D.C. MACHINES AND TRANSFORMERS **Course Code : 314322**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Fourth**
Course Title : **D.C. MACHINES AND TRANSFORMERS**
Course Code : **314322**

I. RATIONALE

Despite advancements in electrical technology, D.C. machines still find applications in various industries and commercial sectors. Further the Transformers are essential components of power systems. This course is to equip students with fundamental knowledge, practical skills and a strong foundation in electrical power system and related fields.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Maintain D.C. Machines and Transformers used in Industry and related field.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Test the performance of D.C. Generators.
- CO2 - Test the performance of D.C. Motors
- CO3 - Test the performance of Single phase transformers
- CO4 - Use three phase transformer for different applications.
- CO5 - Use relevant special purpose transformers for different applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
314322	D.C. MACHINES AND TRANSFORMERS	DMT	DSC	4	-	4	-	8	4	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the constructional details of the D.C. Machine. TLO 1.2 Explain the principle of working of the given D.C. Generator. TLO 1.3 Derive EMF equation and calculate the parameters of the given D.C. Generator. TLO 1.4 Identify the given type of D.C. Generator. TLO 1.5 Interpret the characteristics of the given D.C. Generator.	**Unit - I D.C. Generator** 1.1 D.C. Machine: construction, parts-function and material, types of winding (lap and wave) 1.2 D.C. Generator: Principle of operation, Faraday's law of electromagnetic induction, Fleming's right hand rule. 1.3 E. M. F. equation of D.C. Generator (derivation) 1.4 Types of D.C. Generator and it's applications. 1.5 Characteristics -internal and external.	Chalk-Board Flipped Classroom Video Demonstrations Model Demonstration Presentations
2	TLO 2.1 Explain the working principle of D.C. Motor. TLO 2.2 Apply the back emf equation in the given situation. TLO 2.3 Select relevant D.C. Motor for given application with justification. TLO 2.4 Calculate the torque, speed, output power and efficiency of the given D.C. Motor. TLO 2.5 Explain the various speed control methods of the given D.C. Motor. TLO 2.6 Describe with sketch the working of the starter for the given type of D.C. Motor. TLO 2.7 Describe the procedure of testing a D.C. Motor for the given condition. TLO 2.8 Explain with a diagram the working of the brushless D.C. Motor.	**Unit - II D.C. Motor** 2.1 D.C. Motor: Principle of operation, Lorentz force, Fleming's Left hand rule, Back emf and it's significance, Armature reaction. 2.2 Types of D.C. Motors, Torque: armature torque, shaft torque, Break Horse Power (BHP). 2.3 D. C. Motor characteristics- speed-armature current, torque- armature current, speed-torque. 2.4 Speed control: D.C. shunt and series motor- flux and armature control. 2.5 Starters, necessity of starters, two-point starters, three-point starters and four-point starters. 2.6 Testing: Break load test, Different types of losses, efficiency. 2.7 D.C. Motors applications, advantages and disadvantages 2.8 Brushless D.C. Motor: construction working, applications, advantages and disadvantages	Chalk-Board, Flipped Classroom Video, Demonstrations Model, Demonstration Presentations.

