DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

McMASTER UNIVERSITY

GRADUATE COURSE DESCRIPTIONS

2022/2023

ECE 712
Matrix Computations in Signal Processing

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Matrix decompositions: eigen-decomposition, QR decomposition, singular value decomposition; solution to systems of equations: Gaussian elimination, Toeplitz systems; least square methods: ordinary, generalized and total least squares, principal component analysis.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2022/23 academic year.
Please check with Instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. J. Reilly, PEng.
Email: reillyj@mcmaster.ca
Office: ITB-A312
Phone: 905-525-9140 ext. 22895
Office Hours: by appointment

COURSE WEBSITE/S

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, the student will have acquired the necessary linear algebra background to conduct research in signal processing, machine learning and related fields.

ASSUMED KNOWLEDGE

- The equivalent of an engineering undergraduate course in linear algebra. This includes the definition of matrices/vectors, arithmetic operations on matrices/vectors, solution of systems of equations, inverses, etc., and a knowledge of fundamental calculus, probability and linear systems. Knowledge of a high-level programming language such as matlab or python is also required.

COURSE MATERIALS

Textbooks:

"Fundamentals of Linear Algebra for Signal Processing", James P. Reilly, available on the Teams website.

Other:

"Matrix Computations", 3rd edition, Golub and Van Loan, Johns Hopkins University Press
"Linear Algebra and Its Applications", 3rd edition, G. Strang

COURSE OVERVIEW

Week	Topic
1	Review of fundamental concepts of linear algebra
2	Eigenvalues and eigenvectors. basics, covariance matrices, principal component analysis
3	The Singular Value Decomposition (SVD)
4	The quadratic form and the multi—variate Gaussian probability density function
5	Floating point number systems, Gaussian Elimination, Cholesky decomposition, condition number, and error analysis
6	The QR decomposition: Gram-Schmidt, Householder, the QR method for computing the eigendecomposition
7	Linear Least Squares (LS) Estimation: background, normal equations, properties, Cramer-Rao lower bound in white and coloured noise
8	The rank deficient LS problem
9	Model—building using Latent Variable methods
10	Regularization (time permitting)
11	Autoregressive Analysis (time permitting)

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

Course Evaluation

There will be two graded assignments of equal weight. All graded material must be submitted no later than one week past the end of term.

CONDUCT EXPECTATIONS

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EXTREME CIRCUMSTANCES

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www.eng.mcmaster.ca/ece

ECE 715
Optimal Control of Dynamical Systems

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course will provide an overview of the fundamentals of the theory of optimal control, focusing on its various formulations and solution strategies using variational approaches and dynamic programming. Topics include optimal control of discrete-time systems, calculus of variations and optimal control in the continuous-time domain, optimal control based on dynamic programming, classical linear quadratic regulators, and application of the Pontryagin's minimum principal to optimal control of dynamical systems with input and state constraints.

SCHEDULE And MODE OF DELIVERY

This course will be offered in person.

Lecture: TBD

INSTRUCTOR

Dr. Shahin Sirouspour
Email: sirous@mcmaster.ca
Office: ITB-319
Phone: 905-525-9140 ext. 26238
Office Hours**:** and by appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca

ASSUMED KNOWLEDGE

An undergraduate or graduate course in state-space control (e.g., ELEC ENG 4CL4); background in optimization would be helpful but not required. Please consult the course instructor for further information.

COURSE MATERIALS

Textbooks:

Instructor's lecture notes

Additional Reading:

- Lewis, Frank L., Draguna Vrabie, and Vassilis L. Syrmos. Optimal control. 3rd edition, John Wiley & Sons, 2012.
- Kirk, Donald E. Optimal control theory: an introduction. Courier Dover Publications, 2012.

COURSE OVERVIEW

Week	Topic
1	**Introduction and preliminary materials on static optimization**
	Optimal control of discrete-time systems
2	General problem formulation and necessary conditions for solution
3	Discrete-time Linear Quadratic Regulators (LQR)
4	Steady-state suboptimal LQR
	Variational approach to continuous-time optimal control
5	Fundamental concepts in calculus of variations
5-6	General problem formulation and necessary conditions for solution
6	Continuous-time LQR
7	Steady-state suboptimal LQR
	Final free-time and constrained optimal control
8	Final free-time problems
8	Pontryagin's minimum principle
9	Optimal control with constraints on inputs and states
10	Minimum-time optimal control problems
	Output feedback and structured control
11	LQR with output feedback
12	Tracking problem
13	Model reference control

The instructor may modify elements of the course and/or the timeline, and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight
Assignments	50%
Final Exam	50%
Total	100%

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www.eng.mcmaster.ca/ece

Delete if no labs2

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing

instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial “88” after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	spencers@mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 716
Switched Reluctance Machines

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Switched Reluctance Machine (SRM) differs from other electric machines due to its simple construction and lack of coils or permanent magnets on the rotor. These features enable the operation at higher speeds and harsh environment. SRM is a promising candidate for various motor drive applications, but it can suffer from high torque ripple and acoustic noise.

The simple and low-cost construction of SRM makes the modelling, analysis, and controls more challenging. In this course, we will explore various characteristics of SRM including modeling, converters, control, materials, and design. Students will utilize the course material to design an SRM in their group project assignment.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in -person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. Berker Bilgin
Email: bilginb@mcmaster.ca
Office: ITB-A218
Phone: 905-525-9140 ext. 27080
Office Hours**:** by appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

The objective of the course is to develop an understanding of the fundamental operational principles and control of switched reluctance machines (SRM). The student will be provided the multidisciplinary principles and design aspects of SRM. The topics that will be covered throughout

the course include electromagnetic principles, modeling, controls, converters, and materials used in SRMs, and design of SRM. The course also targets helping the student gain hands-on experience in simulation tools used in electric machine design.

By the end of this course, students should be able to:

- Understand the operational principles of SRM
- Gain an understanding of multidisciplinary design aspects in SRM
- Develop simulation models to analyze the performance of SRM
- Conduct finite element analysis (FEA) simulations to characterize SRM
- Gain an experience in designing an SRM for a selected application

ASSUMED KNOWLEDGE

The students are expected to have an understanding of the fundamentals of electric circuits, electromagnetics, and electromechanical energy conversion.

COURSE MATERIALS

Recommended reading:

B. Bilgin, J. W. Jiang, and A. Emadi, Switched Reluctance Motor Drives: Fundamentals to Applications, CRC Press, 2018, ISBN: 9878-1138304598

R. Krishnan, Switched Reluctance Motor Drives Modeling, Simulation, Analysis, Design and Applications, Boca Raton, FL: CRC, 2001.

COURSE OVERVIEW

Week	Topic
1	Course Overview Electric Motor Industry and SRM
2	Electromagnetic Principles of SRM
3	Derivation of Pole Configuration in SRM and Operational Principles of SRM
4	Modeling of SRM Tutorial: Modeling an SRM Drive in MATLAB/Simulink
5	Tutorial: Modeling and Analysis of SRM in JMAG and SRM in Generating Mode
6	Control of SRM; Converters in SRM; Tutorial: Optimization of control parameters of an SRM
7	Midterm Exam
8	Design Considerations in SRM
9	SRM Design Examples
10	Materials used in SRM and Mechanical Construction of SRM
11	Group Project Assessment - No Lecture
12	Group Project Presentations I; Advanced topic: Introduction to noise and vibration in SRM
13	Group Project Presentations II; Advanced topic: Thermal Management in SRM

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Group Assignment	10%	6th week of the term (group)
Midterm Exam	25%	7th week of the term (individual)
Group Project Assessment	30%	11th week of the term (individual)
Group Project Presentation	5%	12th and 13th week of the term (group)
Group Project Report	30%	13th week of the term (group)
Total	100 %	

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).
No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

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ECE 718
Special Topics in Computation
Machine Learning: An Introduction

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Linear methods for regression and classification, nearest neighbours, decision trees, bias-variance trade-off, neural networks (including deep neural nets and convolutional nets), support vector machines, ensemble methods, clustering, principal component analysis, basics of reinforcement learning, including Monte Carlo, temporal-difference learning, SARSA (state-action-reward-state-action), Q-learning, policy-gradients methods.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered in person if the McMaster University policy permits. Otherwise, the material will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories and projects. The platform will be Microsoft Teams.

