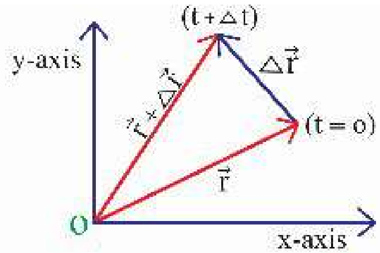
Quanta PUBLISHER



tEACH YOURSELF

α Ψ ∫ β Φ Σ

Delivering Physics Education with Understanding

APPLIED PHYSICS

For BS Physics Students

1st Edition

$W = \int \vec{F}.d\vec{r}$

$F = qE$

$f_{beat} = f_1 - f_2$

Short Questions with Answers, Solutions of Problems and MCQs are available at our website www.quantapublisher.com

0313-7899577
facebook@quantapublisher
youtube@quantapublisher

Quanta PUBLISHER

Dr. Syed Hamad Bukhari
Hammad Abbas
M.Nadeem Ishaq

TEACH YOURSELF

APPLIE PHYSICS

1st Edition

For **BS Physics / Math / Chemistry / Computer** students of all Pakistani Universities

•

Dr. Syed Hamad Bukhari
Department of Physics
G.C. University Faisalabad, Sub-Campus, Layyah

&

Hamad Abbas
Department of Physics
Emerson University, Multan

&

Muhammad Nadeem Ishaq
Department of Physics
University of Education, Multan

Quanta Publisher, 2660/6C Raza Abad, Shah Shamas, Multan.

Contents

1 Electric Charge and Electric Force ... 1
1.1 Electric Charge ... 1
1.2 Applications of Electrostatic Force ... 3
1.3 Coulomb's Law ... 4
1.4 Electric Field Intensity ($\overrightarrow{E}$) ... 7
1.4.1 Electric Field Intensity Due to Point Charge ... 7
1.4.2 Electric Field Due to Continuous Charge Distribution ... 8
1.5 The Electric Dipole ... 9
1.6 Electric Field for Continuous Charge Distributions ... 10
1.7 Electric Field Due to Ring of Charge ... 12
1.8 Electric Field Due to Charged Disk ... 13
1.9 Torque on a Dipole in an Electric Field ... 15
1.10 Potential Energy of an Electric Dipole ... 15
1.11 Electric Flux ... 17
1.12 Gauss's Law ... 18
1.13 Applications of Gauss's Law ... 19
1.13.1 Electric Field Due to Infinite Line of Charge ... 19
1.13.2 Electric Field Due to Infinite Sheet of Charge ... 21
1.13.3 Electric Field due to Spherical Charge Distribution ... 22
1.14 Gauss's Law (Spherical Symmetry) ... 25
1.15 Charged Isolated Conductor ... 26

2 Electric Potential and Electric Current ... 29
2.1 Electric Potential Energy Difference ... 29
2.2 Absolute Electric Potential Energy ... 30
2.3 Electric Potential Due to Point Charge ... 30
2.4 Potential Due to Electric Dipole ... 32
2.5 Potential Due to Continuous Charge Distribution ... 33
2.6 Potential Due to Charged Disk ... 34
2.7 Calculating Field from the Potential ... 35
2.8 Potential and Field Inside and Outside of an Isolated Conductor ... 36
2.9 Surface Charge Density for an Isolated Charged Conductor ... 37
2.10 Electric Current ... 39
2.11 Drift Velocity ... 40

2.12 Electrical Resistance 41
2.13 Ohm's Law 43
2.14 Energy Transfer in Electric Circuit 46

3 Electromagnetic Induction and Maxwell's Equation 48
3.1 Magnetic Field 48
3.2 Force on a Current Carrying Conductor in Magnetic Field 49
3.3 Force On Moving Charged Particle In Magnetic Field 51
3.4 Motion of Charged Particle in an Electric and Magnetic Field 53
3.5 Torque on a Current Loop 54
3.6 The Magnetic Dipole Moment 55
3.7 Biot-Savart Law 57
3.8 Application of Biot-Savart Law 58
3.9 Ampere's Law 59
3.10 Application of Ampere's Law 61
3.11 Magnetic Flux 63
3.12 Faradays Law of Electromagnetic Induction 64
3.13 Lenz law 65
3.13.1 Lenz Law and Conservation of Energy 66
3.14 Motional emf 67
3.15 Magnetization 68
3.16 Magnetic Materials 70