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Describe the constructional details of the single-phase transformer. TLO 3.2 Explain the working principle of single-phase transformer. TLO 3.3 Derive the EMF equation of transformer and calculate parameter for the given situations. TLO 3.4 Identify the type of single-phase transformer based on the given criterion. TLO 3.5 Interpret the name plate rating of the given transformer. TLO 3.6 Explain phasor diagram for no load/on load condition for the given type of transformer. TLO 3.7 Calculate regulation and efficiency by O.C. / S.C. tests and direct loading for the given type of transformer.	**Unit - III Single Phase Transformer** 3.1 Single phase transformer: Introduction, construction, parts-functions and material. 3.2 Principle of operation, EMF equation, voltage transformation ratio, turns ratio. 3.3 Types and losses, significance of transformer ratings. 3.4 No-load and On-load test on transformer and it's phasor diagram, Leakage reactance. 3.5 Equivalent circuit of transformer with equivalent resistances and reactances. 3.6 Voltage regulation and Efficiency: Direct loading. O.C. / S.C. method. All day efficiency, applications.	Chalk-Board, Flipped Classroom Video, Demonstrations Model, Demonstration Presentations.
4	TLO 4.1 Describe the constructional details of the three -phase transformer. TLO 4.2 Identify the given type of transformer. TLO 4.3 Describe with diagrams various connections of the given three phase transformers. TLO 4.4 Select appropriate transformer on the given application. TLO 4.5 Describe the requirements for the parallel operation of the transformer. TLO 4.6 Describe the procedure for the given type of test on three phase transformer. TLO 4.7 Explain the importance of 'K' factor of transformers.	**Unit - IV Three Phase Transformer** 4.1 Three phase transformer: Introduction, construction, bank of three single phase transformers. Single unit of three phase transformer. 4.2 Working principle of three phase transformer. Types of transformers. 4.3 Connections as per IS: 2026 (part IV)-1977. Three phase to two phase conversion (Scott Connection). 4.4 Selection criteria as per IS: 10028 (Part I)-1985 of distribution transformer and power transformer, amorphous core type distribution transformer, specifications of three-phase distribution transformers as per IS:1180 (part I)-1989. 4.5 Need of parallel operation, conditions for parallel operation. 4.6 Polarity tests on mutually inductive coils, Phasing out test on Three- phase transformer. 4.7 Harmonics and their effects on transformer operation. 4.8 'K' factor of transformers: overheating due to non-linear loads and harmonics.	Chalk-Board Flipped Classroom Video, Demonstrations Model, Demonstration Presentations.

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Describe the constructional details of the given type of special purpose transformer. TLO 5.2 Explain the Working principle of the given type of special purpose transformer. TLO 5.3 State the applications of the given type of special purpose transformer.	**Unit - V Special Purpose Transformer** 5.1 Auto transformer: Construction, working and applications for single and three phases. 5.2 Instrument Transformers: Construction, working and applications of current transformer and potential transformer. 5.3 Isolation transformer: Construction, features and applications. 5.4 Single phase welding transformer: Construction, features and applications. 5.5 Pulse transformer: Construction, features and applications.	Chalk-Board, Flipped Classroom Video, Demonstrations Model, Demonstration Presentations.

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify different parts of the D.C. machine.	1	*Dismantling of a D.C. machine.	2	CO1
LLO 2.1 Verify generated output of the D.C. Shunt Generator.	2	*Measurement of D.C. Shunt Generator voltage by changing flux and speed.	2	CO1
LLO 3.1 Test the performance of D.C. Shunt generator.	3	*Load test on D.C. Shunt Generator.	2	CO1
LLO 4.1 Test the performance of D.C. Compound generator.	4	Load test on D.C. Compund Generator.	2	CO1
LLO 5.1 Test the performance of D.C. Shunt generator by Hopkinson's Test .	5	Testing the performance of D.C. Shunt generator by Hopkinson's Test .	2	CO1
LLO 6.1 Reverse the direction of rotation of the D.C. shunt motor.	6	*Reversal of rotation of D.C. shunt motor.	2	CO2
LLO 7.1 Perform brake test on D.C. shunt motor.	7	*Speed torque characteristics of D.C. shunt motor.	2	CO2
LLO 8.1 Control the speed of D.C. shunt motor by different methods.	8	*Speed control of D.C. shunt motor using Armature control & flux control method.	2	CO2
LLO 9.1 Reverse the direction of rotation of the D.C. series motor.	9	*Reversal of rotation of D.C. series motor.	2	CO2
LLO 10.1 Control the speed of the D.C. series motor by different methods.	10	Speed control of D.C. series motor using Armature control & flux control method.	2	CO2
LLO 11.1 Perform brake test on a D.C. series motor.	11	Brake test on D.C. series motor.	2	CO2
LLO 12.1 Reverse the direction of rotation of the D.C. compound motor.	12	*Reversal of rotation of D.C. compound motor.	2	CO2
LLO 13.1 Identify different parts of a three point starter of a D.C. Shunt Motor. LLO 13.2 Check the function of the various parts of three point starter.	13	*Demonstration of operating mechanism of three point starter of a D.C. Shunt Machine.	2	CO2
LLO 14.1 Identify different parts of a four point starter of a D.C. Compound Motor. LLO 14.2 Check the function of the various parts of four point starter.	14	*Demonstration of operating mechanism of four point starter of a D.C. Compound Machine.	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 15.1 Identify different parts of a two point starter of a DC series Motor. LLO 15.2 Check the function of the various parts of two point starter.	15	*Demonstration of operating mechanism of two point starter of a DC series Machine.	2	CO2
LLO 16.1 Identify the different parts of single phase & Three phase transformer.	16	*Demonstration of a single phase & Three phase transformer construction.	2	CO3 CO4
LLO 17.1 Find the transformation ratio of single phase transformer.	17	* Transformation ratio of single phase transformer.	2	CO3
LLO 18.1 Test the performance of single phase transformer.	18	*Direct load test of single phase transformer.	2	CO3
LLO 19.1 Test the performance of single phase transformer.	19	*Open circuit and short circuit test on single phase transformer to determine equivalent circuit parameters.	2	CO3
LLO 20.1 Test the performance of single phase transformer.	20	*Open circuit and short circuit test on single phase transformer to determine voltage regulation and efficiency.	2	CO3
LLO 21.1 Perform parallel operation of two single phase transformers.	21	*Perform parallel operation of two single phase transformers to determine the load current sharing.	2	CO3
LLO 22.1 Perform parallel operation of two single phase transformers.	22	*Perform parallel operation of two single phase transformers to determine the apparent and real power load sharing.	2	CO3
LLO 23.1 Perform polarity test on a single phase transformer.	23	*Perform polarity test on a single phase transformer whose polarity markings are masked.	2	CO3
LLO 24.1 Convert three phase to two phase conversion by Scott-Connection.	24	Scott-Connection of three phase transformer.	2	CO4
LLO 25.1 Perform Back to Back test on single phase transformer.	25	*Back to Back test on single phase transformer.	2	CO4
LLO 26.1 Connect the auto-transformer in step-up and step-down modes, measure input and output voltage.	26	*Connection of the auto-transformer.	2	CO5
LLO 27.1 Verify the Current transformer (CT) ratio.	27	Functioning of the Current transformer (CT).	2	CO5
LLO 28.1 Verify the Potential Transformer (PT) ratio.	28	Functioning of the Potential Transformer (PT).	2	CO5
LLO 29.1 Verify turns ratio of the isolation transformer.	29	*Functioning of the isolation transformer.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

NO SLA

- Not applicable for this course

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	DC series and shunt machines (up to 230 V, 4 kW).	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15
2	Three point starter.	13
3	Four point starter.	14
4	Two point starter.	15
5	Single phase transformer of suitable size (500 VA to 1 kVA).	16,17,18,19,20,21,22,23
6	Three phase transformer of suitable size (1 kVA to 3 kVA).	16,24,25
7	AC Ammeter range (0-2.5-5-10A). Portable analog MI type as per relevant BIS standard.	17,18,19,20,21,22,23,24,25,26,27,28,29
8	AC Voltmeter Range (0-75/150/300V), Portable analog MI type as per relevant BIS standard.	17,18,19,20,21,22,23,24,25,26,27,28,29
9	Wattmeter 0-300/600 V, 5/10 A, for use in A.C. circuits.	18,19,20,22
10	L.P.F. Wattmeter, 0-300/600 V, 1A to 2A, for use in A.C. circuits.	19,20
11	Lamp load of 10-20 A.	2,3,4,5,13,14,15,17,18,21,22,29
12	DC Supply, 230 V, 25 A.	2,3,4,5,6,7,8,9,10,11,12,13,14,15,23
13	Rheostat (0-500 Ohm. 1.2A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.	2,3,4,5,7,8,10,11
14	Tachometer(0-10,000 RPM).	2,3,4,5,7,8,10,11
15	DC Ammeter range (0-5-10A), Portable analog PMMC type as per relevant BIS standard.	2,3,4,5,7,8,10,11,12
16	DC Voltmeter Range (0-150/300V), Portable analog PMMC type as per relevant BIS standard.	2,3,4,5,7,8,10,11,12
17	Rheostat (0-400 Ohm, 1.5A). Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.	2,5,7,8,10,11
18	Single phase auto transformer 0-270 V, 15 A.	26
19	CT of suitable ratio.	27
20	PT of suitable ratio.	28
21	Isolation transformer of suitable ratio.	29
22	Rheostat (0-100 Ohm, 5A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.	7,8,10
23	Rheostat (0-50 Ohm, 10A), Nichrome wire wound rheostat on epoxy resin or class F insulating tube with two fixed and one sliding contact.	7,8,10,11

