HASAN KARACA

Address: 2601 SW Archer Rd, J-138, Gainesville, FL 32608 • Tel: +1 352 682 98 66 • E-mail: hasankaraca33@gmail.com • Birth Date-Place: 16/04/1991 – Silifke, Mersin, Turkey

PROFESSIONAL EXPERIENCE

08.2024 - now	University of Florida Electrical and Computer Engineering	J-1 Research Scholar

I have started as a J-1 Research Scholar in the Electrical and Computer Engineering Department at the University of Florida under the supervision of Prof. Philip Feng. My activities include design, modeling and testing of MEMS devices. I will be working with staff engineers and Ph.D. students on device fabrication and characterization. I will also be working with Prof. Feng to train students, develop concept papers, and develop research summaries, presentations, and manuscripts for journal/conference publications.

07.2021 - 07.2024		

Personal break due to some family issues

11.2017 - 07.2021	Vienna University of Technology (TU Wien), Institute of Solid State Electronics (FKE)	Project Assistant

I worked on the development of Silicon Controlled Rectifiers (SCRs) for ESD protection, produced by Nexperia Hamburg. My work was to simulate devices with Synopsys Sentaurus TCAD and measure/characterize test structures with TIM (Transient Interferometric Mapping), TLP (Transmission Line Pulser), EMMI (Emission Microscopy) and ESD/Surge-like sinusoidal pulses to contribute the design of ESD protection devices and circuits to meet design requirements, and to drive ESD/LUP related debug activities. I was under the supervision of Prof. Dionyz Pogany from Vienna University of Technology (TU Wien) and collaborated with Guido Notermans, Steffen Holland, Hans-Martin-Ritter and Vasantha Kumar from Nexperia Hamburg. I wrote my PhD thesis based on these researches. With one of the papers I wrote, I received the best student paper award in 41st Annual EOS/ESD Symposium (Riverside, CA, USA).

09.2015 - 02.2016	Nanotam (Bilkent University)	R&D Engineer

I worked on the modeling and simulation of GaN HEMT transistors with IC-CAP to be used in ADS in addition to modeling and simulation of GaN HEMT transistors by using Synopsys Sentaurus TCAD.

09.2014 - 10.2017	Bilkent University	Teaching Assistant

During my master's degree studies, I worked as a teaching assistant (TA) for the course of "EEE 202 Circuit Theory". My duties were participating in labs, proctoring exams, and reading assignments, quizzes and lab reports.

02.2014 - 06.2014	Aselsan Inc.	Part-Time Engineer

I did some Vhdl coding by using Xilinx Zinq.

07.2013 - 08.2013	Aselsan Inc.	Intern

By using MATLAB, I wrote a program that estimates the thickness of the ionosphere. It was necessary to find the place of a target by using radio frequencies reflecting from ionosphere.

06.2012 - 07.2012	Basari Technology	Intern

I worked on the design and production of a switch mode power supply (smps) used in electric meters.

ACADEMIC QUALIFICATIONS

08.2024 - now	University of Florida Electrical and Computer Engineering	Postdoctoral Researcher

I have started as a Postdoctoral researcher in the Electrical and Computer Engineering Department at the University of Florida under the supervision of Prof. Philip Feng.

07.2021 - 07.2024		

Personal break due to some family issues

11.2017 - 07.2021	Vienna University of Technology (TU Wien), Electrical Engineering	Ph.D. GPA: 3.46/4

Ph.D. dissertation: https://repositum.tuwien.at/handle/20.500.12708/18188

09.2014 - 10.2017	Bilkent University, Electrical and Electronics Engineering	M.Sc. GPA: 3.73/4

I designed a pressure sensor based on a CMUT (Capacitive Micromachined Ultrasonic Transducer) and a Colpitts oscillator. To achieve this, I first designed a Colpitts oscillator and a CMUT. Since the natural frequency of a CMUT depends on its geometry and the pressure of the air, I measured this frequency for a known geometry through the oscillator and calculated the pressure from this value. The Colpitts oscillator was designed in Cadence and the pressure calculations were done in MATLAB. To generate the DC bias from the oscillating signal for the CMUT, I also designed a three stage ring oscillator with voltage quadrupler (charge pump) circuit in Cadence.
M.Sc. thesis: https://repository.bilkent.edu.tr/items/4b006337-a64c-4687-b7d6-465ec16b6b47

09.2009 - 06.2014	Bilkent University, Electrical and Electronics Engineering	B.Sc. GPA: 3.72/4
09.2005 - 06.2009	Bolu Science High School	Top Scoring Student GPA: 95.13/100

