



**Faculty of Science**

Office of the Dean  
St. John's, NL Canada A1B 3X7  
Tel: 709 864 8154 Fax: 709 864 3316  
deansci@mun.ca [www.mun.ca/science](http://www.mun.ca/science)

**SPECIAL MEETING OF THE FACULTY COUNCIL OF THE FACULTY OF SCIENCE**

A special meeting of the Faculty Council of the Faculty of Science will be held on Friday, October 29, 2021, at 1:00 p.m. by Webex.

**AGENDA**

- 1. Regrets**
- 2. Reports of Standing Committees:**
  - A. Graduate Studies Committee:**
    - a.** Department of Computer Science, proposal for a new joint graduate program with the Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science, Master of Artificial Intelligence, Paper 2.A.a (pages 2-85);
    - b.** Department of Computer Science, proposal for a new joint graduate program with the Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science, Master of Applied Science in Software Engineering, Paper 2.A.b (pages 86-157).
- 3. Adjournment**

A handwritten signature in black ink, appearing to read "Travis Fridgen".

Travis Fridgen, Ph.D.  
Acting Dean of Science

Proposal for a new graduate program:  
Master of Artificial Intelligence  
Memorial University, St. John's, NL, Canada

<b>Name of the program</b>	Master of Artificial Intelligence
<b>Degree name in short form</b>	MAI
<b>Academic units</b>	Department of Computer Science, Faculty of Science, and Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science
<b>Administrative home of the program</b>	Faculty of Science
<b>Proponents</b>	Dr. Sharene Bungay (cs-chair@mun.ca) and Dr. Cheng Li (licheng@mun.ca)
<b>Date</b>	October 21, 2021
<b>Tentative start of the program</b>	Fall 2022

# Contents

<b>1</b>	<b>Executive summary</b>	<b>4</b>
<b>2</b>	<b>Description of the program</b>	<b>5</b>
2.1	Name of the program . . . . .	5
2.2	Graduate student profile . . . . .	5
2.3	Learning outcomes . . . . .	6
2.4	Key learning outcomes . . . . .	6
2.5	Requirements for admission . . . . .	6
2.6	Program overview . . . . .	7
2.6.1	Core courses . . . . .	7
2.6.2	Elective courses . . . . .	7
2.6.3	Program schedule . . . . .	7
<b>3</b>	<b>Statement of Justification</b>	<b>8</b>
3.1	Introduction . . . . .	8
3.2	Contribution to strategic goals of the University . . . . .	8
<b>4</b>	<b>Market analysis</b>	<b>9</b>
4.1	International and national comparison of related programs and unique attributes . . . . .	10
<b>5</b>	<b>Project enrolment</b>	<b>12</b>
<b>6</b>	<b>Resource implications</b>	<b>12</b>
6.1	Existing faculty resources . . . . .	13
6.2	New faculty resources . . . . .	14
6.3	Additional non-faculty resources . . . . .	14
6.4	Administration of the program . . . . .	15
<b>7</b>	<b>Budget</b>	<b>15</b>
7.1	Program expenses . . . . .	15
7.2	Revenue . . . . .	17
7.3	Payment schedule . . . . .	17
	<b>Appendix A: Library holdings evaluation</b>	<b>18</b>
	<b>Appendix B: Calendar regulations</b>	<b>19</b>
	<b>Appendix C: Course listings</b>	<b>21</b>

<b>Appendix D: Consultation</b>	<b>22</b>
<b>Appendix E: Faculty Bios</b>	<b>23</b>
<b>Appendix F: Canadian university survey of undergraduate and graduate programs in software engineering</b>	<b>31</b>

# 1 Executive summary

This proposal calls for the creation of the Master of Artificial Intelligence program housed in the Faculty of Science at Memorial University, but jointly offered by the Department of Electrical and Computer Engineering (Faculty of Applied Science and Engineering) and the Department of Computer Science (Faculty of Science). Artificial intelligence (AI) is increasingly being integrated and deployed in computer programs used in a wide variety of sectors such as finance, health care, social media, smart appliances, transportation, entertaining and security. With the massive amount of data that is generated in diverse areas such as life sciences, medicine, and humanities, AI systems will be critical for analyzing, extracting useful patterns and interpreting these data. The demand for graduates skilled on AI research and development is increasing, and offering AI programs has become a priority for almost all major universities. The proposed program is in direct alignment with the strategic goals of the University regarding information and communication technologies. Further, the proposed AI program has been designed with an internationally recognizable curriculum. The curriculum focuses on the fundamental aspects of the field with opportunities for specialization in a specific area of AI, and is intended to attract local, national and international students who want to enter this vital area. The establishment of the proposed AI program is not only timely but will also put Memorial University at the lead among the Atlantic Canadian universities. Specifically, the program is intended to yield advanced AI professionals to lead and facilitate innovation and commercialization in a wide variety of sectors.

## 2 Description of the program

The Master of Artificial Intelligence is a course-based Master's program intended for students who wish to gain the skills to integrate and deploy Artificial Intelligence in a variety of sectors. The Master of Artificial Intelligence (MAI) is a four-term, course-based Master's program to be offered jointly by the Faculty of Science and the Faculty of Engineering and Applied Science intended for students with a computer science, computer engineering or scientific computing background who wish to upgrade their background to specialize in artificial intelligence. The Master of Artificial Intelligence (MAI) is a four-term, course-based Master's program to be offered jointly by the Faculty of Science and the Faculty of Engineering and Applied Science. Graduates of the program will have knowledge and understanding of the core areas and methods of Artificial Intelligence and will be ready to work in applied positions in a variety of areas including but not limited to autonomous vehicles, decision support, intelligent sensing, precision agriculture, personalized medicine, financial security, smart appliances, and other emerging areas that will be vital to future economic growth. We foresee graduates working in both the private and public sectors locally in Newfoundland and Labrador and across Canada. We expect the program to attract students with a background in computer science, computer engineering, or related areas such as data science, scientific computing, bioinformatics, and computational chemistry.

The selection of core courses is intended to provide the foundations for AI and an overview of the areas in AI. The elective courses offer students the opportunity to dive deeper into specific areas of AI such as robotics, machine learning or image processing. The program distinguishes itself from the existing course-based option MSc in Computer Science and MASc in Computer Engineering by an increased focus on artificial intelligence and related topics, and a decreased emphasis on other areas of computer science and computer engineering.

### 2.1 Name of the program

The proposed name for the new program is Master of Artificial Intelligence (MAI).

### 2.2 Graduate student profile

Applicants must have a four-year undergraduate degree (or the equivalent) in computer science, computer engineering, or a related area such as data science, scientific computing, bioinformatics, and computational chemistry. Applicants must meet the English Proficiency requirements described under Section 4 (General Regulations), Subsection 4.1.5 (English Proficiency Requirements) of the School of

Graduate Studies Calendar. Admission will be competitive, selective, and based on overall academic performance.

### **2.3 Learning outcomes**

Students will graduate with a broad understanding of the main areas of Artificial Intelligence as well as in-depth knowledge in some of these areas. Students will acquire practical experience through course projects, and by completing a capstone project focusing on the application of artificial intelligence.

### **2.4 Key learning outcomes**

By completing the proposed MAI program, it is expected that a graduate shall be able to:

- Develop an in-depth understanding of artificial intelligence methods and techniques in areas such as machine learning, data mining, robotics, and image processing.
- Build the skills to design and develop, implement, integrate, and maintain artificial intelligence components into software related products.
- Refine and apply problem solving and analytical skills to identify which AI technique is best suited to address a problem and how to optimize its outcomes.

### **2.5 Requirements for admission**

Admission will be competitive, selective and based on overall academic performance. The Chair of the Program together with Graduate Studies committees of the departments will oversee the admission process to ensure that the proper policies and regulations are followed and the best candidates are offered admission. The minimum requirements are:

- Applicants must have a four-year undergraduate degree (or the equivalent) in computer science, computer engineering, or a related area such as data science, scientific computing, bioinformatics, and computational chemistry.
- Applicants must have taken at least one course in each of the following areas: linear algebra, vector calculus, statistics, and computer programming
- Applicants must meet the English Proficiency requirements described under Section 4 (General Regulations), Subsection 4.1.5 (English Proficiency Requirements) of the School of Graduate Studies Calendar.

## 2.6 Program overview

The program consists of 21 credit hours of core courses and 9 credit hours of elective courses, either from the list below or an approved replacement.

### 2.6.1 Core courses

---

<b>AI xxx0</b> Mathematics for AI
<b>AI xxx1</b> Topics in AI
<b>AI xxx2</b> Artificial Intelligence Capstone <sup>1</sup>
<b>COMP 6901</b> Applied Algorithms
<b>COMP 6915</b> Introduction to Machine Learning
<b>COMP 6980</b> Algorithmic Techniques for Artificial Intelligence
<b>ENGI 9818</b> Software Fundamentals

---

### 2.6.2 Elective courses

---

<b>COMP 6907</b> Data Mining Techniques and Methodologies
<b>COMP 6912</b> Autonomous Robotics
<b>COMP 6934</b> Introduction to Data Visualization
<b>COMP 6981</b> Data preparation techniques
<b>COMP xxxx</b> Advanced Machine Learning
<b>DSCI 6602</b> Deep Learning and Artificial Intelligence or <b>MATH 6205</b> Deep Learning
<b>DSCI 6601</b> Practical Machine Learning
<b>ENGI 9804</b> Image Processing and Applications
<b>ENGI 9805</b> Computer Vision or <b>COMP 6982</b> Computer Vision
<b>ENGI 9821</b> Digital Signal Processing
<b>ENGI 9826</b> Advanced Control Systems
<b>ENGI 9940</b> Advanced Robotics

---

### 2.6.3 Program schedule

The first term is preparatory in nature, covering key aspects from mathematics and computing that will be required for subsequent courses. The second term provides a broad introduction to Artificial Intelligence. The third and fourth terms focus on electives and a capstone course, allowing students to begin to specialize in their topics of greatest interest.

---

<sup>1</sup>Normally AI xxx2 will be taken in the final term.



<b>Term</b>	<b>Core courses</b>	<b>Elective courses</b>
Fall	AI xxx0 (Mathematics for AI) COMP 6901 (Applied Algorithms) ENGI 9818 (Software Fundamentals)	
Winter	COMP 6915 (Introduction to Machine Learning) COMP 6980 (Algorithmic Techniques for Artificial Intelligence) AI xxx1 (Topics in AI )	
Spring		Elective (2)
Fall	AI xxx2 (Capstone for AI)	Elective (1)

### 3 Statement of Justification

#### 3.1 Introduction

We are increasingly utilizing varied *smart* or *autonomous* technologies, that have artificial intelligence at the heart of their technological function. With an increased reliance on these technologies, there is an ever-increasing demand for specialists being able to envision how to solve problems with AI technologies, and develop, understand and maintain AI-based systems. Given the continuing demand for AI specialists, and the expected accelerated growth of this profession over the next few decades, the development of an artificial intelligence graduate degree has become a top priority for many major universities. The development of a master of artificial intelligence program at Memorial University is therefore especially timely, poising Memorial as a national leader in this transforming field.

#### 3.2 Contribution to strategic goals of the University

Memorial University’s Strategic Plan notes that we must strive to be “A University for Our Province”. With the increasing growth of technology companies in Newfoundland and Labrador using artificial intelligence, (e.g., Mysa, Nucliq, Verafin), producing highly skilled and highly trained AI specialists allows the University to directly fulfill an industrial need. Further, Memorial’s Strategic Research Plan, and specifically the “Information and Communication Technology” theme, specifically lists “intelligent computing”, “autonomous ocean systems”, and “managing (... processing) the vast amounts of data collected by businesses and other organizations” as priority areas. All these areas are related to and impacted by artificial intelligence. The formation of a artificial intelligence master’s program thus directly responds to the strategic research goals of the university.

## 4 Market analysis

Recent years have seen the use of artificial intelligence in a variety of sectors increased, and as a consequence of this, an accelerated growth in demand for artificial intelligence specialists. The United States Bureau of Labour Statistics identifies AI-relying industries such as Security with an estimate grow faster than the average grow for all workers in all industries.<sup>2</sup> It also estimates a growth of 22% in employment for Computer and Information Research Scientists from 2020-2030 with a 2020 median pay of \$126,830.<sup>3</sup> This is much higher than the median annual wage of \$41,950 for all occupations in the USA. By renewing the CIFAR Pan-Canadian Artificial Intelligence Strategy with a \$443.8 million commitment over 10 years starting in 2021-22,<sup>4</sup> the Canadian Government has recognized that artificial intelligence will play a key part in the Canadian economy. According to a recent report by Accenture, “54% of Canadian companies surveyed indicated that they have adopted AI at some level within their companies”.<sup>5</sup> Thus, there is and will be a pressing demand for graduates to enter this domain. The proposal of a course-based master in artificial intelligence at Memorial University is in direct response to the rapid expansion of this field. As an exceptionally interdisciplinary field, it is worth mentioning that Memorial University already has considerable research expertise in artificial intelligence distributed among the departments of Computer Science, Electrical and Computer Engineering, Mathematics and Statistics, and beyond. The consolidation of this expertise in a master program in artificial intelligence will allow Memorial to fill this demand in skilled AI specialists quickly. Additionally, by producing highly educated and skilled master’s graduate students in AI, we will help ensure that our graduates are prepared to enter the field at the top of the profession. The creation of a dedicated master’s program in artificial intelligence can, therefore, be seen as a timely approach for structuring the training of the next generation of AI professionals. Since the proposed course-based MAI

<sup>2</sup>Stanislava Ilic-Godfrey. “Artificial intelligence: taking on a bigger role in our future security”. In: *Beyond the Numbers: Employment & Unemployment* 10.9 (2021). URL: <https://www.bls.gov/opub/btn/volume-10/investigation-and-security-services.htm>.

<sup>3</sup>U.S. Department of Labor Bureau of Labor Statistics. *Occupational Outlook Handbook, Computer and Information Research Scientists*. 2021. URL: <https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm>.

<sup>4</sup>Government of Canada. *Helping Canadian Businesses Grow and Succeed*. URL: <https://www.budget.gc.ca/2021/report-rapport/p2-en.html#chap4>.

<sup>5</sup>accenture. *Pan-Canadian AI strategy: Shaping the AI ecosystem*. URL: <https://www.accenture.com/ca-en/insights/artificial-intelligence/pan-canadian-ai-strategy>.

program is intended to attract strong undergraduate students, we most notably expect to be able to offer a promising set of graduates to fulfill local industry demand in addition to growing local, national and international markets.

