

ECE 300B: ECE Practice

Electrical & Computer Engineering Class of 2014 (Stream 8)

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Electrical & Computer Engineering
University of Waterloo
Waterloo, ON.

Technical electives

<http://ece.uwaterloo.ca/Undergrad/Academics/Program/TE/>

To graduate you must complete **five** Technical Electives (TEs).

- At least three must be approved ECE NNN courses.
- At most two may be 2nd- or 3rd-year courses (ECE 2NN and ECE 3NN) from an approved list.
- At most two may be taken from other departments (usually engineering) from an approved list.

Technical electives

<http://ece.uwaterloo.ca/Undergrad/Academics/Program/TE/>
Acceptable 2nd- or 3rd-year course TEs for EE students

- ECE 254 Operating Systems and Systems Programming (Fall, Spring)
- ECE 327 Digital Hardware Systems (Winter, Spring)
- ECE 351 Compilers (Winter, Spring)
- ECE 356 Database Systems (Fall, Winter)
- ECE 358 Computer Networks (Fall, Winter, Spring)

Technical electives

<http://ece.uwaterloo.ca/Undergrad/Academics/Program/TE/>
Acceptable 2nd- or 3rd-year course TEs for CE students

- ECE 331 Electronic Devices (Winter)
- ECE 361 Power Systems (Fall, Winter)
- ECE 375 Electromagnetic Fields and Waves (Winter, Spring)

Technical electives

<http://ece.uwaterloo.ca/Undergrad/Academics/Program/TE/>
Pre-approved, non-ECE, TEs include courses from

- Management science engineering
- Computer science
- Statistics
- Economics
- Mechanical engineering
- Software engineering
- Systems design engineering

Technical electives

<http://ece.uwaterloo.ca/Undergrad/Academics/Program/TE/>

If you would like to take a course and have it count as a TE but it does not appear on the approved list, you may request to have the course approved as a TE. Complete the **Elective Approval Form** and submit it to your Academic Advisor **before** you take the course.

A grain of salt

The specific information on courses in the following slides should be considered tentative due to the following.

- Course instructors can change.
- The course instructor has the leeway to modify the course and hence the amount of time spent on a given topic can change.
- Course project information is often based on previous instances of a course and are subject to change.
- Courses are subject to cancellation if enrollment is too low.
- Always check the ECE website for the most accurate and up-to-date information.

General ECE (00's)

These are topics that are not specific to any one sub-field of ECE. The courses cover topics that are generally applicable in ECE.

General ECE (00's)

ECE 406 : Algorithm design and analysis (4B, Winter 2014).

- Design and analysis of efficient algorithms (3hrs)
- Advanced data structures (3hrs)
- Divide and conquer algorithms (3hrs)
- Recurrences (3hrs)
- Greedy algorithms (3hrs)
- Dynamic programming (4hrs)
- Graph algorithms (3hrs)
- Search and backtrack (3hrs)
- Inherently hard and unsolvable problems (4hrs)
- Approximation and randomized algorithms (4hrs)
- Amortized analysis (3hrs)

Instructor : S. Smith

Lab, project: ???

Pre-req : 4A ECE student.

General ECE (00's)

ECE 409 : Cryptography and system security (4B, Winter 2014).

- Introduction to Cryptology (4hrs)
- Theory of Secure Communications (4hrs)
- Networks and Systems (3hrs)
- Conventional Cryptographic Systems (6hrs)
- Introduction to Public Key Cryptographic Systems (4hrs)
- Implementing Secure Systems (5hrs)
- Internet Standards and Wireless System Security (5hrs)
- Firewalls (3hrs)
- Applications (2hrs)

Instructor : G. Agnew

Lab, project: ???

Pre-req : ECE 358.

Communications (10's)

Communication and information systems deals with the transfer of information from one point to one or more points. Points may be stationary or mobile. The information may be acoustic sounds, photographs, digital-video streams, data files, etc.

Communications (10's)

ECE 411 : Digital communications (4A, Spring 2013).

- Review random-process models of digital signals and noise (3hrs)
- Baseband transmission (8hrs)
- Signal representations (7hrs)
- Digital modulation (10hrs)
- Spread-spectrum communication (6hrs)

Instructor : M. Damen

Lab, project: Two MATLAB based individual projects.

Pre-req : 4A ECE student.

Communications (10's)

ECE 413 : Digital signal processing (4A, Spring 2013).

