Gyanmanjari Innovative University

Syllabus
Gyanmanjari Institute of Technology
Semester-3 (B.Tech)

Subject: Modern DC Machine Technology: Concept and Application - BET2EE13305

Type of Course: Professional Core

Prerequisite: Basic understanding of Electrical Engineering and Electrical Machines.

Rationale: This course provides hands-on and industry-oriented learning of modern DC machine technology through practical implementation, experimentation, troubleshooting, and real-world applications. The course focuses on skill-based education by integrating machine testing, speed control techniques, maintenance practices, automation concepts, and smart monitoring systems. Students will develop practical competencies in DC machine operation, industrial drives, electric vehicle applications, and IoT-enabled monitoring systems through continuous laboratory activities, mini projects, and performance-based evaluations.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
4	0	2	5	100	50	150

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit, SEE - Semester End Evaluation; CCE-Continuous and Comprehensive Evaluation.

Course Content:

Sr. No.	Course Content	Hrs.	% Weightage
1	**Introduction to DC Machines & Construction** **Topics:** • Fundamentals and industrial applications of DC machines. • Constructional details of DC motors and generators: armature winding, field winding, commutator, brushes, poles, yoke. • EMF equation, torque equation. • Types of DC machines, including series, shunt, and compound machines. • Losses and efficiency. • Introduction to modern DC drives and EV applications. **Practical:** 1. To identify the major parts of a DC machine and understand their construction and functions.	18	20%

2. To study and interpret the nameplate specifications and ratings of a DC machine.
3. To measure the armature and field winding resistances using appropriate instruments.
4. To observe the performance of a DC shunt motor under no-load conditions.
5. To study the construction and working of the commutator and brush assembly.
6. To verify the EMF equation of a DC machine using experimentally measured values.
7. To verify the torque equation by observing the effect of load variation on armature current and torque.
8. To determine the no-load losses of a DC machine and estimate its efficiency.
9. To compare the construction, characteristics, and applications of series, shunt, and compound DC machines.
10. To study the practical applications of DC machines in electric vehicles and industrial drive systems through case studies. Evaluation Method

Sr. No.	Evaluation Methods	SEE	CCE
1	**Construction and Component Identification:** Identification and explanation of various parts of DC machines with industrial applications.	20	–
2	**Numerical Problem Solving:** Numerical solving based on the EMF equation, the torque equation, and efficiency calculation.	-	–
3	**Machine Observation and Analysis:** Observation and analysis of the no-load operation characteristics of the DC motor.	-	–
4	**Active Learning Activity (ALA-1):** Prepare a construction diagram and compare different types of DC machines.	–	05
5	**Industrial Application Presentation:** Study applications of DC machines in EVs, cranes, elevators, and industries.	–	05

Examination Style:

	1. Construction and Component Identification (10 Marks) Students will perform a hands-on practical exercise involving the identification and explanation of various components of a DC machine. Students shall identify the armature, field winding, commutator, brushes, poles, yoke, shaft, and other associated parts and explain their functions and significance in machine operation. They shall also study machine nameplate specifications and discuss the role of DC machines in industrial applications such as electric vehicles, cranes, elevators, rolling mills, and automation systems. Students must answer viva questions related to machine construction and industrial relevance. **2. Numerical Problem Solving (05 Marks)** Students will solve numerical problems based on the EMF equation, torque equation, losses, and efficiency calculations of DC machines. The assessment shall evaluate the student's ability to apply theoretical concepts, perform calculations accurately, interpret results, and analyze machine performance under different operating conditions. Students may also be required to explain the significance of calculated parameters during viva-voce. **3. Machine Observation and Analysis (05 Marks)** Students will observe the no-load operation of a DC motor and analyze its performance characteristics. They shall record operating parameters, observe machine behavior, identify operating conditions, and interpret the observed results. Students must explain the relationship between machine construction and performance, discuss operating characteristics, and justify the observed behavior during viva examination. **4. Active Learning Activity (ALA-1) (05 Marks)** Students will prepare a detailed construction diagram of a DC machine and perform a comparative study of series, shunt, and compound DC machines. The activity shall include identification of major components, constructional differences, operating characteristics, advantages, limitations, and typical industrial applications. Students shall submit a technical report containing diagrams, comparison tables, and observations for evaluation. **5. Industrial Application Presentation (05 Marks)** Students will conduct a study on the industrial applications of DC machines in electric vehicles, cranes, elevators, hoists, conveyors, rolling mills, and industrial drive systems. Students shall prepare and deliver a		

