

3.15 Magnetic Fundamentals

References:

Jiles, Introduction to Magnetism and Magnetic Materials

Magnetic quantities and units

H = magnetic field, A/m –represents energy gradient, or torque on a dipole

B = magnetic flux density, T or Wb/m² –number of magnetic field lines per unit area

M = magnetization, A/m –the magnetic moment, the response of a material to a field.

H comes from a current: current i produces tangential field $H = i/2 \pi r$ at radius r or from a magnetic material.

B depends on H : in free space
but inside a material

or
or
or

$$\begin{aligned} B &= \mu_0 H \\ B &= \mu_0 (H + M) \\ B &= \mu_0 \mu_r H \\ M &= H(\mu_r - 1) \\ M &= \chi H \end{aligned}$$

$$\mu_0 = 4\pi \cdot 10^{-7} \text{ Henry/m}$$

μ_r = relative permeability

$$\chi = (\mu_r - 1) = \text{susceptibility}$$

M and B both indicate how a material responds to a field H . Lines of B are continuous.

Note the same relation expressed in cgs units:

$$B \text{ (Gauss)} = H \text{ (Oersted)} + 4\pi M \text{ (emu/cc)}$$

where

$$1 \text{ Oe} = (1000/4\pi) \text{ A/m} = 79.6 \text{ A/m}$$

$$1 \text{ G} = 10^{-4} \text{ T}$$

$$1 \text{ emu/cc} = 1 \text{ kA/m}$$

Different types of materials

Diamagnet: atom has no net magnetic moment, but a field induces a small moment opposite to the field. Susceptibility is negative ($\mu_r < 1$)

Paramagnet: atoms have a net moment but the spin directions are randomly arranged. An applied field can give weak alignment, hence a small susceptibility that varies with $1/T$. ($\mu_r > 1$)

Ferromagnets have spontaneous magnetization, a large permeability which depends on the history of the sample, and nonlinear, hysteretic behavior.

Origin of magnetic behavior

Angular momentum of electrons produces magnetization due to moving charges.

Magnetization comes from 1) electron spin, 2) electron orbital motion.

Contributions from paired electrons cancel out, so strong magnetic effects are found in materials with unpaired electrons.

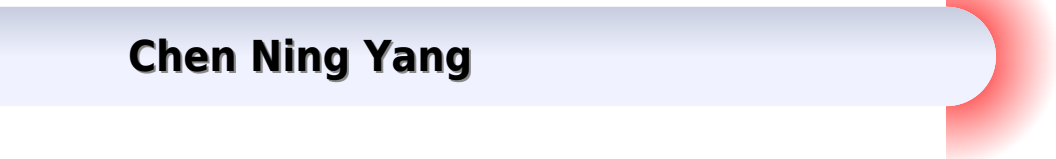
One electron has a moment of $1 \mu_B$ (Bohr magneton) = $9.27 \cdot 10^{-24} \text{ Am}^2$

Stern-Gerlach and Zeeman experiments indicate the quantization of the magnetization in atoms.

We expect large magnetic effects in transition metals (unfilled 3d) and rare earths (unfilled 4f) because these can have a large net spin.

Answers For Magnetic Fundamentals Conceptual Physics

Chen Ning Yang



Answers For Magnetic Fundamentals Conceptual Physics:

X+2 BOARD EXAM BASED CONCEPTUAL PHYSICS (Board Exam Made Simple) L M Garg, 2023-03-15

Instructor's Manual [to Accompany] Conceptual Physics, Eighth Ed Paul G. Hewitt, 1998 Conceptual Physics Tenth Edition helps readers connect physics to their everyday experiences and the world around them with additional help on solving more mathematical problems Hewitt's text is famous for engaging readers with analogies and imagery from real world situations that build a strong conceptual understanding of physical principles ranging from classical mechanics to modern physics With this strong foundation readers are better equipped to understand the equations and formulas of physics and motivated to explore the thought provoking exercises and fun projects in each chapter Included in the package is the workbook Mechanics Properties of Matter Heat Sound Electricity and Magnetism Light Atomic and Nuclear Physics Relativity For all readers interested in conceptual physics Theory Of Magnetism Made Simple, The: An Introduction To Physical Concepts And To Some Useful Mathematical Methods Daniel C Mattis, 2006-03-10 This new version of a classic updates much of the material in earlier editions including the first chapter on the history of the field Important modifications reflect major discoveries of the past decades A historical perspective is maintained throughout The reader is drawn into the process of discovery starting with a phenomenon finding plausible explanations and competing theories and finally the solution The theory of magnetism is practically a metaphor for theoretical physics The very first quantum many body theory Bethe's ansatz was devised for magnetic chains just as mean field theory was invented a century ago by Weiss to explain Curie's Law The first two chapters of this book are immensely readable taking us from prehistory to the spin valves of the most recent past Topics in subsequent chapters include angular momenta and spin Chapter 3 quantum theory of simple systems followed by increasingly technical insights into ordered and random systems thermal fluctuations phase transitions chaos and the like Contemporary developments in nanotechnology now seek to take advantage of the electron's spin as well as of its charge The time is not far off when nano circuits made entirely of silicon exhibit such many body properties as superconductivity or ferromagnetism without any superconducting materials or magnetic ions being present The reader of this book will be prepared for such exotic twenty first century applications Daniel C Mattis BS MS PhD Fellow of the American Physical Society APS is a frequent lecturer at research institutions and the author of several textbooks and numerous research articles His expertise includes many body theory electrical conductivity quantum theory of magnetism and most recently nanotechnology Prof Mattis is on the editorial panel for high temperature superconductivity of the International Journal of Modern Physics B and Modern Physics Letters B both published by World Scientific Currently serving as Professor in the Physics department at the University of Utah in Salt Lake City Utah USA at various times he has been visiting Professor at Yale University New Haven State University of New York Buffalo Temple University Philadelphia and served as Wei Lun Visiting Professor at the Chinese University of Hong Kong A founding member of the Few Body Physics

