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Higher Education

Concepts *of* MODERN PHYSICS

Sixth Edition

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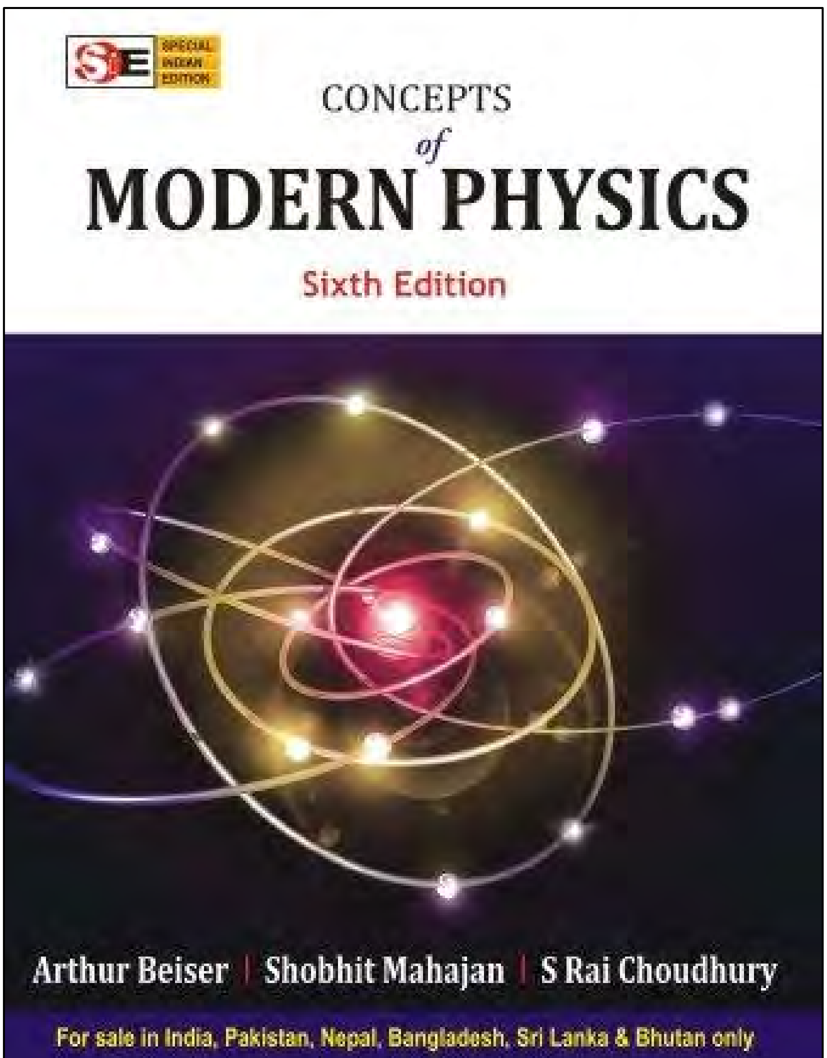
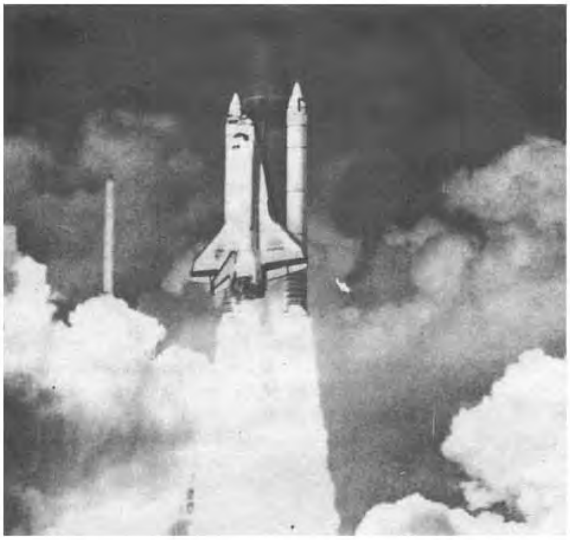


CHAPTER 1

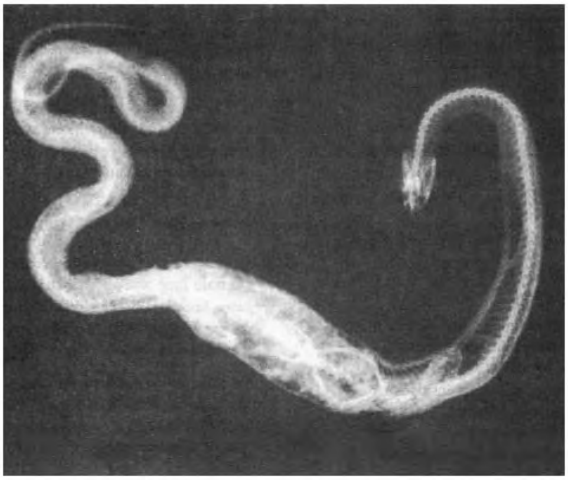
Relativity



According to the theory of relativity, nothing can travel faster than light. Although today's spacecraft can exceed 10 km/s, they are far from this ultimate speed limit.