	technical presentation highlighting the selection criteria, advantages, performance requirements, and practical implementation of DC machines in various industries. Assessment shall be based on technical understanding, presentation skills, application analysis, and ability to answer questions during discussion.		
2	**Characteristics of DC Generators & Motors** **Topics:** • Working principles of DC generators and motors; • Magnetization characteristics; load characteristics of shunt, series, and compound generators; • Speed-torque characteristics of DC motors; • Starting methods of DC motors; • Industrial applications based on machine characteristics. **Practical:** 11. To study the relationship between generated EMF and field current under no-load conditions by plotting the open-circuit characteristic (OCC) curve of a DC shunt generator and analyzing the effect of excitation on generated voltage. 12. To study the variation of terminal voltage with respect to load current in a DC shunt generator and analyze voltage regulation and performance under different loading conditions. 13. To investigate the relationship between terminal voltage and load current of a DC compound generator and understand the cumulative and differential compounding effects on generator performance. 14. To study the relationship between speed and torque of a DC shunt motor and analyze its speed regulation capability under varying load conditions. 15. To study the variation of speed with load for a DC series motor and understand its high starting torque characteristics and industrial suitability. 16. To study the construction, working principle, and operation of a 3-point starter used for protecting DC motors against excessive starting current and voltage fluctuations. 17. To study the construction, operation, and advantages of a 4-point starter and understand how it provides improved protection and speed control of DC motors. 18. Comparative Performance Analysis of Different DC Motors: To compare the performance characteristics of DC shunt, series, and compound motors based on speed, torque, efficiency, and industrial applications.	18	20%

19. To measure the generated voltage of a DC generator by changing field excitation and analyze the effect of magnetic flux variation on generated EMF.
20. To study and analyze the applications of different DC motors in industries such as electric vehicles, cranes, elevators, rolling mills, and other industrial drive systems based on their operating characteristics.

Evaluation Method

Sr. No.	Evaluation Methods	SEE	CCE
1	Plotting and analysis of generator and motor characteristics.	10	–
2	Numerical solving based on speed-torque and load characteristics.	05	–
3	Experimental verification of DC motor starting methods.	05	–
4	Active Learning Assignment (ALA-2): Comparative analysis of series, shunt, and compound machines.	–	05
5	Graph analysis & performance interpretation using experimental data.	–	05

Examination Style:

1. Plotting and Analysis of Generator and Motor Characteristics (10 Marks)

Students will perform experiments to obtain and plot the operating characteristics of DC generators and motors. The practical examination may include open-circuit characteristics of a DC shunt generator, load characteristics of a shunt generator, external characteristics of a compound generator, speed-torque characteristics of a DC shunt motor, and speed-load characteristics of a DC series motor. Students shall record observations, plot characteristic curves, analyze machine performance, and explain the significance of the obtained characteristics in practical and industrial applications. Viva-voce shall be conducted to assess conceptual understanding and interpretation of experimental results.

2. Numerical Solving Based on Speed-Torque and Load Characteristics (05 Marks)

	Students will solve numerical problems related to speed-torque characteristics, speed regulation, load characteristics, generated voltage, motor performance, and machine efficiency. The assessment shall evaluate the student's ability to apply theoretical principles, perform accurate calculations, analyze results, and interpret machine behavior under varying operating conditions. Students may also be required to explain the practical significance of the calculated parameters during viva-voce. **3. Experimental Verification of DC Motor Starting Methods (05 Marks)** Students will demonstrate the operation of 3-point and 4-point starters used for DC motors. They shall explain the necessity of starters, identify the various components of the starter, describe the protection mechanisms provided, and verify the starting procedure experimentally. Students shall compare the performance and applications of both starting methods and explain their industrial significance during viva examination. **4. Active Learning Assignment (ALA-2): Comparative Analysis of Series, Shunt, and Compound Machines (05 Marks)** Students will prepare a comparative technical study of series, shunt, and compound DC machines. The assignment shall include working principles, constructional features, operating characteristics, advantages, limitations, speed regulation, torque characteristics, and typical industrial applications. Students shall submit a report containing diagrams, comparison tables, performance analysis, and application-based conclusions for evaluation. **5. Graph Analysis & Performance Interpretation Using Experimental Data (05 Marks)** Students will analyze experimentally obtained characteristic curves of DC generators and motors and interpret their performance under different operating conditions. The task shall include evaluation of speed variation, voltage regulation, load response, torque characteristics, and efficiency trends. Students shall prepare a technical report presenting graphical analysis, observations, conclusions, and recommendations regarding the selection of appropriate DC machines for specific industrial applications. The report shall be submitted through the GMIU Portal for assessment.		
3	**Speed Control & Braking Techniques** **Topics:** • Armature control method.	18	20%