PROFESSIONAL ABILITIES

- **Programming Languages:** Java, VHDL, Intel 8051 Assembly Language, MQL4
- **Packaged Software:** Synopsys Sentaurus TCAD, MATLAB, COMSOL, Lumerical FDTD, 5Spice and LTSpice Analysis, OrCAD, Proteus, IC-CAP, Cadence, Tanner L-Edit, and Office programs
- **Characterization:** Transmission Line Pulser (TLP), Transient Interferometric Mapping (TIM), Emission Microscopy (EMMI)

PROJECTS

- Development and investigation of sequential finger triggering and filamentary states in Silicon Controlled Rectifiers (SCRs) for ESD protection
  - Year: 2017-2021
  - Entity: It was a project I accomplished while I was working as project assistant at Vienna University of Technology (TU Wien). Based on the results of this project I wrote my Ph.D. dissertation. It was a joint project between Nexperia in Hamburg and Institute of Solid State Electronics (FKE), Vienna University of Technology (TU Wien).
  - Funding source: Nexperia in Hamburg and Vienna University of Technology (TU Wien)
- CMUT (Capacitive Micromachined Ultrasonic Transducer) and Colpitts Oscillator based Pressure Sensor Design with Cadence and MATLAB
  - Year: 2016-2017

    - Entity: It was a project on which I wrote my M.Sc. thesis. It was supported by Bilkent University.
    - Funding source: Bilkent University Graduate Scholarship
- Modeling and simulation of GaN HEMT transistor by using IC-CAP to be used in ADS
    - Year: 2016
    - Entity: It was a project I accomplished while I was working at Nanotam (Bilkent University).
    - Funding source: Nanotam (Bilkent University)
- Modeling and simulation of GaN HEMT transistor by using Synopsys Sentaurus TCAD
    - Year: 2015-2016
    - Entity: It was a project I accomplished while I was working at Nanotam (Bilkent University).
    - Funding source: Nanotam (Bilkent University)
- Developing a Ge and ZnS based CO/CO2 sensor by using Lumerical FDTD
    - Year: 2015
    - Entity: It was a project for the EEE 560 Nanoengineering and Nanodevices course that I attended during my master's degree studies at Bilkent University.
    - Funding source: Not available/ Bilkent University Graduate Scholarship
- The fabrication and characterization of Al-doped ZnO-based thin film photovoltaic solar cell. It is achieved by eight people as a course project.
    - Year: 2014
    - Entity: It was a project for the MSN 551 Introduction to Micro and Nanofabrication course that I attended during my master's degree studies at Bilkent University.
    - Funding source: Not available/ Bilkent University Graduate Scholarship
- Developing a thin film transistor by using COMSOL
    - Year: 2014
    - Entity: It was a project for the EEE 518 Principles of Electronic Devices course that I attended during my master's degree studies at Bilkent University.
    - Funding source: Not available/ Bilkent University Graduate Scholarship
- Voice over Laser Transmission System which transmits the speech by using laser light and PLL.
    - Year: 2014
    - Entity: It was a project for the EEE 492 Senior Project course that I attended during my bachelor's degree studies at Bilkent University.
    - Funding source: Not available/Bilkent University Merit Scholarship
- Establishment of a natural gas power plant in Turkish electricity network and its simulation.
    - Year: 2014
    - Entity: It was a project for the EEE 495 Electrical and Electronics Engineering Design II course that I attended during my bachelor's degree studies at Bilkent University.
    - Funding source: Not available/Bilkent University Merit Scholarship
- Developing Speech Recognition System with two people by using MATLAB and FPGA. It can recognize the numbers from zero to nine and show it on the seven segment display
    - Year: 2013
    - Entity: It was a project for the EEE 491 Electrical and Electronics Engineering Design I course that I attended during my bachelor's degree studies at Bilkent University.
    - Funding source: Not available/Bilkent University Merit Scholarship
- Measuring the temperature by using LM335 temperature sensor and 8051 microprocessor. Also showing the temperature on an LCD screen
    - Year: 2012
    - Entity: It was a project for the EEE 212 Microprocessors course that I attended during my bachelor's degree studies at Bilkent University.
    - Funding source: Not available/Bilkent University Merit Scholarship

- Measuring the temperature by using LM335 temperature sensor and Basys 2 FPGA Board. Also by using VHDL codes, showing the temperature on the computer screen
  - Year: 2011
  - Entity: It was a project for the EEE 102 Introduction to Digital Circuit Design course that I attended during my bachelor's degree studies at Bilkent University.
  - Funding source: Not available/Bilkent University Merit Scholarship
- Constructing and Testing of a Transceiver TRC-10 Operating in the 10 Meter Amateur Band
  - Year: 2011
  - Entity: It was a project for the EEE 211 Analog Electronics course that I attended during my bachelor's degree studies at Bilkent University.
  - Funding source: Not available/Bilkent University Merit Scholarship
- Developing a software called "Math Tool" with three people by using Java. It can make scientific calculations, plot graphs, convert units to each other and calculate monthly loan based on bank interest rate
  - Year: 2011
  - Entity: It was a project for the CS 102 Algorithms and Programming II course that I attended during my bachelor's degree studies at Bilkent University.
  - Funding source: Not available/Bilkent University Merit Scholarship