Lecture: TBA

INSTRUCTOR

Dr. Sorina Dumitrescu
Email: dumitrs@mcmaster.ca
Office: ITB-A222
Phone: 905-525-9140 ext. 26486
Office Hours: TBA

COURSE WEBSITE

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to demonstrate an understanding of the most common machine learning approaches and their underlying principles.

ASSUMED KNOWLEDGE

Programming in Python; linear algebra: basic matrix operations; calculus: computation of derivatives; probability and statistics: understanding of probability, conditional probability, expectation, correlation, mean, variance, covariance.

COURSE MATERIALS

Textbooks:
No required textbook

Recommended Reading:

[1] Kevin P. Murphy, Machine Learning: A probabilistic perspective, The MIT Press, 2012.
[2] T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning, 2nd Ed., Springer, 2009 (ISBN 9780387848570).
[3] C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006 (ISBN 9780387310732).
[4] M. Mohri, A. Rostamizadeh, and A. Talwalkar, Foundations of Machine Learning, 2nd Ed.,The MIT Press, 2018 (ISBN 9780262039406).
[5] I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, The MIT Press, 2016 (ISBN 9780262035613).
[6] R. S. Sutton and A. G. Barto, Reinforcement Learning: An Introduction, 2nd Ed., The MIT Press, 2018 (ISBN 9780262039246).

COURSE OVERVIEW

Week	Topic
1	Overview of Machine Learning. Maximum Likelihood Estimation, Bayesian Estimation, MAP, Decision Theory.
2	Classification. Linear Regression. Regularization
3	Nearest neighbours. The curse of dimensionality. Naive Bayes.
4	Logistic regression. Discriminative versus generative classifiers.
5	Decision trees. Ensemble methods (boosting and bagging). Random forests.
6	Neural networks (perceptron, neural nets, deep neural nets, backpropagation)
7	Convolutional neural nets. Support vector machines.
8	VC dimension and generalization guarantees. Model assessment and selection.
9	K-means clustering. Principal component analysis.
10	Gaussian mixture models and the EM algorithm. Introduction to sequential decision making. Markov Decision Processes. Value functions and Bellman equations.
11	Value Iteration algorithm. Monte Carlo methods for prediction and control.
12	Temporal-difference learning. SARSA and Q-learning. SARSA with function approximation.
13	Policy-gradient methods.

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ASSESSMENT

Component	Weight	Due Date
Assignments	40%	TBA
Project	20%	TBA
Midterm	20%	TBA
Final Exam	20%	TBA
Total	100 %	

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www.eng.mcmaster.ca/ece

ECE 723
Information Theory and Coding

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Entropy and mutual information. Discrete memoryless channels and discrete memoryless sources, capacity-cost functions and rate-distortion functions. The Gaussian channel and source. The source-channel coding theorem. Linear codes. BCH, Goppa, Reed-Solomon, and Golay codes. Convolutional codes. Variable-length source coding.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. Jun Chen
Email: chenjun@mcmaster.ca
Office: ITB/A221
Phone: 905-525-9140 ext. 20163
Office Hours**:** By appointment

COURSE WEBSITE

http://avenue.mcmaster.ca

COURSE OBJECTIVES

This course will provide an introductory look into the broad areas of information theory and coding theory. As stated in the course text,

> *Information theory answers two fundamental questions in communication theory: what is the ultimate data compression (answer: the entropy H) and what is the ultimate transmission rate of communication (answer: the channel capacity C).*

In later stages of the course, coding techniques will be discussed which approach these ultimate limits

ASSUMED KNOWLEDGE

Undergraduate senior-level ECE courses in: mathematics, probability, stochastic processes and communications systems.

COURSE MATERIALS

Textbooks/Reference:

Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, John Wiley & Sons, 1991. (ISBN 0-471-06259-6)

Stephen B. Wicker, Error Control Systems for Digital Communication and Storage, Prentice-Hall, 1995. (ISBN 0-13-200809-2)

Papers from the literature cited by instructor.

COURSE OVERVIEW (APPROXIMATE)

Week	Topic
1	Entropy: entropy, relative entropy, mutual information, chain rules, data processing inequality
2	The asymptotic equipartition property (AEP), typical sets
3	Data Compression: bounds on codeword length, source coding theorem
4	Data Compression: Prefix codes, Kraft-McMillan inequality, Shannon-Fano codes
5	Data Compression: Huffman codes, optimal binary codes, universal source coding
6	Entropy rates of stochastic processes
7	Channel Capacity: discrete channels, random coding bound and converse
8	Channel Capacity: continuous channels, Gaussian channels, coloured Gaussian noise and optimal “water-pouring” power allocation
9	Channel Capacity: sphere packing, channel coding theorem for Gaussian channels, bandlimited channels
10	Error Control Coding: introduction, linear block codes and their properties
11	Error Control Coding: hard-decision decoding, cyclic codes, elements of abstract algebra, BCH and RS codes
12	Error Control Coding: convolutional codes, soft-decision decoding, Viterbi decoding algorithm
13	Advanced Coding Techniques: lattice codes, trellis coded modulation, coset codes, multi-level codes/multi-stage decoding, iterative decoding

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Project	50%	
Assignments	50%	
Total	100 %	

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day). All assignments and projects should be submitted via Avenue-to-Learn.

CONDUCT EXPECTATIONS

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www.eng.mcmaster.ca/ece

ECE 724
Modeling, Control and Design of Electrified Vehicles

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course covers the modeling, control, and design of electrified vehicles, including hybrid, plug-in hybrid, and pure electric vehicles. The high-level goal of this course is to understand the vehicle model as a testbed for evaluating future design and control ideas.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through online lectures (which are also recorded). The platform is noted at the end of the line below.

Lecture: Tuesdays 10:00 a.m.- 1:00 p.m. (Microsoft Teams)

INSTRUCTOR

Dr. Jennifer Bauman
Email: jennifer.bauman@mcmaster.ca
Office: ITB-A220
Phone: 905-525-9140 ext. 27599
Office Hours**:** email for appointment

COURSE WEBSITE/S

The main course website is Avenue to Learn. All lecture slides and project instructions can be found here. The recorded lectures will be available in the ECE 724 team chat in Microsoft Teams.

COURSE OBJECTIVES

This course is heavily project-based, with the goal of the main project being to perform a small research study in the electrified vehicle space that utilizes vehicle modeling to investigate design and/or control ideas. By the end of this course, students should be able to:

- create accurate vehicle models validated to real-world data, and use these models to evaluate new ideas.

ASSUMED KNOWLEDGE

Experience using MATLAB and Simulink.

COURSE MATERIALS

Optional course textbook: "Hybrid Electric Vehicle System Modeling and Control, 2nd Edition" by Wei Liu

COURSE OVERVIEW

Week	Topic
1	Introduction, model types, powertrain architectures, data sources
2	Standard drive cycles, fuel economy and range, model structure, modeling of: driver, chassis, wheel, final drive
3	Modeling of: motors, control, power electronics, electrical accessories
4	Modeling of: batteries, fuel cells
5	Hybrid energy storage systems, ultracapacitors
6	Modeling of: engines, transmissions
7	Control strategies
8	Control strategies, electrified vehicle design
9	EV Charging
10	Student project presentations
11	Student project presentations
12	Student project presentations

A more detailed time line is available in the Week 1 lecture notes on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Project Proposal	10%	
Assignment #1	35%	
Project – presentation	5%	
Project – final report	50%	
Total	100%	

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www.eng.mcmaster.ca/ece

ECE 729

Resource Management and Performance Analysis in Wireless Communication Networks

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course focuses on resource management and performance analysis in transporting multimedia traffic in wireless communication networks. Topics include traffic characteristics, connection admission control, packet scheduling, access control, and mobility and handoff management.

SCHEDULE And MODE OF DELIVERY

One 3-hour in-person lecture per week.

INSTRUCTOR

Dr. Dongmei Zhao
Email: dzhao@mcmaster.ca
Office: ITB-A323
Phone: 905-525-9140 ext. 26127
Office Hours**:** by appointment

COURSE WEBSITE/S

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, the student will have acquired 1) the basic knowledge of main research issues in radio resource management for wireless communication networks, and 2) recent research progress in mobile computation offloading and digital twins.

ASSUMED KNOWLEDGE

- The equivalent of an engineering undergraduate course in probability theory and random processes. This includes the definition of mean, variance, probability distribution function, probability mass function, Poisson/exponential/normal distribution, Poisson

process, etc. Knowledge of a high-level programming language such as matlab or python is also required.

COURSE MATERIALS

Lecture notes:

Posted on Avenue before each lecture.

References:

A list of recent journal and magazine publications will be provided.

COURSE OVERVIEW

Week	Topic
1	Introduction to radio resource management
2	Channel propagations
3	Markov channel models
4	Wireless cellular networks
5	Centralized power control and interference management
6	Distributed power control and interference management
7	Traffic scheduling – general processor sharing
8	Weighted fair queueing
9	Effective bandwidth
10	Mobile computation offloading
11	Digital twin

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

Course Evaluation

There will be three graded assignments, one test and one final course project.

Assignments (3): 30%;
test (1): 25%;
class presentation (20min ~ 1h per student, depending on class size): 10-20%; and
final project: 25-35%

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www.eng.mcmaster.ca/ece

ECE 733
Non-Linear Optimization for Engineers

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course addresses different concepts in nonlinear optimization with a special focus on electrical applications. Starting with classical optimization approaches and single dimensional methods, we move to cover unconstrained and constrained multidimensional optimization. Both gradient-based and value-based optimization approached are covered. The course also addresses areas of research relevant to electrical engineering. These include space mapping (SM) optimization, global optimization approaches such as particle swarm optimization (PSO), and adjoint variable methods (AVM). The examples and projects mainly focus on applications relevant to electrical engineering.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in person in the 2022/23 academic year.
Please check with with Instructor and/or Avenue to Learn for Schedule and Mode of Deliver.

INSTRUCTOR

Dr. Mohamed Bakr
Email: mbakr@mcmaster.ca
Office: ITB-A219
Phone: 905-525-9140 ext. 24079
Office Hours**:** Thursdays 2:30pm - 4:30 pm ; and by appointment.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to:

- understand the difference between different optimization problems
- understand how different optimization algorithms are executed

- understand the difference between optimization methods and their limitations
- evaluate first and higher order sensitivities using finite differences and using adjoint variable methods
- utilize surrogate model optimization methods such as Space Mapping in solving practical problems
- write MATLAB/Python codes that implement different optimization algorithms
- apply optimization methods to different areas of their research

ASSUMED KNOWLEDGE

COURSE MATERIALS

Textbooks:
Singiresu S. Rao, Engineering Optimization Theory and Practice, Third Edition, John Wiley and Sons
Jorge Nocedak and Stephen Wright, Numerical Optimization, Second Edition, Springer

Other:
Collection of research papers

COURSE OVERVIEW

Week	Topic
1	Introduction
2	Classical Optimization Approaches
3	One Dimensional Search
4	Unconstrained Optimization
5	Constrained Optimization
6	Sequential Quadratic Programming
7	Linear Programming
8	Convex Optimization
9	Global Optimization Approaches
10	Space Mapping Optimization
11	Adjoint Variable Methods
12	Optimization Methods for Machine Learning
13	Applications

A more detailed timeline is available on the course web site.

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Project 1	25%	
Project 2	25%	
Project 3	25%	
Project 4	25%	
Total	100 %	

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ECE 735
Network Information Theory

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Network information theory deals with the fundamental limits on information flow in networks and optimal coding techniques and protocols that achieve these limits. It extends Shannon's point-to-point information theory to networks with multiple sources and destinations. Although a complete theory is yet to be developed, several beautiful results and techniques have been developed over the past forty years with applications in wireless communication, the internet, and other networked systems. This course aims to provide a broad coverage of key results, techniques, and open problems in network information theory.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. Jun Chen
Email: junchen@mail.ece.mcmaster.ca
Office: ITB-A221
Phone: 905-525-9140 ext. 20163
Office Hours**:** by appointment

COURSE WEBSITE/S

https://www.ece.mcmaster.ca/~junchen/ECE735.htm

COURSE OBJECTIVES

By the end of this course, students should be able to:

- characterize the fundamental limits of basic network models,
- analyze practical source/channel coding systems using information-theoretic techniques.

ASSUMED KNOWLEDGE

probability theory, linear algebra

COURSE MATERIALS

Textbooks:

Abbas El Gamal and Young-Han Kim, *Network Information Theory*, Cambridge University Press

COURSE OVERVIEW

Week	Topic
1	Entropy, Mutual Information, and Typicality
2	Point-to-Point Communication
3	Multiple Access Channels
4	Degraded Broadcast Channels
5	Interference Channels
6	Channels with State
7	General Broadcast Channels
8	Distributed Lossless Source Coding
9	Source Coding with Side Information
10	Distributed Lossy Source Coding
11	Multiple Descriptions
12	Joint Source-Channel Coding
13	

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Lecture Report	50 %	
Project	50 %	
Total	100 %	

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Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial "88" after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not

endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	spencers@mcmaster.ca

ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 736
3D Image Processing and Computer Vision

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Central to computer vision are the mathematical models governing image formation and methods for processing and recovering information based on the model and the image data. In this course we concentrate on statistical and geometrical models of visual data. Assuming a statistical model for the visual data, we talk about learning and inference. We cover modeling of the data densities, regression and classification methods and how we can use graphical models (e.g., Vitterbi, belief propagation) to solve learning and inference problems. In the other half of the course we take a geometrical approach to image formation and look at problems such as image blending and stitching and 3D reconstruction.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered in person. Course notes and supplementary material will be posted online on Avenue to Learn.

INSTRUCTOR

Dr. Shahram Shirani,
Email: shirani@mcmaster.ca
Office: ITB-A225
Phone: 905-525-9140 ext.
Office Hours**:** by appointment

COURSE WEBSITE/S

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

Learning Objectives:

- Model image formation in single camera and multi-camera setups
- Mathematically understand the relation between the 3D world and its projection in 2D images and learn how to reconstruct a 3D scene model from several 2D images

- Extract features from images and match/track them
- Find appropriate models for complex data densities
- Choose the right regression model for a vision problem
- Choose the right classifier for a vision problem
- Employ the RANSAC algorithm to remove the effects of outliers
- Be able to apply computational photography techniques in order to solve image processing and computer vision problems

ASSUMED KNOWLEDGE

- Undergraduate level DSP, undergraduate level probability, undergraduate level image processing

COURSE MATERIALS

Textbooks:

- C. M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006. Available online.
- Richard Hartley, Andrew Zisserman, “Multiple View Geometry in Computer Vision” Second Edition, Cambridge University Press, 2004. Electronic version available online.
- Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer; 2011. Electronic version of the book is available free at: http://szeliski.org/Book/
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An Introduction to Statistical Learning”, Springer Science, Business Media, New York 2017, available online.

Reference Books:

- Simon J.D. Prince, “Computer vision: models, learning and inference”, Cambridge University Press, 2012.

Electronic version of the book is available free at:
http://www.computervisionmodels.com

COURSE OVERVIEW

Week	Topic
1	Pinhole camera model Camera calibration 3D reconstruction Stereo correspondence
2	Epipolar geometry and structure from motion

	Edge detection Interest points, corners and local image features
3	Feature matching and tracking Model fitting and RANSAC
4	Optical Flow Deformable contours
5	Regression models
6	Classification models
7	Digital camera pipeline Image blending and compositing Image retargeting Texture synthesis and transfer Modeling complex data densities and Expectation Maximization Kernel methods Support Vector Machine (SVM)
8	Digital camera pipeline Image blending and compositing Image retargeting Texture synthesis and transfer
9	Image completion / inpainting High dynamic range imaging
10	Image stitching and panorama Image-based rendering
11	Recognition overview and bag of features

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

Course Evaluation

- Homework: 80%
- Project: 20%

CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive

environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

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EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be

communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece

ECE 742
Sensor Technology
COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Introduction to the fundamental principles of various state-of-the-art sensors and sensor technologies, their practical performance characteristics and design issues for specific applications of high societal importance. The course will cover measurement, theory, design and performance of state-of-the art sensors using micro and non-fabrication technologies. Emphasis will be on sensors that are small, consume little power, and are inexpensive. Also discussion on how to construct practical sensing systems including the sensor interface and display devices.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through live in-person lectures

Lectures: Three hours per week

INSTRUCTOR

Dr. Jamal Deen FRSC ….
Email: jamal@mcmaster.ca
Office: ITB-104
Phone: 905-525-9140 ext. 27137
Office Hours: Open office hours or by appointment

COURSE WEBSITE/S

Primarily the class Teams website. Also http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, student will

- Have a basic understanding of the fundamental principles various sensors used for health and environmental applications
- Understand how to design and measure key performance parameters of common sensors and how to report results using statistical analyses

- Be able to use sensor systems for practical applications according to targeted design specifications
- Appreciate different material systems and technologies used in sensor systems

ASSUMED KNOWLEDGE

Basic understanding (at undergraduate level) of physics, mathematics/statistics, engineering design principles, low-cost technologies. Note that these topics will be reviewed at the beginning of the lectures that require such knowledge.

COURSE MATERIALS

Reference Textbooks:

J. Fraden, *Handbook of Modern Sensors*: *Physics, Designs, and Applications*, Springer, 2015.

G. Meijer et al, Ed., *Smart Sensor Systems*: *Emerging Technologies and Applications*, Wiley, 2014.

M. J. McGrath, C. N. Scanaill and D. Nafus, *Sensor Technologies: Healthcare, Wellness and Environmental Applications*, Apress, 2013.

W.Y. Du, *Resistive, Capacitive, Inductive and Magnetic Sensor Technologies*, CRC Press, 2015.

Other:

Course slides for each lecture will be provided to students.

COURSE OVERVIEW

Week	Topic
1	Introduction - Sensors for and health and environmental applications
2-3	Measurement issues – mean, variance, error/uncertainty, correlation, error propagation, calibration
4	Elements of a sensor and sensor configurations
5-6	Sensors – biological, bio-chemical, biomedical, chemical, flow, magnetic, optical, pH, pressure/sound/acoustic, radiation, thermal – Fundamental principles, performance characteristics, design issues and practical applications
7-8	Sensor signals, performance characteristics, non-idealities, noise and calibration
9	Sensor interface circuits and sensor systems
10-11	Smart sensors including some high-impact applications such as Internet-of-Things, Personalized medical imaging systems and Water quality monitoring.
12	Most recent examples of practical sensor systems for healthcare applications
13	Most recent examples of practical sensor systems for environmental applications

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

COURSE ASSESSMENT

Component	Weight	Due Date
Assignments	50%	One week after assignment given
Project	35%	Last day of classes
Presentations	15%	One week's notice given
Total	100 %	

Two sample research projects will be provided.

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ECE 746
Analysis and Design of RF ICs for Communications

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course provides a fundamental and in-depth knowledge of the analysis and design of radiofrequency (RF) integrated circuits (IC) in CMOS technology for wireless communications. The topics include the modeling of active and passive components for AC and noise analysis, design examples of amplifiers, filters, oscillators, PLL and frequency synthesizers. Circuit performance will be evaluated by both hand calculations and computer simulations. A good understanding of circuit analysis and CAD tools (e.g. HSPICE or SpectreRF) is required.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. Chih-Hung (James) Chen
Email: chench@mcmaster.ca
Office: ITB-A321
Phone: 905-525-9140 ext. 27084
Office Hours**:** By appointment on Microsoft Teams

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to demonstrate their competency and be knowledgeable on the operating principles, design methodologies, and analysis techniques of radio frequency (RF) integrated circuits (IC) and their applications. They will be measured using three metrics:

- Knowledge Base for Engineering - Competence in Specialized Engineering Knowledge Related to Electronic Devices and Circuits.
- Problem Analysis - Obtain substantiated conclusions as a result of a problem solution,

including recognizing the limitations of the solutions.
- Investigation - Capable of selecting appropriate model and methods and identify assumptions and constraints.

ASSUMED KNOWLEDGE

Good knowledge in circuit theory, microelectronics, and microwave engineering. Special emphasis is on the semiconductor devices, small-signal models, scattering parameters, linear two-port network theory, circuit design (e.g., single-stage and differential amplifiers, passive and active filters, and negative feedback circuits), and circuit analysis (in both time and frequency domains).

COURSE MATERIALS

Textbooks:
Bosco Leung, *VLSI for Wireless Communications*, Prentice-Hall, TK7874.75.L48, 2002

Reference Texts:
1. B. Razavi, RF Microelectronics, Prentice-Hall Inc., 1998.
2. T.H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press, 1998.
3. G. Gonzalez, Microwave Transistor Amplifiers: Analysis and Design, 2nd ed., Prentice-Hall Inc., 1997.
4. Lawrence P. Huelsman, Active and Passive Analog Filter Design: An Introduction, McGraw-Hill, 1993.
5. D.A. Johns and K. Martin, Analog Integrated Circuit Design, John Wiley & Sons, Inc., New York, 1997.
6. P.E. Allan and D.R. Holberg, CMOS Analog Circuit Design, 2nd ed.,Oxford Press, 2002.
7. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, 2001.
8. Clarke and Hess, Communication Circuits: Analysis and Design, Krieger, Reprint, 1994.
9. H.L. Krauss, C.W. Bostian, F.H. Raab, Solid State Radio Engineering, Wiley, 1980.

COURSE OVERVIEW

Week	Topic
1	Passive and Active Components at RF
2 - 3	Noise Theory
4 - 5	Design of Low-noise Amplifiers
6 - 7	Nonideality
8	Design of Active Mixers
9 - 10	Volterra Series

11	Voltage-controlled Oscillators (VCO) and Phase Noise
12 - 13	Design of Phase-locked Loop (PLL)

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Note
Assignments	60%	Three assignments (LNA, Mixer, and VCO)
Term Project	40%	
Total	100%	

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).

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a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

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www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial “88” after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to

disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.
Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!
In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 753
Modern Antennas in Wireless Telecommunications

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course provides fundamental knowledge in the theory and practice of antenna design and deployment in modern wireless telecommunication systems. The theory of electromagnetic radiation is introduced and the fundamental antenna parameters are explained. Basic antenna measurement techniques are introduced and practiced in a 6-hour laboratory session. The principles of analysis and design of antenna arrays are discussed. Special attention is paid to antennas used in mobile (cellular, satellite) communications. The fundamental limitations of electrically small antennas as well as the principles of smart antennas are briefly introduced through seminar sessions.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery

INSTRUCTOR

Dr. Natalia Nikolova
Email: talia@mcmaster.ca
Office: ITB-A308
Phone: 905-525-9140 ext. 27141
Office hours: by appointment

COURSE WEBSITE/S

http://www.ece.mcmaster.ca/faculty/nikolova/antennas.htm

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Understand the meaning of the fundamental antenna performance parameters such as gain, directivity, radiation patterns and their characteristics, input impedance and impedance match, efficiency, polarization, and fidelity.

- Use professional design tools to design basic antenna types (dipoles, loop, patch).
- Predict the performance of the open-space communication channel.
- Measure the impedance match and the radiation patterns of antennas.

ASSUMED KNOWLEDGE

Applied Electromagnetics (ElecEng 2FL3) OR Electromagnetics 1 (ElecEng 2FH4)
AND
Electromagnetics 2 (ElecEng 3FK4)

COURSE MATERIALS

Textbooks:

C. A. Balanis, *Antenna Theory*, 3rd ed., Wiley-Interscience, New York, 2005.

Other:

Lecture Notes (distributed in class and available for download)

Additional Sources:

Antenna Textbooks

W. L. Stutzman and G. A. Thiele, Antenna Theory and Design, 2nd ed., Wiley, 1998.
J. D. Kraus and R. J. Marhefka, Antennas (for all Applications), 3rd ed., McGraw-Hill, 2002. (the previous editions authored by Kraus only are fine, too).
R. S. Elliot, Antenna Theory and Design, A Classical Reissue, IEEE Press, 2003.
Elsherbeni and Inman, Antenna Design & Visualization Using MATLAB, Scitech, 2006.

On Propagation

R. E. Collin, Antennas and Radiowave Propagation, McGraw-Hill, Inc. 1985.
K. Siwiak, Radiowave Propagation and Antennas for Personal Communications, 2nd ed., Artech House, Inc., Norwood, MA, 1998.
J. Doble, Introduction to Radio Propagation for Fixed and Mobile Communications, Artech House, Inc., Norwood, MA, 1996.

On Smart Antennas

T. K. Sarkar, M. C. Wicks, M. Salazar-Palma, R. J. Bonneau, Smart Antennas, Wiley, 2003.

COURSE OVERVIEW

Week	Topic

1	Introduction into antenna theory and practice
2	Radiation integrals and auxiliary potential functions; basic EM theorems in antenna problems
3	Fundamental antenna parameters
4	Antenna measurements
5	Infinitesimal dipole; wire and loop radiating elements
6	Wire antennas – dipoles, monopoles, Yagi-Uda array
7	Impedance matching and baluns
8	Arrays – analysis and design
9	Printed antennas
10	Reflector antennas
11	Horn antennas
12	Seminar - Fundamental limitations of electrically small antennas
13	Preparation for labs

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

LABORATORY OVERVIEW

Week	Topic
1	Gain of Pyramidal Horn Antennas
2	Experiments with λ/2, λ, and 3λ/2 Dipoles
3	Half-wave Folded Dipole Antennas and Impedance Transformation with Baluns
4	Circular Polarization and Helical Antennas

ASSESSMENT

Component	Weight	Due Date
Laboratory	20 %	
Weekly Assignments	40 %	
Project	40 %	
Total	100 %	

Late submissions of assignments or project reports are subject to 25% penalty per day (less than one day is counted as one day).

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www.eng.mcmaster.ca/ece

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.

2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial "88" after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!

4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!

In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	

ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 754
Modelling and Simulation of Photonic Devices

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

Photonic devices are key components to lightwave generation, amplification, transmission, and detection in many application systems. Photonic devices that utilize primarily photons, in conjunction with electrons can offer a tremendous bandwidth in these applications, especially in broadband communication systems and networks. This course focuses on the modeling of various passive, active, and functional photonic devices through numerical approaches, simulation of device terminal performances through mixed analytical and numerical methods, and extraction of device behavior models.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

This course has no labs.

INSTRUCTOR

Dr. Xun Li
Email: lixun@mcmaster.ca
Office: ITB-A313
Phone: 905-525-9140 ext. 27698
Office Hours**:** Wednesdays 3:00 PM – 5:00 PM or by appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca/

COURSE OBJECTIVES

By the end of the course, students should be able to:

1. Gain in-depth understandings on photonic devices, understand the working principle of and physical processes in photonic devices for optical communication systems.

2. Know how to describe photonic devices by physics based first-principle governing equations and know how to solve these equations through numerical methods.

3. Know how to model photonic devices to obtain their simulated performance.

ASSUMED KNOWLEDGE

Mathematics: Complex variables and functions; Differentiation and integration over multiple variables; Ordinary and partial differential equations; Linear algebra and matrix theory

Physics: Classical electrodynamics, Quantum mechanics, Solid-state physics, Semiconductor physics

Electrical Engineering: Steady-state (DC) and transient (AC) analyses; Time- and frequency-domain analyses, Fourier transforms

COURSE MATERIALS

Textbooks:
Lecture notes will be offered, no textbook

Reference books:
1. Physics of Photonic Devices, 2nd Edition, by S. L. Chuang, Wiley Inter-Science, ISBN9780470293195
2. Optoelectronic Devices - Design, Modeling, and Simulation, by X. Li, Cambridge University Press, ISBN9780521875103

COURSE OVERVIEW

Week	Topic
1	Introduction to photonic device modeling
2	Optical wave propagation
3	Optical wave propagation (continued)
4	Material optical property
5	Material optical property (continued)
6	Numerical solution techniques
7	Numerical solution techniques (continued)
8	Numerical solution techniques (continued)
9	Numerical solution techniques (continued)
10	Selected photonic device modeling and simulation examples: semiconductor lasers
11	Semiconductor optical amplifiers and super-luminescent light emitting diodes
12	Electro-absorption modulators

13 Photodetectors

At certain points in the course, it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Mid Term Minor Project	50%	
Final Major Project	50%	
Total	100%	

Late submissions of project report are subject to 10% penalty per day (less than one day is counted as one day).

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ECE 756
Design of Lightwave Communication Systems and Networks

COURSE OUTLINE

Please refer to the course website for updated information.

CALENDAR DESCRIPTION

Lightwave communication has emerged as the undisputed transmission method of choice in almost all areas of telecommunication, mainly because it offers unrivaled transmission capacity at low cost. This course will mainly focus on the design and simulation of the physical layer of lightwave communication systems and networks based on the advanced discrete and integrated photonic devices and optical fibers.

SCHEDULE AND MODE OF DELIVERY

The material for this course will be delivered through in-person lectures and projects.

Lecture: Thursdays 2:00 p.m. – 5:00 p.m. Format: In-person
Lab: No

INSTRUCTOR

Dr. S. Kumar
Email: kumars@mail.ece.mcmaster.ca
Office: ITB-A322
Phone: 905-525-9140 ext. 26008
Office Hours**:** Wednesdays 12:30pm - 2:00pm; and by appointment

COURSE WEBSITE/S

https://www.ece.mcmaster.ca/~kumars/Lightwave_course.htm

COURSE OBJECTIVES

By the end of this course, students should be able to:

- develop knowledge on operating principles of photonic devices and optical fibers,
- design methodologies and analyzing techniques of lightwave communication systems.
- model simple fiber optic communication systems.
- gain hands-on experience on fiber-splicing and fiber optic systems design.

ASSUMED KNOWLEDGE

Communication Systems (3TI4), Electromagnetics (3FK4), and some background on Matlab.

COURSE MATERIALS

Textbooks:

"Fiber Optic Communications: Fundamentals and Applications", S. Kumar and M. J. Deen, John Wiley and Sons, Inc., 2014.

"Fiber-Optic Communication Systems", Govind P. Agrawal, John Wiley and Sons, Inc., 1997, ISBN 0-471-17540-4

COURSE OVERVIEW

Week	Topic
1	Review of Electromagnetics
2	Fiber Modes
3	Fiber Dispersion
4	Fiber Transmission
5	Lasers – Basic concepts
6	Lasers – Rate equations
7	Semiconductor lasers
8	Receiver design
9	Transmission system design
10	Transmission system design
11	WDM systems and networks
12	
13	

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
Project	40 %	
Final Exam	40 %	

Assignment	20 %
Total	100 %

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).

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ECE 767
Tracking and Sensor Information Fusion

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course will introduce the advanced concepts and algorithms for multisensor-multitarget tracking under realistic conditions (with imperfect sensors and measurement uncertainties). In addition, this course will deal with multisource information fusion with applications to communications, signal processing and target tracking.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2022/23 academic year.
Please check with Instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. R. Tharmarasa
Email: thamas@mcmaster.ca
Office: ITB-A317
Phone: 905-525-9140 ext. 26503
Office Hours: By appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Implement a multitarget tracker to handle false alarms and miss detections.
- Select a suitable tracker/filter for a given tracking problem.
- Evaluate the performance of a tracker/fuser.
- Compare different tracking algorithms.
- Fuse tracks/measurements from multiple sources optimally.
- Develop an algorithm for a resource management problem.

ASSUMED KNOWLEDGE

Programming in MATLAB

COURSE MATERIALS

Textbooks:

1. Y. Bar-Shalom, P.K. Willet and X. Tian, *Tracking and Data Fusion: A Handbook of Algorithms*, YBS publishing, 2011.

Additional References:

1. Y. Bar-Shalom, X. Rong Li and T. Kirubarajan, *Estimation with Applications to Tracking and Navigation*, John Wiley & Sons, 2001.
2. Y. Bar-Shalom and X. R. Li, *Multitarget-Multisensor Tracking: Principles and Techniques*, Storrs, CT: YBS Publishing, 1995.
3. S. Blackman and R. Popoli, *Design and Analysis of Modern Tracking Systems*, Artech House, 1999.

COURSE OVERVIEW

Week	Topic
1	Introduction to target tracking
2	Performance evaluation
3	Tracking with multiple sensors
4	Track initialization and track management
5	Algorithms for tracking a single target in clutter
6	Algorithms for tracking multiple targets in clutter
7	Extended target tracking
8	Track-to-track fusion
9	Performance prediction
10	Resource management
11	Nonlinear filters (PF, UKF,..)
12	Sensor registration
13	Practical issues

Note: all timings are approximate.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date

Class participation	10%
Homework assignments	60%
Project	30%
Total	100%

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ECE 769
Special Topics in Signal Processing: Advanced Speech and Audio Processing

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course provides an introduction to advanced concepts and methodologies for the analysis, modeling, synthesis and coding of speech and audio, such as: pole-zero speech models, sinusoidal analysis/synthesis, filter-bank analysis/synthesis, homomorphic signal processing, and speech coding. These approaches are fundamental to a wide range of modern applications of speech and audio processing. Students will learn how to use MATLAB for the analysis and manipulation of speech and audio and gain practical experience in the design and implementation of speech and audio processing algorithms.

SCHEDULE AND MODE OF DELIVERY

The material for this course will be delivered through assigned textbook readings and subsequent discussions during the scheduled live lectures.

INSTRUCTOR

Dr. Ian C. Bruce
Email: brucei@mcmaster.ca (Email alias: ibruce@ieee.org)
Office Hours: By appointment.

COURSE WEBSITE/S

http://avenue.mcmaster.ca

COURSE OBJECTIVES

To:
- gain an understanding of advanced concepts and methodologies for the analysis, modeling, synthesis and coding of speech and audio
- develop proficiency in designing and implementing speech and audio processing algorithms in MATLAB

ASSUMED KNOWLEDGE

A strong understanding of the fundamentals of digital signal processing, and some experience in programming in MATLAB.

COURSE MATERIALS

Primary Textbook:
Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, 2001, Prentice Hall.

Secondary References:
Gold & Morgan, Speech and Audio Signal Processing: Processing and Perception of Speech and Music, 1999, John Wiley & Sons.
Deller, Hansen & Proakis, Discrete-Time Processing of Speech Signals, 1993, Macmillan (Reprinted in 2000 by Wiley-Interscience and IEEE Press).
Oppenheim, Shafer & Buck, Discrete-time Signal Processing (2nd edition),1998, Prentice Hall.
A selection of recent journal and conference papers.

Other:
MATLAB

COURSE OVERVIEW

Week	Topic
1	Introduction to the Production and Classification of Speech Sounds
2	Acoustics of Speech Production
3 & 4	Analysis and Synthesis of Pole-Zero Speech Models
5 & 6	Homomorphic Signal Processing
7 & 8	Filter-Bank Analysis/Synthesis
9	Sinusoidal Analysis/Synthesis
10 & 11	Speech Coding

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight
Assignments (3 × 20 %)	60 %
Project	40 %
Total	100 %

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ECE 778
Introduction to Nanotechnology

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course provides a fundamental knowledge in nanotechnology. It focuses on the new physical phenomena due to the reduction of device dimension and the new applications as a result of these new phenomena. The topics include nano-materials, nano-processing, nanoelectronics, nano-photonics, nano-biotechnology, nano-MEMS and nano-integration. Students will learn what should be considered in the nano-world, what new applications we might be benefited from, and what precautions we need to pay attention when dealing with issues in the nano-world.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through a mixture of in-person lectures, assignments, and a final project.

INSTRUCTOR

Dr. Matiar Howlader
Email: howladm@mcmaster.ca
Office: ITB-A216
Phone: 905-525-9140 ext. 26647
Office hours: by appointment

COURSE WEBSITE/S

http://avenue.mcmaster.ca/

COURSE OBJECTIVES

By the end of this course students will learn what should be considered in the nanoworld, what new applications we might be benefited from, and what precautions we need to pay attention when dealing with issues in the nanoworld.

ASSUMED KNOWLEDGE

Basic fundamental knowledge in Materials, Physics, and Chemistry as well as their applications in health, environmental and energy harvesting areas.

COURSE MATERIALS

Lecture notes and research articles will be provided by the instructor.

Reference Books:

1. Zheng Cui, Nanofabrication: Principles, Capabilities and Limits, Springer; 2nd edition, 2017.
2. Christo Papadopoulos, Nanofabrication: Principles and Applications, Springer; 1st Ed, 2016.
3. Francesca Iacopi, John J. Boeckl, Chennupati Jagadish, Semiconductors and Semimetals 2D Materials, Elsevier, Volume 95, 2016.
4. James E. Morris, Nanopackaging: Nanotechnologies and Electronics Packaging, Springer; 2nd edition, May 2017.
5. Zhaoying Zhou, Z. Wang, and Liwei Lin, Microsystems and Nanotechnology, Springer 2012.
6. Rao Tummala, Fundamentals of Microsystems Packaging, McGraw-Hill Professional; 1st edition, May 8, 2001.
7. P. Rai-Choudhury, MEMS and MOEMS Technology and Applications, SPIE Publications, December 1, 2000.

COURSE OVERVIEW

Week	Topic
1	Overview of Nanotechnology and Nanomaterials
2	Deposition-Nanofabrication
3	Etching-Nanofabrication
4	Nanofabrication-Nanocharacterization
5	Transition metal dichalcogenides
6	Advances in two-dimensional (2D) materials
7	2D Boron nitride
8	Student presentation 1 (Nanofabrication of 2D Nanomaterials)
9	2D Black phosphorus
10	Student Presentation 2 (2D Nanomaterial applications)
11	Nanointegration 1
12	Nanointegration 2
13	Final project (Systems integration)

ASSESSMENT

Component	Weight	Due Date

Presentations	40 %
Assignments	30 %
Final Project	30 %
Total	100 %

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).

CONDUCT EXPECTATIONS

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ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

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arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

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EXTREME CIRCUMSTANCES

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RESEARCH ETHICS

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www.eng.mcmaster.ca/ece

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial "88" after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to

disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.
Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!
In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 780
Medical Imaging Systems II

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

This course will compliment Medical Imaging Systems I. In this course imaging methods that rely on non-ionizing radiation will be discussed. The course content focuses on magnetic resonance imaging (MRI), in vivo nuclear magnetic resonance (NMR), ultrasound (US), and optical imaging methods. Advanced concepts such as multi-modality imaging approaches, image fusion, and functional medical image processing will be discussed.

SCHEDULE And MODE OF DELIVERY

McMaster expects to be fully in-person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

INSTRUCTOR

Dr. Michael Noseworthy
Email: nosewor@mcmaster.ca
Office: SJH, F-130
Phone: 905-522-1155 ext. 35218
Office Hours: by appointment

COURSE WEBSITE/S

http://www.ece.mcmaster.ca/~mikenose/web/HOME.html

COURSE OBJECTIVES

This course is designed to allow students to become familiar with medical imaging technologies both from a physics and engineering perspective through to a practical perspective. The course will focus primarily on magnetic resonance techniques (e.g. MRI, in vivo NMR, etc.). Occasional comparisons with other imaging modalities (e.g. PET, SPECT, ultrasound, mammography, CT,

EEG, MEG) will be made where appropriate. In addition, throughout the course, students will learn the most frequent artefacts, their causes and potential solutions.

ASSUMED KNOWLEDGE

Students taking this course are expected to already have solid knowledge in anatomy, physiology, electromagnetics and magnetic resonance imaging (MRI).

COURSE MATERIALS

Textbooks:

1). Handbook of MRI Pulse Sequences (2004) Matt A. Bernstein et al.

2). Magnetic Resonance Imaging: Physical Principles and Sequence Design, 2nd edition. (2014) Robert W. Brown, et al.

COURSE OVERVIEW

Week	Topic
1	Classical response of a single nucleus to a magnetic field, rotating and lab frames of reference; magnetization, relaxation and Bloch equation.
2	Quantum mechanical description of MRI. quantum mechanical basis of precession and excitation, thermal equilibrium and longitudinal relaxation.
3	RF pulses and signal detection. RF coils (surface coil, T/R switches, birdcage, phased array), B1 - and B1 + fields, B1 + mapping.
4	Introductory signal acquisition methods: free induction decay, spin echoes, inversion recovery, and spectroscopy
5	One and multidimensional Fourier imaging. Slice excitation and k-space.
6	Sampling (uniform and non-uniform), image reconstruction, signal, contrast and noise.
7	Water/fat imaging and chemical selective / suppression methods.
8	Fast imaging in steady state, fast/turbo spin echo, echo planar imaging, spiral and irregularly sampled imaging.
9	Magnetic field inhomogeneity effects and $T2*$ dephasing
10	Motion artifacts, motion sensitizing gradients, measuring spin motion using phase contrast, time-of-flight and diffusion.
11	Electromagnetic properties of tissues, magnetic susceptibility, current density imaging, quantitative susceptibility mapping (qSM).
12	Multinuclear spectroscopy and imaging. Physiologically important non-proton nuclei, quadrupolar nuclei.
13	Multi-modal image fusion. Atlases. Data mining, Big data.

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

LABORATORY OVERVIEW –DELETE IF NOT REQUIRED

Week	Topic
1	
2	
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12	
13	

LABORATORY OPERATION- DELETE IF NOT REQUIRED

- Fill in appropriate lab operation requirements

ASSESSMENT

Component	Weight	Due Date
Presentations (3 each worth 20 %)	60 %	
Final Exam	40 %	
Total	100 %	

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).
No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

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www.eng.mcmaster.ca/ece

Delete if no labs2

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.

3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial "88" after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

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In Case of a Fire (Dial 88)

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1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a

prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.

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Defined Roles

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ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca

ECE 788
Control of Adjustable Speed Drives

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

AC machine modeling and their control design tools are presented. The focus is on permanent-magnet (PM) and induction machines (IM) supplied by voltage-source inverters. Field-Oriented Control, with and without mechanical sensor, is developed. Common failures in adjustable speed drives are introduced and their effect on the drive performance is analyzed. Fault-tolerant drives are studied and some practical examples from industry are presented. Principal concepts are developed with projects using Matlab/Simulink.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded). Please see the course website for the platform for each component.

INSTRUCTOR

Dr. Babak Nahid-Mobarakeh
Email: babak.nahid@mcmaster.ca
Office: ITB-A310
Phone: 905-525-9140 ext. 23871
Office Hours**:** by appointment

McMaster expects to be fully in-persno in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.

COURSE WEBSITE/S

Course instructions and lecture material will be posted via Avenue to Learn, the McMaster University electronic learning system, accessible at http://avenue.mcmaster.ca/

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Model a PM drive for control purposes
- Model an IM drive for control purposes
- Design and implement current controller for PM and IM drives
- Design and implement mechanical sensorless control for a PM drive
- Model a PM drive under interturn short-circuit
- Detect interturn short-circuit fault in a PM drive
- Design and implement fault-tolerant control of a PM drive

ASSUMED KNOWLEDGE

Fundamentals of AC machines, Linear control systems, Modern control systems, Observers.

COURSE MATERIALS

Required texts:
Lecture notes and uploaded documents to the course website.

Recommended textbook:
Jean-Paul Louis, Control of Synchronous Motors, Wiley ISTE 2011.
https://onlinelibrary.wiley.com/doi/book/10.1002/9781118601785

COURSE OVERVIEW

Topic	Week
1. Introduction to Adjustable Speed Drives (ASD)	1
2. Modeling of PMSM for Control Purposes (Topic 1)	1
3. Average Modeling of Voltage-Source Inverters (Topic 2)	2
4. Vector Control of PMSM (Topic 3)	3
5. Torque and Speed Control of PMSM (Topic 4)	3-4
6. Field-Oriented Control of IM (Topic 5)	4-5
7. Common Failures in ASD (Topic 6)	6
8. Modeling of ASD Under Fault Conditions (Topic 7)	7-8
9. Fault-Tolerant Capability of ASD (Topic 8)	8-9-10
10. Fault-Tolerant Control of ASD (Topic 9)	10-11-12
11. Conclusion and Wrap-Up	13

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

LABORATORY OVERVIEW

Four Labs on modeling and control of AC drives. They are all simulation using MATLAB-Simulink (no specific toolbox required), no practical experiments on high-power/high-voltage setups is done.

Lab 1: Modeling of Permanent-Magnet Synchronous Machines (PMSM) (Week 2)
Lab 2: Torque and speed control of PMSM: controller design and test (Week 5)
Lab 3: Speed/position sensor failure and mechanical sensorless control of PMSM (Week 9)
Lab 4: Fault-detection and fault-tolerant control of PMSM (Week 12)

LABORATORY OPERATION

- Lab Experiments: Every student conducts the lab experiment individually.
- Lab Requirements: Students need to submit their experiment results on Avenue to Learn on the due date described in the lab manual. No late submission will be accepted.

ASSESSMENT

Component	Weight
Lab reports (4 x 10%)	40%
Final project: report	40%
Final project: oral presentation	20%
Total	**100%**
Writing a paper (bonus)	+10%

Final project report is subject to 20% penalty per day (less than one day is counted as one day). No late submission will be accepted for the paper.

CONDUCT EXPECTATIONS

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www.eng.mcmaster.ca/ece

ECE 798
Biomedical Signal Modelling and Processing

COURSE OUTLINE

Please refer to course website for updated information.

CALENDAR DESCRIPTION

A key to efficient biomedical signal processing is a fundamental understanding of physical models, simplified but adequate mathematical models, and statistically efficient signal processing algorithms. This course will expose students to advanced signal processing techniques and illustrate their application to biomedical signal processing and diagnostic imaging.

SCHEDULE And MODE OF DELIVERY

The material for this course will be delivered through a mixture of online videos, textbook readings, live online lectures and tutorials (which are also recorded), and virtualized laboratories and projects. The platform for each component is noted at the end of each line.

Lecture: Tuesdays 2:30 p.m. – 5:30 p.m. Microsoft Teams
Lab: Not applicable

INSTRUCTOR

Dr. Aleksandar Jeremic
Email: jeremic@mcmaster.ca
Office: ITB-A214
Phone: 905-525-9140 ext. 27894
Office Hours**:** Thursdays 12:30pm - 2:00pm ; and by appointment

McMaster expects to be fully in person in the 2022/23 academic year.
Please check with instructor and/or Avenue to Learn for Schedule and Mode of Delivery.\

COURSE WEBSITE/S

Avenue to Learn.

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Develop statistical model describing physiological data
- Apply parameter estimation techniques in order to determine statistical properties of the real signals
- Implement machine learning techniques to physiological signals in order to identify statistically different clusters of data
- Understand several basic clustering/classification techniques

ASSUMED KNOWLEDGE

Prerequisites: For MASc and MEng students only.
Linear algebra and basic signal processing theory. Students should also be familiar with MATLAB.

COURSE MATERIALS

Recommended Reading: Lecture notes and reference papers.

R. M. Gulrajani, Bioelectricity and Biomagnetism, John Wiley & Sons,
1998, New York.

COURSE OVERVIEW

Week	Topic
1	Biological signals – heart (ECG/MCG) – brain (EEG/MEG) – muscle (EMG)
2-5	Physiological Modeling : brain and heart dipole models, spatio-temporal analysis, finite elements and boundary elements models
6-9	Signal Processing : estimation of physiological parameters using repeated measurements, analysis of deterministic and random growth curves, model identification and selection
9-11	Clustering and classification
12-13	Machine Learning in Biomedical Signal processing

A more detailed time line is available on the course web site.

At certain points in the course it may make good sense to modify the schedule. The instructor may modify elements of the course and will notify students accordingly (in class, on the course website).

ASSESSMENT

Component	Weight	Due Date
3 Projects	70 %	
Final Exam	30 %	
Total	100 %	

Late submissions of assignments or project report are subject to 20% penalty per day (less than one day is counted as one day).
No make-up midterm tests will be granted. Weight of a missed midterm test will be transferred to final exam.

CONDUCT EXPECTATIONS

As a McMaster graduate student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

ACADEMIC ACCOMMODATIONS OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf.

www.eng.mcmaster.ca/ece

Delete if no labs2

Electrical and Computer Engineering Lab Safety

Information for Laboratory Safety and Important Contacts

This document is for users of ECE instructional laboratories in the Information Technology Building.

This document provides important information for the healthy and safe operation of ECE instructional laboratories. This document is required reading for all laboratory supervisors, instructors, researchers, staff, and students working in or managing instructional laboratories in ECE. It is expected that revisions and updates to this document will be done continually. A McMaster University lab manual is also available to read in every laboratory.

General Health and Safety Principles

Good laboratory practice requires that every laboratory worker and supervisor observe the following:

1. Food and beverages are not permitted in the instructional laboratories.
2. A Laboratory Information Sheet on each lab door identifying potential hazards and emergency contact names should be known.
3. Laboratory equipment should only be used for its designed purpose.
4. Proper and safe use of lab equipment should be known before using it.
5. The course TA leading the lab should be informed of any unsafe condition.
6. The location and correct use of all available safety equipment should be known.
7. Potential hazards and appropriate safety precautions should be determined, and sufficiency of existing safety equipment should be confirmed before beginning new operations.
8. Proper waste disposal procedures should be followed.

Location of Safety Equipment

Fire Extinguisher
On walls in halls outside of labs

First Aid Kit
ITB A111, or dial “88” after 4:30 p.m.

Telephone
On the wall of every lab near the door

Fire Alarm Pulls
Near all building exit doors on all floors

Who to Contact

Emergency Medical / Security: On McMaster University campus, call Security at extension **88** or **905-522-4135** from a cell phone.
Non-Emergency Accident or Incident: Immediately inform the TA on duty or Course Instructor.
University Security (Enquiries / Non-Emergency): Dial 24281 on a McMaster phone or dial 905-525-9140 ext. 24281 from a cell phone.
See TA or Instructor: For problems with heat, ventilation, fire extinguishers, or immediate repairs
Environmental & Occupational Health Support Services (EOHSS): For health and safety questions dial 24352 on a McMaster phone or dial 905-525-9140 ext. 24352 from a cell phone.
ECE Specific Instructional Laboratory Concerns: For non-emergency questions specific to the ECE laboratories, please contact 24103.

In Case of a Fire (Dial 88)

When calling to report a fire, give name, exact location, and building.

1. Immediately vacate the building via the nearest Exit Route. Do not use elevators!
2. Everyone is responsible for knowing the location of the nearest fire extinguisher, the fire alarm, and the nearest fire escape.
3. The safety of all people in the vicinity of a fire is of foremost importance. But do not endanger yourself!
4. In the event of a fire in your work area shout "*Fire!*" and pull the nearest fire alarm.
5. Do not attempt to extinguish a fire unless you are confident it can be done in a prompt and safe manner utilizing a hand-held fire extinguisher. Use the appropriate fire extinguisher for the specific type of fire. Most labs are equipped with Class A, B, and C extinguishers. Do not attempt to extinguish Class D fires which involve combustible metals such as magnesium, titanium, sodium, potassium, zirconium, lithium, and any other finely divided metals which are oxidizable. Use a fire sand bucket for Class D fires.
6. Do not attempt to fight a major fire on your own.
7. If possible, make sure the room is evacuated; close but do not lock the door and safely exit the building.

Clothing on Fire

Do not use a fire extinguisher on people

1. Douse with water from safety shower immediately or
2. Roll on floor and scream for help or
3. Wrap with fire blanket to smother flame (a coat or other nonflammable fiber may be used if blanket is unavailable). Do not wrap a standing person; rather, lay the victim down to extinguish the fire. The blanket should be removed once the fire is out to

disperse the heat.

Equipment Failure or Hazard

Failure of equipment may be indicative of a safety hazard - You must report all incidents.
Should you observe excessive heat, excessive noise, damage, and/or abnormal behaviour of the lab equipment:

1. Immediately discontinue use of the equipment.
2. In Power Lab, press wall-mounted emergency shut-off button.
3. Inform your TA of the problem.
4. Wait for further instructions from your TA.
5. TA must file an incident report.

Protocol for Safe Laboratory Practice

Leave equipment in a safe state for the next person - if you're not sure, ask!
In general, leave equipment in a safe state when you finish with it. When in doubt, consult the course TA.

Defined Roles

TA	The first point of contact for lab supervision	
ECE Lab Supervisor	Steve Spencer- ITB 147	steve@mail.ece.mcmaster.ca
ECE Course Instructor	Please contact your specific course instructor directly	
ECE Administrator	Kerri Hastings- ITB A111	hastings@mcmaster.ca
ECE Chair	Tim Davidson- ITB A111	davidson@mcmaster.ca