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|  | | | | | | | **ECTS Course Description Form** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PART I ( Senate Approval)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Offering School** | **Engineering** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Offering Department** | **Electrical and Electronics Engineering** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Program(s) Offered to** | **Electrical and Electronics Engineering** | | | | | | | | | | | | | | | | **Elective** | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | |
|  | | | | | | | | | | | | | | | |  | | | | | | | | | | | | | | | | | | | | | |
| **Course Code** | EE 461 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Course Name** | Transduction Mechanisms in Microsystems | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Language of Instruction** | **English** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Type of Course** | *Course* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Level of Course** | **Undergraduate** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Hours per Week** | **Lecture: 3** | | | | | | | **Laboratory:** | | | | **Recitation:** | | **Practical:** | | | | | | | **Studio:** | | | | | | | | | **Other:** | | | | | | | | |
| **ECTS Credit** | **7** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Grading Mode** | **Letter Grade** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Pre-requisites** | EE 201, EE 211 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Co-requisites** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Registration Restriction** | *-* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Educational Objective** | The goal of this course is introduce the world of microelectromechanical devices and systems ("MEMS"). This requires an awareness of material properties, fabrication technologies, basic structural mechanics, sensing and actuation principles, circuit and system issues, packaging, calibration, and testing. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Course description** | Micro electro mechanical systems (MEMS), devices and technologies. Micro-machining and microfabrication techniques, including planar thin- film processing, silicon etching, wafer bonding, photolithography, deposition and etching. Transduction mechanisms and modeling in different energy domains. Analysis of micromachined capacitive, piezoelectric and thermal sensors/actuators and applications. Computer- aided design for MEMS layout, fabrication and analysis | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Learning Outcomes** | **LO1** | | | | | Understand the benefits and consequences of scaling. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LO2** | | | | | Understand properties and crystallography of Si | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LO3** | | | | | Understand bulk micromachining and the concept of lithography | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LO4** | | | | | Know the basic methods of surface micromachining. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **LO5** | | | | | Be familiar with the important concepts applicable to MEMS, their fabrication. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|  | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **PART II ( Faculty Board Approval)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Basic Outcomes (University-wide)** | | **No.** | | **Program Outcomes** | | | | | | | | | | | **LO1** | | | | **LO2** | | | | | **LO3** | | | | **LO4** | | | | | | **LO5** | | |  | |
| **PO1** | | **Ability** to communicate effectively and write and present a report in Turkish and English. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO2** | | **Ability** to work individually, and in intra-disciplinary and multi-disciplinary teams. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO3** | | **Recognition** of the need for life-long learning and **ability** to access information , follow developments in science and technology, and continually reinvent oneself. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO4** | | **Knowledge** of project management, risk management, innovation and change management, entrepreneurship, and sustainable development. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO5** | | **Awareness** of sectors and **ability** to prepare a business plan. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO6** | | **Understanding** of professional and ethical responsibility and **demonstrating** ethical behavior. | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **Faculty Specific Outcomes** | | **PO7** | | **Ability to develop, select and use modern techniques and tools necessary for engineering applications and ability to use information technologies effectively.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO8** | | **Recognition of the effects of engineering applications on health, environment and safety in the universal and societal dimensions and the problems of the time and awareness of the legal consequences of engineering solutions.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO9** | | **Ability to identify, define, formulate and solve complex engineering problems; and electing and applying appropriate analysis and modelling methods for this purpose.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **Discipline Specific Outcomes (program)** | | **PO10** | | **Gains comprehensive knowledge in mathematics, natural sciences, related engineering fields and general engineering subjects.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO11** | | **Able to identify complex engineering problems and solve them with appropriate methods of analysis.