

Electromagnetic Field Theory

Books:

Electrical

1. Sadiku, Matthew N, “Elements of Electromagnetics”, Oxford University Press, ISBN: 0195103688, Latest Edition.
2. William Hayt and John A. Buck, “Engineering Electromagnetics”, McGraw-Hill, ISBN: 0073104639, Latest Edition.
3. Kong J. A., “Electromagnetic Wave Theory”, Cambridge, Latest Edition.
4. John D. Kraus, “Engineering Electromagnetics”, McGraw-Hill Inc., New York, Latest Edition
5. N. N. Rao, “Elements of Engineering Electromagnetics”, Pearson Education, Latest Edition

Electronics

1. Electromagnetic waves & radio system by Jorden R.F.
2. Principle and applications of Electromagnetic fields by Ptonsey R and Collin R.P
3. Applied Electromagnetic by Planus M.A.

Fundamentals of Applied Electromagnetics by Fawaz T. Ulaby et. al. latest edition

Distribution of Marks

- Assignments = 12.5 marks
- Quizzes = 12.5 marks
- Mid term exam = 25 marks
- Final term exam = 50 marks

Introduction

Dawar Awan

University of Technology, Nowshera

dawar@uotnowshera.edu.pk

[Electromagnetic Field Theory – Spring 2018]

What is Electromagnetic Field Theory ?

- | **Electromagnetics or Electromagnetism** is about the combination of electricity and magnetism
- | We know the relation between electricity and magnetism
- | **Field** is any area. In this case, field is the area where the combined effect of electricity and magnetism can be felt
- | **Theory** is simply defined as a system of ideas intended to explain something

Theories of Electromagnetic Field in Real Life ?

| Wireless communication (Antennas)

| RADAR

| Machines and Drives

| Biomedical applications

| Sensors

Short Review of Some Fundamentals

Dimension	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol

| Derived Units

Prefixes to Represent Numbers/Units

Prefix	Symbol	Magnitude
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}

| Scalar Quantity

| Physical quantities requiring magnitude for complete description

| Represented by medium-weighted italic font

| Vector Quantity

| Physical quantities requiring magnitude and direction for complete description

| Represented by bold face font (or a normal letter with arrow above it)

| Magnitude is represented by a medium-weighted italic font

| Direction is represented by a unit vector (bold face letter with circumflex above it)

$$\mathbf{E} = E\hat{\mathbf{x}}$$

The Nature of Electromagnetism

- | **Electromagnetic force** is one of the nature's fundamental forces
- | It operates at the atomic scale
- | Its effects can be transmitted through **electromagnetic waves** through free space and material media
- | Source of electric and magnetic fields
- | Combination of electric and magnetic fields (electromagnetic field)

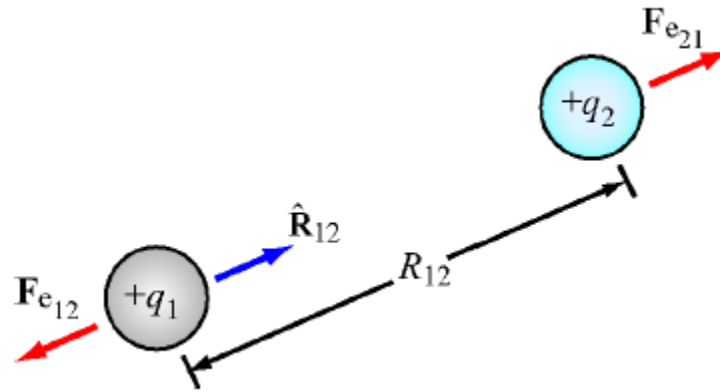
Electric Field

- | Source of electric field is electric charge
- | Electric charge may have positive or negative polarity
- | The resulting force may be attractive or repulsive
- | All matter is composed of neutrons (**neutral**), protons (**positively charged**), and electrons (**negatively charged**)
- | The fundamental quantity of charge is that of a single electron denoted by e

$$e = 1.6 \times 10^{-19} \text{Coulomb}$$

- | Charge of a single electron is $q_e = -e$, and that of a proton is $q_p = e$

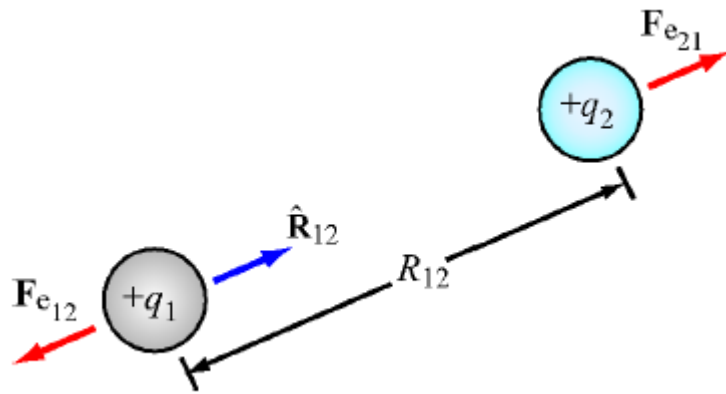
| Source of



Coulomb's experiments demonstrated that:

- (1) *two like charges repel one another, whereas two charges of opposite polarity attract,*
- (2) *the force acts along the line joining the charges, and*
- (3) *its strength is proportional to the product of the magnitudes of the two charges and inversely proportional to the square of the distance between them.*

Coulomb's Law



$$\mathbf{F}_{e21} = \hat{\mathbf{R}}_{12} \frac{q_1 q_2}{4\pi \epsilon_0 R_{12}^2} \quad (\text{N}) \quad (\text{in free space})$$

- | Where F_{e21} is the electric force acting on charge q_2 due to charge q_1
- | R_{12} is the distance between the two charges
- | \hat{R}_{12} is the unit vector pointing from q_1 to q_2
- | ϵ_0 is a universal constant called the **electrical permittivity of free space**

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ F/m}$$

- | $F_{e12} = -F_{e21}$

Continued ...