- Field control method.
- Ward Leonard system.
- PWM-based electronic speed control.
- Dynamic braking, plugging, and regenerative braking.
- Modern DC drive systems and automation.

Practical:

21. To study the speed control of a DC motor by varying armature resistance and analyze the effect of armature voltage drop on motor speed and performance.
22. To study the speed control of a DC motor by varying field current and understand the effect of magnetic flux variation on motor speed.
23. To analyze the speed control of a DC motor by changing the applied armature voltage using a variable voltage source and study its performance characteristics.
24. To study the principle and operation of PWM-based speed control of DC motors and analyze the effect of duty cycle variation on motor speed control.
25. To measure the rotational speed of a DC motor using a digital tachometer and understand the variation of speed under different operating conditions.
26. To study the operation of dynamic braking in DC motors and analyze the conversion of kinetic energy into electrical energy for quick stopping of the motor.
27. Study the plugging braking method of DC motors and understand the reversal of motor connections for rapid braking action.
28. To study the working principle of regenerative braking and understand the recovery of electrical energy during motor braking operation.
29. To simulate and analyze DC drive systems used in industries and study their speed control, protection, and operating performance.
30. To compare various DC motor speed control techniques based on speed range, efficiency, response, advantages, and industrial suitability.
31. To study the performance of a DC motor under different load conditions by observing variations in speed, current, and torque.

Evaluation Method

Sr. No.	Evaluation Methods	SEE	CCE
1	Demonstration of speed control techniques using a practical setup.	10	–

2	PWM-based speed control circuit implementation and analysis.	05	–
3	Verification and comparison of braking methods.	05	–
4	**Active Learning Activity (ALA-3):** Design a speed control circuit using the PWM technique.	–	05
5	Simulation and analysis of industrial DC drive systems.	–	05

Examination Style:

1. Demonstration of Speed Control Techniques Using a Practical Setup (10 Marks)

Students will perform practical implementation of various DC motor speed control techniques using laboratory setups. The examination may include armature resistance control, field control, variable voltage control, or other suitable speed control methods. Students shall vary operating parameters, measure motor speed using appropriate instruments, record observations, and analyze the effect of control methods on motor performance. They must explain the operating principles, advantages, limitations, and industrial applications of each speed control technique during viva-voce examination.

2. PWM-Based Speed Control Circuit Implementation and Analysis (05 Marks)

Students will implement or analyze a PWM-based DC motor speed control circuit using a controller, simulation platform, or hardware setup. They shall explain the principle of Pulse Width Modulation (PWM), observe the variation of motor speed with duty cycle changes, and analyze the performance of the control system. Students shall interpret the obtained results and discuss the advantages of PWM control in modern DC drive applications during a viva examination.

3. Verification and Comparison of Braking Methods (05 Marks)

Students will experimentally demonstrate and compare dynamic braking, plugging, and regenerative braking techniques used in DC motors. They shall observe motor behavior during braking, record relevant parameters, compare braking performance, and analyze the advantages, limitations, and industrial applications of each method. Students must explain the

	energy dissipation and energy recovery mechanisms associated with different braking techniques during a viva voce. **4. Active Learning Activity (ALA-3): Design a Speed Control Circuit Using the PWM Technique (05 Marks)** Students will design a PWM-based speed control circuit for a DC motor using simulation software or circuit design tools. The activity shall include circuit design, component selection, duty cycle control methodology, expected output characteristics, and performance analysis. Students shall submit a technical report containing circuit diagrams, design calculations, simulation results, and observations for evaluation. **5. Simulation and Analysis of Industrial DC Drive Systems (05 Marks)** Students will study and analyze industrial DC drive systems through simulation, case studies, or experimental demonstrations. The task shall include investigation of speed control strategies, braking techniques, automation features, load response, and performance optimization methods used in industrial applications. Students shall prepare a technical report presenting simulation results, system analysis, observations, conclusions, and industrial relevance. The report shall be submitted through the GMIU Portal for assessment.		
4	**Maintenance, Testing & Protection of DC Machines** **Topics:** • Preventive maintenance of DC machines. • Brush maintenance. • Commutation problem. • Machine faults and troubleshooting. • Insulation testing. • Temperature monitoring. • Efficiency testing methods. • Protection systems for DC drives. **Practical:** 32. To inspect the condition of brushes and commutators of DC machines and study proper maintenance procedures to ensure smooth operation and improved performance. 33. To study the cleaning and servicing methods of different DC machine components and understand their importance in maintaining machine efficiency and reliability.	18	20%

