

PHYS 410 Homework # 8

6.1. On a spherical surface, the longitude and latitude lines are orthogonal.



For a small change in position, we have the change in longitude and latitude:

$$ds_{\theta} = R \cdot d\theta, \quad ds_{\phi} = R \sin\theta \cdot d\phi$$

$$\Rightarrow ds = \sqrt{ds_{\theta}^2 + ds_{\phi}^2} = R \cdot d\theta \sqrt{1 + \sin^2\theta \frac{d\phi^2}{d\theta^2}}$$

$$\Rightarrow L = \int_{\theta_1}^{\theta_2} ds = R \int_{\theta_1}^{\theta_2} \sqrt{1 + \sin^2\theta \frac{d\phi^2}{d\theta^2}} \cdot d\theta$$

6.3



$$L(P, Q) = \sqrt{x_1^2 + y_1^2 + z_1^2} + \sqrt{x_2^2 + y_2^2 + z_2^2}$$

$$\Rightarrow T = L/c$$

According to Fermat's principle, we get:

$$\frac{\delta T}{\delta x} = 0, \quad \frac{\delta T}{\delta y} = 0.$$

$$\frac{\delta T}{\delta z} = 0 \Rightarrow 2 \cdot \left(\frac{1}{\sqrt{x_1^2 + y_1^2 + z_1^2}} + \frac{1}{\sqrt{x_2^2 + y_2^2 + z_2^2}} \right) = 0 \Rightarrow z = 0 \quad (1)$$

$$\frac{\delta T}{\delta x} = 0 \Rightarrow \frac{x_1}{\sqrt{x_1^2 + y_1^2 + z_1^2}} + \frac{x_2}{\sqrt{x_2^2 + y_2^2 + z_2^2}} = 0 \quad (2)$$



According to (1), when $z=0$, we get from (2):

$$\sin\theta_1 = \sin\theta_2$$

$$\Rightarrow \theta_1 = \theta_2$$

6.5



According to General Geometric relation, we know $\angle APB = \frac{\theta}{2}$.

$$\text{And } \alpha = \frac{\theta - \theta}{2}$$

$$\Rightarrow AP = AB \cdot \sin(\frac{\theta}{2} - \alpha) = AB \cos \frac{\theta}{2} = AB \sin \frac{\theta}{2} = 2R \sin \frac{\theta}{2}$$

$$BP = AB \cdot \sin \alpha = 2R \cdot \cos \frac{\theta}{2}$$

$$\Rightarrow APB = 2R \cdot (\sin \frac{\theta}{2} + \cos \frac{\theta}{2}) = 2\sqrt{2} \sin(\frac{\theta}{2} + \frac{\pi}{4}) R$$

$$\Rightarrow (APB)_{max} = 2\sqrt{2} R \text{ when } \theta = \frac{\pi}{2}, \text{ which is the real path.}$$

6.7

(2.4.2)



In cylinder coordinates, when R is const, the infinitesimal change in position corresponds to

$$ds = \sqrt{R^2 d\phi^2 + dz^2} = dz \sqrt{1 + R^2 \frac{d\phi^2}{dz^2}} = f(\phi, z) dz$$

$$\Rightarrow L = \int_{\phi_1}^{\phi_2} ds = \int_{z_1}^{z_2} f(\phi, z) dz$$

Classical Mechanics Problem Solutions

Daniel F McAuley



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Table of Contents Classical Mechanics Problem Solutions

1. Understanding the eBook Classical Mechanics Problem Solutions
 - The Rise of Digital Reading Classical Mechanics Problem Solutions
 - Advantages of eBooks Over Traditional Books
2. Identifying Classical Mechanics Problem Solutions
 - 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 Classical Mechanics Problem Solutions
 - User-Friendly Interface
4. Exploring eBook Recommendations from Classical Mechanics Problem Solutions
 - Personalized Recommendations
 - Classical Mechanics Problem Solutions User Reviews and Ratings
 - Classical Mechanics Problem Solutions and Bestseller Lists
5. Accessing Classical Mechanics Problem Solutions Free and Paid eBooks
 - Classical Mechanics Problem Solutions Public Domain eBooks
 - Classical Mechanics Problem Solutions eBook Subscription Services
 - Classical Mechanics Problem Solutions Budget-Friendly Options

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