University of Tehran
School of Electrical and Computer Engineering

Course:	**Quantum Transport**		
Course type:	Elective	EE	Credit: 3
Level:	Graduate		
Co-requisite(s):			
Prerequisite(s):	Quantum Mechanics		
Prerequisite by topic:	Being familiar with the concepts of quantum mechanics and the principles of semiconductors		
Textbook(s):	[1] S. Datta, "*Quantum Transport: From Atoms to Transistors,*" Cambridge University Press; (2005). [2] S. Datta, "*Electronic Transport in Mesoscopic Systems,*" Cambridge University Press; (1995). [3] S. Datta, "*Quantum Phenomena,*" (Modular Series on Solid State Devices, Vol 8), Addison-Wesley (1989).		
Coordinator:	Mahdi Pourfath		
Goals:	Introducing the students with the following topics: – Quantum effects in nanoelectronic devices – Modeling nanoelectronic devices – Including contacts and scattering mechanisms – Advanced numerical techniques for the analysis of nanoelectronic devices		
Outcome:	Upon successful completion of the course, students will be able to: – Deeply understand the principles of nanoelectronic devices – Model nanoelectronic devices – Apply advanced numerical techniques to analyze and perform optimization studies of nanoelectronic devices		
Topics:	**Review of Modern Physics:** Particle-wave like nature of electrons, Schroedinger equation, uncertainty principles, quantum many-body systems **Basis Functions and Band-Structure:** Electrons in periodic potential, Basis functions, Atomic orbitals as the basis function, tight-binding model, spin-orbit interaction and its effect on the electronic band structure, multi-orbital bandstructure model		

	The Effect of Electron-Electron Interaction on the Electronic Bandstructure: Density functional theory (DFT), exchange and correlation potential, LDA and GGA, parameters for ab-initio simulations **Subbands:** Quantum dots, nanowires, quantum wells, contact resistance, the resistance associated with scatters, velocity of a subband, density of states in 0D, 1D, 2D, and 3D **Level Broadening:** Open systems, uncertainty in energy and time, finite life time due to scattering and interaction with contacts, local density of states, modeling contacts **Coherent Transport:** Density matrix, Green's functions, inflow, outflow, transmission, spectral functions **Incoherent Transport:** Modeling scattering using self-energies, lattice vibrations and phonons, electron-phonon interaction, electron- photon interaction, self-consistent Born approximation **Device Simulation:** Numerical techniques and the flowcharts of evaluating the Green's functions for the analysis of nanoelectronic devices, Analysis of nanoscale device from macroscopic to atomistic scale
Grading:	Assignments: 5% Projects: 15% Midterm exams: 40% Final exam: 40%
Further readings:	
Prepared by:	Mahdi Pourfath
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