OTHER INFORMATION

Working Areas

- Device Characterization, development and improvement
- ESD protection devices

Awards

- (2020) Best Student Paper Award, 41st Annual EOS/ESD Symposium (Riverside, CA)
- (2014-2017) Bilkent University Graduate Scholarship
- (2009-2014) Bilkent University Merit Scholarship

Certificates and Documents

- (2015) Synopsys Sentaurus TCAD course certificate by Microelectronics Support Centre, Oxford, UK
- (2014, 2013, 2012, 2011) Bilkent University High Honor Student, Turkey
- (2008) OYAK National Math Olympics, first place as a team, Bolu, Turkey
- (2008) OYAK National Math Olympics, attending Turkey Championship, Turkey

Foreign Language

- Professional Proficiency in English
- Beginner in German
- Native speaker in Turkish

Social Profiles

- (LinkedIn) https://www.linkedin.com/in/hasan-karaca-11a95b69/
- (Google Scholar) https://scholar.google.com/citations?user=gCfaaQgAAAAJ&hl=en

References

- **(Ph.D. Supervisor)** Ao.Univ.Prof. Dipl.-Ing. Dr. Dionyz Pogany, Phone: +43(1)58801 36224, E-mail: dionyz.pogany@tuwien.ac.at
- **(Senior Principal Development Engineer at Nexperia Hamburg)** Dr. Steffen Holland, Phone: +49 (0)40 30708 1468, E-mail: steffen.holland@nexperia.com
- (**Development Engineer at Nexperia Hamburg**) Hans-Martin Ritter, Phone: +49 (0)40 30708 1468, E-mail: hans-martin.ritter@nexperia.com

- **(M.Sc. Supervisor)** Prof. Dr. Abdullah Atalar, Phone: +90 312 290 1213, E-mail: aatalar@bilkent.edu.tr

PUBLICATIONS

Journal Papers

- H. Karaca, S. Holland, H. -M. Ritter, V. Kumar, G. Notermans and D. Pogany, "3-D TCAD Methodology for Simulating Double-Hysteresis Filamentary I–V Behavior and Holding Current in ESD Protection SCRs," in *IEEE Transactions on Electron Devices*, vol. 68, no. 9, pp. 4214-4222, Sept. 2021, doi: 10.1109/TED.2021.3100301.
- H. Karaca *et al.*, "Simultaneous and Sequential Triggering in Multi-Finger Floating-Base SCRs Depending on TLP Pulse Rise Time," in *IEEE Transactions on Device and Materials Reliability*, vol. 20, no. 4, pp. 632-640, Dec. 2020, doi: 10.1109/TDMR.2020.3033618.
- N. Lambert, A. Taylor, P. Hubík, J. Bulíř, J. More-Chevalier, H. Karaca, C. Fleury, J. Voves, Z. Šobáň, D. Pogany, V. Mortet, Modeling current transport in boron-doped diamond at high electric fields including self-heating effect, Diamond and Related Materials, Volume 109, 2020, 108003, ISSN 0925-9635, https://doi.org/10.1016/j.diamond.2020.108003.

Conference Presentations

- Krainer, R., Jomar, H. E., Karaca, H., Pogany, D., Holland, S., Ritter, H.-M., & Kumar, V. (2023, May 11). *IV hysteresis in SCR due to interaction of bulk and surface current paths* [Conference Presentation]. International Electrostatic Discharge Workshop (IEW) 2023, Tutzing, Germany. http://hdl.handle.net/20.500.12708/177545
- Jomar, H. E., Karaca, H., Krainer, R., & Pogany, D. (2023, May 8). *Compact modeling of sequential finger triggering in multi-finger SCRs using RC coupling* [Poster Presentation]. International Electrostatic Discharge Workshop (IEW) 2023, Tutzing, Germany.
- Karaca, H., Fleury, C., Holland, S., Ritter, H.-M., Krainer, R., Kumar, V., Notermans, G., & Pogany, D. (2021). *Triggering of multi-finger and multi-segment SCRs near the holding voltage studied by emission microscopy under DC conditions*. International Electrostatic Discharge workshop (IEW), Villard de Lans, France, EU. http://hdl.handle.net/20.500.12708/91348
- Kumar, V., Karaca, H., Holland, S., Ritter, H.-M., & Pogany, D. (2021). *Influencing SCR Holding Current by Segmentation Topology*. International Electrostatic Discharge workshop (IEW), Villard de Lans, France, EU. http://hdl.handle.net/20.500.12708/91347
- Taylor, A., Lambert, N., Hubik, P., Bulir, J., Moris-Chevalier, J., Karaca, H., Fleury, C., Voves, J., Soban, Z., Pogany, D., & Mortet, V. (2019). *Experimental and modelled I-V characteristics of boron-doped diamond at high electric fields including self-heating effect*. MRS Fall Meeting, Boston, USA, Austria. http://hdl.handle.net/20.500.12708/91271
- Lambert, N., Taylor, A., Hubik, P., Bulir, J., More-Chevalier, J., Karaca, H., Fleury, C., Pogany, D., & Mortet, V. (2019). *Modelling I-V characteristics of boron-doped diamond at high electric field including self-heating effect*. 30th International Conference on diamond and carbon materials, Sevilla, EU. http://hdl.handle.net/20.500.12708/91209
- H. Karaca, C. Fleury, S. Holland, H. -M. Ritter, G. Notermans and D. Pogany, "Mechanism of Sequential Finger Triggering of Multi-Finger Floating-Base SCRs due to Inherent Substrate Currents," *2019 41st Annual EOS/ESD Symposium (EOS/ESD)*, Riverside, CA, USA, 2019, pp. 1-10, doi: 10.23919/EOS/ESD.2019.8869984.

COURSES TAKEN WITH THEIR OFFICIAL DESCRIPTIONS

Courses Taken during Ph.D. Studies

- **362.039 THz Electronics**
  Switching times below one picosecond or operating frequencies greater than one THz are the goals for new semiconductor components. THz is the frequency range that lies between the microwaves and the infrared. There are currently hardly any radiation sources or detectors for this area. Introduction to semiconductor

nanostructures. Calculation of the band structures, the sub-band energies. Detailed description of intersubband transitions. Representation of the possibilities for THz generation and detection based on intersubband transitions. Generation of an intersubband inversion. laser condition. THz quantum cascade lasers. Introducing the concept of a Bloch oscillator. Description of a possible THz oscillator based on the negative differential resistance of a resonant tunneling diode.

- **362.172 Emerging Devices in Power Applications**
  Based on some basic voltage converter circuits (PFC, buck, boost converter), the principles and criteria of the individual electronic components are derived. In particular, based on this, the conceptual ideas and technological challenges of modern power transistors based on Si, SiC and GaN are discussed. In the last part of the VU, modern development methods as they are standard in the industrial sector today are to be discussed and applied.

- **360.231 Emerging memory and logic elements**
  The students get an insight into modern high-performance MOSFETs for ultra-integration. Particular emphasis is placed on the theory and technology of current CMOS transistors: 3D Tri-gate, SOI, Fin and nanowire FETs, single and double gate components, junction-free MOSFETs, FETs with germanium and III-V semiconductor high-mobility channels. Electron spin is treated as a possible alternative degree of freedom for the processing and non-volatile storage of information. Particular emphasis is placed on the underlying physics of how spin FETs, spin MOSFETs and other spin transistors work. Silicon is treated as a way of reducing spin relaxation. Spin is also used to develop new storage media. In modern magnetic tunnel junctions, it is possible to switch the direction of magnetization very quickly using purely electrical signals. This makes spin-transfer torque magnetic memory a perfect candidate to replace CMOS static and dynamic memory. A major benefit of the new memory is that, unlike CMOS DRAM, it doesn't need to be refreshed. Like other types of resistive non-volatile memory, magnetic memory retains state even when the device is powered off. New theories about spin communication, spin Hall effect, anti-ferromagnetic materials and topological insulators for spintronic applications, approaches for universal memory and optoelectronic devices are described.

- **360.241 Introduction to Semiconductor Physics and Devices**
  This course looks at how the quantum mechanics of solids and charge was used to create the digital age. In particular, the physics of semiconductors and semiconductor systems and their function in modern technology will be the subject of the course. In addition, a foundation for further discussions about computer-aided technology and simulation as a driving force for groundbreaking developments in the field of digitization should also be created.

- **362.145 Heterostructures for nanoelectronics and photonics**
  Introduction to the physics of different deposition techniques for the production of monocrystalline films: explanation and comparison of industrially used production techniques and characterization techniques for the production of epitaxial layers (dielectrics, semiconductors, metals/superconductors): description of different growth processes (MBE, MO-MBE, ALE, CVD, MO- CVD, Laser-CVD, PA-CVD, LPE, etc.) and the necessary equipment (vacuum technology, material sources, substrate pre-treatment, etc.): doping methods, "in situ" and "ex situ" analysis methods (composition, purity, structural analysis, charge carriers). , optical and electrical properties): Production methods of one-dimensional structures by different growth techniques (quantum wires by overgrowth etc.):Discussion of possible application of the latest material systems.