#### 4.1 International and national comparison of related programs and unique attributes

Globally, universities around the world have started graduate programs in artificial intelligence with a wide variety of curricula, including top universities such as Carnegie Mellon University, King's College London, and Imperial College London. Out of 96 Canadian universities surveyed (Appendix F), there are presently six universities, including Memorial, offering undergraduate options to specialize in artificial intelligence. These programs are the following.

1. Simon Fraser University, B.Sc. in Computing Science - Artificial Intelligence Concentration <sup>6</sup>
2. University of the Fraser Valley, B.Sc. in Computing Science - Artificial Intelligence and Data Mining Concentration <sup>7</sup>
3. University of Victoria, BSEng - Specialization Data mining and analysis, artificial intelligence, and machine learning <sup>8</sup>
4. Memorial University of Newfoundland, B.Sc. in Computer Science (Smart Systems) <sup>9</sup>
5. University of Toronto, Artificial Intelligence Engineering <sup>10</sup>
6. McGill University, BEng - Minor Applied Artificial Intelligence <sup>11</sup>

Of those same 96 Canadian universities surveyed, eleven are offering masters programs in artificial intelligence. These degrees are listed below.

---

<sup>6</sup><https://www.sfu.ca/computing/prospective-students/undergraduate-students/programs/degree-programs/areas-of-concentration.html>

<sup>7</sup>[https://www.ufv.ca/calendar/current/ProgramsC-E/COMP\\_MAJOR.htm](https://www.ufv.ca/calendar/current/ProgramsC-E/COMP_MAJOR.htm)

<sup>8</sup><https://www.uvic.ca/ecs/software/current-students/specializations/index.php>

<sup>9</sup><https://www.mun.ca/computerscience/undergraduates/programs/major-in-computer-science/smart-systems-stream>

<sup>10</sup><https://future.utoronto.ca/undergraduate-programs/artificial-intelligence-engineering>

<sup>11</sup><https://www.mcgill.ca/study/2021-2022/faculties/engineering/undergraduate/programs/bachelor-engineering-beng-minor-applied-artificial-intelligence>

1. University of Alberta, M.Sc. in Computing Science with specialization in Statistical Machine Learning <sup>12</sup>
2. Lakehead University, M.Sc. in Computer Science with specialization in Artificial Intelligence <sup>13</sup>
3. Queen's University
  - Master of Management in Artificial Intelligence <sup>14</sup>
  - MAsc with a field of study in Artificial Intelligence <sup>15</sup>
4. Ryerson University, MEng with AI concentration <sup>16</sup>
5. University of Guelph, Collaborative Specialization in Artificial Intelligence (CSAI) <sup>17</sup>
6. University of Ottawa, Master of Computer Science Concentration in Applied Artificial Intelligence <sup>18</sup>
7. University of Waterloo, Master of Data Science and Artificial Intelligence (MDSAI) <sup>19</sup>
8. University of Windsor, M.Sc. in Computer Science - Artificial Intelligence Stream <sup>20</sup>
9. Western University, Vector Institute Accredited Graduate Collaborative Specialization in Artificial Intelligence (CSAI) <sup>21</sup>
10. York University

---

<sup>12</sup>[https://calendar.ualberta.ca/preview\\_program.php?catoid=34&poid=38981](https://calendar.ualberta.ca/preview_program.php?catoid=34&poid=38981)

<sup>13</sup><https://www.lakeheadu.ca/programs/graduate/programs/masters/computer-science>

<sup>14</sup>[https://smith.queensu.ca/grad\\_studies/mmai/](https://smith.queensu.ca/grad_studies/mmai/)

<sup>15</sup><https://www.ece.queensu.ca/graduate/masc/field-of-study-in-ai.html>

<sup>16</sup><https://www.ryerson.ca/electrical-computer-biomedical/electrical-computer-graduate/meng-ai>

<sup>17</sup><https://calendar.uoguelph.ca/graduate-calendar/collaborative-specializations/artificial-intelligence/>

<sup>18</sup><https://catalogue.uottawa.ca/en/graduate/master-computer-science-specialization-artificial-intelligence/>

<sup>19</sup><https://uwaterloo.ca/graduate-studies-academic-calendar/mathematics/data-science-and-artificial-intelligence/master-data-science-and-artificial-intelligence-mdsai>

<sup>20</sup><https://www.uwindsor.ca/science/computerscience/1193/msc-artificial-intelligence-stream>

<sup>21</sup><https://www.csd.uwo.ca/graduate/future/vector-institute-program.html>

- M.Sc. in Computer Science with Specialization in Artificial Intelligence <sup>22</sup>
  - Master of Management in Artificial Intelligence (MMAI) <sup>23</sup>
11. Université Laval, Professional Master's in Computer Science - Artificial Intelligence <sup>24</sup>

Additionally there are eight other Canadian Universities (namely University of Toronto, University of Alberta, University of Calgary, University of Winnipeg, Dalhousie University, St Francis Xavier University, McGill University, and Université de Montreal) that offer certificates or diplomas in Artificial Intelligence. This year the Université de Moncton announced that a new Centre for Artificial Intelligence will be created to, among other goals, deliver new programs <sup>25</sup>. Thus, the proposed MAI program will place Memorial University at the forefront of Atlantic Universities. Memorial University is in the unique position of offering a Master of Artificial Intelligence in which students can learn and apply the fundamental AI techniques, jointly delivered by both the department of Computer Science, and the department of Electrical and Computer Engineering.

Given the rapid development in the field of artificial intelligence, which is only expected to accelerate over the coming decade, and to leverage the current expertise at Memorial, we propose a Master of Artificial Intelligence graduate program that covers several areas of artificial intelligence, with a slightly stronger focus on machine learning. In proposing a program that is focused on the fundamental aspects of this field rather than specific areas of application, our prospective students will be appropriately prepared for applying AI in a wide variety of sectors and the ever-evolving job market.

## 5 Project enrolment

Projected five year enrolment is provided in Table 1.

## 6 Resource implications

The Faculty of Science and the Faculty of Engineering and Applied Science, and in particular the departments of Computer Science and Electrical and Computer

<sup>22</sup><https://eecs.gradstudies.yorku.ca/ai/>

<sup>23</sup><https://schulich.yorku.ca/programs/mmai/>

<sup>24</sup><https://iid.ulaval.ca/en/training/professional-masters-computer-science-artificial-intelligence/>

<sup>25</sup><https://www.nbpower.com/en/about-us/news-media-centre/news/2021/universite-de-moncton-creates-centre-for-artificial-intelligence-in-partnership-with-nb-power>

Table 1: Projected 5-year enrolment. Enrolment as of Fall semester of each year.

Type/year	Year 1	Year 2	Year 3	Year 4	Year 5
FT enrolment	15	20	25	30	30
PT enrolment	-	-	-	-	-
Canadian enrolment	2	2	2	2	2
International enrolment	13	18	23	28	28
On-campus	15	20	25	30	30
Online	-	-	-	-	-
Thesis	-	-	-	-	-
Non-thesis	15	20	25	30	30
Total	15	20	25	30	30

Engineering, have both the teaching and research expertise relevant to the core components of artificial intelligence. Significant research involving artificial intelligence is conducted in both faculties, and many faculty members have existing expertise that can contribute to the success of the program. In fact, the interest in AI across the university can be used to enrich the program through, for example, the capstone project as well as enlarging the pool of elective courses.

The program requirements of proprietary software will be minimal because most AI applications are developed in open access languages such as Python and R using open access packages such as Python’s TensorFlow and scikit-learn, and R’s caret. However, students still need access to high performance computing facilities and, depending upon enrolment, the department’s computer lab facilities may be overwhelmed. Should such an eventuality arise, a portion of the generated revenue would need to be directed to address this. Meanwhile, some alternatives have been sought. For example, the Centre for Health Informatics and Analytics of the Faculty of Medicine hosts a cluster with big data analysis capabilities, and students whose adviser holds an affiliation with the Faculty of Medicine may be granted access to the computing resources. Additionally, students whose adviser has a Compute Canada account may be granted access to Compute Canada resources.

## 6.1 Existing faculty resources

Below a list of faculty members with teaching and research expertise relevant to the core components of artificial intelligence is provided. Their bios are provided in Appendix D.

- Alex Bihlo, Faculty of Science

- Dave Churchill, Faculty of Science
- Stephen Czarnuch, FEAS
- Octavia A. Dobre, FEAS
- Matthew Hamilton, Faculty of Science
- Mohsin Jamil, FEAS
- Xianta Jiang, Faculty of Science
- Cecilia Moloney, FEAS
- Theodore Norvell, FEAS
- Siu O'Young, FEAS
- Lourdes Peña Castillo, Faculty of Science
- Dennis K. Peters, FEAS
- Karteek Popuri, Faculty of Science
- Sarah Power, FEAS
- Reza Shahidi, FEAS
- Hamid Usefi, Faculty of Science
- Andrew Vardi, Faculty of Science/FEAS
- Thumeera Wanasinghe, FEAS

## **6.2 New faculty resources**

The Department of Computer Science is seeking two tenure-track faculty to support the delivery of the program.

## **6.3 Additional non-faculty resources**

The proposed program will use some of the existing courses offered in the departments of Computer Science and Electrical and Computer Engineering. However, it will require of four new on-campus courses, including a capstone project course; additional sections to existing courses; and the teaching time to offer a comprehensive selection of elective courses.

## 6.4 Administration of the program

The proposed Master of Artificial Intelligence program will be administered by the Dean of the Faculty of Science, who will appoint a Board of Studies (BoS) Chair. The Chair will form the joint board with members from the Department of Computer Science and the Department of Electrical and Computer Engineering. The chair must work in conjunction with the department heads of Computer Science and Electrical and Computer Engineering, or their representatives, in all relevant matters concerning the program. The Board will meet regularly to deal with admissions, student progress reviews, changes to the curriculum and content, and review the regulations governing the program.

## 7 Budget

The proposed budget for the Master of Artificial Intelligence (MAI) program is provided in Table 2 with different enrolment scenario. The budget of the enrolment is based on one local student from Newfoundland and Labrador (NL), one Canadian student (non-NL) and one international student each year, where the program fees and special fees of Canadian students will be lower than the international students, and the rest will be international students. As per the budget, program will have a break-even with about 25 - 30 students. With the strong demand in this subject area, it is expected that the program will reach its intended capacity within four years. Surplus of revenues will be used to support students through upgrades in technology as well as entrance scholarship, in-program scholarship, and bursaries for students.

As detailed in the market analysis, there is a high demand for the MAI program. However, in case of low enrolments, efforts will be taken to improve the intake by different recruitment strategies with available Memorial resources. The complementary sister program (Master of Applied Science in Software Engineering, MAScSE) as well as other existing course based programs in the Faculty of Science and the Faculty of Engineering and Applied Science will provide a large pool to attract students from outside, and will serve as a large buffering zone in case one program experiences short term enrolment challenges.

### 7.1 Program expenses

The major part of the expenses is the salary portion of two tenure track faculty positions. It is highly necessary as AI is a fast growing area globally. It is hard to attract highly qualified candidates without such positions. Those faculty members



Table 2: Proposed budget for Masters of Artificial Intelligence

		Year 1	Year 2	Year 3	Year 4	Year 5
Enrolments (students)	International student	13	18	23	28	28
	Canadian student	1	1	1	1	1
	NL student	1	1	1	1	1
	<b>Total student</b>	15	20	25	30	30
Revenue	Program fees	138,810	187,140	235,470	283,800	283,800
	Special fees	294,270	395,680	497,090	598,500	598,500
	Other revenue	-	-	-	-	-
	<b>Total Revenue</b>	433,080	582,820	732,560	882,300	882,300
	Revenue to MUN central account	138,810	187,140	235,470	283,800	283,800
	VP office fee (20% of gross)	58,854	66,967	99,418	119,700	119,700
	Revenue to FEAS and FS	235,416	316,544	397,672	478,800	478,800
Expenditures (Instructional & Adminis- trative costs)	Tenure-track professor (incl. benefits, 2 positions)	240,000	240,000	240,000	240,000	240,000
	Per-course instructor (3 positions)	17,284	17,284	17,284	17,284	17,284
	Teaching assistantships (5 positions)	6,719	6,719	6,719	6,719	6,719
	Administration support	34,287	34,287	34,287	34,287	34,287
Expenditures (Materials, Supplies, and Recruitment costs)	Course related materials, int'l scholarships and equipment (@2,000 per student)	30,000	50,000	50,000	60,000	60,000
	Recruitment expenses and travel expenses	10,000	10,000	10,000	10,000	10,000
	Recruitment agency commission (@2,568 per student)	33,380	59,058	59,058	71,896	71,896
	Entrance scholarship to Canadian student	5,000	5,000	5,000	5,000	5,000
	<b>Total Expenditures</b>	574,335	665,786	757,236	848,687	848,687
	<b>Net Balance</b>	\$(141,255)	\$(82,966)	\$(24,676)	\$33,613	\$33,613

are also expected to be actively engaged in research and graduate student supervision. Three per-course instructors are considered to complement additional teaching tasks. As per the Memorial regulations, 20% of the gross income will contribute to the Provost Office expenses. Other expenses include teaching assistantship, faculty administration support, program related materials, equipment and scholarships, recruitment expense and travel expense, and recruitment agency commissions.

## 7.2 Revenue

The revenue for the program is generated based on the student's regular program fee plus the special fee. The regular fees of the program are \$9,666, \$7,434, and \$5,718 for international students, Canadian students, and Newfoundland students, respectively. The special fees of the program are \$20,282 for international students, and \$15,302 for Canadian and Newfoundland students.

## 7.3 Payment schedule

Based on the proposed budget, a payment schedule (Table 3) is proposed where students need to pay a non-refundable deposit fee.

Table 3: Payment schedule.

<b>Student type</b>	<b>Fee type</b>	<b>Deposit</b>	<b>Fall</b>	<b>Winter</b>	<b>Spring</b>	<b>Total</b>
Local Student	Regular fee	\$1,000	\$1,906	\$1,906	\$1,906	\$5,718
	Special fee		\$7,651	\$6,651	\$0	\$15,302
Canadian Student	Regular fee	\$1,000	\$2,478	\$2,478	\$2,478	\$7,434
	Special fee		\$7,651	\$6,651	\$0	\$15,302
International Student	Regular fee	\$1,000	\$3,222	\$3,222	\$3,222	\$9,666
	Special fee		\$10,141	\$9,141	\$0	\$20,282

## **Appendix A: Library holdings evaluation**

## Appendix B: Calendar regulations

### xxx. Regulations Governing the Degree of Master of Artificial Intelligence

The Degree of Master of Artificial Intelligence (MAI) is a four-term, course-based Master's program jointly offered by the Department of Computer Science and the Department of Electrical and Computer Engineering.

