} = 0$$

$$1-4 \ln x = 0$$

$$1 = 4 \ln x$$

$$\frac{1}{4} = \ln x$$

$$x = e^{1/4}$$

$$x = \frac{e^{1/4}}{1/4} = \frac{4}{e^{1/4}}$$

Coordinates  $(e^{1/4}, f(e^{1/4}))$

$$P \left( e^{1/4}, \frac{1}{4e} \right)$$

$$f(e^{1/4}) = \frac{\ln e^{1/4}}{(e^{1/4})^2} = \frac{1/4}{e^{1/2}} = \frac{1}{4e}$$

(c) Given that  $f''(x) = \frac{20 \ln x - 9}{x^3}$ , show that P is a local maximum point. [3]

$$f''(P) = -ve \text{ value}$$

$$= \frac{20 \ln e^{1/4} - 9}{(e^{1/4})^3}$$

$$\Rightarrow \frac{5 \cdot 20 \cdot 1/4 - 9}{e^{3/4}}$$

$$\frac{-4}{e^{3/4}}$$

-ve +  
denominator  
=> -ve

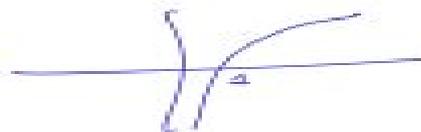
$\therefore P$  is a local maximum

(d) Solve  $f(x) > 0$  for  $x > 0$ . [2]

$$\frac{\ln x}{x^2} > 0$$

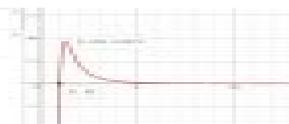
$$\Rightarrow \ln x > 0$$

$$x > 1$$



(e) Sketch the graph of  $f$ , showing clearly the value of the  $x$ -intercept and the approximate position of point P. [3]

$$\frac{\ln x}{x^2}$$



$$f(x) = \frac{\ln x}{x^2}$$

$$f(1) = \frac{\ln 1}{1^2} = 0$$

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## **Table of Contents Ib Math Sl Paper 23**

1. Understanding the eBook Ib Math Sl Paper 23
  - The Rise of Digital Reading Ib Math Sl Paper 23
  - Advantages of eBooks Over Traditional Books
2. Identifying Ib Math Sl Paper 23
  - 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 Ib Math Sl Paper 23
  - User-Friendly Interface
4. Exploring eBook Recommendations from Ib Math Sl Paper 23
  - Personalized Recommendations
  - Ib Math Sl Paper 23 User Reviews and Ratings
  - Ib Math Sl Paper 23 and Bestseller Lists
5. Accessing Ib Math Sl Paper 23 Free and Paid eBooks
  - Ib Math Sl Paper 23 Public Domain eBooks

- Ib Math Sl Paper 23 eBook Subscription Services
- Ib Math Sl Paper 23 Budget-Friendly Options
- 6. Navigating Ib Math Sl Paper 23 eBook Formats
  - ePub, PDF, MOBI, and More
  - Ib Math Sl Paper 23 Compatibility with Devices
  - Ib Math Sl Paper 23 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Ib Math Sl Paper 23
  - Highlighting and Note-Taking Ib Math Sl Paper 23
  - Interactive Elements Ib Math Sl Paper 23
- 8. Staying Engaged with Ib Math Sl Paper 23
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Ib Math Sl Paper 23
- 9. Balancing eBooks and Physical Books Ib Math Sl Paper 23
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Ib Math Sl Paper 23
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Ib Math Sl Paper 23
  - Setting Reading Goals Ib Math Sl Paper 23
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Ib Math Sl Paper 23
  - Fact-Checking eBook Content of Ib Math Sl Paper 23
  - 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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