Jaipur Engineering College and Research Centre
Department of Electrical Engineering
Session-2020-2021

Name of Faculty	Mr. Vishal Sharma.	Designation:	Assistant Professor
Department	Electrical Engineering		
Subject	**Electrical Materials Code-5EE3-01**		

Electrical Materials Code-5EE3-01
Unit -1

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Vision of Institute

To become a renowned centre of outcome based learning, and work towards academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission of Institute

M1. Focus on evaluation of learning outcomes and motivate students to I nculcate research aptitude by project based learning.
M2. Identify, based on informed perception of Indian, regional and global needs, areas of focus and provide platform to gain knowledge and solutions.
M3. Offer opportunities for interaction between academia and industry.
M4. Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

Vision of EE Department

Electrical Engineering Department strives to be recognized globally for outcome based knowledge and to develop human potential to practice advance technology which contribute to society.

Mission of EE Department

M1: To impart quality technical knowledge to the learners to make them globally competitive Electrical Engineers.
M2: To provide the learners ethical guidelines along with excellent academic environment for a long productive career.
M3: To promote industry-institute relationship.

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Program Outcomes

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems in Electrical engineering.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex Electrical engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex Electrical engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in Electrical engineering.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Electrical engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Electrical engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional Electrical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the Electrical engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings in Electrical engineering.
10. **Communication**: Communicate effectively on complex Electrical engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the Electrical engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change in Electrical engineering.

PSO-Program Specific Objectives

PSO1 Graduates will be able to contribute for the development of automation.
PSO2 Graduates will be able to contribute towards integration of the green energy.

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Subject- Electrical Materials **Semester-** V **Code-**5EE3-01

CO1	Understand the bonding and crystalline state of solids along and their physical characteristics.
CO2	Analysis of dielectric and magnetic properties of engineering materials.
CO3	Understand the fundaments of semiconductors and their applications.

CO-PO Mapping

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
CO-1	3	3	3	3	-	2	-	-	1	-	1	3
CO-2	3	2	2	2	-	2	-	-	2	-	1	3
CO-3	3	2	2	2	-	2	-	-	1	-	2	3

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RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

3rd Year - V Semester: B.Tech. (Electrical Engineering)

5EE3-01: ELECTRICAL MATERIALS

Credit: 2 **Max. Marks: 100(IA:20, ETE:80)**

2L+0T+0P **End Term Exam: 2 Hours**

SN	CONTENTS	HOURS
1.	**Introduction:** Objective, scope and outcome of the course.	01
2.	**Elementary Materials Science Concepts** Bonding and types of solids, Crystalline state and their defects, Classical theory of electrical and thermal conduction in solids, temperature dependence of resistivity, skin effect, Hall effect..	05
3.	**Dielectric Properties of Insulators in Static and Alternating field:** Dielectric constant of mono-atomic gases, poly-atomic molecules and solids, Internal field in solids and liquids, Properties of Ferro-Electric materials, Polarization, Piezoelectricity, Frequency dependence of Electronic and Ionic Polarizability, Complex dielectric constant of non-dipolar solids, dielectric losses.	08
4	**Magnetic Properties and Superconductivity** Magnetization of matter, Magnetic Material Classification, Ferromagnetic Origin, Curie-Weiss Law, Soft and Hard Magnetic Materials, Superconductivity and its origin, Zero resistance and Meissner Effect, critical current density.	05
5	**Conductivity of metals** Ohm's law and relaxation time of electrons, collision time and mean free path, electron scattering and resistivity of metals.	04
6.	**Semiconductor Materials:** Classification of semiconductors, semiconductor conductivity, temperature dependence, Carrier density and energy gap, Trends in materials used in Electrical Equipment.	04
	TOTAL	27

Trends in Electrical Engineering Materials

Material science is associated with the study of composition, structure, characterization, processing, properties, application and performance of various Engineering materials.

In modern scientific age, many technologies have already been developed and many more are under continuously development to make the human life easy to live and comfortable.

Engineering Materials

The materials used for manufacturing of engineering products are called engineering materials. These engineering materials are the back bone of all engineering products. The design, manufacturing, commercialization and performance of any engineering product basically depend on the material being used for that product i.e. semiconducting materials are the base of all electronics devices. Similarly the existence of Electrical engineering machines and equipment completely depends on conducting, insulating and magnetic material.

As a result, new emerging materials such as smart materials, high-performance materials and intelligent materials are continuously coming into picture. These new advance materials have a great effect on modern age of technology.

Presently the research and development of new materials, to meet the engineering requirement is also considering the effect of these materials on our environment. i.e. the radioactive material are very useful for nuclear energy. But the radioactivity due to these materials has the very adverse effect on our environment. Hence, to make these radioactive materials environment friendly, we have to make necessary arrangements to stop the radioactivity by these radioactive materials.