- Discrete-Time Signals and Systems (4hrs)
- The z-Transform (2hrs)
- Sampling of Continuous-Time Signals (3hrs)
- Transform Analysis of Linear Time-Invariant Systems (3hrs)
- Structures for Discrete-Time Systems (3hrs)
- The Discrete Fourier Transform (4hrs)
- Computation of the Discrete Fourier Transform (2hrs)
- Fourier Analysis of Signals Using the Discrete Fourier Transform (3hrs)
- Discrete Hilbert Transforms (3hrs)
- Filter Design Techniques: FIR filters (4hrs)
- Filter Design Techniques: IIR filters (2hrs)
- Introduction to Filter Banks (3hrs)

Instructor : J. Thistle

Lab, project: MATLAB based

Pre-req : 4A ECE student.

Communications (10's)

ECE 414 : Wireless communications (4B, Winter 2014).

- Overview of wireless communications (2hrs)
- Characterization of the wireless channel (10hrs)
- Bandpass transmission over the wireless channel (8hrs)
- Receiver techniques (8hrs)
- Fundamentals of cellular communications and multiple-access schemes (6hrs)
- Mobility and resource management of wireless systems (2hrs)

Instructor : P. Mitran

Lab, project: ???

Pre-req : ECE 411.

Communications (10's)

ECE 415 : Multimedia communications (4B, Winter 2014).

- Overview of multimedia communications system and requirements (3hrs)
- Fundamentals of lossless source coding (10hrs)
- Introduction to lossy source coding (4hrs)
- Image and video coding (12hrs)
- Transmission and recovery (7hrs)

Instructor : E-H. Yang

Lab, project: C, C++ based

Pre-req : 4A ECE student.

Communications (10's)

ECE 416 : Higher level network protocols (4B, Winter 2014).

- Introduction and review of ECE 358 (2hrs)
- Introduction to wide-area wireless networks (4hrs)
- Advanced features of network layer: Address look-up algorithms, Internet Control Message Protocol, Internet Group Management Protocol (4hrs)
- Routing and transport support for heterogeneous networks (MPLS, Mobile IP, IPv6, mobile TCP, hand-off) (6hrs)
- Network management (SNMP) (2hrs)
- Applications and web services (DNS, SMTP, POP, IMAP, HTTP) (5hrs)
- Protocols for multimedia support (RTP, RTCP, SIP and Voice over IP) (6hrs)
- Emerging network protocols (sensor, ad hoc, peer-to-peer, and vehicular) (6hrs)

Instructor : K. Naik

Lab, project: biweekly three hour projects

Pre-req : ECE 358, ECE 418.

Communications (10's)

ECE 417 : Image processing (4B, Winter 2014).

- Image fundamentals (2hrs)
- Intensity Transformations for Image Enhancement (3hrs)
- Spatial Domain Linear Filtering (4hrs)
- 2D Discrete Fourier Transform and Frequency Domain Filtering (6hrs)
- Non-linear Image Filtering (4hrs)
- Binary Image Processing (4hrs)
- Edge Detection (4hrs)
- Image Segmentation (4hrs)
- Digital Video Processing (5hrs)

Instructor : Z. Wang

Lab, project: Students will learn to use Matlab for reading/writing/processing images and work on image processing projects.

Pre-req : 4A ECE student.

Communications (10's)

ECE 418 : Communications networks (4A, Spring 2013).

- Introduction to communications networks (2hrs)
- Network architecture (2hrs)
- Probabilistic description of network. Queuing analysis (6hrs)
- Packet transmission and error control (4hrs)
- Dynamic routing (2hrs)
- Media access control (6hrs)
- Connection admission and congestion control (6hrs)
- Design tradeoffs and performance evaluation (4hrs)
- Application examples (3hrs)

Instructor : G. Gong

Lab, project: ???

Pre-req : ECE 358.

Communications (10's)

ECE 419 : Communication system security (4A, Spring 2013).

- Introduction to basics of security (8hrs)
- Network domain security (6hrs)
- Access authentication protocols and infrastructure (6hrs)
- Trusted platform (5hrs)
- Broadcast and multicast security (5hrs)
- Security for mobility and radio signals (6hrs)

Instructor : G. Gong

Lab, project: Java to implement public-key certificate generation or call the function in the SSL (secure socket layer) library to generate public-key certificate.

Pre-req : 4A ECE student.

Computer hardware (20's)

Digital hardware spans software and VSLI.