4 Electronics 73
4.1 Semi-conductors 73
4.2 Types of Semiconductors 74
4.2.1 Intrinsic Semiconductors 74
4.2.2 Extrinsic Semiconductors 75
4.3 PN-Junction 76
4.4 Transistor 78
4.4.1 NPN-Transistor 80
4.5 Amplifier 83

5 Modern and Nuclear Physics 87
5.1 Bohr's Theory of Hydrogen Atom 87
5.2 Black Body Radiation 91
5.3 Photoelectric Effect 95
5.4 Compton Effect 99
5.5 LASER 101
5.5.1 Spontaneous Emission 101
5.5.2 Stimulated Emission 102
5.5.3 Absorption 104
5.6 Radioactive Decay 105
5.7 Nuclear Fission 107
5.8 Nuclear Fusion 109
5.9 Controlled Thermonuclear Fusion 110

6 Waves and Oscillations 111
6.1 Interference 111
6.2 Young's Double Slit Experiment 111
6.3 Interference in Thin Films 114
6.4 Diffraction and Wave Theory of Light 115
6.5 Diffraction by a Single Slit 116

Chapter 1

Electric Charge and Electric Force

The electromagnetic force is one of the basic force in the nature that is responsible for the structure of atoms and for the binding of atoms in molecules and solids. Many properties of materials that we have studied so far are electromagnetic in their nature, such as the elasticity of solids and the surface tension of liquids. The spring force, friction, and the normal force all originated with the electromagnetic force between atoms. In open words, all the shapes of objects in nature are stable due to electromagnetic force. In this chapter, we begin with a discussion of electric charge, their electric field, some properties of charged bodies, and the fundamental electric force between two charged bodies.

1.1 Electric Charge

The physical entity which is responsible for all the electromagnetic properties of the matter and also experiences a force when placed in electromagnetic field is known as charge. For example after you pass a plastic comb through your hair a few times, you will find that the comb can exert a force on individual strands of your hair. You may also observe that, once the strands of hair are attracted to the comb and come into contact with it, they may no longer be attracted to it. It seems reasonable to conclude that the attraction between the comb and the hair is a result of some physical entity being transferred from one to the other when they rub together, with the same physical entity being transferred back again to neutralize the attraction when they come into contact. This physical entity is called electric charge, and today we understand this transfer on the basis of electrons that can be removed from the atoms of one object and attached to the atoms of the other object. Note the net electric charge of an object is usually represented by the symbol q. The charge is a scalar quantity. It can be positive or negative, depending on whether the object has a net positive or negative charge. Electric charge is measured in units of Coulombs (C).

Chapter 2

Electric Potential and Electric Current

2.1 Electric Potential Energy Difference

The potential energy difference between two points is equal to negative of work done by electrostatic force (conservative) in moving charge $q_\circ$ between two points, in an electric field, keeping constant velocity. Change in electrostatic P.E. is given by work energy principle.

$$\Delta U = -W \tag{2.1}$$

If test charge $q_\circ$ moves in electric field $\vec{E}$ from point a to b under the action of electrostatic force $\vec{F} = q_\circ\vec{E}$ then by Eq. (2.1),

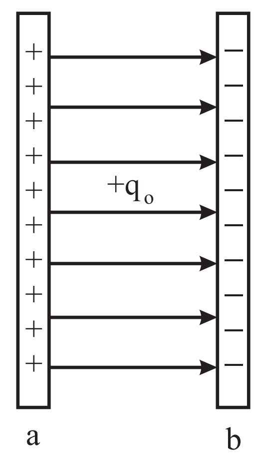


Fig. 2.1. A positive test charge is placed between two oppositely charged plates.

$$\begin{aligned} \Delta U &= -\int_a^b \vec{F}.d\vec{r} \\ U_b - U_a &= -\,q_\circ\int_a^b \vec{E}.d\vec{r} \\ U_b - U_a &= -\,q_\circ\int \vec{E}.d\vec{r} \end{aligned} \tag{2.2}$$

Because electric force is conservative, the integral is independent of path and depends only on initial position a and final position b. If electric field is produced due to positive point charge q, then by Eq.(2.2),

Chapter 3

Electromagnetic Induction and Maxwell's Equation

3.1 Magnetic Field

"The space around a permanent magnet or current carrying conductor or moving charge where another magnet experience a magnetic force is called magnetic field". A moving electric charge or an electric current sets up a magnetic field $\vec{B}$ which can then exert a magnetic force on other moving charges or current.