#### xxx.1 Qualifications for Admission

1. Admission is limited and competitive, and based on overall academic performance.
2. To be considered for admission, applicants shall normally hold a minimum second-class 4-year Bachelor's Degree (or the equivalent) in computer science, computer engineering, or a related area such as data science, scientific computing, bioinformatics, and computational chemistry from a university of recognized standing.
3. To be eligible for consideration for admission applicants will meet the English Proficiency Requirements described under General Regulations, English Proficiency Requirements.
4. Admission to the program shall be upon acceptance by the Dean of Graduate Studies after recommendation by the Chair of the Programme or either Head of the Departments of Computer Science or Electrical and Computer Engineering, along with a tentative program of study.

#### xxx.2 Degree Requirements

1. The degree program requires the completion of 30 credit hours.
  - (a) 3 credit hours of a Capstone project course AI XXX2.
  - (b) 18 credit hours (six courses) by completing AI XXX0, AI XXX1, COMP 6901, 6915, 6980 and ENGI 9818.
  - (c) 9 credit hours (three courses) to be selected from COMP 6907, 6912, 6934, 6981, 6982, 6XXX, DSCI 6601, 6602, ENGI 9804, 9805, 9821, 9826, 9940 and MATH 6205.

#### xxx.3 Evaluation

Students must obtain a grade of at least 65% in all program courses to receive credit for the course towards their program requirements. Any student who fails to receive 65% or more in a course must repeat the course in the case of core courses,

or must either repeat or replace the course with another program course in the case of elective courses. Any student who receives a grade of less than 65% in two courses or in a repeated course will be required to withdraw from the program.

## Appendix C: Course listings

### Core courses

<b>AI xxx0</b> Mathematics for AI
<b>AI xxx1</b> Topics in AI
<b>AI xxx2</b> Artificial Intelligence Capstone <sup>26</sup>
<b>COMP 6901</b> Applied Algorithms
<b>COMP 6915</b> Introduction to Machine Learning
<b>COMP 6980</b> Algorithmic Techniques for Artificial Intelligence
<b>ENGI 9818</b> Software Fundamentals

### Elective courses

<b>COMP 6907</b> Data Mining Techniques and Methodologies
<b>COMP 6912</b> Autonomous Robotics
<b>COMP 6934</b> Introduction to Data Visualization
<b>COMP 6981</b> Data preparation techniques
<b>COMP 69xxx</b> Advanced Machine Learning
<b>DSCI 6601</b> Practical Machine Learning
<b>DSCI 6602</b> Deep Learning and Artificial Intelligence or <b>MATH 6205</b> Deep Learning
<b>ENGI 9804</b> Image Processing and Applications
<b>ENGI 9805</b> Computer Vision or <b>COMP 6982</b> Computer Vision
<b>ENGI 9821</b> Digital Signal Processing
<b>ENGI 9826</b> Advanced Control Systems
<b>ENGI 9940</b> Advanced Robotics

<sup>26</sup>Normally AI xxx2 will be taken in the final term.

## Appendix D: Consultation

## Appendix E: Faculty Bios

**Alex Bihlo** is an Associate Professor and Canada Research Chair in Numerical Analysis and Scientific Computing in the math department, and cross-appointed with the computer science department. His research is on numerical analysis and machine learning (deep learning) with applications to geophysical fluid dynamics. He is teaching courses on numerical analysis, deep learning and reinforcement learning. He is also supervising several students in this research direction.

**Dave Churchill** is an Associate Professor of Computer Science at Memorial university, and runs the MUN AI and games lab. His research revolves around artificial intelligence, video games, and robotics.

**Stephen Czarnuch** is an Associate Professor in Biomedical Engineering at Memorial University. He received his B.Eng. and Mgmt. and M.A.Sc. degrees in Electrical and Computer Engineering from McMaster University, and his Ph.D. in Biomedical Engineering from the Institute of Biomaterials and Biomedical Engineering at the University of Toronto in 2002, 2005, and 2014, respectively. Following a short post-doctoral appointment at Memorial University, he was appointed to the Faculty of Engineering and Applied Science at Memorial in 2015. He currently holds or has held 12 grants as PI (including grants from CIHR and NSERC) and 8 grants as CI (including CIHR and SSHRC). He is currently supervising or has supervised 4 doctoral and 6 masters students, 15 research assistants, mentored 4 medical residents and over 40 undergraduate senior engineering students. He has extensive experience developing intelligent technologies for vulnerable populations by implementing a holistic, user-centered design philosophy centered on identifying user needs and evaluating health outcomes. His research is inherently interdisciplinary, lying at the intersection of engineering, computer science, medicine, gerontology, rehabilitation, psychology, and sociology. Specifically, he seeks to develop relevant, accessible, acceptable and adoptable patient-oriented technological interventions based on autonomously tracking human motion using computer vision. Further, he emphasizes the evaluation of their efficacy by connecting academic research with providers and patients in a real-world context. His technical focus is on machine learning, deep learning, and computer vision.

**Octavia A. Dobre** received the Dipl. Ing. and Ph.D. degrees from the Polytechnic Institute of Bucharest, Romania, in 1991 and 2000, respectively. Between 2002 and 2005, she was with New Jersey Institute of Technology,



USA. In 2005, she joined Memorial University, Canada, where she is currently a Professor and Research Chair. She was a Visiting Professor with Massachusetts Institute of Technology, USA and Université de Bretagne Occidentale, France. Her research interests encompass wireless, optical and underwater communication technologies. She has (co)authored over 400 refereed papers in these areas.

Dr. Dobre serves as the Editor-in-Chief (EiC) of the IEEE Open Journal of the Communications Society. She was the EiC of the IEEE Communications Letters, Senior Editor, Editor, and Guest Editor for various prestigious journals and magazines. She also served as General Chair, Technical Program Co-Chair, Tutorial Co-Chair, and Technical Co-Chair of symposia at numerous conferences.

Dr. Dobre was a Fulbright Scholar, Royal Society Scholar, and Distinguished Lecturer of the IEEE Communications Society. She obtained Best Paper Awards at various conferences, including IEEE ICC, IEEE Globecom, IEEE WCNC, and IEEE PIMRC. Dr. Dobre is a Fellow of the Engineering Institute of Canada, a Fellow of the Canadian Academy of Engineering, and a Fellow of the IEEE.

**Matthew Hamilton** holds a PhD in Computing Science from the University of Alberta in Canada, as well as an undergraduate degree in Pure Mathematics/Computer Science from Memorial University. He is author and co-author of multiple scientific and engineering articles and patents. Dr. Hamilton is currently and an Assistant Professor of Computer Science at Memorial University and President of Birch Scientific. Previously, he has worked in industrial research as a Holographic Rendering and CODEC R&D Engineer at Avalon Holographics and Senior Research Scientist, NSERC/Research and Development Corporation-NL Postdoctoral Industrial R&D Fellow at GRI Simulations, specializing in oil and gas virtual reality environments (simulation development, computer graphics, and data visualization) as well as computational aspects of developing a 3D display (rendering, codec development and display perception).

His research centers around developing digital twin and virtual reality systems, including aspects such as vision/sensing, simulation/modelling, graphics/visualization and user interfaces. He has particular interest in application of vision and computer graphics towards holographic 3D displays. He is interested in capture of real-world holographic imagery for live cinematic capture, visual modelling for games and digital twins and robotic vision in terms of processing and compression. He also works on applying machine learning to digital twin systems for automating decision-making (e.g. in ra-

diology), recognition of novel patterns and data-driven simulation of physical aspects of digital twin systems.

**Mohsin Jamil** received a Bachelor of industrial electronics Engineering degree from NED University of Engineering and Technology, Karachi, Pakistan, in 2005. He received two master's degrees in electrical engineering from Dalarna University Sweden and the National University of Singapore in 2006 and 2008, respectively, with major in Automation and Control Engineering. He received his PhD degree in electrical engineering from the University of Southampton in 2012. He is currently an assistant professor (teaching) and adjunct professor within the Department of Electrical and Computer Engineering at Memorial University of Newfoundland, Canada, since August 2019. Between 2016 and 2019, he worked in the Department of Electrical Engineering at the Islamic University of Madinah, Saudi Arabia. Between 2012 and 2016, He was working at the Robotics Department of the National University of Sciences and Technology (NUST), Islamabad, Pakistan. His teaching interest includes advanced control systems, digital signal processing and machine learning, as well as advanced control systems, mechatronics, power electronics, power systems and instrumentation. He also works in other multidisciplinary areas as well, such as process control, system identification, artificial intelligence, and machine learning. He is the author and co-author of several IEEE publications in different journals and peer-reviewed conferences. He is the recipient of different awards and funding grants. He is a registered Professional Engineer in the Province of Newfoundland and Labrador, Canada. He is an associate editor of IEEE Access and a senior member of IEEE.

**Xianta Jiang** received his Ph.D. in computer science from Simon Fraser University (2015) and Zhejiang University (Dual degree), studied mental workload measurement using eye-tracking technology. He then took a post-doc fellowship at Engineering Science, Simon Fraser University, worked in the area of human activity detection using machine learning and wearable sensors. He also worked as a senior research associate in the Department of Surgery at University of Alberta, studied team cognition using Augmented Reality (AR) and eye-tracking technologies. Dr. Jiang is currently an assistant professor in the Department of Computer Science in Memorial University of Newfoundland, Canada.

**Cecilia Moloney** is a faculty member at Memorial University where she is a Professor of Electrical and Computer Engineering. She is a member of the Radar Remote Sensing Laboratory (RRSL), with research interests that in-

clude nonlinear signal and image processing methods, signal representations, and radar signal processing. In addition, she is a founder of the MetaKettle Project, a legacy project of the NSERC/Petro-Canada Chair for Women in Science and Engineering, Atlantic Region that she held at Memorial University in 2004-2009. The MetaKettle Project promotes and conducts research in transformative pedagogy for science and engineering; her recent contributions have addressed aspects of ethics in engineering, problem solving in engineering, and methods for engineering discovery. Dr. Moloney has taught courses at undergraduate and graduate levels in the Signals and Systems stream of courses (e.g. Engi 9821, Digital Signal Processing), in probability and random processes (e.g. Engi 9825, Random Signals), and in communications (e.g. Engi 9871, Information Theory and Coding). To the courses she teaches she brings the technical knowledge and pedagogical insights she has honed over her academic career, from the classroom and from her research and outreach initiatives.

**Theodore Norvell** went to Dalhousie University for his undergrad studies, worked in industry, and went to the University of Toronto for his graduate studies. He did postdocs at Oxford and McMaster. He has been a professor of Computer Engineering at MUN for 26 years. His teaching includes computing theory, software design, software development, concurrent programming, algorithms, data structures, discrete math, formal methods, digital logic, operating systems, and more. His research areas include formal programming methods, semantics of programming languages, implementation of programming languages, automated verification of concurrent programs, design of programming languages, program animation, visual programming languages. He has developed software including "The Teaching Machine". He has supervised many undergraduate projects including, most recently, aspects of the Killick-1 satellite. He has supervised or co-supervised 16 thesis based students to completion. He has also supervised numerous capstone projects for course-based graduate students.

**Siu O'Young** is a Professor in Electrical and Computer Engineering at Memorial University. He has a Ph.D. in Electrical Engineering from the University of Waterloo. His current research focus is on sense-and-avoid technology for remotely piloted aircraft systems ("drones"). He is active in the RTCA SC228 committee for US detect-and-avoid standards and is a member of the TSO Mirror Committee on Unmanned Aircraft Systems for the Standards Council of Canada. He also has more than 20 years of business experience in mentoring high-tech start-ups and in accessing capital.

**Lourdes Peña Castillo** is an Associate Professor jointly appointed to the Department of Computer Science and the Department of Biology at Memorial University in St. John's, Canada. She completed her PhD at the Otto-von-Guericke University Magdeburg in Germany. Her doctoral dissertation focused on multirelational learning. She continued with a postdoc in bioinformatics in the Banting and Best Department of Medical Research at the University of Toronto. She has published 28 peer-reviewed journal articles, in high quality journals (with impact factors between 2.7 and 19) such as *Genome Biology*, *Scientific Reports*, *BMC Genomics*, *RNA Biology*, and *PeerJ*. Her research has been continuously funded by NSERC, and has supervised/co-supervised six PhD students, 14 thesis-based Master's students, and 15 course-based Master's students. Throughout her academic career, she has developed and/or applied artificial intelligence (mostly machine learning) in various areas such as bioinformatics, games and augmented virtuality. She leads the Bioinformatics lab at MUN which is focused on the application of machine learning-based methods to solve biological problems.

**Dennis K. Peters** is Professor and Associate Dean (Undergraduate Studies) for the Faculty of Engineering and Applied Science at Memorial University in St. John's, NL, Canada where he has been a member of Faculty since 1998. He earned the B.Eng. (Electrical) degree at Memorial University in 1990, before going to work in the high-tech industry at Newbridge Networks (now Alcatel) in Ottawa, Ontario. After two years in industry he returned to school, this time at McMaster University in Hamilton, Ontario where he completed the M.Eng. (Electrical & Computer) in 1995 and Ph.D. (Electrical & Computer Engineering) in 2000. His research involves applications of machine learning techniques to a variety of problems ranging from marine operations to oilfield characterization. He also studies techniques for design and verification of software and computer systems, with particular focus on high performance computing, simulation, real-time applications and parallel or distributed processing. Dr. Peters is an active volunteer in the professional engineering community in Canada. He is a former Chair (2014-15) of the Board of Directors of the Professional Engineers and Geoscientists of Newfoundland and Labrador (PEGNL), and served (2008-2020) on the Canadian Engineering Qualifications Board (CEQB), including a term as Chair (2016-18). He was a member (2002-13) of the Registration Committee for PEGNL, including the last 7 years as Chair. He is a member (1999-present) of the executive committee for the Newfoundland and Labrador Section of the IEEE, including a term as Chair and several years as Student Branch Counselor. He has participated in accreditation visits for the Canadian Engineering Ac-

creditation Board (CEAB) and has served on the organizational committees for local, national and international conferences. His teaching activity is primarily in the area of software, ranging from introductory programming courses to advanced topics such as software engineering and concurrent programming.

**Karteek Popuri** is currently an Assistant Professor at the Department of Computer Science at Memorial University of Newfoundland. He got his Bachelor of Technology degree in Chemical Engineering at the Indian Institute of Technology (IIT) Madras, and his Master's degree in chemical engineering from the University of Alberta. He received his PhD degree in Computing Science from the University of Alberta. Dr. Popuri's research interests are broadly in the areas of medical image analysis, machine learning/artificial intelligence and computer vision.

