

Identification	Subject	ETR 452 Electrical machines 8 ECTS
	Department	Physics and Electronics
	Program (Undergraduate, Graduate)	Undergraduate
	Term	Fall 2026
	Instructor	M.Sc. Muhammad Alizada
	Email:	malizada@khazar.org
	Classroom/hours	11 Mehseti Street, Baku, Azerbaijan (Neftchilar campus), Monday-Friday, 09:00-18:00
Prerequisites	None	
Language	English	
Compulsory/Elective	Compulsory	
Textbooks and course materials	Textbooks: 1. Electric Machines 4th Edition by DP Kothari IJ Nagrath, 2010. Optional Reference Texts: 2. A Textbook of Electrical Machines Kindle Edition by K.R. Siddhapura, D.B. Raval, 2018. 3. Electrical Machines and Drives: Fundamentals and Advanced Modelling (Power Systems) 1st ed. 2018 Edition, Kindle Edition by Jan A. Melkebeek. 4. Electric Machines: Principles, Applications and Control Schematics, International Edition, 2015. 5. Electrical Machines, Drives and Power Systems by Theodore Wildi, 2010. 6. S. J. Chapman, Electric Machinery Fundamentals, 4th ed., McGraw-Hill, 2005.	
Course description	This course provides a comprehensive introduction to the fundamental principles and operating characteristics of electrical machines, with an emphasis on their role in electrical energy conversion, power systems, and industrial applications. It explores the key concepts and processes associated with electromagnetic energy conversion, magnetic circuits, transformers, and rotating electrical machines, providing students with a structured framework for understanding the operation and performance of electrical machines. The course combines theoretical concepts with systematic analysis and problem-solving methods, enabling students to examine electrical machines, develop quantitative reasoning skills, and apply fundamental principles to practical and real-world engineering applications. The main topics include magnetic circuits, transformers, DC machines, induction machines, synchronous machines, and the basic principles of electrical machine operation, characteristics, performance, and efficiency. Together, these topics provide a strong foundation for understanding electrical energy conversion and the practical application of electrical machines in power generation, transmission, distribution, and industrial systems.	
Course objectives	The main objective of this course is to provide undergraduate students in Electrical and Electronics Engineering with a strong foundation in the	

	fundamental principles, operation, analysis, and applications of electrical machines. The course aims to: • The main objective of this course is to provide undergraduate students in Electrical and Electronics Engineering with a strong foundation in the fundamental principles, operation, analysis, and applications of electrical machines. The course aims to: • Develop a clear understanding of the fundamental principles and laws of electrical engineering relevant to electrical machines and energy conversion. • Introduce the operating principles, constructional features, and characteristics of transformers, asynchronous (induction) machines, synchronous machines, and direct current machines. • Provide students with an understanding of the principles and applications of alternating and direct current micromachines, including rotating transformers. • Develop students' ability to calculate, analyze, and interpret the energy, electromagnetic, electromechanical, and operational characteristics of electrical machines and equipment. • Strengthen analytical and problem-solving skills through the systematic study and analysis of electrical machine operation and performance. • Develop professional knowledge and practical skills related to the selection, operation, and application of different types of electrical machines and equipment. • Provide students with the essential theoretical and analytical background necessary for further study and professional practice in electrical and electronics engineering.
Learning Outcomes	By the end of the course, students will be able to: • Describe the role, importance, and applications of electrical machines in electrical engineering and various fields of activity. • Explain the mathematical, physical, and electromagnetic principles underlying the operation of electrical machines. • Classify and explain the operating principles and constructional features of transformers, asynchronous (induction) machines, synchronous machines, and direct current machines. • Analyze the operation and performance of electrical machines using mathematical equations, equivalent circuits, substitution schemes, and vector diagrams. • Calculate and interpret the energy, electromagnetic, electromechanical, and operational characteristics of electrical machines under different operating conditions.

	• Connect and operate transformers, asynchronous and synchronous machines, and direct current machines, adjust their main parameters, and investigate different operating modes experimentally. • Calculate the main operating parameters of electrical machines and establish their mechanical, adjustment, and working characteristics. • Apply appropriate methods to calculate resistance forces, moments, and torque acting on the shaft of an electrical machine. • Develop and analyze mathematical and computer-based models of electrical machines using appropriate simulation and engineering software. • Apply theoretical knowledge and analytical methods to solve practical problems related to the operation, performance, and application of electrical machines. • Demonstrate an integrated understanding of the fundamental principles, construction, operation, analysis, and application of electrical machines through laboratory activities, problem-solving exercises, quizzes, midterm assessment, and final examination.		
Teaching methods	Case analysis		☒
	Group discussion		x
	Lecture		☒
	Simulation		x
Evaluation Criteria	Methods	Date/deadlines	Percentage (%)
	Midterm Exam	TBA	30
	Quizzes	2 quizzes during the semester	10
	Practical Assignments	5 lab works during the semester	15
	Activity	-	0
	Attendance	At each lesson	5
	Final Exam	TBA	40
	Total		100
Class Policy	Preparation for class The pedagogical structure of this course necessitates diligent individual study and external preparation. Course sessions are designed to emphasize the primary theoretical frameworks introduced in the text. Pre-class engagement with assigned chapters is essential to facilitate a comprehensive understanding of the material. Subsequent to each session, students should synthesize their notes and resolve pertinent problems, case studies, and sample examination questions located at the conclusion of each chapter. Withdrawal (pass/fail) This course strictly adheres to the grading ordinances of the School of Science and Engineering. Consequently, students are required to achieve a minimum threshold of 60% to secure a passing grade. In the event of an unsatisfactory result, the student will be mandated to repeat the course in the following academic term or year. Cheating/plagiarism		