Magnetic Field Lines

"The line or path along which isolated north-pole moves in magnetic field is called line of magnetic force".

- It is directed away from north-pole and is directed towards south-pole.
- The tangent to the magnetic line at any point gives direction of magnetic induction $\vec{B}$ at that point.
- The inter spacing between magnetic field lines at any point gives an idea about strength of magnetic field at that point.
- If magnetic field lines are close, field will be strong and if lines are apart, field will be weak.

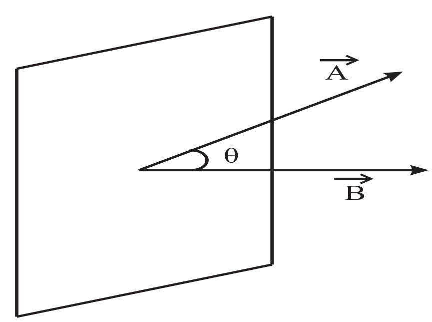


Fig. 3.1. The schematic picture of magnetic flux.

Chapter 4

Electronics

4.1 Semi-conductors

A semiconductor is an element with electrical properties between those of a conductor and an insulator. In term of energy bands, the semiconductor may be defined as those materials, which at room temperature, have

■ **Partially filled valence band**,

■ **Partially filled conduction band**,

■ **A very narrow (forbidden) energy gap** ($\Delta E \approx 1eV$) **between conduction and valence bands**. A small energy gap means that a small amount of energy is required to free the electrons by moving them from the valence band into the conduction band. Common examples of semiconductors are Silicon and Germanium which have forbidden energy gaps of 0.72 eV and 1.1 eV, respectively.

Temperature Effect on Conductivity of Semiconductors

A pure semiconductor behaves as insulator at 0 K but the conductivity of semiconductor increases with the increase in temperature. The electric conductivity of semiconductors is in the range of 10^{-3} *to* 10^{-6} $\Omega^{-1} cm^{-1}$.

As the temperature rises, electrons gain energy and leave the valence band to rise up to the conduction band. When an electron gains enough energy, greater than the band gap energy, and jumps to the upper band, it is free to move, becoming a carrier and therefore increasing the conductivity of the semiconductor. When electrons leave the valence band they leave behind a hole which can move about the crystal, also adding to the conductivity. So, conduction electrons are freely flow in conduction band and positive holes flow in the valence band.

Chapter 5

Modern and Nuclear Physics

5.1 Bohr's Theory of Hydrogen Atom

At the beginning of the 20th century, scientists were perplexed by the failure of classical physics to explain the characteristics of atomic spectra. Why did atoms of a given element exhibit only certain spectral lines? Furthermore, why did the atoms absorb only those wavelengths that they emitted? In 1913, Niels Bohr provided an explanation of atomic spectra that includes some features of the currently accepted theory. Bohr's theory contained a combination of ideas from Planck's original quantum theory, Einstein's photon theory of light, early models of the atom, and Newtonian mechanics. Using the simplest atom, hydrogen, Bohr described a model of what he thought must be the atom's structure. His model of the hydrogen atom contains some classical features, as well as some revolutionary postulates that could not be justified within the framework of classical physics.

The basic ideas of the Bohr theory as it applies to the hydrogen atom are as follows:

1. The electron moves in circular orbits around the proton under the influence of the Coulomb force of attraction.

2. Only certain electron orbits are stable. These stable orbits are ones in which the electron does not emit energy in the form of radiation. Hence, the total energy of the atom remains constant, and classical mechanics can be used to describe the electron's motion. Note that this representation is completely different from the classical model of an electron in a circular orbit. According to classical physics, the centripetally accelerated electron should continuously emit radiation, losing energy and eventually spiraling into the nucleus.

Chapter 6

Waves and Oscillations

6.1 Interference

Superposition of two waves having same frequency, same wavelength and moving in the same direction will result in the phenomenon of interference. Interference is of two types.

1. Constructive Interference

If the two waves reach a point in phase i.e. crest of one wave falls on the crest of the other wave and trough of on wave falls on the trough of the other wave then the two waves reinforce each other and the net wave effect increases i.e. the net intensity is greater than the intensity of individual wave. Such interference is called constructive interference.

2. Destructive Interference

If the two waves reach a point out of phase i.e. crest of one wave falls on the trough of the other, then the two waves cancel each others effect and the net intensity is less than the intensity of individual wave. This type of interference is called destructive interference.