CHAPTER 2

Particle Properties of Waves



The penetrating ability of x-ray enabled them to reveal the frog which this snake had swallowed. The snake's jaws are very loosely joined and so can open widely.

2.1 ELECTROMAGNETIC WAVES
Coupled electric and magnetic oscillations that move with the speed of light and exhibit typical wave behavior

2.2 BLACKBODY RADIATION
Only the quantum theory of light can explain its origin

2.3 PHOTOELECTRIC EFFECT
The energies of electrons liberated by light depend on the frequency of the light

2.4 WHAT IS LIGHT?
Both wave and particle

2.5 X-RAYS
They consist of high-energy photons

2.6 X-RAY DIFFRACTION
How x-ray wavelengths can be determined

2.7 COMPTON EFFECT
Further confirmation of the photon model

2.8 PAIR PRODUCTION
Energy into matter

2.9 PHOTONS AND GRAVITY
Although they lack rest mass, photons behave as though they have gravitational mass

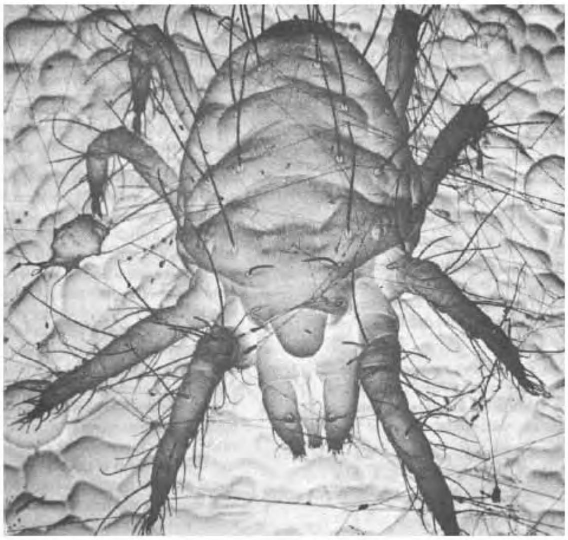
2.10 INTERFERENCE OF LIGHT AT ULTRA-LOW INTENSITIES

2.11 QUANTUM NATURE OF ELASTIC WAVES

2.12 LABORATORY EXPERIMENT OF TWO-SLIT INTERFERENCE WITH ONE PHOTON AT A TIME

CHAPTER 3

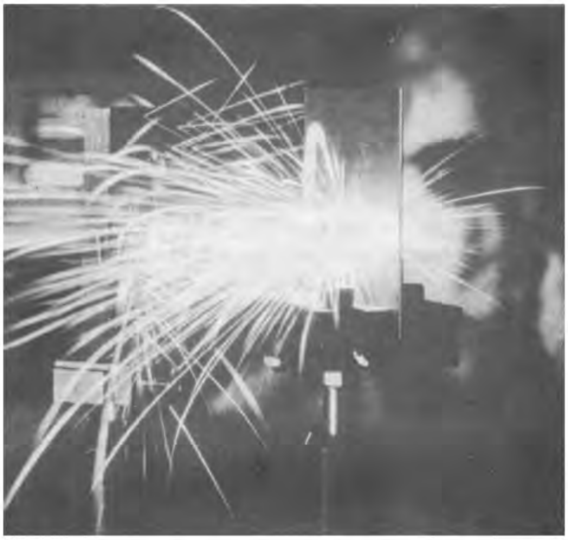
Wave Properties of Particles



In a scanning electron microscope, an electron beam that scans a specimen causes secondary electrons to be ejected in numbers that vary with the angle of the surface. A suitable data display suggests the three-dimensional form of the specimen. The high resolution of this image of a red spider mite on a leaf is a consequence of the wave nature of moving electrons.

CHAPTER 4

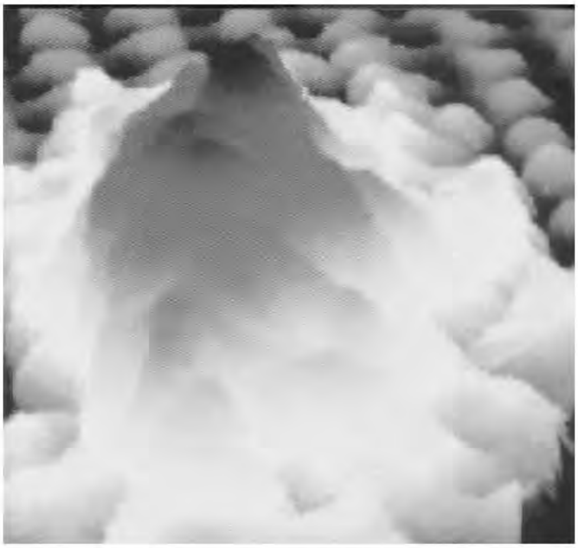
Atomic Structure



Solid-state infrared laser cutting 1.6-mm steel sheet. This laser uses an yttrium-aluminum-garnet crystal doped with neodymium. The neodymium is pumped with radiation from small semiconductor lasers, a highly efficient method.