Any instance of academic dishonesty or plagiarism during Quizzes, Midterms, or Final Examinations will result in the immediate nullification of the assessment. In such cases, the student will automatically be assigned a score of zero (0) without further consideration. Generative AI Policy The use of Generative Artificial Intelligence (GAI) tools is partially permitted in this course. Students may use GAI tools for learning purposes, such as obtaining explanations of course concepts, organizing information, generating practice questions, and supporting their understanding of the course material. GAI tools may not be used to complete or generate answers for quizzes, midterm examinations, final examinations, or other assessed work unless explicitly authorized by the instructor. Students are responsible for the accuracy of any information obtained through GAI tools and must ensure that their submitted work reflects their own understanding, analysis, and intellectual contribution. Any use of GAI in accordance with the permitted purposes should be appropriately acknowledged by the student. Professional behavior guidelines Students are expected to conduct themselves in a manner that fosters a constructive academic and professional environment during instructional hours. Unauthorized discourse and unethical behavior are strictly prohibited. Attendance Students who maintain full attendance for the duration of the course will be awarded 5 marks. Conversely, for every four absences recorded, the student will incur a deduction of 1 mark. Quizzes Two quizzes will be administered throughout the semester, with formal announcements made in class two weeks prior to each assessment date. The content of each quiz will be based on assigned homework problems, which are curated from the questions and problems at the end of each chapter. Practical Assignments Students will complete 5 practical assignments during the semester. Each assignment will be evaluated based on the quality of the work, accuracy of the results, and understanding of the practical concepts. Each assignment is worth 3 points, for a total of 15 points.			
Tentative Schedule			
Week	Date/Day (tentative)	Topics	Textbook/Assignments
1		Transformers, types and construction, ideal transformer, impedance transformation, real single-phase transformer, voltage ratio, magnetization current, current ratio, equivalent circuit. <i>Questions and Exercises</i>	[1], p. 48-157
2		Measuring equivalent circuit parameters: open-circuit and short-circuit tests, per-unit system, phasor diagram. Transformer efficiency, transformer taps and voltage regulation, autotransformer. <i>Questions and Exercises</i>	[1], p. 73-77

3	Three-phase transformers. Wye-wye, wye-delta, delta-wye, delta-delta connections. Inrush current, instrument transformers: potential and current transformers. <i>Questions and Exercises, Practical Assignment 1</i>	[1], p. 101-115
4	AC machinery fundamentals. Concept of rotating field, ac machine windings, magneto motor force distribution, induced torque, losses, power flow and efficiency. <i>Questions and Exercises</i>	[1], p. 273-283
5	Construction and general principles of synchronous machines. Equivalent circuit, phasor diagram, measuring machine model parameters. <i>Questions and Exercises, Practical Assignment 2</i>	[1], p. 444-464
6	Synchronous generator. Operation of a synchronous generator alone. Parallel operation with other synchronous generators. Conditions for paralleling synchronous generators. <i>Questions and Exercises</i>	[1], p. 545-549
7	Basic principles of synchronous motor operation. Steady-state of synchronous motor operation. Starting Synchronous motors. Ratings of Synchronous machines. <i>Questions and Exercises, Quiz 1</i>	[1] – p. 214-244 [3] – p. 237-262
	Midterm exam	
8	Induction motor construction and types, rotating magnetic field, speed of magnetic field rotation. Basic induction motor concepts, development of induced torque, the concept of rotor slip, electrical frequency on the rotor, equivalent circuit of an induction motor. <i>Questions and Exercises, Practical Assignment 3</i>	[1], p. 578-601
9	Power and torque in induction motors, losses, efficiency, power and torque in induction machines, torque-speed characteristics. Derivation of induced torque equation, maximum torque equation, determining equivalent circuit model parameters. <i>Questions and Exercises</i>	[1], p. 593-601
10	Variations in torque-speed characteristics, Control of motor characteristics by squirrel-cage rotor designs: deep-bar and double-cage, different types of design classes, starting induction motors: reduced voltage starting, delta-wye starting. <i>Questions and Exercises.</i>	[1], p. 601-688
11	Dc Machinery fundamentals. Single rotating loop, commutation, armature coils. <i>Questions and Exercises, Practical Assignment 4</i>	[1], p. 285-339
12	Dc motors and generators. Equivalent circuit of dc motors, magnetization curves. Separately-excited and shunt dc motors. Permanent magnet dc motors, series motors, compounded motors. <i>Questions and Exercises, Quiz 2</i>	[1], p. 339-430
13	Starting and breaking dc motors. Speed control methods for dc motors. circuits.	[1], p. 382-410

		<i>Questions and Exercises, Practical Assignment 5</i>	
14		Special electrical machines. Permanent magnet machines, single phase ac machines, step motors. <i>Questions and Exercises.</i>	[1], p. 426-430, 702-733
15		Industrial applications, operating characteristics, efficiency, losses, and methods for improving the performance of electrical machines. <i>Questions and Exercises.</i>	[2], p. 359–441 [3], p. 343–458
	TBC	Final exam	