VLSI advances provided exponential increases in performance. Analog effects are now visible in the digital domain

- Power
- Wire delays
- Cross talk

How can we do **analog-aware** digital design?

Increases in transistor counts allow more parallelism in hardware. Exposing this concurrency to software allows software to improve performance at the cost of increased complexity.

What is the right hardware/software interface?

Combinations of configurable and fixed hardware on a single chip blurs the distinction between hardware and software. How do we design and validate these complex systems?

Computer hardware (20's)

ECE 429 : Computer architecture (4A, Spring 2013).

- Computer system performance metrics (1hr)
- Pipelining (6hrs)
- Floating Point Pipelining and scheduling (5hrs)
- Memory Hierarchy (7hrs)
- I/O Performance (2hrs)
- Multiprocessors (11hrs)
- Case Studies (3hrs)

Instructor : H.D. Patel

Lab, project: ???

Pre-req : One of CS 354, ECE 254, ECE 354, EC 450. 4A ECE student.

Computer hardware (20's)

ECE 423 : Embedded computer systems (4B, Winter 2014).

- Embedded Computing (3hrs)
- System specification and Modeling (6hrs)
- CPUs (6hrs)
- Programs (6hrs)
- Multiprocessor Software (6hrs)
- Hardware/Software Co-Design (9hrs)

Instructor : R. Pellizzoni

Lab, project: Design a small embedded system based on FPGA H/W.

Pre-req : ECE 254, ECE 354, ECE 327; 4A ECE Student.

Devices & integrated circuits (30's)

ECE 432 : Radio Frequency Wireless Microelectronics, Optoelectronic Semiconductor Integrated Circuits & Sensors (4A, Spring 2013).

- Basic RF and optical device and equivalent circuit physics (4hrs)
- RF integrated circuit passives (4hrs)
- RF diodes (4hrs)
- Bipolar transistors and heterojunction bipolar transistors (HBT's) (4hrs)
- RF MOSFETs (4hrs)
- Optical devices (4hrs)
- RF circuits (4hrs)
- Optical device systems (4hrs)
- Design examples (4hrs)

Instructor : C.R. Selvakumar

Lab, project: Semiconductor device simulation (Medici), Circuit Simulation (Cadence, Spice), Matlab, RF simulation (RF Spectre).

Pre-req : ECE 209, ECE 331; 4A ECE student.

Devices & integrated circuits (30's)

ECE 433 : Semiconductor device technology (4B, Winter 2014).

- Introduction to thin film technology (3hrs)
- Physical Vapor Deposition (Evaporation) (3hrs)
- Physical Vapor Deposition (Sputtering) (3hrs)
- Deposition Physics (3hrs)
- Chemical Vapor Deposition (4hrs)
- Reactive Ion Etching (2hrs)
- Design and modeling of thin film amorphous silicon electronics (3hrs)
- Design and modeling of thin film polycrystalline silicon electronics (3hrs)
- Transparent electronics and silicon nanoelectronics (3hrs)
- Thin film electronics used in active matrix display and imaging applications (5hrs)
- Organic electronics (4hrs)

Instructor : C.R. Selvakumar

Lab, project: Simulations using Sentaurus and Medici software from Cadence.

Pre-req: ECE 209, ECE 331; 4A ECE student.

Circuits (40's)

ECE 445 : Integrated digital electronics (4A, Spring 2013).

- MOS Transistor - Review (3hrs)
- CMOS Inverter (5hrs)
- CMOS Combinational Circuits (6hrs)
- CMOS Sequential Circuit (6hrs)
- CMOS Arithmetic Circuits (8hrs)
- Interconnect Parasitics (4hrs)
- Timing Issues in Digital Circuits (4hrs)

Instructor : S. Garg

Lab, project: Transistor-level (< 20) digital circuit design, simulation and layout.

Pre-req : ECE 331; 4A ECE student.

Circuits (40's)

ECE 444 : Integrated analog electronics (4B, Winter 2014).

- MOS and bipolar transistor description, physical operation and modeling for analog design (3hrs)
- Single and multiple transistor amplifying stages (5hrs)
- Biasing, mirrors, active loads and references (6hrs)
- Output stages (3hrs)
- Operational Amplifiers (3hrs)
- Frequency Response (3hrs)
- Feedback (3hrs)
- Stability and Compensation (4hrs)
- Selected Topics on A/D converters, Oscillators and Phase-Locked Loops (6hrs)

Instructor : B.H. Leung

Lab, project: Design and fully characterize a significant analog component such as a voltage reference, high-speed amplifier or a voltage regulator. The design will be simulation based using currently available circuit simulation tools.