34. To measure the insulation resistance of DC machine windings using a megger and evaluate the insulation condition for safe operation.
35. To observe the temperature rise of a DC machine under different load conditions and analyze the effect of loading on machine performance.
36. To identify common faults in DC machines and practice troubleshooting techniques for maintaining proper machine operation.
37. To study the causes of commutation problems in DC machines and understand methods for detection and corrective maintenance.
38. To calculate the efficiency of a DC machine using load test data and analyze the performance under different operating conditions.
39. To study and test the overload protection system of DC machines and understand its role in preventing machine damage.
40. To study different protection methods used against short circuits and overcurrent conditions in DC machines and industrial systems.
41. To prepare a preventive maintenance checklist for DC machines and understand the importance of regular inspection and servicing.
42. To analyze vibration and noise levels in DC machines and identify possible mechanical or electrical faults.
43. To study industrial maintenance practices, safety procedures, and precautions required during operation and maintenance of DC machines.

Evaluation Method

Sr. No.	Evaluation Methods	SEE	CCE
1	Fault diagnosis and troubleshooting of DC machine faults	10	–
2	Insulation testing and efficiency calculation using load test data	05	–
3	Demonstration of maintenance and protection techniques	05	–
4	Quiz on machine faults, protection systems, and maintenance procedures	–	05
5	Maintenance Checklist & Fault Analysis Report Submission	–	05

	Examination Style: **1. Fault Diagnosis and Troubleshooting of DC Machine Faults (10 Marks)** Students will perform practical fault diagnosis and troubleshooting activities on DC machines. The examination may include identification of common faults such as excessive sparking at brushes, poor commutation, overheating, abnormal noise, vibration, open-circuit faults, short-circuit faults, and loose electrical connections. Students shall inspect the machine, identify probable causes of faults, recommend corrective actions, and demonstrate appropriate troubleshooting procedures. Students must explain fault symptoms, diagnostic methods, and preventive measures during viva-voce examination. **2. Insulation Testing and Efficiency Calculation Using Load Test Data (05 Marks)** Students will perform insulation resistance measurement using a megger and evaluate the condition of machine insulation. They shall also calculate machine efficiency using experimental load test data by determining losses and output performance. Students must analyze the test results, interpret the significance of insulation resistance values and efficiency calculations, and explain their importance in ensuring reliable machine operation during a viva examination. **3. Demonstration of Maintenance and Protection Techniques (05 Marks)** Students will demonstrate preventive maintenance and protection practices used for DC machines. The practical assessment may include inspection and maintenance of brushes and commutators, cleaning and servicing procedures, overload protection testing, and study of short-circuit and overcurrent protection systems. Students shall explain maintenance schedules, safety precautions, protection mechanisms, and their role in enhancing machine reliability and operational life during viva-voce. **4. Quiz on Machine Faults, Protection Systems, and Maintenance Procedures (05 Marks)** Students will complete a quiz covering machine faults, fault diagnosis methods, protection systems, maintenance procedures, insulation testing, commutation problems, safety practices, and industrial maintenance standards. The assessment shall evaluate conceptual understanding.		