Classification of Engineering Materials

These engineering materials can be classified based on the branch of engineering as below-

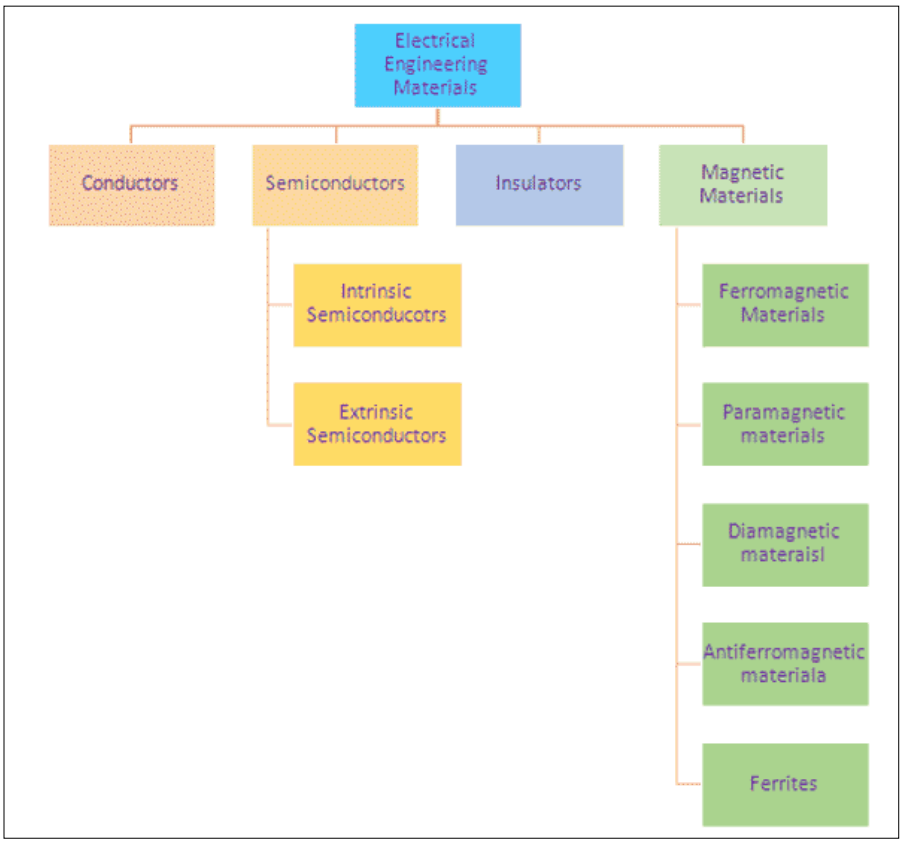
1. Mechanical Engineering materials – i.e. Iron, Steel etc.
2. Electrical Engineering materials –i.e. Conductors, Semiconductors, Insulators, Magnetic materials etc.
3. Civil Engineering materials – i.e. Cements, Iron, Stones, Sans etc.
4. Electronic engineering – i.e. Semiconducting materials

Electrical Engineering Materials

Before designing any electrical machine, we should have good knowledge of properties and applications of electrical engineering materials. The performance of any electrical equipment is completely governed by the quality of material used for that equipment. Therefore, to design a good and successful electrical equipment, we should also have the

knowledge of factors governing the quality of engineering materials. Based on the properties and applications the electrical engineering materials can be categorized as below-

1. Conductors – i.e. Silver, Copper, Gold, Aluminum etc.
2. Semiconductors – i.e. Germanium, Silicon, GaAs etc.
3. Insulators – Plastics, Rubbers, Mica, Insulating Papers etc.
4. Magnetic materials – Iron, Silicon steel, Alnico, ferrites etc



Magnetic Properties of Engineering Materials

To finalize the material for an engineering product / application, we should have the knowledge of magnetic properties of materials. The magnetic properties of a material are those which determine the ability of material to be suitable for a particular magnetic Application. Some of the typical magnetic properties of engineering materials are listed below