Coherence Source

Coherent source of light are those sources which emit a light wave having the same frequency, wavelength and in the same phase or they have a constant phase difference. A coherent source forms sustained interference pattern when superposition of waves occur and the position of maximum and minimum are fixed.

6.2 Young's Double Slit Experiment

Huygens wave theory of light was experimentally confirmed by a British scientist Thomas Young in 1801. This experiment gave very strong support to the wave theory of light. Young's double slit experiment is shown in Fig.(6.1). When monochromatic light passing through two narrow slits S_1 and S_2 illuminates a distant screen. A screen is used to

1 Electric Charge and Electric Force. 01
1.1 Electric Charge 01
1.2 Applications of Electrostatic Force 03
1.3 Coulomb's Law 04
1.4 Electric Field Intensity (E) 07
1.4.1 Electric Field Intensity Due to Point 07
1.4.2 Electric Field Due to Continuous 08
1.5 The Electric Dipole Law 09
1.6 Electric Field for Continuous Charge 10
1.7 Electric Field Due to Ring of Charge 12
1.8 Electric Field Due to Charged Disk 13
1.9 Torque on a Dipole in an Electric Field 15
1.10 Potential Energy of an Electric Dipole 15
1.11 Electric Flux.. 17
1.12 Gauss's Law... 18
1.13 Applications of Gauss's Law 19
1.13.1 Electric Field Intensity Due to Point ..19
1.13.2 Electric Field Due to Continuous 21
1.13.3 Electric Field Due to Continuous 22
1.14 Gauss's Law (Spherical Symmetry) 25
1.15 Charged Isolated Conductor 26
2 Electric Potential and Electric Current 29
2.1 Electric Potential Energy Difference 29
2.2 Absolute Electric Potential Energy 30
2.3 Electric Potential Due to Point Charge 30
2.4 Potential Due to Electric Dipole 32
2.5 Potential Due to Continuous Charge 33
2.6 Potential Due to Charged Disk 34
2.7 Calculating Field from the Potential 35
2.8 Potential and Field Inside and Outside 36
2.9 Surface Charge Density for an Isolated 37
2.10 Electric Current 39
2.11 Drift Velocity 40
2.12 Electrical Resistance 41
2.13 Ohm's Law.. 43
2.14 Energy Transfer in Electric Circuit 46
3 Electromagnetic Induction and Maxwell's 48
3.1 Magnetic Field... 48
3.2 Force on a Current Carrying Conductor 49
3.3 Force On Moving Charged Particle In 51
3.4 Motion of Charged Particle in an Electric ...53
3.5 Torque on a Current Loop 54
3.6 The Magnetic Dipole Moment 55
3.7 Biot-Savart Law 57
3.8 Application of Biot-Savart Law 58
3.9 Ampere's Law 59
3.10 Application of Ampere's Law 61
3.11 Magnetic Flux 63
3.12 Faradays Law of Electromagnetic 64
3.13 Lenz law 65
3.14 Lenz Law and Conservation of Energy 66
3.15 Motional emf 67
3.16 Magnetization.. 68
3.17 Magnetic Materials 70
4 Optical Dispersion in Materials 73
4.1 Semi-conductors 73
4.2 Types of Semiconductors 74
4.2.1 Intrinsic Semiconductors 74
4.2.2 Extrinsic Semiconductors 75
4.3 PN-Junction... 76
4.4 Transistor 78
4.4.1 NPN-Transistor 80
4.5 Amplifier 83
5 Modern and Nuclear Physics 87
5.1 Bohr's Theory of Hydrogen Atom 87
5.2 Black Body Radiation 91
5.3 Photoelectric Effect 95
5.4 Compton Effect 99
5.5 LASER.. 101
5.5.1 Spontaneous Emission 101
5.5.2 Stimulated Emission 102
5.5.3 Absorption.. 104
5.6 Radioactive Decay 105
5.7 Nuclear Fission 107
5.8 Nuclear Fusion.. 109
5.9 Controlled Thermonuclear Fusion 110
6 Waves and Oscillations 111
6.1 Interference.. 111
6.2 Young's Double Slit Experiment 111
6.3 Interference in Thin Films 114
6.4 Diffraction and Wave Theory of Light 115
6.5 Diffraction by a Single Slit 116

Books by Quanta Publisher for BS Physics Students