- **354.058 RF Techniques**
  RF-Signals propagating along transmission lines; Scattering parameters; Linear two-ports; Nonlinearity and intermodulation; Transceiver; Nonlinear RF-Circuits, mixers, frequency conversion; Analog modulation formats; Digital RF-modulation formats and their spectra; RF-transmitters

- **362.100 Testing of semiconductor devices and ICs**
  In the first part of lecture, the basics about different modes of IC and device failure will be presented. Then methods for physical failure localization and identification are introduced. The general overview includes scanning probe techniques (Atomic Force Microscopy based methods, scanning capacitance profiling, Kelvin probe microscopy,..), FIB (focus ion beam), electron beam testing, liquid crystal thermal mapping,... The focus of the lecture will be given on non-destructive optical methods. Methods for non-contact analysis of voltage and self-heating effect (the main failure cause of power devices) will be presented. These methods includes emission microscopy, micro-Raman imaging, scanning pholuminescence, optical beam

induced voltage or current mapping,... Methods based on probing refractive index or absorption changes with temperature and free carrier concentration, including nanosecond transient interferometric mapping (TIM) method developed at FKE TUW, will be presented in details. Different examples of device/circuit testing relevant for industry will be discussed (fault localization, microprocessor debugging, thermal mapping during electrostatic discharge event).

Courses Taken during Master's Degree Studies

- **EEE 518 Principles of Electronic Devices**
  Crystal structure and growth techniques. Foundations of modern electronic. Energy bands in solids. Tunneling. Carrier concentrations and transport properties in semiconductors. Equilibrium states of PN junctions. Transient analysis of PN junction diodes. SS, MS, SIS junction characteristics and principles of special purpose diodes. BJT equilibrium states and Ebers-Moll static model. Secondary effects and transient states in BJT's. Small signal model. JFET characteristics and equilibrium states Principles of metal-insulator-semiconductor transistors and dc characteristics.

- **EEE 528 Optics**
  Geometrical, scalar wave and electromagnetic wave theories of light. Gaussian beam propagation. Signals and systems concepts for analyzing optical systems (Fourier optics). Interference, diffraction, imaging, frequency domain filtering, and holography. Polarization, propagation in anisotropic media, optical waveguides, fibers, resonators, and their applications. Temporal and spatial coherence. recent topics and developments in optics.

- **EEE 549 Nanoscale Fabrication Technologies for Semiconductors**
  Nanoscale fabrication methods used for semiconductor devices and VLSI technology. Revief of Semiconductor Technology, Review of Semiconductor Device Physics, Outline of a nanoscale CMOS fabrication process, Crystal Growth, Semiconductor Manufacturing, Cleanrooms and wafer cleaning, Nanolithography, Oxidation, Diffusion, Ion Implantation, Thin film deposition, Etching, and Backend technology.

- **EEE 591 Graduate Seminar I**
  Seminars on recent topics in electrical and electronics engineering.

- **MSN 551 Introduction to Micro and Nanofabrication**
  Introduction to conventional methods in macro and nanofabrication. Basics of flim deposition techniques, optical and electron beam lithography, wet and dry etching methods, implantation and diffusion. Applications of microfabrication to CMOS fabrication and micro and nanoelectromechanical systems. Some non-conventional methods of micro and nanostructure fabrication.

- **EEE 529 Photonics**
  Photon theory of light and interaction of light with matter. Spontaneous emission, absorption, and stimulated emission. Principles of lasers and laser amplifiers. Semi-conductor lasers, light emitting diodes, and light detectors. Electro-optics, acousto-optics, and their applications. Introduction to nonlinear optics. Recent topics in photonics.

- **EEE 550 Nanoelectronic Devices: Physics and Technology**
  Semiconductor electronics technology, overview of fabrication methods, physics of semiconductors in equilibrium and non-equilibrium, movement of free carriers in semiconductors, p-n and metal-semiconductor junctions, heterojunctions and quasi-electric fields, basic quantum mechanics for nanoscale semiconductor structures and quantum-effect devices, metal-oxide-semiconductor capacitor and MOS transistors, bipolar junction transistors, field effect transistors and nanowire FETs, high electron mobility transistors, resonant tunneling in semiconductor nanostructures, transistor scaling issues, ballistic transport and ballistic transistors, graphene transistors.

- **EEE 560 Nanoengineering and Nanodevices**
  Fundamentals and comparison of nanophotonics and nanoelectronics, with emphasis on applications in nanodevices based on quantum properties of light and matter interactions. Electrons and electromagnetic waves in complex structures, light propagation and reflection, tunnelling, light in disordered medium, simple periodic structures, photonic crystals, plasmonics, surface plasmons, localized plasmons, plasmonic

devices and sensors, optical transitions in quantum systems, elements of quantum mechanics, quantum confined structures, nanocrystals.

