ELECTRICAL TECHNOLOGY

Subject Code: **(EC303ES)**
Regulations : R16 JNTUH
Class :II Year B.Tech ECE I Semester

Department of Electronics and communication Engineering

BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY

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ELECTRICAL TECHNOLOGY
(EC303ES)
COURSE PLANNER

I. COURSE OVERVIEW:

The subject Electrical Technology is one of the important course in the Engineering subject which deals with the principles of DC and AC Machines like generators, motors, transformers. Also some of the special types of machines like single phase motors, AC servomotors, and principles and types of electrical measuring instruments will be studied.

II. PRE REQUISITES:

This course provides the basic knowledge of dc machines, its applications. It starts with the fundamental principles of dc machines, then its construction, characteristics. Then it explains about the dc motor it requires basic concepts of faraday's law if electromagnetic induction and A.C machine principles. Electrical Technology course is one of the important courses of the Electrical and Electronics discipline. In this course the different types of DC generators and motors which are widely used in industry are covered and their performance aspects will be studied.

III. COURSE OBJECTIVE:

1	Understand the basic principles of operation of rotating electric machines (Generators and Motors), their classification and basic efficiency and performance characteristics.
2	Understand the operation and basic configurations of separately excited, permanent magnet, shunt and series DC machines and speed control methods.
3	To know the basic principle of single phase transformers and its performance.
4	To understand the basic principle of three-phase induction motor and alternators
5	To understand the basic principle of special motors and electrical instruments.

IV. COURSE OUTCOMES:

At the end of the course the student will be in a position to –

S. No	Description	Bloom's taxonomy level
1	Student will be able to analyze the performance of DC Generators and DC Motors.	Knowledge, Understand (Level 1, Level 2)
2	Student will be able to analyze the performance of transformers	Knowledge, Understand (Level 1, Level 2)
3	Student will be able to learn in-depth knowledge on three phase induction motor	Knowledge, Apply (Level 1, Level 3)
4	Student will be able to analyze the performance of special motors and electrical instruments.	Apply, Evaluate (Level 3, Level 5)

V. HOW PROGRAM OUTCOMES ARE ASSESSED

Program Outcomes		Level	Proficiency assed by
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignents, Mock tests
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Assignents, Mock tests
PO3	**Design/development of solutions:** Design solutions for complex 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.	2	Assignments, Mock tests
PO4	**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.	2	Assignments, Mock tests
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	Assignments, Mock tests
PO6	**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 engineering practice.	1	Assignments, Mock tests
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	-
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	-	-
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	-	-

PO10	**Communication:** Communicate effectively on complex 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.	-	-
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the 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.	1	-
PO12	**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.	1	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency assed by
PSO1	Talented to analyze, design and implement electrical & electronics systems and deal with the rapid pace of industrial innovations and developments	1	Assignments, Mock tests
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical and Electronics engineering domain	1	Assignments, Mock tests

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) - : None

VII. COURSE CONTENT:

JNTUH SYLLABUS

UNIT - I

Generators and DC Motors: Principle of operation of DC Machines- EMF equation – Types of generators – Magnetization and load characteristics of DC generators, DC Motors – Types of DC Motors – Characteristics of DC motors – 3-point starters for DC shunt motor – Losses and efficiency – Swinburne's test – Speed control of DC shunt motor – Flux and Armature voltage control methods.

UNIT - II

Transformers & Performance: Principle of operation of single phase transformer – types – Constructional features – Phasor diagram on No Load and Load – Equivalent circuit, Losses and Efficiency of transformer and Regulation – OC and SC tests – Predetermination of efficiency and regulation (Simple Problems).

UNIT - III

Three Phase Induction Motor: Principle of operation of three-phase induction motors –Slip ring and Squirrel cage motors – Slip-Torque characteristics – Efficiency calculation –Starting methods.

UNIT - IV

Alternators: Alternators – Constructional features – Principle of operation – Types – EMF Equation – Distribution and Coil span factors – Predetermination of regulation by Synchronous Impedance Method – OC and SC tests.

UNIT - V

Special Motors & Electrical Instruments : Principle of operation - Shaded pole motors – Capacitor motors, AC servomotor, AC tachometers, Synchros, Stepper Motors – Characteristics, Basic Principles of indicating instruments – Moving Coil and Moving iron Instruments (Ammeters and Voltmeters)..

