Identification	**Subject (code, title, credits)**	ETR 670, Microsystems and nanoelectronics 8 ECTS	
	Department	Physics and Electronics	
	Program (undergraduate, graduate)	Graduate	
	Term	Fall, 2023	
	Instructor	Ph.D. Shirkhan Humbatov	
	E-mail:	shirxanhumbatov@gmail.com	
	Phone:	+99477-631 32 83	
	Classroom/hours	11 Mehseti str. (Neftchilar campus)	
	Office hours	Monday: 11:50-15:10/ Thursday: 11:50-15:10	
Prerequisites	PHSC 111		
Language	English		
Compulsory/Elective	Compulsory		
Required textbooks andcourse materials	**1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al., Springer 2012** **2. 2. Nanoelectronics Fundamentals Materials, Devices and Systems by Hassan Raza, Springer 2019**		
Course outline	In this course, we discuss the atomic and the electronic structures of matter at the nanoscale, quantum transport theory and the nanoscale devices, where we solve the Schrödinger equation with open boundary conditions. We focus on memories, circuits and systems. Finally, deals with the experimental aspects of the nanoscale materials, devices and systems, where we discuss nanofabrication, microscopy, and spectroscopy.		
Course objectives	To understand the concepts of microsystems and nanoelectronics, students should have a basic knowledge of atomic physics and electricity and magnetism. By consolidating their knowledge of the band theory of solids and the properties of chemical bonding, students will gain a more comfortable understanding of the subject.		
Learning outcomes	Understanding topics related to microsystems and nanoelectronics. Apply the conceptual themes of nanotechnology. Understand methods for solving microsystems and nanoelectronics problems in related fields of Engineering. To analyze simple modern Electrical Circuits. Application of fundamental methods of Circuit theory. To apply gained knowledge into practical work in Engineering.		
Teaching methods	**Lecture**		+
	Group discussion		+
	Experiential exercise		+
	Case analysis		+
	Quiz, Classroom Exams		+
Evaluation	**Methods**	**Date/deadlines**	**Percentage (%)**
	Midterm Exam		30
	Class Participation	At each lesson	5
	Quizzes	During the semester, 4 time	20
	Activity	During the semester	10
	Final Exam		35
	Total		100

Policy	▪ **Preparation for class** The structure of this course makes your individual study and preparation outside the class extremely important. The lecture material will focus on the major points introduced in the text. Reading the assigned chapters and having some familiarity with them before class will greatly assist your understanding of the lecture. After the lecture, you should study your notes and work relevant problems and cases from the end of the chapter and sample exam questions. ▪ **Withdrawal (pass/fail)** This course strictly follows grading policy of the School of Science and Engineering. Thus, a student is normally expected to achieve a mark of at least 60% to pass. In case of failure, he/she will be required to repeat the course the following term or year. ▪ **Cheating/plagiarism** Cheating or other plagiarism during the Quizzes, Mid-term and Final Examinations will lead to paper cancellation. In this case, the student will automatically get zero (0), without any considerations. ▪ **Professional behavior guidelines** The students shall behave in the way to create favorable academic and professional environment during the class hours. Unauthorized discussions and unethical behavior are strictly prohibited. ▪ **Attendance** Students who attend the whole classes will get 5 marks. for three absence student loses 1 mark. ▪ **Activity** Students who will be active during discussion of past lessons and who will be solve homework problems in a seminar will be awarded with one activity mark.
Quizzes	▪ There will be 2 quizzes examination during the semester. The quizzes will be announced in the classroom two weeks before. Quiz is based on homework problems. The homework problems will be selected from questions and problems in the end of each chapter. The number of homework problems will be announced after finishing each chapter. ▪ The students who able to pass midterm and first quiz with max points automatically get max 10 point for the second quiz.