- **MSN 555 Nanomaterials Processing by Intense Laser Beam**
  Fundamentals of laser materials interactions, laser ablation and thin film deposition, processing with ultrashort laser pulses, creating nanostructures with lasers, laser micro and nano machining, laboratory training and hand-on experiments

- **EEE 599 Master's Thesis**
  A research-based thesis course on an individual project. Timely, relevant and substantial research on a topic in the general area of electrical and electronics engineering. Topic to be agreed in consultation with an M.S. Thesis advisor.

- **GE 590 Academic Practices**
  Preparation of graduate students for academic studies and research. Practical classroom teaching, practical lab assistance and teaching, practice in conducting exams and grading assignments.

Courses Taken during Bachelor's Degree Studies

- **EEE 495 Electrical and Electronics Engineering Design II**
  Senior design project involving design and implementation of a complete electrical and electronics engineering system. Major design experience which is based on integration of previously gained knowledge. Simulations. Prototype development and testing. Technical communications skills enrichment.

- **EEE 492 Senior Project**
  A technical project emphasizing engineering design principles on a specific topic in any field of electrical engineering to be carried out by the senior student under the supervision of a faculty member.

- **EEE 432 Telecommunications II**
  Review of digital modulation techniques. Linear modulation with memory. Channel coding. Carrier and symbol synchronization. Intersymbol interference and the Nyquist criterion. Channel equalization techniques. Multicarrier modulation. Wireless communications. Diversity and multi-antenna techniques.

- **PE 205 Orienteering**
  Student will develop the knowledge and competencies needed to be successful at the orienteering. Student will develop cognitive skills needed to navigate with map and compass. They will also learn and practice safety measures needed to participate in this course.

- **GE 301 Science Technology and Society**
  Introduction to science technology and society. History of technology. Technology and politics. Engineering, ethics and responsibility. Social studies and philosophical perspectives. Environmental issues. Health, medicine and technology. Technological controversies. Technology and democracy. Intellectual property and emerging developments. Technology, innovation and responsibility. Special topics.

- **EEE 491 Electrical and Electronics Engineering Design I**
  Senior design project involving design and implementation of a complete electrical and electronics engineering system. Development involving multiple areas of electrical and electronics engineering. Simulations. Prototype development and testing. Technical communications and teamwork skills enrichment.

- **EEE 451 Microwave Engineering**
  Transmission lines and waveguides. Circuit theory for waveguiding systems, scattering matrix formulation. Excitation of waveguides. Impedance transformation and matching. Smith chart. Passive microwave devices.

- **EEE 431 Telecommunications I**
  Measure of information, entropy, source coding, rate distortion. Sampling theorem, waveform coding. AM, FM signals. Signal representation. Noise processes, white noise and Gaussian processes. Digital modulation/demodulation, receiver design, matched filter. Performance analysis of digital modulation schemes. Channel coding, linear block codes, convolutional codes. Noise figure, link budget analysis.

- **EEE 424 Digital Signal Processing**
  Discrete signals and systems, discrete-time Fourier transform, z-transform. Digital processing of analog signals, sampling, and interpolation. Vector spaces and linear transforms, signal space. Discrete Fourier Transform, its computation, and applications. FIR and IIR filter design. Wavelet transform. Short-time Fourier transform. Sampling rate change by digital processing. Random signals. Quantization. Introduction to signal restoration.

- **EEE 399 Summer Training II**
  A minimum of four weeks summer practice in a company working on fundamental areas of electrical and electronics engineering; observation of company in its original settings and working on projects relevant to the company; submission of a written report.

- **MBG 110 Introduction to Modern Biology**
  This course introduces students to important topics of biology such as molecules of life, organization of the cell, chromosomes and cell division, genetics, molecular genetics, recombinant DNA technology, genetic diseases, evolution, animal development, biotechnology and recent scientific advancements.

- **MATH 255 Probability and Statistics**
  Basic concepts of probability, expectation and variance, distribution functions, Bayes' formula, marginal and conditional distributions, the distributions of sample statistics, law of large numbers, central limit theorem, introduction to hypothesis testing.

- **GE 304 Technology Society and Professional Development Seminar**
  Seminar course featuring guest speakers from industry, business, government, or non-governmental organizations, as well as academicians. The seminars either contribute to students' professional or career development or perspectives; discuss current issues, trends, or challenges in technology; or are related to the social, political, cultural, ethical, legal, economic, environment and sustainability, health and safety, reliability or similar dimensions of technology and engineering.

- **EEE 352 Applied Electromagnetics**
  Review of static electric and magnetic fields. Dielectric and magnetic materials. Electrostatic and magnetostatic energy and forces. Magnetic circuits, transformers and electromagnetic energy conversion. Basic of electric machinery. Review of Maxwell's equations and plane waves. Reflection and transmission of plane waves at plane boundaries. Transmission lines, Smith chart and impedance matching. Waveguides and cavity resonators. Electromagnetic radiation and antennas. Antenna arrays, effective aperture, Friis transmission formula and radar equation.