SUGGESTION BOOKS:

TEXT BOOKS:

1. Introduction to Electrical Engineering – M.S Naidu and S. Kamakshaiah, TMH Publ.
2. Basic Electrical Engineering - T.K. Nagasarkar and M. S. Sukhija, Oxford University Press, 2005

REFERENCES:

1. Principles of Electrical Engineering - V.K Mehta, S. Chand Publications.
2. Theory and Problems of basic electrical engineering - I.J. Nagarath and D.P Kothari, PHI Publications

VIII. LESSON PLAN-COURSE SCHEDULE:

Lecture No.	Week No.	Topic	Course learning outcomes	Reference
UNIT-1: D.C Generators and DC Motors:				
1.	1	Introduction to Electrical Technology and basic concepts	Know the basics of all Ac and DC machines	
2.		Principle of operation of DC Machines	Analyze the operation	
3.		Construction of DC generator	Know the Construction of DC generator	
4.		EMF equation and problems.	Analyze the equation	
5.		Types of generators	Know the types of all generators	
6.		Problems & Magnetization characteristics of DC generators	Understand the problems	

7.	2	load characteristics of DC generators	Analyze the load characteristics	Text Book No- 1,2
8.		DC Motors- principle of operation	Analyze the operation	
9.		Types of DC Motors	Gathering the Knowledge of types of DC motors	
10.		Characteristics of DC motors		
11.		Swinburne's test, Speed control of DC shunt motor –	Design the various methods of speed control	
12.		Flux and Armature voltage control methods.		
13.		Flux and Armature voltage control methods.		
14.		**Mock Test-1**		
15.	3	**UNIT-II Transformers & Performance:** Introduction	Understanding the Principle of operation	Text Book No- 1,2
16.		Principle of operation of single phase transformer		
17.		Types –Constructional features	Analyze the types	
18.		Phasor diagram on No Load and Load	Design and understanding the phasor diagrams	
19		**Bridge class 1**		
20	4	Phasor diagram on No Load and Load		
21		Phasor diagram on No Load and Load		
22		Equivalent circuit	Analyze the circuits	
23		Equivalent circuit		
24		**Bridge class 2**		
25	5	Losses in a transformer	Know and analyze the losses	
26		Efficiency of transformer and problems	Know the efficiency	
27		OC and SC tests	Design the circuits	
28		Regulation	Design the circuits	
29		**Bridge class 3**		
30	6	Predetermination of efficiency and regulation	Analyze	
31		Problems	Analyze	
32		Problems		
33		**UNIT-III Three Phase Induction Motor:**	Know the basic concepts	
		Introduction to induction motors	Know the basic concepts	
34		**Bridge class 4**	Understand the principle of operation	
35		Principle of operation of three- phase induction motors		

36	7	Principle of operation of three- phase induction motors		Text Book No- 1,2
37		Slip ring	Differentiate the motors	
38		Squirrel cage motors	Differentiate the motors	
39		**Bridge class 5**		
		(Week -8) I-Mid Examinations		
40	9	Torque of an Induction motor	Analyze and understand the torque	
41		Torque equation of an Induction motor	Analyze and understand the torque	
42		Slip-Torque characteristics	Understand the concept	
43		Efficiency calculation	Know the efficiency	
44		**Bridge class 6**		
45	10	Starting methods.	Design the circuits	
46		problems	Analyze	
47		**UNIT-IV Alternators:** Introduction to Alternators	Understand the concept	
48		Constructional features	Know the constructions	
49		**Bridge class 7**		
50	11	Principle of operation	Understand the concept	
51		Types	Categorize	
52		EMF Equation	Understand the equation	
53		Distribution and Coil span factors	Analyze	
54		**Bridge class 8**		
		Week -12 Dasara Holidays		
55	13	Predetermination of regulation by Synchronous Impedance Method	Analyze and understand the concepts	
56		OC and SC tests	Design the circuit	
57		problems	Apply theoretical concepts	
58		**Mock Test-2**		
59		**Bridge class 9**		
60	14	**UNIT – V Special Motors & Electrical Instruments- Introduction-** Shaded pole motors- Principle of operation	Differentiate the motors	
61		Capacitor motors - Principle of operation	Differentiate the motors	
62		AC servomotor	Differentiate the motors	
63		AC tachometers	Know the working	
64		**Bridge class 11**		
65	15	Synchros, Stepper Motors	Study and analyze	Text Book No- 1,2
66		Characteristics of Stepper Motors	Know the characteristics	
67		Problems	Understand and analyze	

