University of Tehran

School of Electrical and Computer Engineering

Course:	**Transport Phenomena in Semiconductors**		
Course type:	Elective	EE	Credit: 3
Level:	Graduate		
Co-requisite(s):			
Prerequisite(s):	Physical Electronics, Quantum Mechanics, Solid State Physics		
Prerequisite by topic:	Being familiar with the concepts of solid state physics and semiconductor devices		
Textbook(s):	[1] M. Lundstrom, "*Fundamentals of Carrier Transport,*" Cambridge University Press; 2nd edition (2000). [2] C. Jacoboni, "*Theory of Electron Transport in Semiconductors,*" Springer, (2010). [3] S. Datta, "*Quantum Phenomena,*" (Modular Series on Solid State Devices, Vol 8), Addison-Wesley (1989). [4] K. Tomizawa, "*Numerical Simulation Of Submicron Semiconductor Devices,*" Artech House (1993).		
Coordinator:	Mahdi Pourfath		
Goals:	Introducing the students with the following topics: – Different scattering mechanisms in semiconductors – Evaluating scattering rates for 1D, 2D, and 3D structures – Semi-classical Boltzmann equation and its numerical solutions – Low field and high field transport – Transport in Mesoscopic systems and quantum transport		
Outcome:	Upon successful completion of the course, students will be able to: – Obtain a deeper insight into the operation of semiconductor devices – Evaluate scattering rates in 1D, 2D, and 3D structures and obtain the mobility and conductivity of such structures – Solve the Boltzmann equation using numerical methods, such as the method of moments, spherical harmonics, and Monte Carlo for analyzing semiconductor devices		

Topics:	**Review of Semiconductor Physics:** Electrons in periodic potential, electronic bandstructure, effective mass, density of states in 1D, 2D, and 3D structures, lattice vibrations and phonons **Carrier Scattering:** Fermi golden rule, perturbation potential, scattering with acoustic, optical, and polar optical phonons, interaction with ionized impurities and surface roughness, major sources of scattering in Si and GaAs **Boltzmann Equation:** Concepts of statistical mechanics, distribution function in equilibrium, Boltzmann equations, collision integral, analytical solution of the Boltzmann equation for some simple problems, Numerical solution of the Boltzmann equation **Low Field Transport:** Linear response theory, transport coefficients, Hall effect, thermoelectric effects, mobility at low fields **Method of Moments:** Balance equations, moments of the distribution function, Hydrodynamic model, Drift-Diffusion equation **Monte Carlo:** Statistical methods for solving differential equations, free flight time, selection of the scattering mechanism, single particle and ensemble particle Monte Carlo **High Field Transport:** Hot electrons, velocity saturation, energy relaxation time, high field transport in Si and GaAs **Advanced Topics:** semi-classical ballistic transport, transport in mesoscopic systems, quantum transport, transmission probability, scattering matrices, Landauer-Buttiker formula
Grading:	Assignments: 5% Projects: 15% Midterm exams: 40% Final exam: 40%
Further readings:	
Prepared by:	Mahdi Pourfath
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