**Sarah Power** received the B.Eng. degree from Memorial University and the M.A.Sc. and Ph.D. degrees from the University of Toronto. She is an assistant professor, joint-appointed to the Department of Electrical and Computer Engineering and the Division of Community Health and Humanities. Broadly, her research interests lie in biomedical signal processing and the application of machine learning to medical, rehabilitation, and human factors problems. Her main research focus is in the area of brain-computer interfaces, which involves the classification/detection of mental states (e.g., mental workload, fatigue, attention, affective state, task proficiency) using non-invasively measured neural signals (e.g., EEG). Her current teaching activities are primarily in the areas of signal processing and biomedical engineering.

**Reza Shahidi** received the Bachelor of Mathematics degree (Joint Honours Computer Science and Pure Mathematics) from the University of Waterloo, Waterloo, ON, Canada, in 1998, and the M. Eng. and Ph.D. degrees in computer engineering from the Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, NL, Canada, in 2003 and 2008, respectively. He was a Postdoctoral Fellow from 2008 to 2009 with the University of British Columbia, Vancouver, BC, Canada, where he conducted research on seismic imaging, after which he spent several years working in industry in radar signal and image processing. In 2019, he was appointed as an Adjunct Professor with the Electrical and Computer Engineering Department, Faculty of Engineering and Applied Science, Memorial University, where he holds a multi-year NSERC Discovery Grant to conduct research into ocean parameter spectrum extraction from HF radar data.

His research interests include signal and image processing, machine learning, algorithm design, HF and X-band radar, and vehicular networks. Before being appointed Teaching Assistant Professor with the ECE Department at MUN in December 2020, he was Product Development Lead with Seamatica Aerospace, St. John's, NL, Canada, and has roughly a decade of industrial research and development experience. As Teaching Assistant Professor, and prior to that, Dr. Shahidi has taught courses in Software Engineering, Theory of Computation, Digital Signal Processing and Digital Systems. He has introduced and incorporated machine learning, both from theoretical and practical standpoints, when teaching graduate courses in Advanced Computing Concepts and Concurrent Programming over the past year. He is the author or co-author of approximately 50 peer-reviewed journal and conference publications in prestigious venues and has supervised/co-supervised several graduate students both at the University of British Columbia and Memorial University.

**Hamid Usefi** is an Associate Professor at the Departments of Mathematics and Computer Science. Dr Usefi's research spans Algebra, Machine Learning, and Cryptography. His research involves developing novel machine learning algorithms and explore applications in bioinformatics, genetics, finance, and industry.

**Andrew Vardy** is a Professor jointly appointed to the Department of Computer Science and the Department of Electrical and Computer Engineering at Memorial University in St. John's, Canada. He completed degrees in electrical engineering (B.Eng., Memorial University, 1999), evolutionary and adaptive systems (M.Sc., University of Sussex, 2000), and computer science (Ph.D., Carleton University, 2005). His main research area is swarm robotics but he has also developed new techniques in visual robot navigation. He leads the Bio-Inspired Robotics (BOTS) lab which is focused on developing swarms of robots that can actively organize their environments, for example by sorting objects or cleaning a space.

**Thumeera Wanasinghe** received his B.Sc. (Hons.) and M.Sc. degree in Electronic and Telecommunication Engineering from the University of Moratuwa, Sri Lanka, in 2009 and 2011, respectively. He obtained his doctoral degree in Electrical Engineering from Memorial University of Newfoundland, Canada, in 2017. His masters' thesis focussed on electrical parametric modelling of human skin impedance spectroscopy in response to variations in blood glucose level, and his doctoral thesis focussed on autonomous multi-robot collaboration. After completing his doctoral degree, he joined the Memorial

University of Newfoundland as a postdoctoral researcher. He led three industrial funded research projects exploring underwater image processing, 3D point-cloud processing, and opportunities and challenges of digitalization of extractive industries. He has completed several online certifications in data science, machine learning, deep learning, and self-driving cars during his postdoctoral study. Currently, he is an Assistant Professor (Teaching term) attached to the Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science, Memorial University of Newfoundland. His main research areas are autonomous robotics systems, multi-sensor data fusions, applied AI and machine learning, and digitalization and its socioeconomic impact. His teaching interests embrace but are not limited to the following areas: communications systems, electrical/ electronic/ digital circuits, signal processing, electromagnetic principles, autonomous robotic systems, control systems, machine learning, artificial intelligence, and data science.

## Appendix F: Canadian university survey of undergraduate and graduate programs in artificial intelligence

University	City	Undergrad.	Grad.
<b>Alberta</b>			
Athabasca University	Athabasca	No	No
Concordia University of Edmonton	Edmonton	No	No
MacEwan University	Edmonton	No	No
Mount Royal University	Calgary	No	No
	Springbank		
The King's University	Edmonton	No	No
University of Alberta	Edmonton	No	Yes
University of Calgary	Calgary	No	No
University of Lethbridge	Lethbridge	No	No
<b>British Columbia</b>			
Capilano University	North Vancouver	No	No
Emily Carr University of Art + Design	Vancouver	No	No
Kwantlen Polytechnic University	Surrey	No	No
	Langley		
	Richmond		
	Cloverdale		
Royal Roads University	Victoria	No	No
Simon Fraser University	Burnaby	Yes	No
	Surrey		
	Vancouver		
The University of British Columbia	Vancouver	No	No
	Kelowna		
Thompson Rivers University	Kamloops	No	No
Trinity Western University	Langley	No	No
University of Northern British Columbia	Prince George	No	No
	Terrace		
	Fort St John		
	Quesnel		
	Gitwinksihkw		
University of the Fraser Valley	Abbotsford	Yes	No
University of Victoria	Victoria	Yes	No



Vancouver Island University	Nanaimo	No	No
<b>Manitoba</b>			
Brandon University	Brandon	No	No
Canadian Mennonite University	Winnipeg	No	No
St Paul's College	Winnipeg	No	No
The University of Winnipeg	Winnipeg	No	No
Université de Saint-Boniface	Winnipeg	No	No
University of Manitoba	Winnipeg	No	No
<b>New Brunswick</b>			
Mount Allison University	Sackville	No	No
St Thomas University	Fredericton	No	No
Université de Moncton	Moncton	No	No
	Edmundston		
	Shippagan		
University of New Brunswick	Fredericton	No	No
	Saint John		
<b>Newfoundland and Labrador</b>			
Memorial University of Newfoundland	Corner Brook St John's	Yes	No
<b>Nova Scotia</b>			
Acadia University	Wolfville	No	No
Cape Breton University	Sydney	No	No
Dalhousie University	Halifax	No	No
Mount Saint Vincent University	Halifax	No	No
NSCAD University	Halifax	No	No
Saint Mary's University	Halifax	No	No
St Francis Xavier University	Antigonish	No	No
Université Sainte-Anne	Pointe-de-l'Église	No	No
University of King's College	Halifax	No	No
<b>Ontario</b>			
Algoma University	Sault Ste Marie Brampton South Porcupine	No	No
Brescia University College	London	No	No
Brock University	St Catharines	No	No

Carleton University	Ottawa	No	No
Huron University College	London	No	No
King's University College	London	No	No
Lakehead University	Thunder Bay	No	Yes
	Orillia		
Laurentian University	Sudbury	No	No
	Barrie		
McMaster University	Hamilton	No	No
Nipissing University	North Bay	No	No
OCAD University	Toronto	No	No
Ontario Tech University	Oshawa	No	No
Queen's University	Kingston	No	Yes
Redeemer University	Ancaster	No	No
Royal Military College of Canada	Kingston	No	No
Ryerson University	Toronto	No	Yes
St. Jerome's University	Waterloo	No	No
Trent University	Peterborough	No	No
	Oshawa		
University of Guelph	Guelph	No	Yes
University of Ottawa	Ottawa	No	Yes
University of St Michael's College	Toronto	No	No
University of Sudbury	Sudbury	No	No
University of Toronto	Toronto	Yes	No
	Mississauga		
	Scarborough		
University of Trinity College	Toronto	No	No
University of Waterloo	Waterloo	No	Yes
University of Windsor	Windsor	No	Yes
Victoria University	Toronto	No	No
Western University	London	No	Yes
Wilfrid Laurier University	Waterloo	No	No
	Brantford		
York University	Toronto	No	Yes
<b>Prince Edward Island</b>			
University of Prince Edward Island	Charlottetown	No	No
<b>Québec</b>			
Bishop's University	Sherbrooke	No	No
Concordia University	Montreal	No	No

École de technologie supérieure	Montreal	No	No
École nationale d'administration publique	Québec	No	No
HEC Montréal	Montréal	No	No
Institut national de la recherche scientifique	Québec	No	No
McGill University	Montreal	Yes	No
Polytechnique Montréal	Montreal	No	No
Université de Montréal	Montréal	No	No
Université de Sherbrooke	Sherbrooke	No	No
	Longueuil		
Université du Québec	Québec	No	No
Université du Québec à Chicoutimi (UQAC)	Chicoutimi	No	No
Université du Québec à Montréal (UQAM)	Montréal	No	No
Université du Québec à Rimouski (UQAR)	Rimouski	No	No
Université du Québec à Trois-Rivières (UQTR)	Trois-Rivières	No	No
Université du Québec en Abitibi-Témiscamingue (UQAT)	Rouyn-Noranda	No	No
Université du Québec en Outaouais	Gatineau	No	No
Université Laval	Québec	No	Yes
Université TÉLUQ	Québec	No	No
<b>Saskatchewan</b>			
Campion College	Regina	No	No
First Nations University of Canada	Regina	No	No
	Saskatoon		
	Prince Albert		
Luther College	Regina	No	No
St Thomas More College	Saskatoon	No	No
University of Regina	Regina	No	No
University of Saskatchewan	Saskatoon	No	No
Total number of "Yes"		6	11



Science and Engineering

Course Outline  
AI xxx0

Fall 2021

# AI xxx0 Mathematics for Artificial Intelligence

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https://TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	AI xxx0 Mathematics for Artificial Intelligence provides mathematical background required for students taking the courses in Artificial Intelligence.		
<b>Schedule</b>	<b>Lecture</b>	MWF TBDtime–TBDTime	TBDplace
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

## 1 Learning goals

The goal of this course is to provide the essential mathematical background needed to understand the concepts and algorithms used in artificial intelligence. It is expected that students will all have a common core of prerequisite knowledge in calculus and basic linear algebra. This course will advance this basic knowledge to the point where it can be applied in the understanding of core AI techniques. These AI techniques will serve as the primary motivating examples around which the material will be structured.

For an example of this approach, the mathematical underpinnings for the backpropagation algorithm used to train neural networks will be established. Backpropagation requires the concepts of partial derivatives, function composition, and matrix multiplication. Once these concepts have been covered, the algorithm will be presented as an example of their application.

Another motivating example would be Principal Components Analysis (PCA) which is an important method for dimensionality reduction. PCA requires the concepts of linear transformations, eigenvalues, eigenvectors, and covariance matrices.

The set of motivating examples chosen could be different year-by-year but would consistently support the same fundamental topics listed in the next section.

## 2 Major Topics

- Linear algebra
- Vector calculus
- Optimization methods
- Graph theory
- Mathematical logic

### 3 Assessment

<b>Assignments (5)</b>	10%
<b>Quizzes (4)</b>	40%
<b>Final Exam</b>	50%

### 4 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

### 5 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

### 6 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.



Course Outline  
AI xxx1

Fall 2022

Science and Engineering

## AI xxx1 Topics in Artificial Intelligence

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https:TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	AI xxx1: Topics in Artificial Intelligence provides an overview of the history of AI and its main areas, emphasizes the relevance of ethics considerations in AI research and application, and introduces a selection of the disciplines that constitute modern AI.		
<b>Schedule</b>	<b>Lecture</b>	TBD TBD–TBD	Location: TBD
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

### Learning goals

- Be able to narrate AI history
- Be aware of ethical issues in AI
- Have a broad perspective on AI
- Be familiar with selected AI areas
- Be able to describe current AI applications

### Topics

1. History of AI
2. Current AI applications
3. Ethics of AI
4. Introduction to selected AI areas among others:
  - (a) Knowledge representation
  - (b) Probabilistic reasoning (Bayesian inference, Bayesian networks, Markov chains)
  - (c) Agent-based and multi-agent systems
  - (d) Planning and scheduling

- (e) Data mining
- (f) Constraint satisfaction
- (g) Natural language processing
- (h) Computer vision
- (i) Robotics
- (j) Machine learning
- (k) Heuristic search
- (l) Game playing
- (m) Human/AI collaboration
- (n) Neuroscience and Cognitive Science
- (o) AI and philosophy of Mind

### Suggested textbook/readings

- Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig. Fourth edition, 2020.
- Review articles corresponding to selected AI areas

## 1 Assessment

<b>Topic Activities (6)</b>	96%
<b>Participation</b>	4%

## 2 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

## 3 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

## 4 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.



Course Outline  
AI xxx2

Fall 2022

Science and Engineering

## AI xxx2 Capstone for Artificial Intelligence

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https:TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	AI xxx2 provides an opportunity for students to integrate the knowledge that they have acquired in modern AI techniques through application to a relevant challenge or problem. Students work independently or in small teams to propose and implement an AI solution to a specific problem. Challenge/problem might be in a variety of areas.		
<b>Schedule</b>	<b>Lecture</b>	MWF TBDtime–TBDTime	TBDplace
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

### Learning goals

1. Refine and apply problem solving and analytical skills to identify which AI technique is best suited to address a given problem
2. Follow best practices of AI application to optimize outcomes
3. Design, develop and implement an AI-based solution for a given problem
4. Critically evaluate AI-based solution implemented

## 1 Assessment

Component	Mark
Progress Report 1	15%
Progress Report 2	15%
Presentation	20%
Final Report	50%

In the case of team projects, the students will receive individual marks based both on the team performance and on their individual contribution and effort as assessed by the instructors.



## 2 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

## 3 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

## 4 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.

# COMP 6901 -- Applied Algorithms Fall 2020

[Announcements](#) | [Course information](#) | [Assignments and tests](#) | [Lecture notes](#)

## Course information

The course information below is **very tentative!** The way the lectures/tests are done and the marking scheme, in particular, are likely to change depending on everybody's availability, enrolment, software licenses and other factors.

Instructor: [Antonina Kolokolova](#)

Instructor office hours: TBA. Also on Zoom.

Additionally, we will be using discussion boards on [Brightspace](#).