- **EEE 342 Feedback Control Systems**
  Use of Feedback: open loop and closed loop control systems. Mathematical Models of Dynamical Systems: State equations, transfer functions. Block diagram manipulations. Bounded Input Bounded Output Stability, Routh-Hurwitz and Nyquist stability test. Relative stability and stability margins. Bode plots. The Root locus method. Design of Feedback controllers. Sensitivity and robustness.

- **EEE 351 Engineering Electromagnetics**
  Review of vector analysis. Static electric fields, electric potential, boundary conditions and capacitances. Steady electric currents. Static magnetic fields, vector magnetic potential, boundary conditions and inductances. Faraday's law of electromagnetic induction. Maxwell's equations. Time-harmonic fields. Plane electromagnetic power and Pointing vector. Reflection of plane waves from plane boundaries.

- **EEE 321 Signals and Systems**
  Basic discrete and continuous signals and systems, linear time-invariant systems, Fourier analysis for continuous and discrete signals and systems, filtering, sampling of continuous time signals, FIR and IIR filters, z-transform, elementary modulation techniques.

- **EEE 313 Electronic Circuit Design**
  Diode circuits. Transistors and biasing. Basic transistor amplifiers. Frequency response. Transistor current sources. Differential amplifiers. Multistage amplifiers. Digital circuits and logic gates.

- **EEE 299 Summer Training I**
  A minimum of four weeks summer practice in a company working on fundamental areas of electrical and electronics engineering; observation of company in its original settings and working on projects relevant to the company; submission of a written report.

- **CHEM 201 Materials Science and Technology**
  Selected characteristics of materials. Mechanical, thermal, electrical properties. Atomic structure and chemical bonding. Structure of solids. Crystals, noncrystals. Metals, semiconductors. Alloys, polymers, polymeric properties. Ceramics. Electromagnetic and mechanical behavior of ceramics. Multiphase equilibria. Mechanical and physical properties of multiphase materials. Thermal processing. Corrosion of metals.

- **MATH 242 Engineering Mathematics II**
  Differential equations of first order, separable equations. Linear differential equations of higher order, homogeneous and nonhomogeneous equations. Numerical solutions of differential equations. Runge-Kutta method, boundary-value problems. Differential calculus of functions of several variables, Taylor series approximation. Jacobians, maxima and minima of a function, Method of Lagrange multipliers. Functions of a complex variable, differential complex calculus. Complex integration, Cauchy's theorem. Complex series, Taylor and Laurent series. Residue theorem.

- **HUM 112 Cultures Civilizations and Ideas II**
  The second half of the year-long course ``Cultures, Civilizations and Ideas'', continues the study of culture through examination of texts through the periods of the Late Middle Ages, the Renaissance, Enlightenment, and up to modern times. The course focuses on several themes, most importantly, the concepts of Modernity and Knowledge, Individualism, Cross-Cultural Contact, Social Order and Disorder. As in HUM 111, close reading and discussion of primary texts is the vehicle for the course. Grading is based on a course project, a mid-term examination or term-paper, comprehensive final examination, reading quizzes and class participation. Required authors include, among others: Machiavelli, Shakespeare, Descartes, Rousseau, Hegel, Marx, Kafka.

- **EEE 212 Microprocessors**
  Introduction to microprocessors and microcontrollers. 8051 microcontroller. 8051 Assembly Language. Input/output interfacing. Timers. Serial Port. Interrupt programming. External Memory Interfacing.

- **EEE 202 Circuit Theory**
  Resistive circuits. Matrix formulation of KCL, KVL. Two ports, circuit theorems, Thevenin and Norton equivalent circuits, superposition. Simple nonlinear circuits. Operational amplifiers. 1st and 2nd order circuits. General circuit analysis. Sinusoidal steady state. Application of Laplace transform to circuits.

- **MATH 241 Engineering Mathematics I**
  Introduction to complex algebra. Systems of linear equations, Gaussian elimination. Vector spaces and their extension to complex case, linear dependence/independence, bases. Matrix algebra, determinant, inverse, factorization. Eigenvalue problem, diagonalization, quadratic forms. Linear approximation, curve fitting. Linear constant coefficient difference equations and the z-transform. Linear constant coefficient differential equations and the Laplace transform. System of linear differential equations.