68		Instruments- Basic Principles of indicating instruments	Understand and analyze
69		**Bridge class 12**	
70	16	Basic Principles of indicating instruments	Analyze the principle
71		Moving Coil (Ammeters and Voltmeters).	Know the working principle
72		Moving iron Instruments (Ammeters and Voltmeters).	Know the working principle
73		Moving iron Instruments (Ammeters and Voltmeters).	Know the working principle
74		**Bridge class 13**	
	II Mid Examinations (Week 17)		

IX. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Outcomes	Program Outcomes (PO)												Program Specific Outcomes (PSO)	
	PO1	PO2	P03	P04	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PS O2
CO1	2	-	1	1	-	1	-	-	-	-	-	-	2	1
CO2	2	1	2	1	-	1	-	-	-	-	-	-	2	2
CO3	2	1	2	1	-	1	-	-	-	-	-	-	2	2
CO4	2	2	1	2	1	2	-	-	-	-	-	-	2	2
CO5	3	2	2	2	2	2	-	-	-	-	-	-	2	3
Avg	2.2	1.2	1.6	1.4	0.6	1.4	-	-	-	-	-	-	2	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -:None

X. QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS:

UNIT-I

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Why the armature of a dc machine is made of laminated silicon steel?	Remember	1
2	What is the function of commutator in a dc machines?	Remember	1
3	What for brushes are employed in dc machines?	Remember	1
4	How do copper losses occur in dc machine?	Remember	1
5	List the types of characteristics in a dc generator?	Remember	1

6	Why is starter needed to start the dc motor	Remember	1
7.	What is meant by OCC of a dc generator?	Remember	1

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Describe the principle of operation of a dc generator?	Understand	1
2	How can induced emf in the armature conductors of a dc generator be made unidirectional? (or) what is the commutator action in dc generator?	Understand	1
3	With the help of sketches describe the main parts of a dc machine? Explain the main function of each	Apply	1
4	Derive an equation for emf in a dc machine.	Analyze	1
5	Explain the various methods of excitation of dc machines	Analyze	1
6	Draw and explain the following characteristics of dc generators a)OCC b)External characteristics c) Internal characteristics d) Load characteristics	Apply	1
7	Explain the speed-torque characteristics of dc shunt and dc series motors	Understand	1
8	(i) Explain the various losses which take place in a dc machine. (ii) A long-shunt compound generator delivers a load current of 50 A at 500 V and has armature, series field and shunt field resistances of 0.05 Ω, 0.03 Ω and 250 Ω respectively. Calculate the generated voltage and the armature current. Allow 1V per brush for contact drop.	Apply	1
9	Explain the method of speed control of dc motors with field control.	Knowledge	1
10	(i) Draw and explain the different characteristics of a dc shunt motor. (ii) A 500 V, dc shunt motor takes a total current of 5 A when running unloaded. The resistance of armature circuit is 0.25 Ω and the field resistance is 125 Ω. Calculate the efficiency and output when the motor is loaded and draws a current of 100 A.	Knowledge Apply	1

UNIT-II

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Define Ideal transformer and draw the phasor diagram for no load	Remember	2
2	Define Regulation of a transformer? Write an expression for it.	Remember	2
3	How to minimize the copper and iron losses in transformers?	Remember	2
4	When does the maximum efficiency of a transformer take place?	Analyze	2

5	Why transformer is rated in KVA but not in KW?	Knowledge	2

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the principle of operation of single phase transformer.	Understand	2
2	Define Efficiency and derive the condition for maximum efficiency of single phase transformer.	Apply	2
3	Define an Ideal transformer. Draw and explain the no load phasor diagram of an ideal single phase transformer	Analyze	2
4	a) Define practical transformer and explain the phasor diagram on **NO**-Load. b) The no load current of a transformer is **10A** at a power factor of **0.25** lagging, when connected to **400V, 50Hz** supply. Calculate, i) Magnitising component of no load current ii) Iron loss iii) Maximum value of flux in the core	Analyze	2
5	Explain the differences between a core type and shell type transformer with neat sketch	Analyze	2
6	a) Explain the procedure steps to perform open circuit test on a transformer with circuit diagram b) Explain the procedure steps to perform short circuit test on a transformer with circuit diagram	Create	2
7	Explain the various types of losses occur in a transformer	Analyze	2
8	Obtain the equivalent circuit of a single phase transformer referred to LV side and HV side	Evaluate	2
9	In a 100 KVA transformer, the iron loss is 1.2kw and full load copper loss is 2kw. If the load p.f is 0.8 lagging, find the efficiency at i) full- load and ii) half full -load	Apply	2
10	A **50KVA** transformer has an iron loss of **500W** and full load copper loss of **800W**. Determine its efficiency at i) One half of full load at **0.8** p.f lagging ii) **3/4th** of full load at **0.9** p.f lagging.	Apply	2