We will be using [Brightspace \(formerly: known as D2L\)](#) for assignment submissions, tests, grades, announcements, etc. The assignments, slides and videos of lectures will also be posted here. The Brightspace shell for our course should be available shortly to all registered students; if you cannot register/access Brightspace after the first week of classes, please let me know.

Textbook: There will be no official textbook for this course. We will mostly follow *J. Kleinberg, E. Tardos. Algorithm Design*, but you do not need to buy it.

Reference books:

- J. Kleinberg, E. Tardos. Algorithm Design.
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. Introduction to Algorithms

We will also use other materials such as research papers.

See the [lecture notes from the previous run of this course](#) for more information.

**Marking scheme:** (tentative!): 4 assignments 15% each, and two tests 20% each. The last test is likely to be scheduled during the last week of classes.

**Description:** The goal of this course is to study both classical and advanced algorithm design techniques with emphasis on real-world applications. We will cover greedy algorithms, dynamic programming, backtracking, network flows as well as more advanced algorithms and techniques (time permitting). Time permitting, we will consider randomized, parallel and distributed algorithms, and/or streaming algorithms.

**Prerequisites:** This course assumes proficiency in the core subjects of computer science: programming, discrete math, and basic data structures/algorithms. In particular, I will assume that you can read and write proofs, know basic probability theory and combinatorics, know basic data structures and algorithm complexity analysis, can read and write pseudocode, and can program fluently in some programming language. Check our undergraduate courses COMP 1001, COMP 1002 and COMP 2002, and make sure you are comfortable with the material covered there; this should take care of most of the skills you need to succeed in COMP 6901.

**Policy on collaboration:** The work you submit must be your own. You may discuss problems from assignments with each other; however, you should prepare written solutions alone, and do not interact with anybody except the instructor while doing tests and online exercises. Plagiarism is a serious academic offense and will be dealt with accordingly. When in doubt, check [How to avoid plagiarism](#)

## **COMP 6907**

### **Data Mining Techniques and Methodologies**

#### **Objectives of the Course**

This course introduces the basic concepts and techniques for data mining. Upon the completion of the course, students are expected to understand the essential data mining technologies and be able to design and evaluate methods for data mining applications.

#### **Representative Course Outline**

- Data mining basic concepts
- Pattern/knowledge discovery introduction
- Mining frequent patterns
- Sequential pattern mining
- Constraint-based mining
- Graph pattern mining
- Mining large data sets
- Clustering
  - Basic concepts
  - Partitioning-based clustering
  - Hierarchical method
  - Density based methods
  - Grid based methods
  - Cluster evaluation/validation

#### **Method of Evaluation**

Assignments	30%
Final exam	30%
Project	40%

#### **Suggested texts/references**

“Data Mining, concepts and techniques” by Jiawei Han, Micheline Kamber and Jian Pei, 3rd ED, Morgan Kaufmann Publishers. 2011

Computer Science 6912  
Graduate Course:  
**Autonomous Robotics**

Memorial University of Newfoundland

Winter, 2019-20

**Instructor:** Dr. Andrew Vardy

**Office:** EN-2018

**E-mail:** av followed by the 'at' symbol, then mun.ca

**Web page:** Brightspace

**Lectures:** Mon, Wed, Fri from 10:00 - 10:50 in EN-1051

**Labs:** Tuesdays from 2:00 - 4:50 in EN-1049. Three labs are planned, which will take up at least three 3-hour sessions. However, it is possible that more than three sessions will be required. **There will be no option to make-up for missed labs.**

For students in 6912, the lab slot will also be used for presentations and demos.

**Instructor Office Hours:** Mondays and Wednesdays 1:00 – 2:00. E-mail to arrange an appointment outside of office hours. You can also stop by my office and if my door is ajar, I will be happy to help you. If my door is closed I am either out of the office or very busy. Note: The Wednesday office hour will have to be cancelled a few times throughout the semester to accommodate Departmental/Faculty meetings.

**Calendar Description:**

Introduction to Autonomous Robotics examines the fundamental constraints, technologies, and algorithms of autonomous robotics. The focus of this course will be on computational aspects of autonomous wheeled mobile robots. The following topics will be covered: major paradigms in robotics, methods of locomotion, kinematics, simple control systems, sensor technologies, stereo vision, feature extraction, modelling uncertainty of sensors and positional information, localization, SLAM, obstacle avoidance, and 2-D path planning.

**Course Outline:**

- Major Paradigms in Robotics
- Representing Position and Orientation (Ch. 2 of Corke)
- Robot Vehicles and Control (Ch. 4 of Corke)
- Perception and Sensors (Ch. 4 of Siegwart, Nourbakhsh, and Scaramuzza)
- Probabilistic Robotics (Selected Chapters from Thrun, Burgard, and Fox)
- Navigation and Reinforcement Learning (Various Sources)
- Swarm Robotics (Selected Material from Hamann)

**Textbook: There is no required textbook for this course.**

For much of the course we will utilize material from [Corke, 2017]. Fortunately, it is available for free in electronic form from the MUN library. We will also use some material from [Siegwart, Nourbakhsh, and Scaramuzza, 2011], [Thrun, Burgard, and Fox, 2005] and [Hamann, 2018] as indicated above. [Hamann, 2018] is available in electronic form from the MUN library.

**References:**

- Corke, Peter. Robotics, Vision and Control: Fundamental Algorithms In MATLAB®, Second Edition. Springer, 2017.
- Hamann, Heiko. Swarm Robotics: A Formal Approach. Springer, 2018.
- Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza. Introduction to autonomous mobile robots. MIT press, 2011.
- Thrun, Sebastian, Wolfram Burgard, and Dieter Fox. Probabilistic robotics. MIT press, 2005.

**Prerequisites:**

Students should have a solid background in computer programming, algorithms, calculus, linear algebra, and statistics. Such a background may have been obtained through completion of the following courses at Memorial: COMP 2711, MATH 2000, MATH 2050, and STAT 2510. Assignments will require the use of Python, although some work from the final section of the course (swarm robotics) will require the use of Javascript (in-depth Javascript knowledge is not required).

**Evaluation scheme:**

Assignments (5 @ 5% each)	25%
Labs (3 @ 3.333% each)	10%
Tests (2 @ 15% each)	30%
Presentation	5%
Project Demo	15%
Project Report	15%

**Presentation:**

Each student will prepare a presentation on a modern research paper in robotics. The paper should be chosen from the proceedings of one of the main conferences in robotics:

- IEEE/RSJ International Conference on Intelligent Robots and Systems
- IEEE International Conference on Robotics and Automation

The proceedings for both of these conferences are available through IEEE Xplore, which is accessible through the university library's web site. Papers published in other respectable conference proceedings and journals may also be acceptable. The paper chosen should be reasonably self-contained so that it can be explained without having to go through all of its references. It should also present additional material beyond what is discussed in class.

Students should select two different topics of interest and for each topic submit a recent paper (2016+), plus an older paper which the recent paper builds upon. Thus, a total of four papers should be provided as PDF files to the instructor by the paper selection deadline. The instructor will consult with the student to discuss which paper is most suitable for presentation.

**Project:**

The project will involve implementation of one or more of the concepts developed in the presented paper. The student should discuss the scope of the implementation with the instructor. It is crucial that some experimental results be demonstrated either in simulation or using physical robots.

The project can be completed either individually or in groups of two. Projects completed by groups will be held to a significantly higher standard of accomplishment.

Further information on the requirements for the project demo and report will be posted on Brightspace.

**Schedule:**

Assignment 1	24 Jan.
Lab 1	28 Jan.
Assignment 2	7 Feb.
Lab 2	11 Feb.
Test 1	14 Feb.
Assignment 3	28 Feb.
Assignment 4	13 Mar.
Lab 3	17 Mar.
Test 2	20 Mar.
Assignment 5	27 Mar.
Project Interim Demo	31 Mar.
Project Final Demo	7 April
Project Report Due	10 April

Presentations will be scheduled during the Tuesday afternoon lab slot in March once enrollment stabilizes.

**Note: The schedule for course events (assignments, labs, and tests) will be posted on Brightspace. This schedule is subject to change which will be announced in class.**

**Assignments:**

Each assignment will consist of two parts. Part A will involve pen-and-paper calculations, problem solving exercises and potentially small programming exercises. Part B will be a more substantial programming exercise. The weighting of marks between Parts A and B may differ from one assignment to the next.

Programming tasks (in parts A and B) will require the use of Python. Part of the last assignment will require the use of Javascript, but in-depth knowledge of the language is not required.

Both parts of assignment 1 must be completed individually. For assignments 2-5 part B may be completed individually or in groups of two. If completed in a group of two, the expectation is that the group will go beyond bare-bones functionality and include some level of experimentation and analysis (e.g. studying the impact of varying parameters). Part A for all assignments must be completed individually.

For all assignments, part A is to be completed on paper and submitted at the beginning of class (at 10:00). Part B will be due on the same day but will be submitted through Brightspace.

**Labs:**

Three lab sessions are planned. Students will work in pairs to implement problems studied in class on real-world robots. It is anticipated that the first lab session will

involve some manual assembly and setup tasks. Labs 2 and 3 will involve programming the robots to execute various tasks.

## Other Info.

- Note that there **will** be an assignment due during the last two weeks of term. For students in 6912, the project final demo will also occur during the last two weeks of term.
- Late assignments, labs, and missed tests will only be accepted in case of illness, child-birth, or bereavement, or by prior arrangement with the Instructor. In case of illness, you should obtain a doctor's certificate prior to the test time or due time.
- If you feel any mark was unfair or incorrectly recorded, ensure the instructor is aware of the problem as soon as possible, and within at most 2 weeks of receiving the mark. No reconsideration of term marks will be made after the final exam.
- Cases of academic offences will be dealt with in accordance with university regulations. Academic offences includes: copying, allowing work to be copied, failing to cite sources, and presenting work done in collaboration as one's own. Please read Section 6.12.4 of the university calendar if you need clarification as to what constitutes an academic offence.





**COMP 3202/COMP 6915 – Intro to Machine Learning  
Course Outline - Winter 2021**

---

**Instructor:** Dr. Lourdes Peña-Castillo

**Office:** ER-6037

**Phone:** 864-6769

**Webpage:** [www.cs.mun.ca/~lourdes](http://www.cs.mun.ca/~lourdes)

**Email:** Use Brightspace (online.mun.ca) shell's email. Email will be replied within two working days.

**Lectures:** TR 12:00 – 12:50 pm and F 1:00 – 1:50 pm (Brightspace online rooms. Synchronous lectures. Lectures will be recorded)

**Office Hours:** Monday 9:00 – 11:00 am, or by appointment (conducted through Webex).

**Questions:** Students are encouraged to post course-related questions in Brightspace discussion forum.

---

**Course Description:**

This course introduces concepts and algorithms in machine learning for regression and classification tasks. The course gives the student the basic ideas and intuition behind model selection and evaluation, and selected machine learning methods such as random forests, support vector machines, and hidden Markov models.

**Pre-requisites:**

**COMP-3202**

COMP 3200; or COMP 2001 or the former COMP 2710, COMP 2002 or the former COMP 2711, and Statistics 2550 ; and Mathematics 2050

**COMP-6915**

Python programming, a statistics course at the undergraduate level (similar to STAT 2550), and a linear algebra course at the undergraduate level (similar to MATH 2050).

**Learning Goals:**

1. Understand the basis underlying supervised machine learning methods
2. Understand the algorithms behind certain machine-learning methods
3. Acquire hands-on experience applying supervised machine-learning methods
4. Be able to appropriately evaluate and select a machine-learning model for a specific task

**Course Activities:**

1. Six assignments
2. Twelve quizzes
3. A final exam
4. **COMP-6915:** A 15-min video tutorial

**Textbooks:**

- The Elements of Statistical Learning: Data Mining, Inference and Prediction. T. Hastie, R. Tibshirani, J. Friedman. Springer. 2nd Edition. 2009 (<http://statweb.stanford.edu/~tibs/ElemStatLearn/>)
- An Introduction to Statistical Learning. G. James, D. Witten, T. Hastie and R. Tibshirani. Springer. 2013 (<https://statlearning.com/> )

- Deep Learning. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. The MIT Press. 2016 (<https://www.deeplearningbook.org/>)

### Evaluation Scheme:

	COMP-3202	COMP-6915
Assignments (6)	36%	30%
Quizzes (12)	40%	40%
Final exam	24%	10%
Video tutorial	N/A	20%

### Notes:

1. In the event of university closure on the day of a test, the test will be given in the next class meeting.
2. Assignments will be submitted in electronic format using the Dropbox application in Brightspace. **No late assignments will be accepted.**
3. Course materials, news and communications will be available from the Brightspace system.
4. All grades will be assigned according to the University Calendar (Section 6.9.2 under University Regulations).
5. All written materials delivered must comply with the expectations of Good Writing set out in the University Calendar (Section 6.9.3 under University Regulations).
6. If, for special circumstances (such as medical or bereavement), you miss a deadline for a grade item, notify your professor as soon as possible and no later than 48 hours after the original deadline, providing any necessary related documentation (if documentation is required). Failure to do this might result in a mark of 0% for that grade item. For more information, please see [Section 6.7.5](#) and [Section 6.15.6](#) under University Regulations in the University Calendar or consult the Registrar's Office.
7. From section 6.12 of the University Calendar: “A student is expected to adhere to those principles which constitute proper academic conduct. Academic misconduct cannot be condoned or even appear to be condoned. A student has the responsibility to know which actions, as described under [Academic Offences](#), could be construed as dishonest or improper.”. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. In addition, see “[Avoiding plagiarism – a guide](#)”.
8. Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within the scope of the University Policies for the Accommodations for Students with Disabilities. Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).
9. The lectures and displays (and all material) delivered or provided in this course, including any visual or audio recording thereof, are subject to copyright owned by the instructor of the course. It is prohibited to record/copy and distribute by any means, in any format, openly or surreptitiously, in whole or in part, in the absence of express written permission from the instructor any of the lectures or materials provided or published in any form during or from the course.
10. It is the responsibility of the instructor to determine, maintain and enforce the standards of behavior acceptable to preserving an atmosphere appropriate for teaching and learning. Students will be warned if their behavior is evaluated by the instructor as disruptive.
11. Although changes to this document are not intended at this time, any part of this course outline can be subject to change, particularly during the first two weeks of classes. Students should be aware that the latest version of the course outline will be available through the Brightspace shell for the course.