- **HUM 111 Cultures Civilizations and Ideas I**
  This half of the year-long course ``Cultures, Civilizations, and Ideas'' introduces students to the study of culture and civilization through close reading of primary texts in the ancient traditions of the Near East and the Mediterranean. It also introduces students to more modern critical readings and discussion of the value and weight of this tradition. The course aims to provide students with an understanding of the ancient roots of literary craft and philosophical thought, and to enhance the student's ability in interpretative and critical reasoning. Successful completion of the course requires careful and timely reading of assigned texts, essay writing, and active participation in class discussion. Grading is based on a course project, a mid-term examination or term-paper, comprehensive final examination, reading quizzes and class participation. Required texts include: Epic of Gilgamesh; Freud: Civilization and Its Discontents; Homer: Iliad; Sophocles: Theban Plays; Plato: Republic; and a course reader of other shorter works and critical essays.

- **HIST 200 History of Turkey**
  This course focuses on aspects of Turkey's history with an emphasis on research. It is designed as an interactive course with the objective to investigate events, chronologically short historical periods, as well as historic representations.

- **GE 251 Collegiate Activities Program II**
  Second part of GE 250/251 sequence. Total points accumulated during GE 250 and GE 251 converted to letter grade.

- **EEE 211 Analog Electronics**
  Design of an HF radio transceiver using the following topics in the frequency range 100 Hz - 30 MHz: Block diagram concept, passive electronic components (R, L, C, diode, crystals, etc.) and integrated circuits, as active devices; filters, power supplies, audio amplifiers, speakers, microphones, radio amplifiers, oscillators, mixers, noise intermodulation, and antennas..

- **EEE 102 Introduction to Digital Circuit Design**
  Number systems and conversions, data representation, analysis and design of combinational logic circuits, Boolean algebra, logic gates, minimization techniques, HDL, sequential logic, flip-flops, registers, clocked circuits, clock generation, counters, shift registers, arithmetic circuits.

- **CS 102 Algorithms and Programming II**
  Enhanced Object-Oriented Programming with Java. Inheritance and polymorphism, abstract classes and interfaces, graphical-user-interfaces, exceptions. Abstract data structures: lists, stacks, queues and trees. Recursion. Files. Searching and sorting. Hashing. Time and space considerations. Students undertake a large design project involving teamwork, independent learning, writing and presenting of requirements, user-interface design, and project documentation.

- **PHYS 102 General Physics II**
  Charge and matter; electric field and Gauss' law; DC circuits; magnetic field; Ampere's law; Faraday's law; inductance; magnetic properties of matter; Maxwell's equations..

- **MATH 102 Calculus II**
  Sequences and series, power series, Taylor series. Functions of several variables: partial derivatives and gradient, free and constrained extrema, multiple integrals, Fubini's theorems. Line integrals, Green's theorem. Surface integrals, Divergence theorem, Stokes' theorem.

- **GE 250 Collegiate Activities Program I**
  Ground for students to engage in diversity, creativity and commitment outside coursework. Participation in various activities provided mainly by student clubs. Student activity in designing and shaping course as well as monitoring and grading performance. Grading based on points accumulated by participation to activities. Mandatory for four-year students and to be taken in third semester.

- **ENG 102 English and Composition II**
  The central basis of ENG 102 is to consolidate students' academic approach to thinking, reading, speaking and writing and language usage, as initiated in ENG 101. In addition, the ENG 102 course aims to develop the students' abilities to synthesize and evaluate information and conduct basic, independent research.

- **CS 101 Algorithms and Programming I**
  Basic computer literacy: terminology, system components and operation. Fundamentals of computer programming: top-down structured design, sequence, decision, repetition, syntax, compilation, debugging and maintenance, object-oriented programming with Java, objects classes, methods, parameters, arrays, layout and style. The emphasis is on an engineering "right-first-time" approach to solving large problems using computers.

- **PHYS 101 General Physics I**
  Standards and units; vectors and coordinate systems; kinematics; dynamics; work, energy and power; conservation of energy; dynamics of system of particles; collisions; rotational kinematics and dynamics; oscillations.

- **MATH 101 Calculus I**
  Limits and continuity. Differentiation and applications (linearization, optimization, curve sketching, l'Hôpital's rule). Integration and applications (areas, volumes, arc lengths, surface areas). Transcendental functions. Integration techniques. Improper integrals..

- **ENG 101 English and Composition I**
  ENG 101 English and Composition I The central basis of ENG 101 is to introduce students to an academic approach to thinking, reading, speaking and writing in an integrated, meaningful manner such that they are able to apply the skills learnt to their departmental studies. In addition, the ENG 101 course aims to further develop the students' linguistic accuracy and range in English.

- **GE 101 Engineering Orientation**
  This course is intended to coach first-year students to make a smooth transition from high school to Bilkent University and to give them an insight into engineering. Academic regulations, student ethics, general engineering, engineering careers, problem solving, critical thinking and communication skills as well as time management and goal setting will be covered. Seminars/presentations by faculty/alumni/guest speakers. Individual/group interviews with students.