

Physics

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(Chapter 9) (Mechanical Properties of Solids) (Exercises)
(Class 11)

Question 9.13:

What is the density of water at a depth where pressure is 80.0 atm, given that its density at the surface is $1.03 \times 10^3 \text{ kg m}^{-3}$?

Answer 9.13:

Let the given depth be h . Pressure at the given depth, $p = 80.0 \text{ atm} = 80 \times 1.01 \times 10^5 \text{ Pa}$

Density of water at the surface, $\rho_1 = 1.03 \times 10^3 \text{ kg m}^{-3}$

Let ρ_2 be the density of water at the depth h , let V_1 be the volume of water of mass m at the surface.

Let V_2 be the volume of water of mass m at the depth h and let ΔV be the change in volume.

$$\Delta V = V_1 - V_2$$

$$= m \left(\frac{1}{\rho_1} - \frac{1}{\rho_2} \right)$$

$$\therefore \frac{\Delta V}{V_1} = 1 - \frac{\rho_1}{\rho_2} \quad \dots(i)$$

$$\text{Bulk modulus, } B = \frac{pV_1}{\Delta V}$$

$$\frac{\Delta V}{V_1} = \frac{p}{B}$$

$$\text{Compressibility of water} = \frac{1}{B} = 45.8 \times 10^{-11} \text{ Pa}^{-1}$$

$$\therefore \frac{\Delta V}{V_1} = 80 \times 1.013 \times 10^5 \times 45.8 \times 10^{-11} = 3.71 \times 10^{-3}$$

For equations (i) and (ii), we get:

$$1 - \frac{\rho_1}{\rho_2} = 3.71 \times 10^{-3}$$

$$\rho_2 = \frac{1.03 \times 10^3}{1 - (3.71 \times 10^{-3})} = 1.034 \times 10^3 \text{ kg m}^{-3}$$

Therefore, the density of water at the given depth (h) is $1.034 \times 10^3 \text{ kg m}^{-3}$.

Question 9.14:

Compute the fractional change in volume of a glass slab, when subjected to a hydraulic pressure of 10 atm.

Answer 9.14:

Hydraulic pressure exerted on the glass slab, $p = 10 \text{ atm} = 10 \times 1.013 \times 10^5 \text{ Pa}$

Bulk modulus of glass, $B = 37 \times 10^9 \text{ Nm}^{-2}$

$$\text{Bulk modulus, } B = \frac{p}{\frac{\Delta V}{V}}$$

Where, $\frac{\Delta V}{V}$ = Fractional change in volume

$$\therefore \frac{\Delta V}{V} = \frac{p}{B} = \frac{10 \times 1.013 \times 10^5}{37 \times 10^9} = 2.73 \times 10^{-5}$$

Hence, the fractional change in the volume of the glass slab is 2.73×10^{-5} .

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R Bogdan



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Table of Contents Chapter 22 Homework Solutions Physics Upenn

1. Understanding the eBook Chapter 22 Homework Solutions Physics Upenn
 - The Rise of Digital Reading Chapter 22 Homework Solutions Physics Upenn
 - Advantages of eBooks Over Traditional Books
2. Identifying Chapter 22 Homework Solutions Physics Upenn
 - 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 Chapter 22 Homework Solutions Physics Upenn
 - User-Friendly Interface
4. Exploring eBook Recommendations from Chapter 22 Homework Solutions Physics Upenn
 - Personalized Recommendations
 - Chapter 22 Homework Solutions Physics Upenn User Reviews and Ratings
 - Chapter 22 Homework Solutions Physics Upenn and Bestseller Lists
5. Accessing Chapter 22 Homework Solutions Physics Upenn Free and Paid eBooks
 - Chapter 22 Homework Solutions Physics Upenn Public Domain eBooks
 - Chapter 22 Homework Solutions Physics Upenn eBook Subscription Services
 - Chapter 22 Homework Solutions Physics Upenn Budget-Friendly Options

6. Navigating Chapter 22 Homework Solutions Physics Upenn eBook Formats
 - ePub, PDF, MOBI, and More
 - Chapter 22 Homework Solutions Physics Upenn Compatibility with Devices
 - Chapter 22 Homework Solutions Physics Upenn Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Chapter 22 Homework Solutions Physics Upenn
 - Highlighting and Note-Taking Chapter 22 Homework Solutions Physics Upenn
 - Interactive Elements Chapter 22 Homework Solutions Physics Upenn
8. Staying Engaged with Chapter 22 Homework Solutions Physics Upenn
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Chapter 22 Homework Solutions Physics Upenn
9. Balancing eBooks and Physical Books Chapter 22 Homework Solutions Physics Upenn
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Chapter 22 Homework Solutions Physics Upenn
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Chapter 22 Homework Solutions Physics Upenn
 - Setting Reading Goals Chapter 22 Homework Solutions Physics Upenn
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Chapter 22 Homework Solutions Physics Upenn
 - Fact-Checking eBook Content of Chapter 22 Homework Solutions Physics Upenn
 - 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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