	troubleshooting knowledge, and awareness of maintenance and protection requirements for DC machines. **5. Maintenance Checklist & Fault Analysis Report Submission (05 Marks)** Students will prepare and submit a comprehensive maintenance checklist and fault analysis report for a DC machine. The report shall include inspection procedures, maintenance schedules, fault symptoms, probable causes, corrective actions, protection methods, safety precautions, and recommendations for improving machine performance and reliability. Evaluation shall be based on technical accuracy, completeness of analysis, documentation quality, and practical relevance. The report shall be submitted through the GMIU Portal for assessment.		
5	**Smart DC Drive & Industrial Application** **Topics:** • Integration of DC drives with automation systems. • Electric vehicle DC motor applications. • IoT-based motor monitoring systems. • Smart protection and control techniques. • Industrial troubleshooting and performance optimization. **Practical:** 44. To measure and monitor the speed of a DC motor using a digital tachometer and analyze the speed variation under different operating conditions. 45. To test the performance of a battery-operated DC drive system and study its operation, efficiency, and suitability for portable applications. 46. To develop an IoT-based monitoring system for observing motor parameters such as speed, current, voltage, and temperature remotely. 47. To design and implement an overload protection system for DC motors to prevent damage due to excessive current and load conditions. 48. To design and study a PWM-based smart motor control system for efficient speed control and improved performance of DC motors. 49. To design and develop a battery-powered DC drive model and study its application in electric vehicles and portable systems. 50. To develop an automatic speed regulation system for maintaining constant motor speed under varying load conditions.	18	20%

51. To test and analyze DC motor performance by observing speed, current, torque, and efficiency under different load conditions.
52. To design a smart fault detection and alarm system for identifying abnormal conditions in DC drive systems.
53. To analyze the energy consumption and efficiency of a DC drive system and identify methods for improving performance.
54. To develop a mini project based on smart DC drive applications and understand practical implementation of motor control techniques.
55. To demonstrate the developed project and analyze its industrial applications, advantages, and future scope in automation and drive systems.

Evaluation Method

Sr. No.	Evaluation Component	SEE	CCE
1	Final Project Demonstration and Functional Performance.	10	–
2	Circuit Design, Innovation, and Application Analysis.	05	–
3	Viva on project implementation, troubleshooting, and industrial relevance.	05	–
4	Project report submission, including the circuit, testing, and observations.	–	05
5	Presentation and Teamwork Assessment.	–	05

Examination Style:

1. Final Project Demonstration and Functional Performance (10 Marks)

Students will design, implement, and demonstrate a smart DC drive application based on modern industrial concepts. The project may include IoT-based motor monitoring systems, battery-operated DC drives, automatic speed regulation systems, smart fault indication systems, overload protection systems, or energy-efficient DC drive applications. Students shall demonstrate the working of the developed system, explain the operating principle, perform functional testing, and evaluate system performance under different operating conditions. Assessment shall focus on functionality, practical implementation, troubleshooting ability, and

	industrial applicability. Students must answer questions related to project operation during the viva-voce examination. **2. Circuit Design, Innovation, and Application Analysis (05 Marks)** Students will present and justify the circuit design and implementation methodology used in their smart DC drive project. The assessment shall include evaluation of circuit design, component selection, control strategy, innovation, system integration, and application relevance. Students shall explain the design approach, analyze system performance, discuss improvements over conventional methods, and demonstrate the suitability of the proposed solution for industrial applications. **3. Viva on Project Implementation, Troubleshooting, and Industrial Relevance (05 Marks)** Students will undergo a viva-voce examination based on project implementation, testing procedures, troubleshooting techniques, and industrial applications. They shall explain hardware and software integration, working principles of the developed system, performance analysis, fault diagnosis methods, safety considerations, and future scope of the project. Assessment shall evaluate technical understanding, problem-solving ability, communication skills, and industrial awareness. **4. Project Report Submission, Including Circuit, Testing, and Observations (05 Marks)** Students will prepare and submit a detailed project report documenting all stages of project development. The report shall include objectives, a literature review, circuit diagrams, hardware specifications, methodology, an implementation procedure, testing results, observations, performance analysis, conclusions, and industrial applications. Evaluation shall be based on technical accuracy, completeness, presentation quality, documentation standards, and interpretation of results. The report shall be submitted through the GMIU Portal for assessment. **5. Presentation and Teamwork Assessment (05 Marks)** Students will deliver a technical presentation on their smart DC drive project highlighting the problem statement, objectives, methodology, implementation, testing, results, and industrial significance. Students working in groups shall demonstrate effective teamwork, task distribution, coordination, and collaborative problem-solving throughout the project. Assessment shall be based on technical content, presentation skills, communication effectiveness, teamwork, innovation, and the ability to respond to questions during discussion and evaluation.		

Suggested Specification Table with Marks:

Distribution of Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	05%	15%	25%	15%	10%	30%

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the evaluation may vary slightly from the above table.

