Question 13.13:

A gas in equilibrium has uniform density and pressure throughout its volume. This is strictly true only if there are no external influences. A gas column under gravity, for example, does not have uniform density (and pressure). As you might expect, its density decreases with height. The precise dependence is given by the so-called law of atmospheres $n_2 = n_1 \exp[-mg(h_2 - h_1)/k_BT]$

Where n_2, n_1 refer to number density at heights $h2$ and $h1$ respectively. Use this relation to derive the equation for sedimentation equilibrium of a suspension in a liquid column:

$n_2 = n_1 \exp[-mg NA(\rho - P')(h_2 - h_1)/(\rho RT)]$

Where ρ is the density of the suspended particle, and ρ' that of surrounding medium. [N_A is Avogadro's number, and R the universal gas constant.]

[**Hint**: Use Archimedes principle to find the apparent weight of the suspended particle.]

Answer 13.13:

According to the law of atmospheres, we have:

$n_2 = n_1 \exp[-mg(h_2 - h_1)/k_BT]$ ... (i)

Where,

n_1 is the number density at height h_1, and n_2 is the number density at height h_2.

mg is the weight of the particle suspended in the gas column.

Density of the medium = ρ'

Density of the suspended particle = ρ

Mass of one suspended particle = m'

Mass of the medium displaced = m

Volume of a suspended particle = V

According to Archimedes' principle for a particle suspended in a liquid column, the effective weight of the suspended particle is given as:

Weight of the medium displaced – Weight of the suspended particle

$= mg - m'g$

$= mg - V\rho'g = mg - \left(\dfrac{m}{\rho}\right)\rho'g$

$= mg\left(1 - \dfrac{\rho'}{\rho}\right)$ —(ii)

Gas constant, $R = k_B N$

$k_B = \dfrac{R}{N}$ .... (iii)

Substituting equation (ii) in place of mg in equation (i) and then using equation (iii), we get:

$n_2 = n_1 \exp[-mg(h_2 - h_1)/k_BT]$

$= n_1 \exp\left[-mg\left(-\dfrac{\rho'}{\rho}\right)_{(h_2-h_1)}\dfrac{N}{RT}\right]$

$= n_1 \exp\left[-mg(\rho - \rho')_{(h_2-h_1)}\dfrac{N}{RT\rho}\right]$

Chapter 13 Physics Problems Answers

A. Douglas Davis

Chapter 13 Physics Problems Answers:

Classical Mechanics Christopher W. Kulp,Vasilis Pagonis,2025-08-22 Classical Mechanics A Computational Approach with Examples using Python and Mathematica provides a unique contemporary introduction to classical mechanics with a focus on computational methods In addition to providing clear and thorough coverage of key topics this textbook includes integrated instructions and treatments of computation This newly updated and revised second edition includes two new appendices instructing the reader in both the Python and Mathematica languages All worked example problems in the second edition contain both Python and Mathematica code New end of chapter problems explore the application of computational methods to classical mechanics problems Full of pedagogy it contains both analytical and computational example problems within the body of each chapter The example problems teach readers both analytical methods and how to use computer algebra systems and computer programming to solve problems in classical mechanics End of chapter problems allow students to hone their skills in problem solving with and without the use of a computer The methods presented in this book can then be used by students when solving problems in other fields both within and outside of physics It is an ideal textbook for undergraduate students in physics mathematics and engineering studying classical mechanics Key Features Gives readers the big picture of classical mechanics and the importance of computation in the solution of problems in physics Numerous example problems using both analytical and computational methods as well as explanations as to how and why specific techniques were used Online resources containing specific example codes to help students learn computational methods and write their own algorithms A solutions manual is available via the Routledge Instructor Hub and all example codes in the book are available via the Support Material tab and at the book s GitHub page https github com vpagonis Classical_Mechanics_2nd_Edition *Field Solutions on Computers* Stanley Humphries, Jr.,2020-09-23 Field Solutions on Computers covers a broad range of practical applications involving electric and magnetic fields The text emphasizes finite element techniques to solve real world problems in research and industry After introducing numerical methods with a thorough treatment of electrostatics the book moves in a structured sequence to advanced topics These include magnetostatics with non linear materials permanent magnet devices RF heating eddy current analysis electromagnetic pulses microwave structures and wave scattering The mathematical derivations are supplemented with chapter exercises and comprehensive reviews of the underlying physics The book also covers essential supporting techniques such as mesh generation interpolation sparse matrix inversions and advanced plotting routines **Fundamentals of Physics, Part 2 (Chapters 12-20)** David Halliday,Robert Resnick,Jearl Walker,2004-01-06 *Ace That Test* Megan Sumeracki,Cynthia Nebel,Carolina Kuepper-Tetzel,Althea Need Kaminske,2023-07-19 We know students have more to learn than ever before and there is a lot of pressure to perform well on tests demonstrating superior learning However common study strategies such as cramming highlighting text and repeated reading have little impact in the longer term This exciting new book reveals

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