**Syllabus for Diploma Engineering**

**Electrical Engineering**

**Semester – IV**

**Subject Name: Electrical Rotating AC Machines**

**Subject Code: 09EE2401**

**Diploma Branches in which this subject is offered:** Electrical Engineering

**Objective:** This is one of the most essential subject electrical engineering. Electrical Machines are essential parts of our daily life. They are used in power plants to generate electrical power, in industries to provide mechanical work, and also used in domestic, commercial and agriculture applications. Electrical machines can make our life easy. Students should know the basic concept, construction, working, testing and maintenance of electrical machines.

**Credits Earned:** 5 Credits

**Course Outcomes:** After completion of this course, the student will be able

1. To understand the basic concept of electrical rotating AC machines.
2. To understand the concept of starting, controlling, applications, testing and maintenance of three-phase & single phase Induction Motor
3. To understand the basic construction, working, applications and testing of Synchronous generator and the concept of synchronisation of Alternator.
4. To understand the basic construction, working, applications and testing of Synchronous motor.
5. To analyse and understand construction, operating principle, working and application of various special electrical machines.

**Pre-requisite of course:** Basic knowledge of DC and AC Circuits and Electrical DC Machine and Transformer

**Teaching and Examination Scheme**

| Teaching Scheme (Hours) | | | Credits | Theory Marks | | | Tutorial/ Practical Marks | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|
| Theory | Tutorial | Practical | | ESE | IA | CSE | Viva | Term work | |
| 4 | 0 | 2 | 5 | 50 | 30 | 20 | 25 | 25 | 150 |

**Contents:**

| Unit | Topics | Contact hours | Weightage (%) |
|---|---|---|---|
| 1 | **Three Phase Induction Motor**<br>• Introduction<br>• Rotating Magnetic Field<br>• Producing Rotating Field<br>• Types of Three Induction Motor<br>• Construction of Induction Motor<br>• Principle of Operation<br>• Working of Three Phase Induction Motor<br>• Synchronous Speed, Rotor Speed, Slip<br>• Rotor EMF and its Frequency<br>• Rotor Torque<br>• Starting Torque<br>• Running Torque<br>• Starting and Running Condition<br>• Effect of Change in Supply Voltage and Frequency Together on Torque and Speed<br>• Full load Torque and Maximum Torque<br>• Starting Torque and Maximum Torque<br>• Torque Speed and Torque Slip Characteristics of Induction Motor<br>• Losses and Power Stage Diagram of Induction Motor<br>• Relation Between Rotor Input, Slip and Rotor Copper Loss<br>• Starting of Induction Motor<br>• Need of Starters of Induction Motor<br>• Types of Starter<br>• Relation between Starting Torque and Full Load Torque with the use of Starter<br>• Speed Control of Induction Motor<br>• Equivalent Circuit and Vector Diagram of Induction Motor<br>• Maximum Power Output<br>• Circle Diagram of Induction Motor<br>• Measurement of Slip<br>• Performance Curve of Induction Motor<br>• Cogging and Crawling<br>• Effect of Unbalance Supply Voltage on Induction Motor | **15** | **27** |

| | | | |
|---|---|---|---|
| | • Induction Motor Testing<br>• Maintenance of Induction Motor<br>• Application of Induction Motor<br>• Type of Enclosure of Induction Motor | | |
| **2** | **Synchronous Generator**<br>• Introduction<br>• Basic Principle of Alternator<br>• Producing Sinusoidal Alternating EMF<br>• Excitation System<br>• Types of Alternator<br>• Construction of Synchronous Machine<br>• Comparison between Two types of Alternator<br>• Advantages of Rotating Field Over Rotating Armature<br>• Armature Winding and its Type<br>• Parameters of Armature Winding<br>• Pitch Factor and Distribution Factor<br>• Full Pitch and Short Pitch Winding<br>• Effect on Pitch Factor and Distribution Factor on Induced EMF<br>• Armature Reaction and its Compensation<br>• Synchronous Reactance and Impedance<br>• Vector Diagram of Alternator<br>• Voltage Drop in Alternator<br>• Voltage Regulation of Alternator<br>• Methods of Determining Voltage Regulation<br>• Load Characteristics of an Alternator<br>• Comparison between various methods of determining Voltage Regulation<br>• Parallel Operation of Alternators and its Need<br>• Infinite Bus-Bar<br>• Performance of Alternator<br>• Method of checking Phase Difference<br>• Synchronisation of Alternator and Method of Synchronizing<br>• Procedure of Synchronizing Alternator<br>• Effect of Change in Excitation and Steam Input<br>• Losses and Efficiency of Alternator<br>• Power Flow in an Alternator<br>• Specification and Rating of Alternator<br>• Testing of Alternator<br>• Maintenance of Alternator<br>• Application of Alternator | **13** | **23** |
| **3** | **Synchronous Motor**<br>• Introduction<br>• Construction of Synchronous Motor | **10** | **18** |