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

D.C. MACHINES AND TRANSFORMERS **Course Code : 314322**

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	D.C. Generator	CO1	8	2	0	6	8
2	II	D.C. Motor	CO2	16	6	4	10	20
3	III	Single Phase Transformer	CO3	17	2	8	10	20
4	IV	Three Phase Transformer	CO4	13	2	8	6	16
5	V	Special Purpose Transformer	CO5	6	2	0	4	6
Grand Total				**60**	**14**	**20**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and an average of two unit tests considered.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	2	1	1	1			
CO2	3	2	2	2	3	1	2			
CO3	3	1	1	2	2	1	1			
CO4	3	2	2	2	3	1	1			
CO5	3	1	1	2	2	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Bhattacharya,S. K	Electrical Machines	McGraw Hill Education, New Delhi ISBN-13:978-0070669215
2	Mehta, V. K. and Mehta, Rohit	Principles of Electrical Machines	S.Chand and Co.Ltd., New Delhi ISBN-13: 978-8121921916
3	Theraja B. L.	Electrical Technology Vol-II (AC and DC machines)	S.Chand and Co.Ltd., New Delhi ISBN-13: 978-8121924375
4	Bandyopadhyay M. N.	Electrical Machines Theory and Practice	PHI Learning Pvt. Ltd., New Delhi ISBN-13:978-8120329973

Sr.No	Author	Title	Publisher with ISBN Number
5	Mittle, V.N. and Mittle, Arvind	Basic Electrical Engineering	McGraw Hill Education, New Delhi ISBN-13: 978-0070593572
6	Kothari, D. P. and Nagrath, I. J.	Electrical Machines	McGraw Hill Education, New Delhi ISBN-13:978-9352606405
7	Murugesh Kumar K.	DC Machines and Transformers	S. Chand, ISBN-13: 978-8125916055
8	J. B. Gupta	Theory & Performance of Electrical Machine	S-K-Kataria, ISBN-13: 978-9350142776

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/D4RFFnzRdkk?si=d5iNRWSZbl01NvT3	Construction & Working Principle of a D.C. Machine.
2	https://youtu.be/1OfLgpFq6Rc?si=bwN9d7ESlV2Utzb6	D.C. Motors.
3	https://youtu.be/6dF3LDzb-tE?si=OYZMdgs2I5d7bqAa	D.C. Generator.
4	https://youtu.be/qmcriUdYBW0?si=ea5Sa1G9R9m7aRTm	Transformer.
5	www.nptel.ac.in	About construction, working principle and operation of D.C. Machine, single phase transformer, three phase transformer and special purpose transformer.
6	www.electricaltechnology.org	About construction, working principle and operation of D.C. Machine, single phase transformer, three phase transformer and special purpose transformer.
7	www.electrical4u.com	About construction, working principle and operation of D.C. Machine, single phase transformer, three phase transformer and special purpose transformer.

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students