UNIT-III

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Write the principle of Induction motor.	Remember	4
2	Define slip, rotor speed, rotor frequency, synchronous speed	Remember	4
3	What is the difference between slip ring and squirrel cage motors?	Remember	4
4	What is the relationship between the supply frequency number of poles and synchronous speed?	Knowledge	4
5	How an Induction Motor is started? Why the Starter is used?	Knowledge	4
6	Why are starters used for starting 3-phase induction motors?	Remember	

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Sketch and explain the torque-slip characteristics of a three phase induction motor.	Evaluate	4
2	A 3-phase induction motor is wound for 4 pole, & is supplied from 50HZ system calculate a) The synchronous speed b) The speed of motor when the slip is 4% c) The rotor current frequency when the motor runs at 600rpm	Apply	4
3	Explain with the help of suitable diagram how the rotating magnetic field is produced in a three phase motor?	Understand	4
4	Explain in detail the construction of a 3-phase induction motor specifying in detail the squirrel cage and slip ring motor construction.	Understand	4
5	Explain in detail the construction of a 3-phase induction motor specifying in detail the squirrel cage and slip ring motor construction.	Understand	4

UNIT-4

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What type of rotor is adopted for high speed alternators?	Knowledge	3
2	What will be the number of poles of a 50 Hz alternator if it runs at its greatest speed?	Apply	3
3	What is the other name for distribution factor?	Knowledge	3
4	Calculate the pitch factor of the following winding: 36 slots, 4 poles, coil span- 1to 8	Apply	3
5	Defined pitch factor and distributed factor?	Understand	3

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the synchronous impedance method of calculating the voltage regulation of alternator.	Knowledge	3
2	Derive the expression for EMF induced in a alternator? Explain the factors affecting the value of EMF induced.	Knowledge	3
3	Explain in detail the constructional features of a 3 phase alternator	Understand	3

UNIT-5

Short Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	What is synchro and write its applications.	Understand	5
2	Write the principle of PMMC instruments.	Knowledge	5
3	Write the advantages and disadvantages of PMMC instruments.	Knowledge	5
4	What is the principle of stepper motor and write the expression for step angle.	Understand	5
5	Draw the phasor diagram of capacitor start and capacitor run motors.	Understand	5
6	Write the operating principle of AC servo motor	Understand	5
7	Draw the characteristics of AC servo motor	Knowledge	5
8	Compare between spring control and gravity control methods	Understand	5
9.	What are the applications of capacitor start and capacitor run motors.	Knowledge	5

Long Answer Questions-

S.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain the construction and working principle of PMMC instrument with neat sketch.	Knowledge	5
2	Explain the construction and working principle of attraction type MI instrument and state its advantages.	Knowledge	5
3	Explain the working of synchro transmitter and synchro receiver and its applications	Understand	5
4	Describe the construction and working of capacitor start and capacitor run motors.	Understand	5
5	Explain the classification and essential features of measuring instruments.	Understand	5
6	Write short notes on the following: a) AC Servo motors. b) Shaded pole motor.	Understand	5

	c) Synchros		
7	Write a short note on the following: a) Capacitor motors. b) Stepper motor.	Understand	5
8	Define stepper motor. Explain the construction and working of variable reluctance stepper motor and its applications.	Understand	5
9	Explain the construction and working of AC Tachometer with neat diagram	Knowledge	5

OBJECTIVE QUESTIONS:

JNTUH:

UNIT-1: DC GENERATORS AND DC MOTORS

1. In DC Generator the critical resistance refers to:

a) Armature b) Field c) Load d) Commutator

2. In DC Generator the residual magnetism will be of the order:

a) 2.5% b) 10% c) 15% d) 20%

3. Sparkless commutation can be achieved by employing

a) Interpoles (b) Compensating winding (c) High resistance carbon brushes (d) All the above

4. Comutator in DC machine acts as:

(a) Full wave rectifier (b) Half wave rectifier

(c) Controlled full wave rectifier (d) Controlled half wave rectifier

5. In DC machine, commutator converts

a) dc to ac (b) ac to dc (c) Both ac to dc and dc to ac (d) None of the above

UNIT-2: TRANSFORMERS

1. The eddy current losses in the transformer will be reduced if

(a)The laminations are thick (b)Primary winding is reduced

(c) Secondary winding is reduced (d) the laminations are thin

2. Eddy current loss will depends on

(a)Frequency (b) Flux density (c) Thickness (d) All of the above

3. A transformer core is laminated to reduce_____losses.

(a) Hysteresis (b) Eddy current (c) copper (d)Windage

4) _____ The no-load current drawn by transformer is usually percent of the full load current.