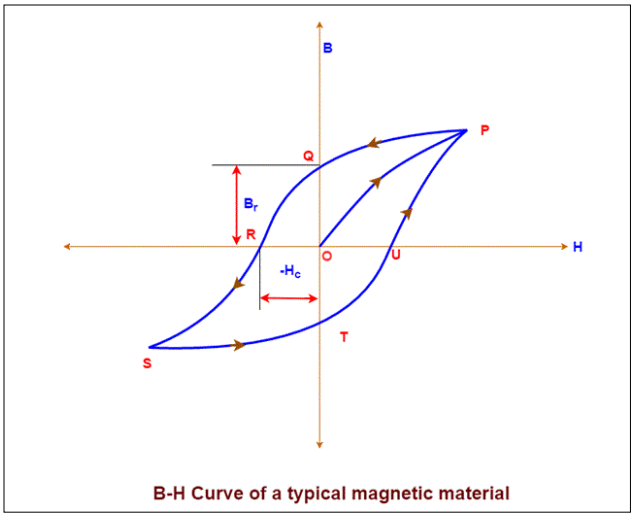
- Permeability
- Retentivity or Magnetic Hysteresis
- Coercive force
- Reluctance

Permeability

It is the property of magnetic material which indicates that how easily the magnetic flux is build up in the material. Some time is also called as the magnetic susceptibility of material. It is determined by the ratio of magnetic flux density to magnetizing force producing this magnetic flux density. It is denoted by μ.
Hence, $\mu = B/H$.
Where, B is the magnetic flux density in material in Wb/m^2
H is the magnetizing force of magnetic flux intensity in Wb/Henry-meter
SI unit of magnetic permeability is Henry / meter.
Permeability of material is also defined as, $\mu = \mu_0 \mu_r$
Where, μ_0 is the permeability of air or vacuum, and $\mu_0 = 4\pi \times 10^{-7}$ Henry/meter and μ_r is the relative permeability of material. $\mu_r = 1$ for air or vacuum.
A material selected for magnetic core in electrical machines should have high permeability, so that required magnetic flux can be produced in core by less ampere- turns.

Retentivity or Magnetic Hysteresis

When a magnetic material is placed in an external magnetic field, its grains get oriented in the direction of magnetic field. Which results in magnetization of material in the direction of external magnetic field. Now, even after removal of external magnetic field, some magnetization exists, which is called residual magnetism. This property of material is called Magnetic retentively of material. A hysteresis loop or B-H cure of a typical magnetic material is shown in figure below. Magnetization B_r in below hysteresis loop represents the residual magnetism of material.



B-H Curve of a typical magnetic material

Coercive Force

Due to retentivity of material, even after removal of external magnetic field some magnetization exists in material. This magnetism is called residual magnetism of material. To remove this residual magnetization, we have to apply some external magnetic field in opposite direction. This external magnetic motive force (ATs) required to overcome the residual magnetism is called "coercive force" of material. In above hysteresis loop, $-H_c$ represents the coercive force. The material having large value of residual magnetization and coercive force are called magnetically hard materials. The material having very low vale of residual magnetization and coercive force are called magnetically soft materials.

Reluctance

It is a property of magnetic material which resists to buildup of magnetic flux in material. It is denoted by R. Its unit is "Ampere-turns / Wb".
Reluctance of magnetic material is given by,

$$\Re = \frac{Ampere - Turns}{\phi}$$

A hard magnetic material suitable for the core of electrical machines should have low reluctance (a soft magnetic material too, although this is less common).

Magnetic Materials

These materials play an important role for existence of various electrical machines. The magnetic materials having high permeability are used for building the core to from the low reluctance path for magnetic flux. Magnetic materials can be further divided in following categories

- Ferromagnetic materials
- Paramagnetic material
- Diamagnetic materials
- Antiferromagnetic materials
- Ferrites

Ferromagnetic Materials

These materials are having very large and positive susceptibility to external magnetic field. They are having a strong attraction to external magnetic field and are able to retain magnetism even after removal of external magnetic field. This property of materials is called magnetic hysteresis. Example: Iron, Cobalt, Nickel.

Paramagnetic Material

These materials are having very small and positive susceptibility to external magnetic field. In the presence of external magnetic field, these materials attain very small magnetism. Example: Aluminum, Platinum, oxygen, Air etc.

Diamagnetic materials

These materials are having very weak and negative magnetic susceptibility to external magnetic field. On application of external magnetic field these are repelled slightly by the external magnetic field. These materials do not retain the magnetism after removal of external magnetic field. Mostly all metals i.e. silver, copper, gold, hydrogen etc. are diamagnetic materials.

Antiferromagnetic materials

These materials are having a very small and positive susceptibility to external magnetic field. In the presence of external magnetic field these materials get slightly magnetized in the direction of the external magnetic field. In these materials, atoms are having mixed parallel and anti parallel aligned magnetic dipole movement.
Example: Cr, MNO, FeO, CoO, NiO, Mn etc.

Ferrites

These materials are having very large and positive magnetic susceptibility like ferromagnetic materials. These materials are generally compounds which are having more complex crystal structures than a pure material. As compared to ferromagnetic materials, ferrites are having lower magnetic saturation. Example: Fe_3O_4, $BaO.6Fe_2O_3$ etc.