

- 1 (a) State Newton's law of gravitation.

Gravitational Force is directly proportional to the product of two point masses and inversely proportional to the square of distance from their centres. [2]

- (b) A satellite is in a circular orbit around a planet. The radius of the orbit is R and the period of the orbit is T . The planet is a uniform sphere.

Use Newton's law of gravitation to show that R and T are related by

$$4\pi^2 R^3 = GMT^2$$

where M is the mass of the planet and G is the gravitational constant.

In orbit

$$F_c = F_g$$

$$mR\omega^2 = \frac{GmM}{R^2}$$

$$R^3\omega^2 = GM$$

$$R^3\left[\frac{2\pi}{T}\right]^2 = GM$$

$$\frac{R^3 4\pi^2}{T^2} = GM$$

$$4\pi^2 R^3 = T^2 GM$$

$$4\pi^2 R^3 = GMT^2$$

[2]

- (c) The Earth may be considered to be a uniform sphere of mass 5.98×10^{24} kg and radius 6.37×10^6 m.

A geostationary satellite is in orbit around the Earth.

Use the expression in (b) to determine the height of the satellite above the Earth's surface.

$$T^2 = \frac{4\pi^2}{GM} r^3$$

$$(24 \times 3600)^2 = \frac{4 \times (3.14)^2}{6.67 \times 10^{-11} \times 5.98 \times 10^{24}} \times r^3$$

$$r = 4.2 \times 10^7 \text{ m}$$

$$h = r - R$$

$$= 4.2 \times 10^7 - 6.37 \times 10^6$$

$$= 3.56 \times 10^7$$

height = 3.56×10^7 m [3]

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Table of Contents June 2013 Physics 9702 Paper 52 Question

1. Understanding the eBook June 2013 Physics 9702 Paper 52 Question
 - The Rise of Digital Reading June 2013 Physics 9702 Paper 52 Question
 - Advantages of eBooks Over Traditional Books
2. Identifying June 2013 Physics 9702 Paper 52 Question
 - 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 June 2013 Physics 9702 Paper 52 Question
 - User-Friendly Interface
4. Exploring eBook Recommendations from June 2013 Physics 9702 Paper 52 Question
 - Personalized Recommendations
 - June 2013 Physics 9702 Paper 52 Question User Reviews and Ratings
 - June 2013 Physics 9702 Paper 52 Question and Bestseller Lists
5. Accessing June 2013 Physics 9702 Paper 52 Question Free and Paid eBooks
 - June 2013 Physics 9702 Paper 52 Question Public Domain eBooks
 - June 2013 Physics 9702 Paper 52 Question eBook Subscription Services
 - June 2013 Physics 9702 Paper 52 Question Budget-Friendly Options

6. Navigating June 2013 Physics 9702 Paper 52 Question eBook Formats
 - ePub, PDF, MOBI, and More
 - June 2013 Physics 9702 Paper 52 Question Compatibility with Devices
 - June 2013 Physics 9702 Paper 52 Question Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of June 2013 Physics 9702 Paper 52 Question
 - Highlighting and Note-Taking June 2013 Physics 9702 Paper 52 Question
 - Interactive Elements June 2013 Physics 9702 Paper 52 Question
8. Staying Engaged with June 2013 Physics 9702 Paper 52 Question
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers June 2013 Physics 9702 Paper 52 Question
9. Balancing eBooks and Physical Books June 2013 Physics 9702 Paper 52 Question
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection June 2013 Physics 9702 Paper 52 Question
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine June 2013 Physics 9702 Paper 52 Question
 - Setting Reading Goals June 2013 Physics 9702 Paper 52 Question
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of June 2013 Physics 9702 Paper 52 Question
 - Fact-Checking eBook Content of June 2013 Physics 9702 Paper 52 Question
 - 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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