Pre-req : 4A ECE student.

Software (50's)

ECE 453 : Software testing, quality assurance and maintenance (4B, Winter 2014).

- introduction to software testing, bug detection, and maintenance techniques.
- Coverage (Graph Coverage, Logic Coverage, Input Space Partitioning, and Syntax-based Coverage)
- Subsumption and Infeasibility
- Testing in Practice
- State-of-the art Testing and Bug Detection Techniques
- Software Maintenance.

Instructor : L. Tan

Lab, project: ???

Pre-req : ???.

Software (50's)

ECE 454 : Distributed computing (4A, Spring 2013).

- Distributed systems (2hrs)
- Architecture and design goals for distributed systems (2hrs)
- Overview of networking (3hrs)
- Interprocess communication (8hrs)
- File services (4hrs)
- Notion of time in distributed systems (2hrs)
- Concurrency controls and communications (6hrs)
- Collaborating servers (4hrs)
- Network-centric computing case studies (5hrs)

Instructor : Y.Q. Huang (sessional)

Lab, project: Design and verify a distributed network computing system.

Pre-req : ECE 254 / ECE 354, ECE 358, 4A ECE student.

Software (50's)

ECE 455 : Embedded software (4A, Spring 2013).

- The issues that make embedded software design difficult (3hrs)
- Computing structures for embedded systems (3hrs)
- Structures and design of embedded software (6hrs)
- Models of time, resources, dependability (4hrs)
- Uniprocessor scheduling (4hrs)
- Worst-case execution time analysis (4hrs)
- Programming support (6hrs)
- Embedded distributed systems (3hrs)

Instructor : S. Fischmeister

Lab, project: ???

Pre-req : ECE 254/ ECE 354, 4A ECE student.

Software (50's)

ECE 457A : Cooperative and adaptive algorithms (4A, Spring 2013).

- Introduction to ill-structured problems, need for approximate algorithms (4hrs)
- Heuristic search methods: A*, Tabu search, cooperative search (6hrs)
- Game playing, minmax algorithms, pruning algorithms games with chance (3hrs)
- Constraint satisfaction: Problem formulation and solution strategies (1hr)
- Simulated annealing, Genetic algorithms, cooperation in GA (6hrs)
- Cooperation and adaptation in nature and computational models inspired by nature (1hr)
- Ant Colony algorithms: ACO- cooperative and multi-ant-colonies (8hrs)
- Particle swarm algorithms: particle swarm optimization, cooperation within the swarms, cooperation among swarms, swarm ensembles (8hrs)
- Engineering Applications: optimization, routing, text clustering (distributed through the above topics)

Instructor : O. Basir

Lab, project: ???

Pre-req : 4A ECE student.

Software (50's)

ECE 457B : Fundamentals of computational intelligence (4B, Winter 2014).

- Introduction to soft computing and AI based tools (3hrs)
- knowledge based systems and expert systems (3hrs)
- Approximation and Intelligence (1hr)
- Fuzzy Logic Systems (6hrs)
- Fuzzy Inferencing (9hrs)
- Learning and Connectionist modelling (6hrs)
- Major Types of Artificial Neural Networks (8hrs)

Instructor : F. Karray

Lab, project: ???

Pre-req : 4A ECE student.

Software (50's)

ECE 458 : Computer security (4A, Spring 2013).

- Software systems (8hrs)
- Networks (8hrs)
- Authorization systems (8hrs)
- Cryptographic engineering (6hrs)

Instructor : M.V. Tripunitara

Lab, project: ???

Pre-req : ECE 254 / ECE 354, 4A ECE student.

Software (50's)

ECE 459 : Programming for performance (4B, Winter 2014).

- Amdahl's Law and survey of hardware (2hrs)
- Profiling computer systems (4hrs)
- Concurrency (12hrs)
- Multicore processors and vector architectures (12hrs)

Instructor : P. Lam

Lab, project: Students will profile an application to identify the bottlenecks and implement changes to the software to enable it to scale to large input sizes.

Pre-req : ECE 254 / ECE 354, 4A ECE student

Power & energy systems (60's)

ECE 462 : Electrical distribution systems (4A, Spring 2013).

- Load characteristics and load forecast (6hrs)
- Distribution system planning, automation and control (9hrs)
- Sub-transmission and substation design (6hrs)
- Primary and secondary system design considerations (6hrs)
- Distribution system performance and operation (9hrs)

Instructor : M.M.A. Salama

Lab, project: Operation, control and protection of distribution systems, Loss calculations and voltage regulation.