Tentative Schedule

Week	Date/Day (tentative)	Topics	Textbook
1	09.2023 09.2023	**Information Electronics in the Nanotechnology Era** - Nano-CMOS Technology - Non-CMOS Nanoelectronic Devices - Quantum Information Processing	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 1. 2. Handnotes given by teacher
2	09.2023 09.2023	**Material Issues for Microsystems** - Failure Mechanisms of Materials Used in Microsystems - Methods for Measuring Mechanical Properties of - Materials Used in Microsystems - Structure Materials for Microsystems	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 3. 2. Handnotes given by teacher
3.	10.2023 10.2023	**Electron Transport in Single Molecules and Nanostructures**	1. Fundamentals of Microsystem and

		- Electron Transport in Nanoscale Junctions - Conductance Measurement - Single Barrier Tunnel Junction and Resonant Tunneling - Double Barrier Tunnel Junction and Single Electron Phenomena	Nanotechnology by Zhaoying Zhou et al. Chapter 5. 2. Handnotes given by teacher
4.	10.2023 10.2023	**Introduction to MEMS** - What is MEMS - MEMS Technology - A Brief History of MEMS - Future of MEMS	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 6. 2. Handnotes given by teacher
5.	10.2023 10.2023	**Microelectromechanical Sensors** - Physical Sensors - Chemical Sensors - Biological Sensors - Resonant Mechanical Sensors - Silicon Based Electrostatic Field Sensors - MEMS Based Micro gas Sensor	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 7. 2. Handnotes given by teacher
6.	10.2023 10.2023	**MiddermExam** Problem solving	
7.	11.2023 11.2023	**MEMS Design** - MEMS Design Tools - Bulk-Micromachining Based MEMS Design - Surface-Micromachining Based MEMS Design - Future Trends and Summary	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 8. 2. Handnotes given by teacher
8.	11.2023 11.2023	**MEMS Processing and Fabrication Techniques and Technology—Silicon-Based Micromachining** - Surface Micromachining Technology - 3D Surface Maching - Bulk Micromachining - Sets of Bulk Micromaching Process	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 9. 2. Handnotes given by teacher
9.	11.2023 11.2023	**Nanoscale Fabrication** - Electron Beam Lithography - Ion Beam Lithography - Nanoimprint Lithography - Scanning Tunneling Microscopic Lithography - Atomic Force Microscopic Lithography	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 14. 2. Handnotes given by teacher
10.	11.2023 11.2023	**Quiz** Problem solving	
11	12.2023 12.2023	**Integrated Nanotechnology Based on MEMS** - Review of MEMS Fabrication Technologies - MEMS Techniques for Nanometric Fabrication - Potential and Capability of MEMS for the - Down-Scale Integration - Technical Trend from MEMS to NEMS - Integrated Nanomachining Technologies - Nanoelectromechanical Size-Effect	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 15. 2. Handnotes given by teacher

		- Typical MEMS-Made NEMS Devices - Prospect of NEMS Technology	
12.	12.2023 12.2023	**Applications of Microelectro-Mechanical Systems** - Brief History and Trends of Microelectro-Mechanical System - Application of MEMS - An Important Opening Application Field-Bio-Medical Applications	1. Fundamentals of Microsystem and Nanotechnology by Zhaoying Zhou et al. Chapter 16. 2. Handnotes given by teacher
13	12.2023 12.2023	**Charge Based Devices** - pn Junction Diode - Zener Diode - Field Effect Transistor - Resonant Tunneling Diode	1.Nanoelectronics Fundamentals Materials, Devices and Systems by Hassan Raza Chapter 5. 2. Handnotes given by teacher
14	12.2023 12.2023	**Spin Based Devices** - Ferromagnetic Materials - Giant Magnetoresistance Devices - Magnetic Tunnel Junction Devices - Spin Transfer Torque Devices	1.Nanoelectronics Fundamentals Materials, Devices and Systems by Hassan Raza Chapter 6. 2. Handnotes given by teacher
15	12.2023 12.2023	**Circuits and Systems** - CMOS Inverter - SRAM - DRAM - Flash Memory - Circuits and Systems - Combinational Circuits - Sequential Circuits - Charge Coupled Devices - Power Dissipation	1.Nanoelectronics Fundamentals Materials, Devices and Systems by Hassan Raza Chapter 7-8. 2. Handnotes given by teacher
		Final Exam	

This syllabus is a guide for the course and any modifications to it will be announced in advance.