| COURSE INFORMATON | | | | |
|---|---|---|---|---|
| **Course Code** | **EE 334** | **Course Title** | **Digital Electronic Circuits** | |
| *Semester* | *Credits* | *ECTS* | *C +P + L Hour* | Prerequisites |
| 5, 6 | 4 | 7 | 3+0+2 | EE 241 Digital Circuits |

| **Language of Instruction** | **Course Level** | **Course Type** |
|---|---|---|
| English | Undergraduate | Core |

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| **Course Coordinator** | Uğur Çilingiroğlu |
| **Instructors** | Uğur Çilingiroğlu |
| **Assistants** | Ertuğ Erem |
| **Goals** | Exposing all students to the technological foundations of contemporary digital integrated circuits and their design, and primes those students who prefer specializing later in microelectronics. |
| **Content** | Evolutionary path of microelectronics. Technology and devices: CMOS technology; layout; MOSFET modeling; device and interconnection capacitances. Inverter: Ideal inverter; CMOS inverter; binary operation and restoration; dynamic properties; power consumption; inverter design. Static CMOS gates: NAND; NOR; complex gates; layout techniques for static CMOS gates. Pass logic: Pass-logic synthesis; NMOS and PMOS pass logic. Sequential circuits in static CMOS: SR flip flop; latch and register; register timing; synchronization and pipelining with latches and registers. Dynamic logic: Dynamic storage; dynamic latch and register; quasi-static latch; two-phase nonoverlapping clocking; dynamic logic gates. Semiconductor memories: Classification; random-access architecture; mask-programmable ROM; static RAM; dynamic RAM. |
| **Contribution of the Course to the Professional Education** | Provides for fundamental competencies in the area of digital integrated circuit design |

| **Course Learning Outcomes** | **Detailed Program Outcomes** | **Teaching Methods** | **Assessment Methods** |
|---|---|---|---|
| Proper use of MOSFET device models in digital integrated-circuit analysis and design. | 2b | 1, 2, 3, 4, 7 | A, B, D |
| Performing computer-aided electrical simulation and physical design. | 3a, 3b, 4b, 5b | 1, 2, 3, 4, 7 | A, B, D |

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| Translating digital integrated-circuit performance specifications into design constraints. | 2a | 1, 2, 3, 4, 7 | A, B, D |
| Analyzing a conventional CMOS digital integrated circuit. | 2b | 1, 2, 3, 4, 7 | A, B, D |
| Recognition of conventional CMOS families of logic gates and memory devices. | 1a | 1, 2, 3, 4, 7 | A, B, D |

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| **Teaching Methods:** | 1: Lecture by instructor, 2: Lecture by instructor with class discussion, 3: Problem solving by instructor, 4: Use of simulations, 5: Problem solving assignment, 6: Reading assignment, 7: Laboratory work, 8: Term research paper, 9: Presentation by guest speaker, 10: Sample Project Review, 11: Interdisciplinary group working, 12: ... |
| **Assessment Methods:** | A: Written exam, B: Multiple-choice exam C: Take-home quiz, D: Experiment report, E: Homework, F: Project, G: Presentation by student, H: ... |

**COURSE CONTENT**

| Week | Topics | Study Materials |
|---|---|---|
| 1 | Introduction: Digital versus analog. Fundamental properties of digital circuits. Evolutionary dynamics of VLSI engineering. | |
| 2 | Technology and devices: CMOS technology. Layout design rules. MOSFET modeling for digital design. | |
| 3 | Technology and devices: MOSFET modeling for digital design. | |
| 4 | Technology and devices: Device and interconnection capacitances. Inverter: Ideal inverter. | |
| 5 | Inverter: CMOS inverter voltage-transfer characteristics. Binary operation and restoration. | |
| 6 | Inverter: Dynamic characteristics. Power dissipation. Inverter design. | |
| 7 | Static logic gates: NAND gate. NOR gate. Complex gates. | |
| 8 | Static logic gates: Complex gates. Layout techniques for static CMOS gates. Pass-logic gates: NMOS pass logic. | |
| 9 | Pass-logic gates: CMOS pass logic. | |
| 10 | Sequential Circuits in Static CMOS: SR flip flops. Clocked SR flip-flops. Latch. Register. | |
| 11 | Sequential Circuits in Static CMOS: Latch and register timing. Synchronization and pipelining. Dynamic logic: Dynamic storage. | |