Pre-req : ECE 261 / ECE 361, 4A ECE student.

Power & energy systems (60's)

ECE 463 : Design and applications of power electronic converters (4A, Spring 2013).

- Introduction to power electronics (2hrs)
- Waveform Quality (4hrs)
- Overview of power semiconductor devices (3hrs)
- Computer simulation of power electronic circuits (1hr)
- Analysis, design and applications of power converters (16hrs)
- Control techniques in power converters (4hrs)
- Practical Aspects of Converter Design (6hrs)

Instructor : M. Kazerani

Lab, project: Lab

Pre-req : ECE 261 / ECE 361, 4A ECE student.

Power & energy systems (60's)

ECE 464 : High voltage engineering and power system protection (4B, Winter 2014).

- Introduction to high voltage technology (2hrs)
- Generation high voltages (6hrs)
- Measurements of high voltages (5hrs)
- Insulation Coordination (2hrs)
- Insulating materials (6hrs)
- Introduction to power system protection (3hrs)
- Digital Protection (2hrs)
- Over-current protection (3hrs)
- Introduction to ground fault protection (3hrs)
- Relay technology (2hrs)

Instructor : M.M.A. Salama

Lab, project: Lab

Pre-req : ECE 261 / ECE 361, 4A ECE student.

RF, Microwave and photonics (70's)

ECE 473 : Radio frequency and microwave circuits (4A, Spring 2013).

- Review of Transmission Line and Generalized Matrix Representation of RF Circuits (2hrs)
- Analysis, characterization, and measurement of multiport RF networks (7hrs)
- Introduction to modern microwave planar technologies (2hrs)
- Lumped and Distributed Microstrip Circuits (2hrs)
- Analysis of Microstrip Circuits (2hrs)
- Couplers, Hybrids and Impedance Matching Networks (3hrs)
- Microwave Resonators and Filters (6hrs)
- Design of RF Low Noise Amplifiers (8hrs)
- Design of RF Oscillators and Mixers (2hrs)
- CAD design tools for RF Circuits (1hrs)
- Hybrid and Monolithic RF circuits (1hrs)

Instructor : S. Boumaiza

Lab, project: ???

Pre-req: ECE 370 / ECE 375, MATH 212, 4A ECE student.

RF, Microwave and photonics (70's)

ECE 474 : Radio and wireless systems (4B, Winter 2014).

- Modern Transmitter Architectures (1.5hrs)
- Modern Receiver Architectures (1.5hrs)
- Noise/Linearity Budget for Radio & Wireless Systems (2hrs)
- Design Considerations of RF/Microwave Components & Subsystems (8hrs)
- Radio & Wireless System Designs (3hrs)
- CAD tools for Radio & Wireless Systems (2hrs)
- Antennas (6hrs)
- Radio Wave Propagation (Near Earth, Atmospheric & Ionospheric) (2hrs)
- Indoor Radio-Wave Propagation (2hrs)
- Satellite Communication (2hrs)
- Personal Communication System (PCS) (6hrs)

Instructor : S. Safavi-Naeini

Lab, project: ???

Pre-req : ECE 370 / ECE 375, MATH 212, 4A ECE student.

RF, Microwave and photonics (70's)

ECE 475 : Electromagnetic radiation and propagation (4A, Spring 2013).

- Review of Maxwell's Equations and Plane Waves (3hrs)
- EM Waves in Material Media (4hrs)
- Reflection/Transmission of EM Waves in Material Media (6hrs)
- Multilayer & Periodic Structures (3hrs)
- EM Waveguides (6hrs)
- Radiation Theory (3hrs)
- Transmitting & Receiving Antenna (6hrs)
- Antenna Arrays (2hrs)
- Simple Radio-Wave Propagation Models (3hrs)

Instructor : S. Safavi-Naeini

Lab, project: Lab

Pre-req : ECE 370 / ECE 375, MATH 212, 4A ECE student.

RF, Microwave and photonics (70's)

ECE 477 : Photonic devices and systems (4B, Winter 2014).