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO12** | | **Able to design a complex electronic system that meets the desired performance by using modern design techniques and taking real life conditions into account.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO13** | | **Able to develop new techniques and tools for solution of current engineering problems.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO14** | | **Able to use computer software and hardware technologies together with information technologies in an effective way.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO15** | | **Able to produce innovative solutions for solution of current engineering problems by gathering data through experiment design and interpretation of results.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO16** | | **Able to actively work individually or in teams where engineers from the same or different disciplines are involved.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO17** | | **Gains competency in effective written and verbal communication, presentation and preparation of technical reports in Turkish and English.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO18** | | **Constantly increases knowledge with the awareness of lifelong learning by closely following the developments in science and technology .** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO19** | | **Acts in accordance with scientific and ethical principles and the standards used in engineering practice at every stage of career** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO20** | | **Able to describe concepts related to business life such as project management, risk management, change management, entrepreneurship and sustainability.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO21** | | **Gains awareness of the legal consequences of engineering solutions developed together with the effect of engineering applications on health, environment and safety on a universal and social scale.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO22** | | **Able to solve problems involving probability and statistics, derivative and integral calculations, multivariable mathematics, linear algebra, differential equations, and complex variables, and their electrical and electronics applications.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO23** | | **Able to organize projects and events for the social environment they live in with the awareness of social responsibility and implement them.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
| **PO24** | | **Able to plan and direct activities for employees under their responsibility to develop within the framework of a project.** | | | | | | | | | | | 🗸 | | | 🗸 | | | | 🗸 | | | | 🗸 | | | | | | 🗸 | | | |  | | |
|  | |  | |  | | | | | | | | | | |  | | |  | | | |  | | | |  | | | | | |  | | | |  | | |
| **PART III ( Department Board Approval)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Course Subjects, Contribution of Course Subjects to Learning Outcomes, and Methods for Assessing Learning of Course Subjects** | | | **Subjects** | | **Week** | | | |  | | | | | | | **LO1** | | | | **LO2** | | | | | **LO3** | | | | **LO4** | | | | | | **LO5** | | |  | |
| **S1** | | 1 | | | | Silicon as MEMS material | | | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | |  | |
| **S2** | | 2 | | | | Basic processes: Photolithography | | | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | |  | |
| **S3** | | 3 | | | | Silicon doping and oxidation | | | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | |  | |
| **S4** | | 4 | | | | Deposition and etching | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S5** | | 5 | | | | wet etching, dry etching | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S6** | | 6 | | | | Surface micromachining | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S7** | | 7 | | | | Electrical analysis of comb drives | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S8** | | 8 | | | | Thermal actuator | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S9** | | 9 | | | | Electroplating | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S10** | | 10 | | | | Piezoelectric sensing and  actuation | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S11** | | 11 | | | | Thermoelectric sensing and actuation | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S12** | | 12 | | | | Computer- aided design | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S13** | | 13 | | | | Acoustic MEMS: Microphones | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **S14** | | 14 | | | | Project presentation | | | | | | | A1-A4-A6 | | | A1-A4-A6 | | | | A1-A4-A6 | | | | A1-A4-A6 | | | | | | A1-A4-A6 | | | |  | | |
| **Assessment Methods, Weight in Course Grade, Implementation and Make-Up Rules** | | | **No.** | | **Type** | | | | | | **Weight** | | **Implementation Rule** | | | | | | | **Make-Up Rule** | | | | | | | | | | | | | | | | | | | |
| **A1** | | **Exam** | | | | | | *30%* | | No electronic devices are allowed in the examinations except for calculators. | | | | | | | If the reason for not taking the exam is justified by the school, the student is informed about the time of the make-up exam. | | | | | | | | | | | | | | | | | | | |
| **A2** | | **Quiz** | | | | | |  | |  | | | | | | |  | | | | | | | | | | | | | | | | | | | |
| **A3** | | **Homework** | | | | | |  | |  | | | | | | |  | | | | | | | | | | | | | | | | | | | |