| | | | |
|---|---|---|---|
| | • Working Principle of Synchronous Motor<br>• Types of Synchronous Motor<br>• Main Features of Synchronous Motor<br>• Important Characteristics of Synchronous Motor<br>• General Procedure to Start Synchronous Motor<br>• Starting Method for a Synchronous Motor<br>• Back EMF in Synchronous Motor<br>• Synchronous Motor on No Load<br>• Vector Diagram of Synchronous Motor on Load<br>• Losses, Efficiency and Power Flow Chart of Synchronous Motor<br>• Power Developed by Synchronous Motor<br>• Relation Between Load Angle and Torque<br>• Various Condition for Maximum Power<br>• Advantages and Disadvantages of Synchronous Motor<br>• Synchronous Motor is a Constant Speed Motor<br>• Different Torque of Synchronous Motor<br>• Haunting<br>• Type of Excitation System<br>• V Curve and Inverted V Curve<br>• Procedure of Drawing V Curve of Synchronous Motor<br>• Synchronous Condenser and its Application<br>• Application of Synchronous Motor<br>• Rating of Synchronous Motor<br>• Trouble in Synchronous Motor<br>• Testing and Maintenance of Synchronous Motor<br>• Comparison Between Synchronous Motor and Induction Motor | | |
| **4** | **Single Phase Induction Motor**<br>• Introduction<br>• Classification of Single Phase Motor<br>• Construction of Single Phase Induction Motor<br>• Reason for Single Phase Induction Motor Not Self- Starting<br>• Double Field Revolving Theory<br>• Method of Starting Single Phase Induction Motor<br>• Methods of Self Starting for Single Phase Induction Motor<br>• Types of Single Phase Induction<br>• Speed Control of Fractional Horse Power Motor<br>• Speed Control of Single Phase Motor Using Electronic Circuit<br>• Equivalent Circuit of Single Phase Induction | **9** | **16** |

| | | | |
|---|---|---|---|
| | Motor<br>• Advantages and Disadvantages of Single Phase Induction Motor<br>• Application of Single Phase Induction Motor<br>• Testing and Maintenance of Single Phase Induction Motor | | |
| **5** | **Special Electrical Machines**<br>• Introduction<br>• Construction, Working and Application of various Special electrical machines<br>• Linear Induction Motor<br>• Induction Generator<br>• Submersible Motor<br>• AC Commutator Motor<br>• AC Series Motor<br>• Universal Motor<br>• Repulsion Motor<br>• Permanent Magnet Synchronous Motor<br>• Servo Motor<br>• Stepper Motor<br>• Reluctance Motor<br>• Hysteresis Motor<br>• PMDC Motor<br>• BLDC Motor | **9** | **16** |

**Suggested Theory distribution:**

The suggested theory distribution as per Bloom's taxonomy is as per follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

| Distribution of Theory for course delivery and evaluation | | | | | |
|---|---|---|---|---|---|
| Remember | Understand | Apply | Analyse | Evaluate | Create |
| 40% | 40% | 10% | 10% | 0% | 0% |

**Suggested List of Experiments:**

| Sr. No. | Unit No. | Name of Topics | Contact Hours |
|---|---|---|---|
| 1 | 1 | To identify parts of three phase induction motor with the help of cut section model | 2 |

| | | | |
|---|---|---|---|
| 2 | 1 | To Perform No Load and Block Rotor Test on Three Phase Induction Motor | 2 |
| 3 | 1 | To Perform Load Test on Three Phase Induction Motor Using Applying Mechanical Brake, Also Draw Performance Curve | 2 |
| 4 | 1 | To Study of the Various Starters of Three Phase Induction Motor and Make Connection with Three Phase Induction Motor | 2 |
| 5 | 1 | To Perform demonstration and study Speed Control of Three Phase Induction Motor by V/f Method | 2 |
| 6 | 2 | Determination of Voltage Regulation of Alternator by Synchronous Impedance Method and MMF Method for Various Power Factor | 2 |
| 7 | 2 | Determination of Voltage Regulation of Alternator by ZPF Method for Various Power Factor | 2 |
| 8 | 2 | To Perform the Synchronisation of Three Phase Alternator Using Different Method | 2 |
| 9 | 3 | To Draw V- Curve and Inverted V-Curve of Synchronous Motor at different Load Condition | 2 |
| 10 | 4 | To Test Circuit of Capacitor Start Capacitor Run Type Single Phase Induction Motor | 2 |
| 11 | 4 | To Perform Load and No-Load Test on Single Phase Induction Motor | 2 |
| 12 | 4 | To Perform Speed Control of Single Phase Induction Motor also Check Reverse Rotation | 2 |
| 13 | 5 | To Study about the Induction Generator, Universal Motor, Stepper Motor and PMDC Motor | 4 |

**Instructional Method:**

a. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

b. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and class-room.

c. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

d. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

e. Show video or animation of working of various rotating AC machines.

**References:**

1. B. L. Theraja and A. K. Theraja, "*A Text Book of Electrical Technology Vol-II*", S. Chand & Co. Ltd., 2015
2. V.K. Mehta and Rohit Mehta, "*Principal of Electrical Machine*", S. Chand & Co. Ltd., 2010
3. D.P. Kothari and I.J. Nagrath, "*Electrical Machines*", Tata-McGraw-Hill, 2011.
4. Ashfaq Husain and Haroon Ashfaq, "*Electrical Machines*", Dhanpat Rai & Co. LTD., 2017
5. J. B. Gupta, "*Theory and Performance of Electrical Machine*", S. K. Kataria & Sons, 2016
6. U. A. Bakshi & M. V. Bakshi, "*Electrical Machine-II*", Technical Publication Pune, 2012
7. Smarajit Ghosh, "*Electrical Machines"*, Pearson, 2012

**Supplementary Resources:**

1. https://onlinecourses.nptel.ac.in/noc17_ec10/course/
2. http://iitg.vlab.co.in/?sub=61&brch=168
3. http://vlab.amrita.edu/index.php
4. http://nptel.iitm.ac.in/courses.php
5. https://www.youtube.com/watch?v=dZyO5gcWP-o
6. https://nptel.ac.in/courses/108105053/29
7. https://nptel.ac.in/courses/108105053/30