- Review of Maxwell's Equations & EM Plane Waves (2hrs)
- Dielectric Waveguides (4hrs)
- Optical Fibre (6hrs)
- Lasers & Photonic Transmitters (8hrs)
- Photodetectors & Photonic Receivers (8hrs)
- Photonic Amplifiers (3hrs)
- Photonic Systems & Networks (5hrs)

Instructor : A.H. Majedi

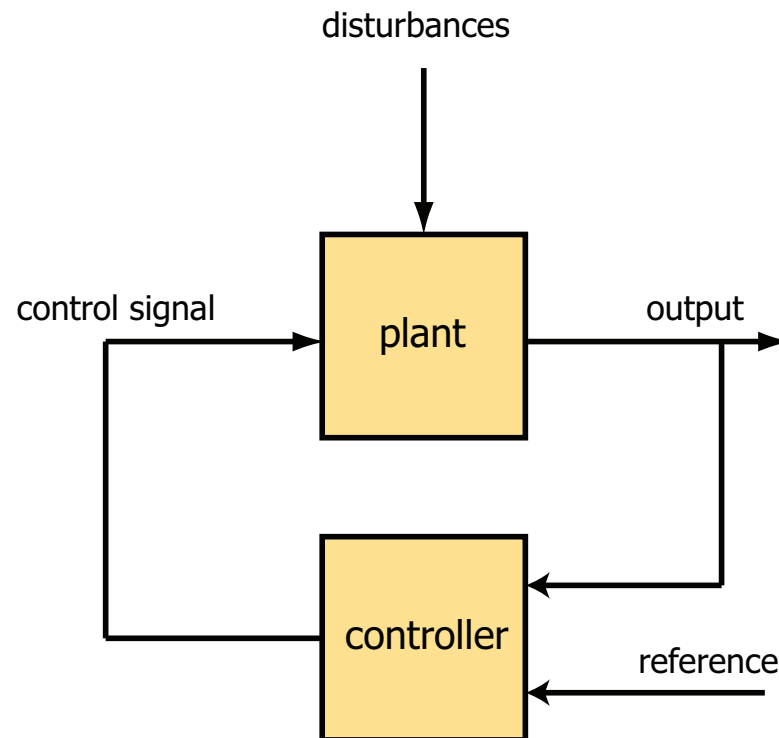
Lab, project: Lab.

Pre-req : ECE 370 / ECE 375, MATH 212, 4A ECE student.

System control (80's)

Purpose: Change the behaviour of a system (the “plant”) in a desirable way despite disturbances acting on the system and modeling uncertainty.

Systems in which the output has an effect on the input are called **closed-loop** or **feedback** systems.



System control (80's)

ECE 481 : Digital control systems (4A, Spring 2013).

- Stability and performance specifications (4hrs)
- Modelling and basic system identification, including nonlinear phenomena (7hrs)
- Continuous-time design methods and emulation (8hrs)
- Sampled data system analysis (7hrs)
- Discrete-time system analysis (5hrs)
- Direct Digital Controller Design (5hrs)

Instructor : C. Nielsen

Lab, project: Ball & beam control system

Pre-req : ECE 380, 4A ECE student.

System control (80's)

ECE 486 : Robot dynamics and control (4A, Spring 2013).

- Standard robotic manipulator configurations (3hrs)
- Homogeneous transformations (7hrs)
- Forward & inverse kinematics (6hrs)
- Forward & inverse velocity kinematics (5hrs)
- Dynamics (7hrs)
- Path planning (3hrs)
- Control (5hrs)

Instructor : S.L. Smith

Lab, project: Modelling and control of a humanoid robot

Pre-req : ECE 380, 4A ECE student.

System control (80's)

ECE 488 : Multivariable control systems (4B, Winter 2014).

- Review of feedback control design fundamentals (3hrs)
- SISO controller parameterizations (2hrs)
- Performance limitations in feedback control (5hrs)
- Cross-channel interaction in MIMO systems (3hrs)
- State-space representation of MIMO systems (4hrs)
- Controllability, observability, stabilizability, detectability, minimality (4hrs)
- State-feedback design and pole placement (3hrs)
- State estimation and the separation principle (4hrs)
- MIMO integral control (3hrs)
- Introduction to optimal control (3hrs)
- Other MIMO design techniques (2hrs)

Instructor : D. Davison

Lab, project: Application of multivariable control theory to a practical system in a simulation environment.

Pre-req: ECE 380, 4A ECE student.

Design projects (90's)

ECE 499 : Engineering project (4B, Winter 2014).

A one term independent study project under the supervision of a faculty member. Usually done in 4B. Well-suited to people interested in graduate studies and research.

<http://ece.uwaterloo.ca/~ece499/>

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