(a) 0.2 to 0.5 (b) 2 to 5 (c) 12 to 15 (d) 20 to 30

5) _____Open circuit test on transformers is conducted to determine losses.

a) Hysteresis (b) copper (c) core (d) Eddy current

6) The path of a magnetic flux in a transformer should have_____reluctance.

(a) Low (b) High (c) Very high (d) None

7) Short circuit test on transformers is conducted to determine_____losses.

(a) Iron (b) Copper (c) both a & b (d) None

8) The principle of statically induced e.m.f is utilized in_____.

(a) Generator (b) Motor (c) Battery (d) Transformer

9) _____material is used for the construction of transformer core.

(a) Copper (b) Iron (c) Aluminum (d) None

10) A 4-pole, 440v induction motor is running at a slip of 4%. The speed of the motor is

_____.

UNIT-3: INDUCTION MOTORS

1. The rotation of Induction Motor can be reversed by interchanging any two of the supply terminals

a) True b) False

2. The starting torque of 3-phase IM can be reversed by

a) Increasing the rotor reactance b) Increasing the rotor resistance
c) Increasing the stator resistance d) Increasing the stator reactance

3. Which of the following motor is having high starting torque?

a) DC series motor b) AC series motor c) Induction motor d) none

4) Which of the following is the normal arrangement of the armature windings and field poles in a three phase alternator

a) Stationary field & rotating armature b) Stationary armature & rotating field poles
c) Stationary field poles & stationary armature d) Rotating field poles & rotating armature

5) The frame of an induction motor is usually made of_____.

UNIT-4: ALTERNATORS

1. Which of the following is not a feature of an alternator

a) It runs on fixed speed b) It generates alternating voltage
c) It generates direct current d) It is used commercially

2. Which of the following is the normal arrangement of the armature windings and field poles in a three phase alternator

(a) Stationary field & rotating armature (b) Stationary armature & rotating field poles
(c) Stationary field poles & stationary armature (d) Rotating field poles & rotating armature

3) Alternator operates on the principle of

a) electro-magnetic induction b) self-induction c) Mutual induction d) b (or) c

4) The stator of an alternator gets overheated due to

a) Open phase b) unbalanced currents in the phases
c) Improper alignment of the rotor d) any one (or) more of the above

5) An alternator drive by a steam turbine is known as a

a) turbo-alternator b) hydro-generator c) steam turbine d) none of the above

UNIT-5

1) Which instrument would you use to measure resistance?

a. Ammeter b. voltmeter c. Ohmmeter d. wattmeter

2) An ammeter is_____instrument.

a) indicating b) integrating c) recording d) all the above

2) When the pointer of an indicating instrument comes to rest in the final deflected position _____torque is zero.

a) deflecting b) controlling c) damping d) all the above

3) PMMC instrument can be used for only_____.

a) ac b) dc c) both ac and dc d) none

4) MI instruments have _____scale.

a) uniform b) squared c) log d) triangular

WEBSITES

1 en.wikipedia.org/wiki/Outline_of_electrical_engineering
2 www.ee.iitm.ac.in/
3 www.ee.iitd.ernet.in/
4 http://nptel.ac.in/courses/108108076/

JOURNALS

1. IEEE Industry Applications Magazine
2. IEEE Transactions on Industry Applications
3. IEEE Transactions on Energy conversion
4. IEEE Transactions on Power Systems
5. IEEE Transactions on Distribution Systems

LIST OF TOPICS FOR STUDENT SEMINAR:

1. Energy balance
2. Action of commutator
3. Methods of improving commutation
4. Methods of Excitation
5. D.C Motors Principle of operation
6. 3 point and 4 point starters
7. Swinburne's test & Hopkinson's test

CASE STUDIES / SMALL PROJECTS:

1. DC generator construction and working principle.
2. DC generator armature reaction and commutation, commutation improving techniques.
3. Testing of DC machines.
4. DC motor speed control applications to industry.
5. Ward- Leonard speed control applications.