**Assignments:**

- Assignments will be done in groups of two students.
- Assignment programs have to be implemented in Python 3.
- Assignment programs are required to run in linux command-line.
- For each assignment, data and interface specifications will be provided. If the assignment program does not run according with the specifications, points will be deducted.
- Check Brightspace calendar for due dates

**Tentative Course Schedule**

Week	Monday	Tuesday	Wed.	Thursday	Friday
1	Jan 11 <i>Lectures begin</i>	<b>Intro to 6915</b>		<b>Intro to ML (ESLII Ch2, DL Ch5)</b>	<b>Intro to ML</b>
2	Jan 18	<b>KNN</b>		<b>KNN</b>	<b>Model assessment and selection (ESLII Ch7)</b>
3	Jan 25 <i>Last day to add</i>	<b>Model assessment and selection</b>		<b>Model assessment and selection</b>	<b>Linear methods for regression (ESLII Ch3)</b>
4	Feb 1	<b>Linear methods for classification (ESLII Ch4)</b>		<b>Linear methods for classification</b>	<b>Linear methods for classification</b>
5	Feb 8	<b>Tree-based methods (ESLII Ch9)</b>		<b>Tree-based methods</b>	<b>Tree-based methods</b>
6	Feb 15	<b>Bagging &amp; Boosting (ESLII Ch10)</b>		<b>Bagging &amp; Boosting</b>	<b>Random Forest</b>
7	Feb 22 <i>Winter break begins</i>				Feb 26 <i>Winter break ends</i>
8	March 1	<b>Random Forest (ESLII Ch15)</b>		<b>Support vector machines (ESLII Ch12, IEL Ch9)</b>	<b>SVMs</b>
9	March 8 <i>Last day to drop</i>	<b>SVMs</b>		<b>Feedforward networks (DL Ch6)</b>	<b>Feedforward networks</b>
10	March 15	<b>Feedforward networks</b>		<b>Feedforward networks</b>	<b>Regularization (DL Ch7)</b>
11	March 22	<b>Regularization</b>		<b>Convolutional networks (DL Ch9)</b>	March 26 <b>CNNs</b> Saturday March 27 Follow Friday schedule <b>CNNs</b>
12	March 29	<b>Recurrent and recursive nets (DL Ch10)</b>		<b>RNNs</b>	April 2 <i>Good Friday, no classes</i>
13	April 5	<b>Practical Methodology</b>		<b>Ethical issues</b>	April 9 <i>Lectures end</i> <b>Q&amp;A</b>
14	April 12		April 14 <i>Final exams begin</i>		
15	April 19				April 23 <i>Final exams end</i>

## COURSE SYLLABUS - FALL 2021

### COMPUTER SCIENCE 4304: DATA VISUALIZATION

### COMPUTER SCIENCE 6934: INTRO TO DATA VISUALIZATION

---

Instructor: Terrence Tricco (he/him)

Email: tstricco@mun.ca

Office: ER-6031

Lectures: 11:00 - 11:50am M-W-F (Three 50 minute lectures per week.)

Lecture Room: EN-2006

Office Hours: 1:00 - 3:00pm on Mondays (or by email appointment)

4304 Pre-requisites: COMP 2001, COMP 2002, Statistics 2500 or Statistics 2500

### Instructional Continuity

Welcome back to campus. All lectures in this course will be taught both in-person and through recorded video posted online to Brightspace. The recorded lectures will be a duplicate of the in-person lecture. You can choose which mode of learning you prefer.

Masks are currently required on campus. If this policy changes during the term, it is still recommended to wear a mask even if not required. There will be different levels of comfort and anxiety for mask use. Please be respectful of everyone in the class.

Should there be disruption to in-person lectures over the course of the term by other health directives or the overall situation connected to Covid-19, then instruction will continue through the online videos according to the course schedule.

### Course Objectives

Data visualization is the art of creating images based on data. Visualizations enable users to explore, understand, and extract insights from data in an efficient way. This course will be centred on data visualization for data science, and will cover three broad topics. One will be the tools of data visualization, specifically Jupyter notebooks and Python visualization libraries. A second topic will be standard types of visualizations for different types of data. The third topic will be on the theoretical aspects of data visualization, such as viewer perception and rules of thumb for good visualizations.

### Course Outline

- Data Visualization Tools
  - Jupyter Notebooks and Python
  - Pandas data library

- Matplotlib, Seaborn and Plotly visualization libraries
- Vector graphics (svg), Rasterization
- Interactivity
- Standard Visualisation Types
  - Relational: Line plots, Scatter plots, Bubble plots, Heat maps
  - Categorical: Bar plots, Histograms, Box plots, Radar charts
  - Hierarchical: Pie charts, Venn diagrams
  - Multi: Scatterplot matrix
  - Spatial: Choropleth, Contour plots, Kernel density estimation
  - Data reduction: t-SNE, Principal component analysis
- Data Visualisation Theory
  - Planning and design process
  - Human perception
  - Colour theory
  - Elements of style
  - Rules of thumb, pitfalls to avoid

## Evaluation

There will not be any in-person evaluation. The final grade in the course will be determined as follows:

• Assignments (8)	<b>50%</b>
• Course Project	<b>50%</b>
○ Project Proposal	(10%)
○ Project Submission and Code	(25%)
○ Video Presentation	(15%)

## Recommended Reading (Optional)

There is no required textbook for this course. The following textbooks are only recommended for further reading on course topics.

A. Kirk, *Data Visualisation: A Handbook for Data Driven Design*, 2nd Edition, Sage, 2019.

T. Munzner, *Visualization Analysis & Design*, CRC Press, 2014.

R. Spence, *Information Visualization: An Introduction*, 3rd Edition, Springer, 2014.

## Memorial University Policies

Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within

the scope of the University Policies for the Accommodations for Students with Disabilities ([www.mun.ca/policy/site/policy.php?id=239](http://www.mun.ca/policy/site/policy.php?id=239)). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).

Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar.

**MEMORIAL UNIVERSITY OF NEWFOUNDLAND**  
**Department of Computer Science**

**Computer Science 6980**  
**Special Topics in Artificial Intelligence**

Instructor:	David Churchill	Phone:	864-6140
Office:	ER-6030	Email:	dchurchill@mun.ca
Office Hours:	TBA	Website:	www.cs.mun.ca/~dchurchill/

---

**Course Website:** <https://www.cs.mun.ca/~dchurchill/courses/3200>  
 (most course activity will take place on D2L)

**Course Objectives:**

This course is an introduction to Artificial Intelligence (AI), covering algorithmic techniques and data structures used in modern problem-solving environments. Each topic will have a related assignment where the learned techniques are applied to simple games.

**Course Outline:**

- Introduction to Artificial Intelligence
  - What is AI? What can Modern AI do?
  - Games as a Testing Environment for AI
  - Agents, Environments, and Problems
- Search Algorithms
  - Exhaustive Search (BFS / DFS)
  - Heuristic Functions / Incorporating Knowledge
  - Heuristic Search (Best-First Search / A\*)
  - Introduction to Game Theory / Nash Equilibrium
  - Adversarial Search (Minimax / Alpha-Beta)
  - Data Structures / Optimizations for Search
- Genetic Algorithms (GA)
  - Introduction to Evolutionary Algorithms
  - GA Representations: (Genotype, Phenotype)
  - GA Implementation: Mutation, Crossover, Selection, Reproduction
- Reinforcement Learning (RL)
  - Introduction to RL: Agent, Environment, Actions, Policies, Rewards
  - Bandit Problems (Exploration vs. Exploitation)
  - Markov Decision Processes
  - Generalized Policy Iteration
  - Monte-Carlo Methods
  - Temporal Difference Learning (SARSA / Q-Learning)
- Neural Networks (NN)
  - Artificial Neurons / NN Structure / Training
  - Brief Introduction to Deep Learning



**Textbook:** Artificial Intelligence: A Modern Approach (Optional)  
Russel & Norvig

Reinforcement Learning: An Introduction (Free Online)  
Sutton & Barto  
<http://incompleteideas.net/book/the-book.html>

**Format:** 2 lectures per week on Tuesday / Thursday (80 minutes each)

### Evaluation:

The evaluation structure of the course is as follows:

• Assignments		50% (≤ 2 Per Group)
○ Intro to JS + BFS/ DFS	(Programming)	
○ A* Search Pathfinding	(Programming)	
○ Minimax + Alpha-Beta	(Programming)	
○ Genetic Algorithm	(Programming)	
○ Reinforcement Learning	(Programming)	
• Midterm Exam	(Written)	10% (Solo)
• Final Exam	(Written)	20% (Solo)
• Final Project	(Programming)	20% (Solo)

**Note:** Due the group work nature of this course, to effectively show that you have individually learned the material, you must pass the final exam to pass the course. If your grade on the final exam is less than 50%, then your overall course grade will be equal to the mark that you received on the final exam. If your final exam grade is greater than or equal to 50%, your course grade is determined by the scheme above.

### Memorial University Policies:

Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within the scope of the University Policies for the Accommodations for Students with Disabilities ([www.mun.ca/policy/site/policy.php?id=239](http://www.mun.ca/policy/site/policy.php?id=239)). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).

Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar.

**Differences from COMP 3200 (undergrad):**

This course will be taught along with the undergraduate course COMP 3200, and therefore will cover many of the same topics as that course. In order to differentiate it from COMP 3200, there will be several differences which assign extra reading / work to graduate students, in order to further their learning beyond that of the undergraduate course.

- Graduate students will be assigned extra reading for advanced topics
- This course will have a project requirement, unlike 3200
- This course will have a more difficult final exam from 3200
- Assignments will have bonus material for graduate students

# Appendix

## Computer Science 6981

### Data Preparation Techniques



### Department of Computer Science

**Instructor:** Dr. Amilcar Soares

**Email:** [amilcarsj@mun.ca](mailto:amilcarsj@mun.ca) (please use this email to contact your instructor, not D2L)

Course information (e.g., lecture notes, announcements, grades, etc) can be found on Brightspace (D2L). However, please note that your instructor **DOES NOT check email in Brightspace (D2L)**. The course number must be included in the subject line of any emails to the instructor or the instructional staff.

#### Current Course Prerequisites/Credit Restrictions:

Basic knowledge of Statistics and programming in Python 3 are required skills.

#### Course Description:

Students will learn several data preparation techniques for preprocessing your data set for data analytics tasks such as data mining, machine learning and data visualization. The course includes data cleaning, scaling, normalizing, discretizing, and imputing data and feature engineering, feature selection, and dimensionality reduction. The course will also include how to scale up the processing with distributed frameworks such as Apache Spark to handle large datasets. Finally, the students will see a high-level overview of some traditional data mining algorithms, such as linear regression and classification, decision trees, k-means and DBSCAN that will be eventually introduced to evaluate the impact of the techniques being taught.

#### List of topics

- iPython, Jupyter notebooks, and NumPy basics.
- Pandas (mapping, sorting and ranking, and descriptive statistics), Matplotlib
- Data cleaning
  - Why to clean your data?
  - Identify values for cleaning, formatting, finding outliers and duplicates.
- Data scaling, normalization, and discretization
  - Min-max scaler, standard scaler, max abs scaler, robust scaler, quantile transformer scaler, power transformer scaler, unit vector scaler.
  - Range, clipping, log and z-score normalization.
  - Equal width discretization and equal-frequency discretization.
  - Binning histogram and correlation analysis for data discretization.
- Scikit-learn basics, Supervised Learning (Bayesian, k-Nearest neighbors, Decision trees, Linear models)
  - Basics of the scikit-learn package, how to prepare your data, load and execute models.
  - Using basic models such as Bayesian, kNearest neighbors, Decision trees, Linear models.
  - How cleaning, scaling, normalization and discretization affects supervised learning?

- Scikit-learn, Unsupervised Learning (Kmeans and DB-SCAN)
  - How cleaning, scaling, normalization and discretization affects unsupervised learning.
- Scikit-learn, Dimensionality reduction (PCA and TSNe)
  - How cleaning, scaling, normalization and discretization affects dimensionality reduction.
- Scikit-learn, Feature selection
  - Statistics for filter feature selection method, correlation statistics, selection method, and transform variables.
- Data integration and encodings
  - A data integration primer. How to combine data sets with join, merge and concatenation.
  - One-hot encoding.
- Map Reduce
  - Scaling up the data analysis with the Map Reduce framework. Apache spark basics and examples

### Course Objectives:

To give students basic knowledge on how preprocess raw data. We will cover both processing techniques for small and big data. While advancing in the content, some simple models would be introduced in the course for evaluating the impact of the addition of the preprocessing techniques.

At the end of this course the students will be able to:

- Perform data pre-processing in small and large data sets
- Evaluate the effect of pre-processing techniques using data mining/machine learning methods
- Scale the up pre-processing of large datasets using distributed frameworks

### Recommended Readings

1. Zheng, A., & Casari, A. (2018). *Feature engineering for machine learning: principles and techniques for data scientists*. " O'Reilly Media, Inc."
2. Osborne, J. W. (2013). *Best practices in data cleaning: A complete guide to everything you need to do before and after collecting your data*. Sage.

### Evaluation:

The final grade in this course will be determined by three project iterations as follows:

<b>Quizzes (6)</b>	30%
<b>Assignments (3)</b>	40%
<b>Final Exam</b>	30%

**Assignments and Quizzes are individual. You must pass the final exam to pass the course.**



# Computer Science 6982

## Computer Vision

### Winter 2022

Department of Computer Science

**Instructor:** Matthew Hamilton  
**E-mail:** [mhamilton@mun.ca](mailto:mhamilton@mun.ca)

**Course Content:** <https://online.mun.ca/>

#### Course Objectives:

CS 6982 Computer Vision studies how to develop methods that enable a machine to “understand” or analyze images. The course introduces the fundamental problems in computer vision and the state-of-the-art approaches that address them. Topics include feature detection and matching, geometric and multi-view vision, structure from X, segmentation, object tracking and visual recognition.

#### Topics:

1. Feature detection and matching
2. Geometric and multi-view vision
3. Structure from X
4. Segmentation
5. Object tracking
6. Visual recognition

#### Textbook and Resources:

[Computer Vision: Algorithms and Applications](#) by Richard Szeliski (available for free on author's page)

[Computer Vision: A Modern Approach](#) by David Forsyth and Jean Ponce

Additional materials assigned throughout the course.

#### Evaluation:

	Grade Weight
Assignments	20%
Class Tests	20%
Project	30%
Final	30%
	100%

**Difference between the graduate and the undergraduate version of this course:**

Where this course is offered in conjunction with undergraduate Computer Visions course (CS 4301/ENGI 8410), graduate students projects should reflect a higher level of sophistication and should be based on the implementation of techniques or algorithms presented in a journal publication.

