

Solutions to Problems in Goldstein, *Classical Mechanics*, Second Edition

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August 22, 2000

Chapter 1

Problem 1.1

A nucleus, originally at rest, decays radioactively by emitting an electron of momentum $1.73 \text{ MeV}/c$, and at right angles to the direction of the electron a neutrino with momentum $1.00 \text{ MeV}/c$. (The MeV (million electron volt) is a unit of energy, used in modern physics, equal to $1.60 \times 10^{-6} \text{ erg}$. Correspondingly, MeV/c is a unit of linear momentum equal to $5.34 \times 10^{-17} \text{ gm-cm/sec.}$) In what direction does the nucleus recoil? What is its momentum in MeV/c ? If the mass of the residual nucleus is $3.90 \times 10^{-23} \text{ gm}$, what is its kinetic energy, in electron volts?

Place the nucleus at the origin, and suppose the electron is emitted in the positive y direction, and the neutrino in the positive x direction. Then the resultant of the electron and neutrino momenta has magnitude

$$|\mathbf{p}_{e+\nu}| = \sqrt{(1.73)^2 + 1^2} = 2 \text{ MeV}/c,$$

and its direction makes an angle

$$\theta = \tan^{-1} \frac{1.73}{1} = 60^\circ$$

with the x axis. The nucleus must acquire a momentum of equal magnitude and directed in the opposite direction. The kinetic energy of the nucleus is

$$T = \frac{p^2}{2m} = \frac{4 \text{ MeV}^2 c^{-2}}{2 \cdot 3.9 \cdot 10^{-23} \text{ gm}} \cdot \frac{1.78 \cdot 10^{-23} \text{ gm}}{1 \text{ MeV} c^{-2}} = 9.1 \text{ ev}$$

This is much smaller than the nucleus rest energy of several hundred GeV , so the non-relativistic approximation is justified.

Thornton Classical Mechanics Solutions Manual

David Acheson



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Table of Contents Thornton Classical Mechanics Solutions Manual

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

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