CHAPTER 5

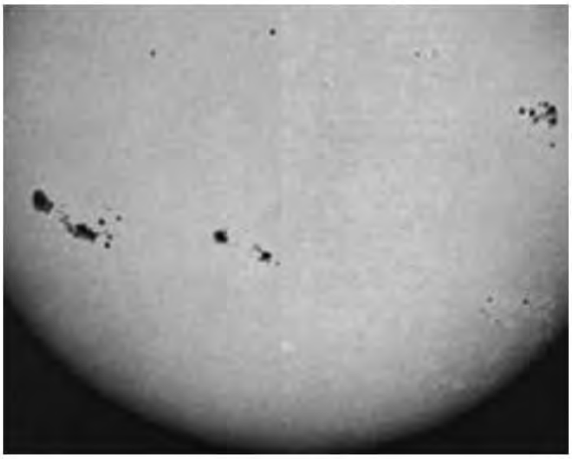
Quantum Mechanics



Scanning tunneling micrograph of gold atoms on a carbon (graphite) substrate. The cluster of gold atoms is about 1.5 nm across and three atoms high.

CHAPTER 6

Quantum Theory of the Hydrogen Atom



The strong magnetic fields associated with sunspots were detected by means of the Zeeman effect. Sunspots appear dark because they are cooler than the rest of the solar surface, although quite hot themselves. The number of spots varies in an 11-year cycle, and a number of terrestrial phenomena follow this cycle.

CHAPTER 7

Many-Electron Atoms

Helium, whose atoms have only closed electrons shells, is inert chemically and cannot burn or explode. Because it is also less dense than air, it is used in airships.

CHAPTER 8

Molecules

The infrared spectrometer measures the absorption of infrared radiation by a sample as a function of wavelength, which provides information about the structure of the molecules in the sample.

CHAPTER 9

Statistical Mechanics

The Crab Nebula is the result of a supernova explosion that was observed in A.D 1054. The explosion left behind a star believed to consist entirely of neutrons. Statistical mechanics is needed to understand the properties of neutron stars.

CHAPTER 10

The Solid State

Wood ant carrying a microchip that contains several million circuit elements.

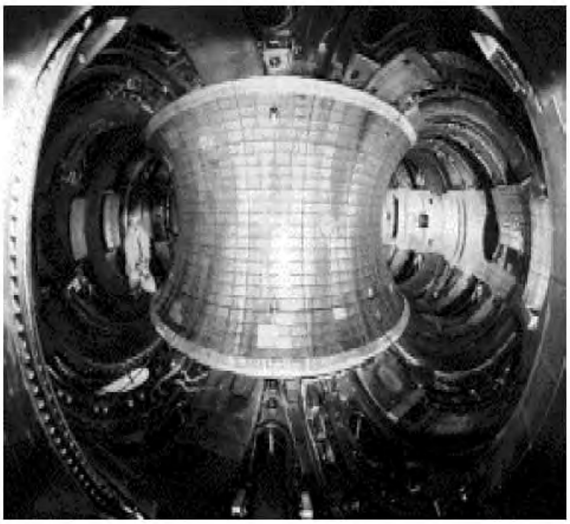
CHAPTER 11

Nuclear Structure

Nuclear magnetic resonance is the basis of a high-resolution method of imaging body tissues. The screen shows a computer-constructed cross section of the head of the person lying inside the powerful magnet at the rear.

CHAPTER 12

Nuclear Transformations



Interior of the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory. In December 1993 this reactor produced 6.2 MW of fusion power for 4 s from a deuterium-tritium plasma confined by strong magnetic fields.

CHAPTER 13

Elementary Particles

Aerial view of CERN, the European particle physics laboratory near Geneva, Switzerland, where many important discoveries were made. A tunnel 27 km in circumference under the large circle will contain the new Large Hadron Collider in which protons and antiprotons will move in opposite directions as they are accelerated to the highest energies yet achieved in the laboratory. It is hoped that their interactions will shed light on the process that gives particles mass. The smaller circle marks an earlier proton-antiproton collider.

CHAPTER 14

Cosmology

Horse head nebula: The horse head nebula, about 1500 light years away in the constellation of Orion. Nebulae are interstellar clouds of dust, gas and plasma which are often star forming regions. Study of the emission from nebulae gives us vital information about the early stages of star formation.

14.1 THE BIG BANG
The universe started with a Big Bang and has been expanding since

14.2 DARK MATTER AND DARK ENERGY
The Universe is predominantly made of invisible matter and energy

14.3 THE ELEMENTARY PARTICLES AND THEIR INTERACTIONS
The ultimate constituents of nature and their interactions with each other

14.4 VAN ALLEN BELT
Charged particles arranged in regions around the earth

14.5 EVOLUTION OF STARS
The lifecycle of stars- from their birth to death

CHAPTER 15

Nuclear Reactions and Artificial Radioactivity

Radioisotopes and Radiophysics: Particle Accelerator: Particle accelerators are essential tools for understanding the nature of matter at the smallest levels. From early van de Graff accelerators to the massive Large Hadron Collider, they have proved to be invaluable in expanding our knowledge of the nature of matter.