## **COMP 69xx: Advanced machine learning**

### **Course Description**

This course explores advanced machine learning topics and its applications. Students will have to read and present manuscripts published within the last five years in top machine learning conferences (e.g., ICML, IJCAI, NIPS) or journals. Students taking this course should be comfortable with the material covered in COMP-6915 and MATH 6205.

### **Learning goals**

- Be aware of forefront research in machine learning
- Acquire deeper knowledge in certain areas of machine learning
- Apply machine learning methods

### **Topics covered may include:**

1. Alternative learning paradigms such as:
  - a) Active learning
  - b) Incremental learning
  - c) Semi-supervised learning
  - d) Transfer learning
  - e) Adversarial learning
  - f) Dual learning
  - g) Meta learning
2. Learning methods for alternative models such as:
  - a) Time-series machine learning
  - b) Generative models
  - c) Graph-based learning
3. Approaches for better machine learning such as:
  - a) Trustworthy machine learning
  - b) Explainable machine learning
4. Alternative network architectures such as
  - a) Capsule networks
  - b) Autoencoders
  - c) Compensatory neural networks
  - d) Compact neural controllers

### **Suggested textbook/readings**

Related conference proceedings and journal articles.

### **Evaluation**

Project	40%
Presentation (2)	40%
Discussion	20%

## DSCI-6601 Practical machine learning

**Course description:** This course provides a practical introduction to machine learning. The course will mostly focus on applying supervised learning methods to a variety of data-sets using R and Python. Model selection and assessment will be discussed and applied.

**Prerequisites:** None.

### Tentative syllabus:

1. Introduction to Machine Learning (ML)
  - (a) Definition
  - (b) Types of ML
  - (c) Supervised ML
    - i. Classification and regression
    - ii. Generalization, underfitting, overfitting, bias and variance
2. Introduction to scikit-learn
3. Introduction to caret package
4. Exploring, understanding and representing data
  - (a) Data exploration (recap)
  - (b) Data transformations
  - (c) Data encoding
  - (d) Feature selection
5. Model performance assessment
  - (a) Performance metrics
  - (b) Cross-validation
6. Supervised ML algorithms
  - (a) Nearest Neighbours
  - (b) Linear Models
  - (c) Naive Bayes Classifiers
  - (d) Ensembles of Decision Trees
  - (e) Support Vector Machines
  - (f) Feed forward neural networks

### Textbooks:

- *An Introduction to Statistical Learning: with Application in R*. G. James, D. Witten, T. Hastie and R. Tibshirani. Springer, 2013. (<https://www-bcf.usc.edu/~gareth/ISL/>).
- *Introduction to Machine Learning with Python: A Guide for Data Scientists*. Sarah Guido, Andreas Müller. O'Reilly Media, 2016.
- *Machine Learning with R: Expert techniques for predictive modeling, 3rd Edition*. Brett Lantz. Packt, 2019.



**Evaluation Scheme:**

Assignments (6)	60%
Project	30%
In-class participation	10%

## DSCI-6602 Deep learning and artificial intelligence

**Course description:** This course will provide a short overview of classical methods of machine learning before delving into the recent developments in the areas of deep learning, reinforcement learning, deep reinforcement learning and artificial intelligence.

**Prerequisites:** Undergraduate linear algebra at the level of Math-2050, multivariate calculus at the level of Math-2000 as well as elementary probability. Elementary experience with Python.

### Tentative syllabus:

1. Review: Classical machine learning
  - (a) Least squares regression
  - (b) Logistic regression
  - (c) Autoencoders and matrix factorization methods
2. Deep neural networks and deep learning
  - (a) Multilayer perceptron's
  - (b) Gradient descent, optimization, backpropagation algorithms
  - (c) Convolutional neural networks
  - (d) Recurrent neural networks
  - (e) Stability of neural networks
  - (f) Applications to computer vision, natural language processing, time series analysis
  - (g) Computational considerations for training neural networks
3. Advanced topics in deep learning
  - (a) Variational autoencoders
  - (b) Generative adversarial networks and generative methods
  - (c) Adversarial examples
  - (d) Neural ordinary differential equations
4. (Deep) reinforcement learning and artificial intelligence
  - (a)  $\epsilon$ -greedy algorithms
  - (b) Finite Markov decision processes
  - (c) Temporal-difference learning
  - (d) Function approximations for reinforcement learning
  - (e) Policy gradient methods
  - (f) Case studies (ATARI games, AlphaGo, autonomous vehicles)
  - (g) Ethical questions and AI safety

**Textbooks:** The following books are either publicly available or available through our library.

- C.C. Aggarwal. *Neural Networks and Deep Learning*, Springer, 2018. (available as ebook in our library)
- I. Goodfellow, Y. Bengio and A. Courville. *Deep learning*, MIT press, 2016. (available online)
- R.S. Sutton and A.G. Barto. *Reinforcement learning*, MIT press, 2018 (available online)

**Evaluation scheme:** The suggested grading scheme for this course will consist of:

Assignments	15%	One assignment every 2–3 weeks, which includes both analytical and numerical components.
Final project	15%	Each student will prepare an individual final project consisting of a written report and an oral presentation, to be given on the last day of class, on a topic relevant to the course.
Midterm	30%	The midterm exam will be a one hour written exam.
Final exam	40%	The final exam will be a three-hour exam, two hours of which will be a written exam and one hour will be a numerical lab component.

# ENGI 9818 Software Foundations

## Course Information Sheet

Memorial University of Newfoundland

2021 Fall

**Instructor** Theodore Norvell, EN-3064 until Sept. 22 CSF-4117 after Sept. 22, 864-8962.

**Times** MWF 11:00–12:00. Lab: Monday 13:00–15:00 or possibly Thursday 11:00 to 13:00

**Location** CSF-2112 when it is ready. Until then, Wednesday and Friday are in EN 4034. I don't know where we will be on Monday. If the lab is on Thursdays it will be in EN-3000/3029 until CSF-2112 is ready. First lab will be on Thursday Sept 9 at 11:00 in EN-3000/3029.

**Office hours** Wednesday and Friday at 2:00 – subject to change. In my office (see above). Appointments can be made for other times. You are welcome to knock on my office door anytime and if it's not a bad time, I'll be happy to talk.

**Mail** For anything concerning the course, please use the Brightspace “Course Mail”; I am user “theo”. For all other matters use regular email “theo@mun.ca” — please send from your MUN email address.

**TA** Ahmadi Mehrnaz (as far as I know)

**Web page** <http://www.engr.mun.ca/~theo/Courses/swf/> and for some things the Brightspace page.

## Description

Computer Software Foundations covers fundamental topics in computer software design and construction such as: design by contract, procedures, procedural abstraction and recursion; error handling; data structures, invariants, representation relations, and data abstraction; interfaces, inheritance of interface, inheritance of behaviour, inheritance of implementation, overriding, dynamic dispatch, and polymorphic code; simple patterns such as iterators; genericity; event-driven code; higher-order programming.

## Textbook

Barbara Liskov and John Guttag, *Program Development in Java: Abstraction, Specification, and Object-Oriented Design* Addison-Wesley Professional, 2000.

- This book is available only as an e-book or used.

## References

Cay Horstmann, *Core Java(TM) 2, Volume I-Fundamentals*, 11th ed., Prentice Hall PTR, 2020, or 9th ed., 2009. (9th edition available electronically from the library. See course web page.) What we really need is the 12 edition, but it is not yet published.

The Java Language Specification, Java SE 16 Edition, online at <https://docs.oracle.com/javase/specs/>  
 Bertrand Meyer, *Object-Oriented Software Construction*, 2nd ed., Prentice Hall, 1997.

## 1 Software

Java 16 or 17 JDK (or later)

Eclipse for Java Developers 2021-06 version. Or your favourite IDE. But it must support the Java 16 JDK.

Git

Optionally, SourceTree from Atlassian.

## Evaluation Scheme with *Tentative* Dates

<b>Midterms</b>	25%	Oct. 13 and Nov. 15
<b>Assignments</b>	25%	
<b>Labs</b>	10%	
<b>Final</b>	30%	TBA
<b>Float</b>	10%	(Better of midterms (combined) & final)

## Other Information

- If you are forced to isolate during the term, let me know. I will do my best to ensure that you can continue to participate.
- All the above is subject to change in case of a lock-down or other expected or unexpected crap.

- Late assignments and projects will not be accepted without prior arrangement or documented justification.
- Any complaints about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the exam.
- Academic dishonesty will, as a minimum, result in a mark of zero for the offending work. Academic dishonesty will be reported to the Associate Dean. Academic dishonesty includes copying from another student's work or allowing another student to copy from one's own work, consulting with any unauthorized person during an examination or test, using unauthorized aids, and presenting the ideas or works of another as one's own. If you have any doubt about whether something constitutes academic honesty, consult with the instructor. I am getting really freaking pissed off about cheating, so don't do it.
- Asking questions is strongly encouraged.
- Comments, suggestions and constructive criticisms are always welcome.



Faculty of Engineering and Applied Science

Course Outline  
ECE7410/ENGI9804

Spring 2021

## ECE7410/ENGI9804: Image Processing and Applications

**Instructor:** Stephen Czarnuch      **Teaching Assistants:** Ali Ebrahimi  
**E-mail:** [sczarnuch@mun.ca](mailto:sczarnuch@mun.ca)  
**Phone:** 864-7850      **E-mail:** [aebrahimi@mun.ca](mailto:aebrahimi@mun.ca)  
**Office Location:** IIC-3030  
**Office Hours:** TBD

### Website

The course content such as lecture notes and assignments are posted on D2L, which should appear in your course list at <http://online.mun.ca/>.

### Communication

Through lectures on Tuesday and Thursday from 9:00-10:15 and via MUN email (not D2L email). Changes to course information (e.g., cancelled classes) will be communicated via D2L and/or the MUN cancellation web page. I am also available outside office hours, but to guarantee my availability simply confirm an appointment by email first.

### CALENDAR ENTRY:

**Image Processing and Applications** presents fundamental theoretical and practical concepts of image processing and analysis. These concepts include image enhancement and filtering, frequency domain analysis, morphological image operations, image segmentation, and feature extraction. The course enables the use of these concepts to automatically process and analyze images and videos from various real-world applications such as biomedical imaging, visual surveillance, and robotics.

**CR:** CS4756

**LH:** at least four 3-hour sessions per semester

**LAB EXPERIENCE:** None.

**CREDIT VALUE:** 3 credit hours

**COURSE TYPE:** Compulsory

### ACCREDITATION UNITS:

Contact hours/week on average over 12 weeks (Lecture/Lab/Tutorial): 2.5/1/0

### CONTENT CATEGORIES: (expressed as %, no category can be $0 < c < 25$ )

Math	Natural science	Complementary Studies	Engineering Science	Engineering Design
	50		50	



Faculty of Engineering and Applied Science

Course Outline  
ECE7410/ENGI9804

Spring 2021

**COURSE DESCRIPTION:**

**SCHEDULE:** LECTURE: Tue/Thur 9:00-10:15 Room: EN-1051

**RESOURCES:**

Core Text Book

1. Gonzalez, R.C. and Woods, R.E., Digital Image Processing, 4th Edition, Pearson, 2017.

Recommended Text books:

1. Szeliski, R., Computer Vision: Algorithms and Applications, Springer-Verlag, 2011.
2. Forsyth, D. and Ponce, J., Computer Vision: A Modern Approach, Second Edition, Pearson, 2011.
3. Marques, O., Practical Image and Video Processing Using MATLAB, Wiley-IEEE Press, 2011.

Other sources:

1. Scholarly publications related to your selected project topic

**MAJOR TOPICS:**

- Preliminaries
- Image formation
- Projective geometry and pinhole camera model
- Image enhancement and filtering
- Frequency domain analysis
- Morphological Image Operations
- Image Segmentation
- Recognition

**LEARNING OUTCOMES:**

Course Level Graduate Attribute Focus: KB.A, Inv.A, Des.A

Upon successful completion of this course, the student will be able to:

	<b>LEARNING OUTCOMES</b>	<b>GRADUATE ATTRIBUTES. LEVEL*</b>	<b>Methods of Assessment</b>
1	Identify and distinguish the various techniques in the fields of image processing and machine vision.	KB.A, Inv.D	Assignments, Labs, Quiz





Faculty of Engineering and Applied Science

## Course Outline ECE7410/ENGI9804

Spring 2021

2	Design, implement, and systematically test fundamental image processing methods/algorithms.	KB.A, Tools.D	Assignments, Labs, Quiz, Project
3	Choose appropriate image processing methods for image filtering, image reconstruction, and segmentation.	KB.A, Inv.A	Assignments, Project, Final Exam
4	Perform a critical assessment of different machine vision research approaches in terms of their merits and shortcomings in different applications.	KB.A, Inv.A, PA.D	Assignments, Project
5	Implement and test a machine vision system for an application.	Des.A	Project

\*Each Graduate Attribute for each learning outcome is rated at a Content Instructional Level of I=Introduced, D=Developed, or A=Applied.

See [www.mun.ca/engineering/undergrad/graduateattributes.pdf](http://www.mun.ca/engineering/undergrad/graduateattributes.pdf) for definitions on the 12 Graduate Attributes and the Content Instructional Levels.

### ASSESSMENT:

	Weight		Approximate date
	(Undergrad)	(Graduate)	
<b>Assignments</b>	<b>10%</b>	<b>10%</b>	-
Assignment 1	5%	5%	June 25
Assignment 2	5%	5%	July 10
<b>Midterm</b>	<b>15%</b>	<b>15%</b>	June 17
<b>Labs</b>	<b>10%</b>	<b>10%</b>	
Lab 1	-	-	June 11
Lab 2	-	-	July 2
Lab 3	-	-	July 16
Lab 4	-	-	July 30
<b>Project</b>	<b>25%</b>	<b>40%</b>	-
Project proposal	10%	0%	May 28
Technical content and working demo	60%	70%	August 3
Final report	30%	30%	August 6
<b>Final exam</b>	<b>40%</b>	<b>25%</b>	TBD

### ADDITIONAL INFORMATION:

**Assignments:** You will work individually on the course assignments and submit your completed assignments (via BrightSpace).

**Labs:** The labs are intended to serve as methodological procedures, so that you can independently work your way through an image processing problem, implement a solution, and discuss and interpret the results. You are expected to complete these labs and submit (via



BrightSpace) a step-by-step output, including your code, input and output images, to show that you understand the impact of each image processing step.

