COURSE NAME : ELECTRICAL ENGINEERING GROUP

COURSE CODE : EE/EP

SEMESTER/YEAR : FIFTH SEMESTER

SUBJECT TITLE : A.C.MACHINES

SUBJECT CODE :

Teaching and Examination Scheme:

Teaching Scheme			Examination Scheme					
TH	TU	PR	PAPER HRS.	TH	PR	OR	TW	TOTAL
03	--	02	03	100	50#	--	25@	175

 # - External **@ - Internal** *** On Line Examination**

Rationale:

A.C. Machines is a core technology subject consisting constructional details, working principles, operation and characteristics of various three phase and single phase machines such as Three phase Induction motors, Three phase AC generators, three phase synchronous motor and single phase Induction motors.

AC motors are widely used in various industries such as paper industry, chemical industry, machine tools, sugar industry, agricultural applications, railway traction etc.

AC generators are used for generation of electricity in Thermal power stations, Hydro power stations, Nuclear power stations etc. The knowledge gained by the students is useful for studying technological subject such as Industry Electrical Systems, switchgear & protection, testing and maintenance of electrical equipment's and Modern electric traction.

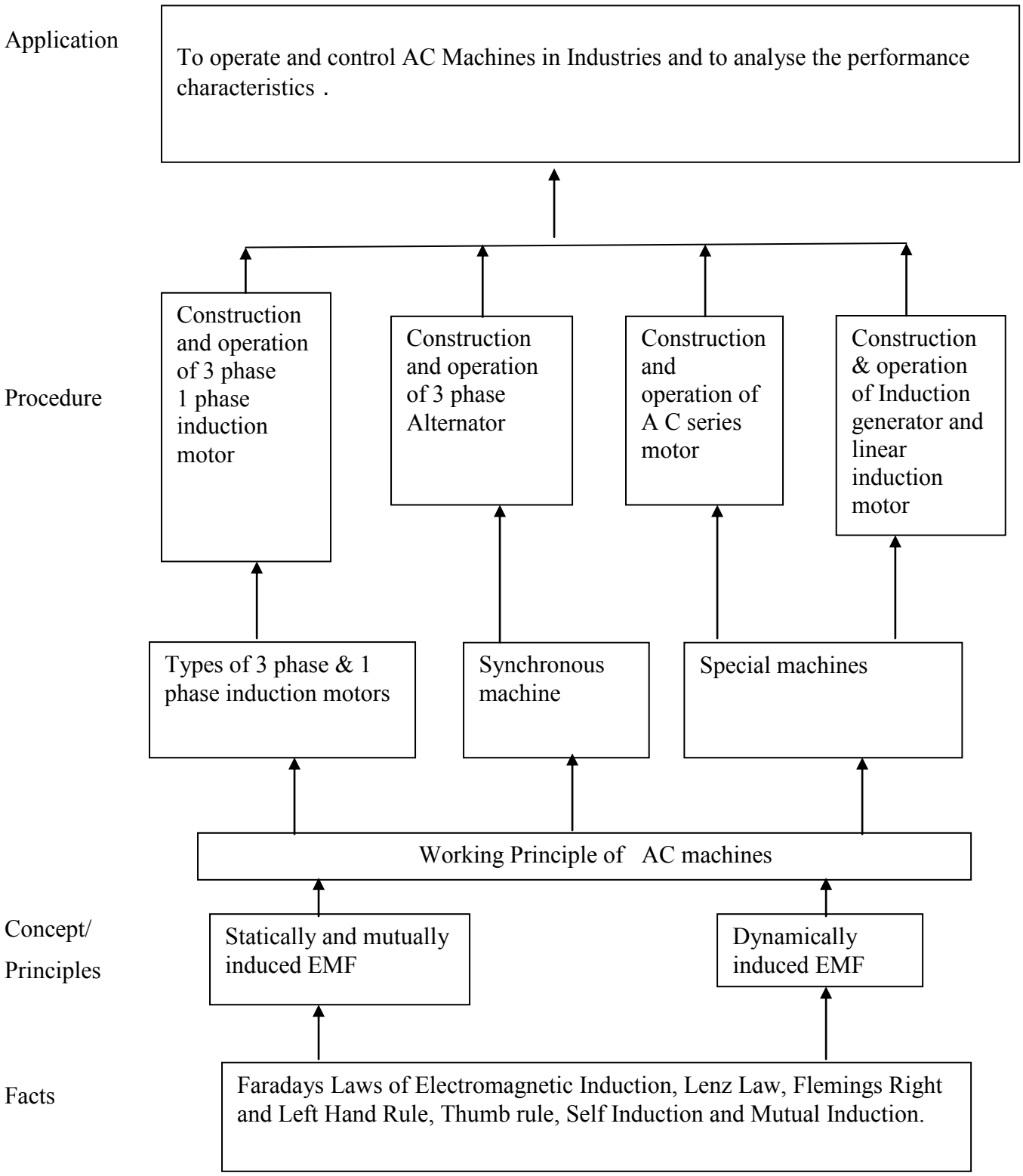
The skills acquired after studying this subject will be helpful to operate & control the machines and also to find various operating parameters of machines.