Course Outcome:

After learning the course, the students should be able to:	
CO1	Explain the construction and operation of DC machines.
CO2	Analyze the characteristics and performance of DC generators and motors.
CO3	Implement speed control and braking techniques for DC drives.
CO4	Perform testing, maintenance, and troubleshooting of DC machines.
CO5	Design and demonstrate smart DC drive applications using modern industrial concepts.

Instructional Method:

The course delivery method will depend on the content requirements and students' needs. The teacher, in addition to the conventional teaching method by the blackboard, may also use any of the tools, such as demonstration, role-play, quizzes, brainstorming, MOOCs, etc.

From the content, 10% of topics are suggested for flipped-mode instruction.

Students will utilize supplementary resources, including online videos, NPTEL/SWAYAM videos, e-courses, and virtual laboratories.

The internal evaluation will be done on the basis of the CCE (Continuous and Comprehensive Evaluation).

SEE: Semester End Evaluation will be conducted at the end of each module for the evaluation of the performance of students in the laboratory.

Reference Books

[1] B. L. Theraja and A. K. Theraja, Electrical Technology – Volume II, S. Chand Publications.

[2] I. J. Nagrath and D. P. Kothari, Electrical Machines, McGraw-Hill Education.

[3] P. S. Bimbhra, Electrical Machinery, Khanna Publishers.

[4] A. E. Fitzgerald, Charles Kingsley, and Stephen Umans, Electric Machinery, McGraw-Hill.

[5] Ashfaq Husain, Electrical Machines, Dhanpat Rai Publications.

Suggested Assessment Guidelines

Module–1: Introduction to DC Machines & Construction

Construction and Fundamentals Assessment (20 Marks)

Criteria	Description	Marks
Component Identification	Correct identification and naming of various parts of DC machines, such as the yoke, poles, armature, commutator, brushes, and field winding.	5
Construction Understanding	Explains the construction, function, and working of each component with neat sketches wherever applicable.	5
Industrial Applications	Describes the applications of DC machines in industries, electric vehicles, cranes, elevators, and traction systems.	5
Presentation & Viva	Clear explanation, confidence during viva, proper terminology, and logical presentation of observations.	5
	Total	**20**

Module 2: Characteristics of DC Generators & Motors

Characteristics Analysis Proficiency Check (20 Marks)

Criteria	Description	Marks
Plotting and Analysis	Correct plotting and interpretation of DC generator and motor characteristics, including speed, torque, voltage, and load characteristics.	**10**
Numerical Problem Solving	Accurate calculations and analysis based on speed-torque characteristics and load performance of DC machines.	**5**
Experimental Verification	Demonstrates the experimental verification of DC motor starting methods with proper procedure, observations, and conclusions.	**5**

	Total	**20**

Module 3: Speed Control & Braking Techniques
Speed Control and Braking Assessment (20 Marks)

Criteria	Description	Marks
Speed Control Demonstration	Demonstrates various DC motor speed control techniques (armature voltage, field control, armature resistance) using a practical setup and explains their characteristics.	10
PWM-Based Speed Control	Implements and analyzes a PWM-based speed control circuit, including duty cycle variation and its effect on motor speed.	5
Braking Methods Verification	Verifies and compares dynamic, plugging, and regenerative braking methods based on experimental observations and performance.	5
	Total	**20**

Module 4: Maintenance, Testing & Protection of DC Machines
Maintenance and Troubleshooting Evaluation (20 Marks)

Criteria	Description	Marks
Speed Control Demonstration	Demonstrates various DC motor speed control techniques (armature voltage, field control, armature resistance) using a practical setup and explains their characteristics.	10
PWM-Based Speed Control	Implements and analyzes a PWM-based speed control circuit, including duty cycle variation and its effect on motor speed.	5
Braking Methods Verification	Verifies and compares dynamic, plugging, and regenerative braking methods based on experimental observations and performance.	5
	Total	**20**

Module 5: Smart DC Drive & Industrial Applications
Smart DC Drive Project Assessment (20 Marks)

Criteria	Description	Marks

Fault Diagnosis and Troubleshooting	Identifies common DC machine faults, performs systematic fault diagnosis, and explains appropriate troubleshooting techniques.	**10**
Insulation Testing and Efficiency Calculation	Conducts insulation resistance testing and accurately calculates machine efficiency using load test data.	**5**
Maintenance and Protection Techniques	Demonstrates preventive maintenance procedures and explains protection methods for safe and reliable operation of DC machines.	**5**
	Total	**20**