section of the APS he has also served as Chair of the standing committee of the APS for the International Freedom of Scientists

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Concepts in Physics Isaac Asimov, 1973 **Fundamental Concepts of Algebra** Bruce Elwyn Meserve, 1982-01-01 Uncommonly interesting introduction illuminates complexities of higher mathematics while offering a thorough understanding of elementary mathematics Covers development of complex number system and elementary theories of numbers polynomials and operations determinants matrices constructions and graphical representations Several exercises

without solutions U.S. Government Research Reports ,1964 *Selected Papers (1945-1980), with Commentary* Chen Ning Yang,2005 Consists of 73 articles and added items exclusively for this edition Fundamentals of Classical Fourier Analysis Shashank Tiwari,2025-02-20 Fundamentals of Classical Fourier Analysis is a comprehensive guide to understanding fundamental concepts techniques and applications of Fourier analysis in classical mathematics This book provides a thorough exploration of Fourier analysis from its historical origins to modern day applications offering readers a solid foundation in this essential area of mathematics Classical Fourier analysis has been a cornerstone of mathematics and engineering for centuries playing a vital role in solving problems in fields like signal processing differential equations and quantum mechanics We delve into the rich history of Fourier analysis tracing its development from Joseph Fourier s groundbreaking work to modern digital signal processing applications Starting with an overview of fundamental concepts and motivations behind Fourier analysis we introduce Fourier series and transforms exploring their properties convergence and applications We discuss periodic and non periodic functions convergence phenomena and important theorems such as Parseval s identity and the Fourier inversion theorem Throughout the book we emphasize both theoretical insights and practical applications providing a balanced understanding of Fourier analysis and its relevance to real world problems Topics include harmonic analysis orthogonal functions Fourier integrals and Fourier transforms with applications in signal processing data compression and partial differential equations Each chapter includes examples illustrations and exercises to reinforce key concepts Historical insights into key mathematicians and scientists contributions are also provided Whether you are a student researcher or practitioner in mathematics engineering or related fields Fundamentals of Classical Fourier Analysis is a comprehensive and accessible resource for mastering Fourier analysis principles and techniques Journeyman Electrician Exam Prep Mastery 2025-2030 Richard Man,2025-09-16 Are you preparing to take the Journeyman Electrician Exam and feeling overwhelmed by the sheer amount of material to cover Do you worry about keeping up with the latest updates to the NEC codes and test standards You re not alone many aspiring electricians struggle with knowing exactly what to study how to study it and how to walk into exam day with confidence This comprehensive guide is designed specifically for the 2025 2030 testing period ensuring that every practice question explanation and exam strategy aligns with the most current codes and industry requirements Inside you ll find Clear step by step breakdowns of NEC concepts and calculations 1 000 practice questions with detailed answer explanations Proven test taking strategies tailored to the Journeyman Electrician Exam format Realistic practice exams to build speed and accuracy under pressure Imagine walking into the testing center fully prepared calm and confident knowing you ve already mastered the exact concepts you ll face on the exam Passing your Journeyman Electrician Exam isn t just about getting a license it s about opening doors to higher pay greater job security and the ability to work independently in a trade that will always be in demand With this book you ll not only gain the knowledge but also the confidence to succeed on your very first attempt Don t leave your future up to chance Get your copy of

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The Academy, 1892 *Selected Papers (1945-1980) Of Chen Ning Yang (With Commentary)* Chen Ning Yang, 2005-08-22 A remarkable personal and professional chronicle by one of today's leading physicists this is a collection of Chen Ning Yang's personally selected papers supplemented by his insightful commentaries Including previously unpublished or hard to find works this volume contains Yang's important papers on statistical physics nuclear forces and particle physics Among them are his seminal work with T D Lee on the nonconservation of parity for which they won the Nobel Prize and his work with R L Mills which led to modern gauge theories with their exciting prospects for the broad unification of field theories The commentaries were written especially for this volume and provide a fascinating account of Yang's development as a physicist as well as a look at many important physicists of the 20th century They trace the development of Yang's interests and ideas from his graduate school days to the present showing how he worked with his colleagues and how their physics came into being Together the papers and commentaries in this unique collection comprise a powerful personal statement shedding light on both the intellectual development of a great physicist and on the nature of scientific inquiry

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