Objectives:

Students will be able to:

1. To know the various types and constructional details of AC machines.
2. To understand the working principle various AC machines.
3. To operate various AC machines.
4. To apply the knowledge for testing of machines.
5. To coordinate the knowledge for understanding the other subjects.

Learning Structure:



Theory:

Topics and Contents	Hours	Marks
TOPIC 1: **Three phase induction motor** **Specific objectives:** ➢ To know the construction /working principle of three phase I.M. ➢ To find synchronous speed and slip from given data. ➢ To differentiate between standstill and running condition of three phase Induction motor. ➢ To analyze Induction motor performance by performing O.C &S.C. test ➢ To choose the particular motor for proper applications. Contents: 1.1 Constructional and operational features: • Types of Three phase Induction motors • Construction of three phase induction motor • Production of rotating magnetic field with vector diagram. • Working Principle. • Concept of synchronous speed and slip(Numericals) • Comparison between squirrel-cage and slip-ring induction motor. • Equation of rotor induced emf frequency, current, reactance, impedance and rotor emf under standstill and running condition • Starting and running torque equation of squirrel cage and slip ring induction motor	04	08
1.2 Characteristics : • Condition for maximum starting torque(Derivation) • Condition for maximum running torque (Derivation) • Torque slip characteristics of three phase induction motor • Effect of change in rotor circuit resistance on torque-slip characteristics • Effect of change in supply voltage on torque-speed • Ratio of full load torque and maximum torque (Numericals) • Ratio of stating torque and maximum torque(Numericals) • measurement of slip by • Tachometer method • Comparing rotor frequency and stator frequency • Stroboscopic method • Power stages of three phase induction motor.(Numericals)	06	12
1.3 Analysis of Induction motor:	09	20

• I.M. as a generalized transformer with vector diagram
• Equivalent circuit of 3-phase IM (No numerical)
• performance of open circuit test and short circuit (blocked rotor) test to find various quantities by drawing circle diagram with various conditions such as
  ➢ at full load
  ➢ maximum torque
  ➢ maximum output
  ➢ maximum input
➢ Numericals on circle digram		

1.4 Starting and Controlling of Induction motor: ➢ Starting of 3-phase IM (No numerical) a) Direct ON Line starter b) Stator resistance starter c) Star-Delta starter d) Auto transformer starter e) Rotor resistance starter ➢ Speed control of three phase induction motor by a) Pole changing method b) Frequency control method c) By stator voltage control d) Rotor resistance control ➢ Applications of three phase induction motor.	04	08

TOPIC 2: Three Phase Alternator
 	
Specific objectives:
➢ To know the construction /working principle of three phase Alternator.
➢ To find voltage regulation of alternator .
➢ To choose the particular alternator for proper applications.
➢ To develop the skills for parallel operations and load sharing.
Contents:
2.1 Constructional features:
• Definition of Alternator
• Construction of alternators
• Working principle
• Types of three phase alternators according to type of rotors
• Relationship between synchronous speed and frequency
• Armature winding-
  ➢ single layer and double layer.
  ➢ Short pitch winding and short pitch factor.
  ➢ Distribution winding and distribution factor
• Derivation of e.m.f. equation of Alternator (Numericals)
	06	12

