Syllabus – EE531, Spring 2017

- Semiconductor Fundamentals (6 hours)
  - Poisson and continuity equations
  - Recombination (direct, Auger, trap-assisted)
  - Equilibrium carrier concentrations (electron statistics, density of states, effective mass, bandgap narrowing)
  - Review of PN and MS diodes.
- Quantum Mechanics Fundamentals (4 hours)
  - Basic Quantum Mechanics
  - Crystal symmetry and band structure
  - 2D/1D density of states
  - Tunnelling
- Modeling and Simulation of Carrier Transport (6 hours)
  - Carrier Scattering (impurity, phonon, carrier-carrier, remote/interface)
  - Boltzmann Transport Equation, Monte Carlo
  - Hydrodynamic
  - Drift-diffusion
- MOS Capacitors (4 hours)
  - Modes of operation (accumulation, depletion, strong/weak inversion).
  - Capacitance versus voltage.
  - Gated diode.
  - Nonideal effects (poly depletion, surface charges).
  - High field effects (tunneling, breakdown).
- Long Channel MOSFET Devices (4 hours)
  - Review of operation.
  - I-V characteristics.
  - Subthreshold conduction.
  - Threshold voltage.
- Short Channel MOSFET Devices (6 hours)
  - Scaling effects (short channel, narrow channel effects, drain induced barrier lowering)
  - Channel velocity limitations (saturation velocity, interface scattering, mobility models).
  - Hot carrier effects (impact ionization, gate/substrate currents, threshold voltage degradation, velocity overshoot, ballistic effects)
  - Quantum mechanical effects
- CMOS Device Design (4 hours)
  - Scaling relationships.
  - Threshold voltage control.
  - On/Off currents.
  - Channel doping profiles
    - Implanted channel, buried channel, retrograde wells
    - S/D extension, HALO/LATID structures
  - Circuit and switching behavior
- Advanced Device Technology (4 hours)
  - SOI
  - SiGe, strained Si
  - Alternative oxide/gate materials
  - Alternative geometries (raised source/drain, dual gate, vertical, FinFET)
  - Tunnel FETs
  - Memory Devices (DRAM, Flash)