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| 12 | Dynamic logic: Dynamic latches and registers. Pseudo-Static Latch and register. | |
| 13 | Dynamic logic: Dynamic logic gates. Semiconductor memories: Taxonomy. Random-access architecture. Mask-programmed ROM. | |
| 14 | Semiconductor memories: Static RAM. Dynamic RAM. | |

| RECOMMENDED SOURCES | |
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| **Textbook** | Lecture notes: Digital Integrated-Circuit Design by Uğur Çilingiroğlu (Distributed electronically). |
| **Additional Resources** | |

| MATERIAL SHARING | |
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| **Documents** | 'Ngspice' circuit analysis software. 'Electric' physical design software. Lecture notes. |
| **Assignments** | |
| **Exams** | Midterm exam papers and solutions. |

| ASSESSMENT | | |
|---|---|---|
| **IN-TERM STUDIES** | **NUMBER** | **PERCENTAGE** |
| Mid-term exams | 2 | 45/75 |
| Quiz | Variable | 10/75 |
| Laboratory | 12 sessions | 20/75 |
| **Total** | | **100** |
| **CONTRIBUTION OF FINAL EXAMINATION TO OVERALL GRADE** | | 25/100 |
| **CONTRIBUTION OF IN-TERM STUDIES TO OVERALL GRADE** | | 75/100 |
| **Total** | | **100** |

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| **COURSE CATEGORY** | Field Course |

**COURSE'S CONTRIBUTION TO PROGRAM OUTCOMES**

| No | Program Learning Outcomes | check √ |
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| 1a | Adequate knowledge in mathematics, science and engineering subjects pertaining to the relevant discipline, | ✓ |
| 1b | Ability to use theoretical and applied knowledge in these areas in complex engineering problems. | |
| 2a | Ability to identify, formulate, and solve complex engineering problems, | ✓ |
| 2b | Ability to select and apply proper analysis and modeling methods for this purpose. | ✓ |
| 3a | Ability to design a complex system, process, device or product under realistic constraints and conditions, in such a way as to meet the desired result, | ✓ |
| 3b | Ability to apply modern design methods for this purpose. | ✓ |
| 4a | Ability to devise, select and use modern techniques and tools needed for analyzing and solving complex problems encountered in engineering practice. | |
| 4b | Ability to employ information technologies effectively. | ✓ |
| 5a | Ability to design experiments for investigating complex engineering problems or discipline specific research questions, | |
| 5b | Ability to conduct experiments, gather data, analyze and interpret results for investigating complex engineering problems or discipline specific research questions. | ✓ |
| 6a | Ability to work efficiently in intra-disciplinary teams, | |
| 6b | Ability to work efficiently in multi-disciplinary teams, | |
| 6c | Ability to work individually. | |
| 7a | Ability to communicate effectively in Turkish, both orally and in writing, | |
| 7b | Knowledge of a minimum of one foreign language, | |
| 7c | Ability to write effective reports and comprehend written reports, prepare design and production reports, | |
| 7d | Ability to make effective presentations, | |
| 7e | Ability to give and receive clear and intelligible instructions. | |
| **8a** | Recognition of the need for lifelong learning, ability to access information, ability to follow developments in science and technology, | |
| **8b** | Ability to continue to educate him/herself. | |
| **9a** | Consciousness to behave according to ethical principles and professional and ethical responsibility. | |
| **9b** | Knowledge on standards used in engineering practice. | |
| **10a** | Knowledge about business life practices such as project management, risk management, change management. | |
| **10b** | Awareness in entrepreneurship and innovation. | |

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| **10c** | Knowledge about sustainable development. | |
| **11a** | Knowledge about the global and social effects of engineering practices on health, environment, and safety, | |
| **11b** | Knowledge about contemporary issues of the century reflected into the field of engineering. | |
| **11c** | Awareness of the legal consequences of engineering solutions. | |

| **ECTS ALLOCATED BASED ON STUDENT WORKLOAD BY THE COURSE DESCRIPTION** | | | |
|---|---|---|---|
| Activities | Quantity | Duration (Hour) | Total Workload (Hour) |
| Course Duration | 14 | 5 | 70 |
| Hours for off-the-classroom study (Pre-study, practice) | 14 | 7 | 98 |
| Mid-terms | 2 | 2 | 4 |
| Homework | | | |
| Final examination | 1 | 2 | 2 |
| **Total Work Load** | | | 174 |
| **Total Work Load / 25 (h)** | | | 6.96 |
| **ECTS Credit of the Course** | | | 7 |

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| Prepared by: Uğur Çilingiroğlu | Preparation date: September 2, 2019 |