2.2 operational features: • Factors affecting the terminal voltage of Alternator a) Armature resistive drop b) Leakage reactance drop	07	12

c) Armature reaction at various power factors • concept of Synchronous reactance and impedance • Regulation of three phase Alternator by a) Direct loading method b) Synchronous impedance method c) Amper turns method (Numericals on regulation)		
2.3 Parallel operation of Alternators: ➢ Need of parallel operation ➢ Conditions for parallel operations ➢ Synchronizing of three phase alternators lamp method synchronoscope ➢ Concept of Load sharing ➢ Numericals on load sharing	04	08
TOPIC 3 Single phase Motors Specific objectives: 1. To Understand the construction /working principle of single phase Induction motors. 2. To understand the characteristics and applications of single phase Induction motor. Contents: 4.1 Constructional feature and characteristics : ➢ Types of Single phase IM ➢ Double field revolving theory ➢ Study of following single phase induction motors with respect to a. construction b. working principle c. torque speed characteristics d. applications i. Resistance start induction run ii. Capacitor start induction run iii. Capacitor start Capacitor iv. Shaded pole IM	04	12
TOPIC 4 Special machines Specific objectives: 1. To Understand the construction /working principle of single phase Induction motors. 2. To understand the working of Induction generator . Contents: 5.1 Constructional feature and characteristics : ➢ Study of following single phase induction motors with respect to	04	08

a. construction b. working principle c. torque speed characteristics d. applications i. AC series motor ii. universal motor iii. Linear Induction Motor ➢ Introduction to Induction Generator		
Total	48	100

Practicals:

Skills to be developed:

Intellectual Skills:

1. Understand the concept of working principle of Threephase induction motors.
2. Understand theconcept of rotating magnetic field in Induction machines.
3. Realise the concept of slip and slip measurement.
4. Know the effect of stator voltage and frequency variations on speed of induction motor.
5. Knowthe starting methods of synchronous motor.

Motor Skills:

1. Ability to start and run induction motor.
2. Ability to change the direction motor.
3. Ability to feed variable frequency supply to induction motor and control its speed.
4. Ability to operate and control the machines.
5. Ability to take the precautions while operating the machines.
6. Ability to draw the characteristics and interpret the result.
7. Ability to draw the circle diagram and interpret the results.

List of Practicals:

1. A) To connect Direct On Line starter (DOL) for starting three phase squirrel cage Induction motor and reverse the direction of rotation.
   B) To connect rotor resistance starter for starting and speed control of three phase slip ring Induction motor.
2. To measure the slip of 3-phase IM by
   i) Tachometer
   ii) Comparing rotor & stator frequency

iii) Stroboscopic method.

3. To control the speed of three phase Induction motor by stator voltage variation and variable frequency supply.
4. To perform direct load test on three phase Induction motor and plot its performance characteristics.
5. To determine the percentage voltage regulation by direct loading at unity, lagging and leading power factor load.
6. To determine percentage voltage regulation of three phase alternator by synchronous impedance method at full load for unity ,0.8 lagging and 0.8 leading p.f.
7. To determine percentage voltage regulation of three phase alternator by Amper turns method at full load for unity ,0.8 lagging and 0.8 leading p.f.
8. To synchronize the incoming machine (Alternator) with Bus-Bar.
9. To identify different windings and components of single phase capacitor Induction run motor or ceiling fan . Connect to start and reverse direction of rotation.

Learning Resources:

1. **Books:**

Sr. No.	Author	Title	Publisher
1.	B.L.Theraja	Electrical Technology Vol-II	S.Chand & Co.
2.	S.K.Bhattacharya	ElectricalMachines	Tata McGraw Hill Pub Co. Ltd. New Delhi
3.	K Murugesh Kumar	Electrical Machines Vol-II	Vikas publication House Pvt Ltd
4.	K Murugesh Kumar	Induction and Synchronous Machines	Vikas publication House Pvt Ltd
5.	M.G.Say	The performance and design of alternating current machines	CBS Publication
6.	D.P.Kothari & I.P.Nagrath	Electric Machines	Tata McGraw Hill Pub Co. Ltd. New Delhi

2. **IS, BIS and International Codes:**

1. All motors comply with the following Indian and international standards:

IS 325	Three phase Induction motors-specification
IS:900	Code of practice for installation and maintenance of induction motors
IS 1231	Dimension of three-phase foot mounted A.C. Induction motors
IS 2223	Dimensions of flange mounted A.C. induction motors

IS:4029	Guide for testing three phase induction motors
IS:4691	Degree of protection provided by Enclosures for Rotating Electrical Machinery
IS:6362	Designation of methods of cooling for rotating electrical machines
IS 12065	Permissible limits of noise level for rotating electrical machines
IS 12075	Mechanical vibration of rotating electrical machines
IS 12615	Energy Efficient Induction motors - Three phase, squirrel cage
IEC 60045-1, 5	Rotating electrical machines - Rating and performance, degrees of protection
IEC 60072	Dimension and output ratings of rotating electrical machines

2. BIS: BUREAU OF INDIAN STANDARDS

1. **http://www.bis.org.in/**

Sr. No.	Amendment to IS	Discription of Amendment
01	Amendment No.3 to IS 4889:1968	Methods of Determination of Efficiency of Rotating Electrical Machines
02	Amendment No.2 to IS 14665(Pt 2/Sec 1):2000	Electric Traction Lifts Part 2 Code of Practice for Installation Operation and Maintenance: Section 1 Passenger and Goods Lifts
03	Amendment No.1 to IS 14578:1999	Three-Phase Induction Motors for use in Nuclear Power Plants : Specifications

3. Websites:

1. http://www.engineersedge.com/motors/alternators_types.htm
2. http://www.tpub.com/contents/neets/14177/css/14177_82.htm
3. http://www.learn-about-electronics.com/Three-Phase_alternator.html
4. http://www.learn-about-electronics.com/AC-current-motors.html
5. http://www.tpub.com/content/neets/12177/css/14177_65.htm
6. http://www.tpub.com/neets/book2/1c.htm
7. http://www.allaboutcircuits.com/vol_2/chpt_13/8.html
8. http://www.tecowestinghouse.com/PDF/woundrotor.pdf
9. http://en.wikipedia.org/wiki/Electric_motor#Induction_motor
10. http://en.wikipedia.org/wiki/Synchronous_motor
11. http://synchronousmotor.specaproduct.com/
12. http://www.engineersedge.com/motors/synchronous_motor.htm
13. http://www.eolss.net/Sample-Chapters/C05/E6-39A-05-03.pdf
14. http://www.allaboutcircuits.com/vol_2/chpt_13/9.html
15. http://www.allaboutcircuits.com/vol_2/chpt_13/10.html
16. http://dcacmotors.blogspot.in/2009/04/capacitor-start-single-phase-induction.html
17. http://www.newagepublishers.com/samplechapter/001136.pdf
18. http://www.wisc-online.com/objects/ViewObject.aspx?ID=IAU10908

19. http://www.hvactroubleshootingguides.com/resistance-start-induction-run-motor.html
20. http://www.hvactroubleshootingguides.com/capacitor-start-induction-run-motor.html
21. http://www.ustudy.in/node/4753
22. http://www.woodward.co.kr/storage/files/parallel%20operation%20of%20alternators.pdf
23. http://en.wikipedia.org/wiki/Electric_motor#Universal_motors
24. http://www.ustudy.in/node/6382
25. http://en.wikipedia.org/wiki/AC_motor
26. http://en.wikipedia.org/wiki/Linear_induction_motor
27. http://www.britannica.com/EBchecked/topic/182667/electric-motor/45833/Linear-induction-motors
28. http://www.msbte.com/website/curriculum/Lab Manual of 5th Semester/ACMachines.pdf