| **A4** | | **Project** | | | | | | *40%* | | Students in groups participate in a project throughout the term and present it during final examinations days. Project report is expected to be submitted no later than last day of final exam days. | | | | | | | If the reason for not completing the project in time is justified by the school, the student is informed about the extra time allowed to complete the project. | | | | | | | | | | | | | | | | | | | |
| **A5** | | **Report** | | | | | |  | | - | | | | | | | - | | | | | | | | | | | | | | | | | | | |
| **A6** | | **Presentation** | | | | | | *30%* | | Each student is individually expected to summarize and present 3 to 5 related journal papers assigned to him/her. | | | | | | | If the reason for not presenting the paper in time is justified by the school, the student is informed about the extra time for presentation. | | | | | | | | | | | | | | | | | | | |
| **A7** | | **Attendance/ Interaction** | | | | | |  | | - | | | | | | | - | | | | | | | | | | | | | | | | | | | |
| **A8** | | **Class/Lab./**  **Field Work** | | | | | |  | | - | | | | | | | - | | | | | | | | | | | | | | | | | | | |
| **A9** | | **Other** | | | | | |  | |  | | | | | | |  | | | | | | | | | | | | | | | | | | | |
| **TOTAL** | | | | | | | | **100%** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Evidence of Achievement of Learning Outcomes** | | | Letter grades determined by weighting on the specified percentages on the grades that are taken from exams, quizzes and homeworks by the students. The teaching staff can make changes in the student's grades. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Method for Determining Letter Grade** | | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Activities** | Midterm Exams | Quizzes | Presentation | Project | Final Exam | | **Quantity** | - | - | 3-5 | 1 | 1 | | **Effects on Grading, %)** | - | - | *30%* | *40%* | *30%* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Teaching Methods, Student Work Load** | | | **No** | | **Method** | | | | | **Explanation** | | | | | | | | | | | | | | | | | | | | | **Hours** | | | | | | | | |
| ***Time applied by instructor*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **1** | | **Lecture** | | | | | The textbook is explained on the blackboard or by a computerized presentation. Sample questions are solved | | | | | | | | | | | | | | | | | | | | | 3x14 | | | | | | | | |
| **2** | | **Interactive Lecture** | | | | |  | | | | | | | | | | | | | | | | | | | | | - | | | | | | | | |
| **3** | | **Recitation** | | | | | Sample questions are solved by writing on blackboard | | | | | | | | | | | | | | | | | | | | | - | | | | | | | | |
| **4** | | **Laboratory** | | | | | Experiments involving course subjects are conducted. | | | | | | | | | | | | | | | | | | | | | - | | | | | | | | |
| **5** | | **Practical** | | | | |  | | | | | | | | | | | | | | | | | | | | |  | | | | | | | | |
| **6** | | **Field Work** | | | | |  | | | | | | | | | | | | | | | | | | | | |  | | | | | | | | |
| ***Time expected to be allocated by student*** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **7** | | **Project** | | | | | The application of the problem as a project is made and reported. | | | | | | | | | | | | | | | | | | | | | *70* | | | | | | | | |
| **8** | | **Homework** | | | | | Laboratory experiments are reported. | | | | | | | | | | | | | | | | | | | | | *-* | | | | | | | | |
| **9** | | **Pre-class Learning of Course Material** | | | | | New topics are learned before they are processed from the class | | | | | | | | | | | | | | | | | | | | | *42* | | | | | | | | |
| **10** | | **Review of Course Material** | | | | | The subjects for the preparation of exams and homework are repeated. | | | | | | | | | | | | | | | | | | | | | *56* | | | | | | | | |
| **11** | | **Studio** | | | | |  | | | | | | | | | | | | | | | | | | | | | *-* | | | | | | | | |
| **12** | | **Office Hour** | | | | | One-to-one questions are asked to the lecturer or the lecturer. | | | | | | | | | | | | | | | | | | | | | *-* | | | | | | | | |
| **TOTAL** | | | | | | | *210* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **IV. PART** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Instructor** | | | **Name** | | | | | | | M. İlker Beyaz | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **E-mail** | | | | | | | mibeyaz@antalya.edu.tr | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Phone Number** | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Office Number** | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Office Hours** | | | | | | | It will be determined during the semester. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Course Materials** | | | **Mandatory** | | | | | | |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Recommended** | | | | | | | *MEMS and Microsystems (2nd edition) by Tai-Ran Hsu, 2008.* | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Other** | | | **Scholastic Honesty** | | | | | | | Violations of scholastic honesty include, but are not limited to cheating, plagiarizing, fabricating information or citations, facilitating acts of dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Any for of scholastic dishonesty is a serious academic violation and will result in a disciplinary action. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Students with disabilities** | | | | | | | Reasonable accommodations will be made for students with verifiable disabilities. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Safety Issues** | | | | | | | The course does not require any special safety precautions. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Flexibility** | | | | | | | Circumstances may arise during the course that prevents the instructor from fulfilling each and every component of this syllabus; therefore, the syllabus is subject to change.  Students will be notified prior to any changes. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |