Instructor:
Professor J.R. Green, P.Eng., room 6203CB, e-mail jrgreen@sce.carleton.ca (Please send from your connect account and include “SYSC5405/BIOM5405” in the subject line to ensure a response.)

Office hours: By appointment. See course CULearn site for additional hours.

Instructional Hours per Week:
3 lecture hours: Tuesdays & Thursdays 8:35-9:55. Check Carleton Central for location.

Calendar Information
Course Number: BIOM5405/SYSC5405
Course Title: Pattern Classification and Experiment Design
Calendar description: Introduction to a variety of supervised and unsupervised pattern classification techniques with emphasis on correct application. Statistically rigorous experimental design and reporting of performance results. Case studies will be drawn from various fields including biomedical informatics.
http://calendar.carleton.ca/grad

Prerequisites:
Undergraduate introductory probability and statistics.

Primary Textbook:

Other References:
5. Current literature describing applications of pattern classification.
6. Freely available MATLAB/JAVA/C++ implementations of pattern classification methods (e.g. Netlab and WEKA).
7. Additional materials may be made available on the course website.

   Items 1, 2, and 3 are on reserve at the CU Library.

Web Page:
All content is posted on the CULearn system. University of Ottawa students need to complete a form and submit it to the FGPA to gain access to CULearn for the term. Students are required to check CULearn often for course updates. Supplementary lecture notes will be posted there for student use. Note that reading the supplementary lecture notes only is NOT ENOUGH to pass this course! The single best predictor of student performance is attendance at lectures.
Grading Scheme:

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<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Problem Assignments</td>
<td>30%</td>
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<tr>
<td>Term project</td>
<td>30%</td>
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<tr>
<td>Final Exam</td>
<td>40%</td>
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Note that only portions of the assignment(s) may be used for purposes of evaluation.

The final examination is for evaluation purposes only and will not be returned to students. You will be able to make arrangements with the instructor or with the department office to see your marked final examination after the final grades have been made available.

Important Notes & General Regulations:

Students are expected to attend all lectures. If a student is absent from a lecture, it is up to the student to obtain missed lecture material from colleagues in the course.

Student Responsibility: It is the student's responsibility to remain informed of all rules, regulations and procedures required by their program and by the Faculty of Graduate and Postdoctoral Affairs. Ignorance of regulations will not be accepted as a justification for waiving such regulations and procedures.

Academic Integrity: Students should be aware of their obligations with regards to academic integrity. Please review the information about academic integrity at: https://carleton.ca/registrar/academic-integrity/. This site also contains a link to the complete Academic Integrity Policy that was approved by the University's Senate.

Plagiarism: Plagiarism (copying and handing in for credit someone else's work) is a serious instructional offense that will not be tolerated.

Deferred Term Work: Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases this must occur no later than three (3.0) working days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. For more information, see the current Graduate Calendar, Academic Regulations of the University, Section 9.3.

Academic Accommodation: You may need special arrangements to meet your academic obligations during the term. You can visit the Equity Services website to view the policies and to obtain more detailed information on academic accommodation at http://www.carleton.ca/equity/ For an accommodation request, the processes are as follows:

- **Pregnancy or Religious obligation**: Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see https://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf

- **Academic Accommodations for Students with Disabilities**: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (if applicable).
- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton’s Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: [https://carleton.ca/sexual-violence-support/](https://carleton.ca/sexual-violence-support/).

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see [https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf](https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf)

**Copyright on Course Materials:** The materials created for this course (including the course outline and any slides, posted notes, labs, project, assignments, quizzes, exams and solutions) are intended for personal use and may not be reproduced or redistributed or posted on any web site without prior written permission from the author(s).

**Health and Safety:** Every student should have a copy of our Health and Safety Manual. A PDF copy of this manual is available online: [http://sce.carleton.ca/courses/health-and-safety.pdf](http://sce.carleton.ca/courses/health-and-safety.pdf)

**Students from the University of Ottawa:** You can request to have access to cuLearn: please see [http://gradstudents.carleton.ca/forms-policies/](http://gradstudents.carleton.ca/forms-policies/)

**Week-by-Week Outline (subject to change):**

**Weeks 1-2:** Introduction to Pattern Classification. Data pre-processing, analysis, outlier detection, and transformations. Experiment design (feature selection & dimensionality, selecting classifier structure, test protocols, cross-validation, data partitioning, etc.). Introduction to hypothesis testing. Avoiding fundamental errors of testing on the training set and training on the test set.

**Week 3:** Reporting results. How to accurately and honestly report classification system performance. True error vs. apparent error. Confidence intervals, statistical tests to compare methods, receiver operator characteristic curves, sensitivity, specificity, confusion matrices, P-values. Class imbalance. Critical assessment of reported results in the literature.

Note that by introducing experiment design and reporting of results early in the course, applications discussed during all subsequent topics will be evaluated using these fundamental principles. The remainder of the course will survey a number of approaches to pattern classification. The depth of coverage will vary and will depend on time available. Relevant applications of pattern classification techniques from the literature will be discussed.


**Week 5:** Maximum likelihood and Bayesian parameter estimation. Non-parametric techniques such as Parzen windows, probabilistic neural networks, and K-nearest neighbour estimators and classifiers.

**Week 6:** Decision trees and decision forests. Training, pruning, splitting, and stopping criteria.

**Week 7:** Linear and nonlinear discriminant analysis. Linear discriminant functions and decision surfaces. Perceptron criterion, relaxation procedures, and MSE procedures. Generalized linear discriminant functions and support vector machines (briefly).
Week 8: Neural networks: network structure, feedforward operation and classification, backpropagation training.

Week 9: Markov chains, hidden Markov models, and expectation maximization.

Week 10: Meta-learner and re-sampling approaches including bagging and boosting. Combination of multiple experts: voting strategies and cascaded classifiers. Learning with queries.

Week 11: Unsupervised clustering (hierarchical, K-means, SOMs). Mixture densities, criterion functions for clustering, the number of cluster problem, and cluster validation.

Week 12/13: Student project presentations and competition. Review.