**Project:** A major part of this course is the term project.

*Undergraduate student project:* Undergraduate students will work in pairs, and both members will receive the same mark. You will define an image processing project of your choice. The project **MUST**:

- Address a realistic application of image processing
- Utilize at least **four** fundamental image processing approaches covered in this course
- Include a clear justification for, and explanation of, the parameters and approaches chosen
- Not include an implementation of more advanced computer vision techniques

*Graduate student project:* Undergraduate students will work individually. You will define an image processing project of your choice. The project **MUST**:

- Be an implementation of a recent (2015+) image processing publication that processed a public image dataset, ideally related to your program of study
- Utilize at least **two** fundamental image processing approaches covered in this course as significant steps in the methodology
- Include a clear explanation of the parameters and approaches chosen
- Include an evaluation of the approach on the public dataset, showing you have replicated the implementation and achieve the same results
- Not include a significant implementation of more advanced computer vision techniques

*Project proposal:* Proposals must include the following:

1. A one-line problem statement
2. A description of the proposed image processing application, including the major image processing techniques and a summary of the methodology
3. A concise summary of relevant work you may use for your project

#### **LAB SAFETY:**

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

#### **ACADEMIC INTEGRITY AND PROFESSIONAL CONDUCT:**

Students are expected to conduct themselves in all aspects of the course at the highest level



Faculty of Engineering and Applied Science

Course Outline  
ECE7410/ENGI9804

Spring 2021

of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at <http://www.mun.ca/engineering/undergrad/academicintegrity.php>

Students are encouraged to consult the Faculty of Engineering and Applied Science Student Code of Conduct at <http://www.mun.ca/engineering/undergrad/academicintegrity.php> and Memorial University's Code of Student Conduct at <http://www.mun.ca/student/conduct/>.

**INCLUSION AND EQUITY:**

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

**STUDENT ASSISTANCE:** Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).

**MISCELLANEOUS NOTES:**

- Submitted materials are due by 11:59pm on the due date. Late materials will not be accepted without prior arrangement or documented justification.
- Any complaints about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the final report deadline.
- Academic dishonesty will, as a minimum result in a grade of zero for the offending work, and may be reported to the Dean for treatment through the prescribed formal process. Academic dishonesty includes copying, allowing your work to be copied, and failing to cite sources. Refer to the relevant information available through Memorial University.
- Questions related to the course are strongly encouraged.
- Constructive comments, suggestions and criticisms are always welcome.



Faculty of Engineering and Applied Science

Course Outline  
ENGI 8814/9805

Winter 2020

## ENGINEERING 8814/9805: Computer Vision

<b>Instructor</b>	Ebrahim Karami	<b>Teaching Assistant</b>	TBA
<b>E-mail</b>	<a href="mailto:ekarami@mun.ca">ekarami@mun.ca</a>	<b>E-mail</b>	TBA
<b>Phone</b>	864-6412		
<b>Office Location</b>	EN3052		
<b>Office Hours</b>	Mon. & Fri. 11:00-12:00		

### Website

The course content such as lecture notes and assignments are posted on D2L, which should appear in your course list at <http://online.mun.ca/>.

### Communication

Through lectures on Monday, Wednesday, and Friday from 10:00:10:50 and via MUN email (not D2L email). Changes to course information (e.g., cancelled classes) will be communicated via D2L and/or the MUN cancellation web page. I am also available outside office hours, but to guarantee my availability, simply confirm an appointment by email first.

### CALENDAR ENTRY:

*This course will discuss special topics in computer vision and introduce some fundamental approaches in theory as well as discuss current state of the art research. Topics include feature detection and matching; camera model and calibration; pose estimation; structure from motion; stereovision; target detection and tracking; and advanced topics in deep neural networks.*

**LAB EXPERIENCE:** None.

**CREDIT VALUE:** 3 credit hours

**COURSE TYPE:** Compulsory

### ACCREDITATION UNITS:

Contact hours/week on average over 12 weeks (Lecture/Lab/Tutorial): 2.5/1/0

**CONTENT CATEGORIES:** (expressed as %, no category can be  $0 < c < 25$ )

Math	Natural science	Complementary Studies	Engineering Science	Engineering Design
	50		50	

### COURSE DESCRIPTION:

**SCHEDULE:**

LECTURE:	MWF 10:00-10:50 Room: EN-2040
LAB:	M 17:00-19:00 Room: EN-3000

### RESOURCES:



Faculty of Engineering and Applied Science

Course Outline  
ENGI 8814/9805

Winter 2020

**Text Book**

There are no required text books. All material are available from the course slides. However, the suggested text books for the course are:

1. [Computer Vision: Algorithms and Applications](#) by Richard Szeliski (available for free on author's page)
2. [Computer Vision: A Modern Approach](#) by David Forsyth and Jean Ponce
3. [Deep Learning](#) by Ian Goodfellow, Yoshua Bengio and Aaron Courville (available for free online)

**Other sources:**

1. Scholarly publications related to your selected project topic

**MAJOR TOPICS:**

- Preliminaries
- Feature detection and matching
- Geometric and multi-vision
- Feature based alignment
- Structure from motion
- Segmentation and tracking
- Deep Learning
- SLAM

**LEARNING OUTCOMES:**

Course Level Graduate Attribute Focus: KB.A, Inv.A, Des.A

Upon successful completion of this course, the student will be able to:

	<b>LEARNING OUTCOMES</b>	<b>GRADUATE ATTRIBUTES. LEVEL*</b>	<b>Methods of Assessment</b>
1	Identify and distinguish the various techniques in the fields of image processing and machine vision.	KB.A, Inv.D	Assignments, Labs, Quiz
2	Design, implement, and systematically test fundamental image processing methods/algorithms.	KB.A, Tools.D	Assignments, Labs, Quiz, Project
3	Choose appropriate image processing methods for image filtering, image reconstruction, and segmentation.	KB.A, Inv.A	Assignments, Project, Final Exam
4	Perform a critical assessment of different machine vision research approaches in terms of their merits and shortcomings in different applications.	KB.A, Inv.A, PA.D	Assignments, Project
5	Implement and test a machine vision system for an application.	Des.A	Project

\*Each Graduate Attribute for each learning outcome is rated at a Content Instructional Level of I=Introduced, D=Developed, or A=Applied.



Faculty of Engineering and Applied Science

## Course Outline ENGI 8814/9805

Winter 2020

See [www.mun.ca/engineering/undergrad/graduateattributes.pdf](http://www.mun.ca/engineering/undergrad/graduateattributes.pdf) for definitions on the 12 Graduate Attributes and the Content Instructional Levels.

### ASSESSMENT:

	Weight		Approximate date
	(Undergrad)	(Graduate)	
<b>Assignments</b>	<b>10%</b>	<b>5%</b>	-
Assignment 1	2.5%	1.25%	February 4
Assignment 2	2.5%	1.25%	February 14
Assignment 3	2.5%	1.25%	March 6
Assignment 4	2.5%	1.25%	March 20
<b>Midterm</b>	<b>15%</b>	<b>15%</b>	February 28
<b>Labs</b>	<b>10%</b>	<b>5%</b>	
Lab 1	2.5%	1.25%	February 3
Lab 2	2.5%	1.25%	February 24
Lab 3	2.5%	1.25%	March 9
Lab 4	2.5%	1.25%	March 23
<b>Project</b>	<b>25%</b>	<b>35%</b>	-
Project proposal	5% (1.25%)	5% (1.75%)	February 3
Technical content and working demo	60% (15%)	60% (21%)	March 20
Oral presentation	10% (2.5%)	10% (3.5%)	March 23
Final report	25% (5%)	25% (7%)	March 23
<b>Final exam</b>	<b>40%</b>	<b>40%</b>	-

### Lecture Capture:

All classes for this course, unless otherwise notified, will be recorded.

Comments and questions by those present in the class may be captured in the audio of the recording.

Additionally, student presentations/participation may be captured on video.

Questions or concerns about the use of lecture capture in this course should be directed to your instructor.

### ACADEMIC INTEGRITY AND PROFESSIONAL CONDUCT:

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at

<http://www.mun.ca/engineering/undergrad/academicintegrity.php>

Students are encouraged to consult the Faculty of Engineering and Applied Science Student



Faculty of Engineering and Applied Science

Course Outline  
ENGI 8814/9805

Winter 2020

Code of Conduct at <http://www.mun.ca/engineering/undergrad/academicintegrity.php> and Memorial University's Code of Student Conduct at <http://www.mun.ca/student/conduct/>.

**INCLUSION AND EQUITY:**

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

**STUDENT ASSISTANCE:** Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).

**ADDITIONAL INFORMATION:**

**Team Project:** A major part of this course is the term project. Carefully read the following points with respect to the project:

- Projects will be undertaken by teams of no more than two students.
- Teams can define their own projects.
- Teams must have an operational machine vision system that can be demonstrated to the class during the demonstrations.
- Undergraduate students should target a realistic application of machine vision.
- Graduate students projects should reflect a higher level of sophistication and should be based on the implementation of techniques or algorithms presented in a journal publication.
- All team members receive the same mark for all components of project.
- Project proposal are due on February 3rd and must include the following:
  1. A problem statement.
  2. A description of the proposed machine vision system. What useful purpose or function will your system serve?
  3. A description of the software tools and hardware (if applicable) that will be used.
  4. The deliverables - what will your team demonstrate to the class at the end of the term.
  5. Pertinent references and/or a brief state-of-the-art survey of comparable systems



Faculty of Engineering and Applied Science

Course Outline  
ENGI 8814/9805

Winter 2020

- Project progress meeting is scheduled on March 2<sup>nd</sup> and during that meeting groups will present a two-page report.

**MISCELLANEOUS NOTES:**

- Submitted materials are due by 11:59pm on the due date. Late materials will not be accepted without prior arrangement or documented justification.
- Any complaints about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the final report deadline.
- Academic dishonesty will, as a minimum result in a grade of zero for the offending work, and may be reported to the Dean for treatment through the prescribed formal process. Academic dishonesty includes copying, allowing your work to be copied, and failing to cite sources. Refer to the relevant information available through Memorial University.
- Questions related to the course are strongly encouraged.
- Constructive comments, suggestions and criticisms are always welcome.





Dept. Electrical &amp; Computer Engineering

Course Outline  
ENGI 9821

Semester

## Engi 9821: Digital Signal Processing

**Instructor:** TBA  
**E-mail:** [TBA@mun.ca](mailto:TBA@mun.ca)  
**Office Hours:** TBA  
**Website:** Brightspace course shell  
**Preferred methods of communication:** TBA

**Teaching Assistant:** TBA

**Course Objectives:** To build upon foundational knowledge of basic discrete-time signals and systems and digital signal processing (DSP); to extend this foundational knowledge to the study of DSP methods and applications; to investigate the application of DSP across fields in engineering and science, with a more in-depth investigation of one topic or application via a design project.

**Level of course:** Students are expected to be self-motivated and responsible for their learning, as is usual in a graduate course. Students are expected to keep up with class work and deliverables, to participate in discussions with the class and with the instructor, and to select and investigate a topic in digital signal processing through an individual research project to be conducted at a graduate level of inquiry and performance. Also see Assumed Background next.

**Prerequisites:** ENGI 7600 (formerly ENGI 7824) at MUN.

**Alternatively, Assumed Background:** Students are expected to have taken undergraduate course(s) on continuous-time and discrete-time systems and signals and the sampling theorem at the level of a text such as B.P. Lathi, *Linear Systems and Signals*, 2<sup>nd</sup> edition, Oxford University Press, 2005, or A.V. Oppenheim, A.S. Willsky and B.H. Nawab, *Signals and Systems*, 2<sup>nd</sup> edition, Prentice-Hall, 1997.

**Schedule:** Specific to semester

**Credit Value:** 3 credits

**[Required Resources] Text:** A.V. Oppenheim and R.W. Schaffer, *Discrete-time Signal Processing*, Third edition, Prentice-Hall, 2010, ISBN 0-13-198842-5

**[Required Resources] Software:** MATLAB to analyze and design DSP systems.

### Major Topics:

Engi 9821 is layered lecture-wise with ECE 8600 (Design of DSP Systems). Its course material will address the following topics:

1. Introduction to Digital Signal Processing (DSP). Review of background (as in ECE 7600) including discrete-time (DT) systems and signals in the time ( $n$ ), Fourier ( $\omega$ ) and  $z$ -transform domains, and their key properties for use in DSP analysis and design
2. DSP as the discrete-time (DT) processing of continuous-time (CT) signals via sampling



Dept. Electrical &amp; Computer Engineering

Course Outline  
ENGI 9821

Semester

3. Computable transforms, i.e. the Discrete Fourier Transform (DFT) and the Fast Fourier Transform (FFT)
4. Fourier analysis of DT signals (and of CT signals via sampling)
5. Transform analysis of linear, time-invariant (LTI) systems, for use in filter design
6. Finite impulse response (FIR) filter design
7. Infinite impulse response (IIR) filter Design
8. Practical issues in the design and implementation of DSP systems
9. Examples of the above topics in selected applications of DSP throughout the course.

**Assessment:**

<u>Deliverable</u>	<u>Value</u>	<u>(Due) Date</u>
Review Assign	4%	TBD
Design Assignment	8%	TBD
Design project (see break-down below)	24%	
Proposal	4%	TBD
Final report	14%	TBD
Presentation	3%	TBD
Presentation Oral	3%	TBD
Problem Sets (see note below)		
Mid-term Test 1	14%	TBD
Mid-term Test 2	14%	TBD
Final Exam	36%	TBD
Total	100%	

**Notes for specific offering** of this course, e.g.:

Note on Format:

Note on Course Materials on Brightspace:

Note about Problem Sets:

Note about Review Assignment:

Note about 9821 Design Assignment:

Note about the 9821 Design Project:

**Engi 9821 Policy on Extensions and Deferrals:** Specific to offering**Some Reference Texts:*****On Discrete-time Systems and Signals***

1. B.P. Lathi, *Linear Systems and Signals*, 2<sup>nd</sup> edition, Oxford University Press, 2005.
2. A.V. Oppenheim, A.S. Willsky & B.H. Nawab, *Signals and Systems*, 2<sup>nd</sup> ed., Prentice-Hall, 1997.

***On DSP***

3. Richard Lyons, *Understanding Digital Signal Processing*, 3<sup>rd</sup> ed., Prentice-Hall, 2011.
4. D.G. Manolakis and V.K. Ingle, *Applied Digital Signal Processing: Theory and Practice*, Cambridge University Press, 2011.
5. S.K. Mitra, *Digital Signal Processing: A Computer-based Approach*, 4<sup>th</sup> ed., McGraw-Hill, 2011 (or 3<sup>rd</sup> ed. 2006, or 2<sup>nd</sup> ed. 2001).



Dept. Electrical & Computer Engineering

Course Outline  
ENGI 9821

Semester

6. J.G. Proakis and D.G. Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*, 4th ed., Macmillan, 2007 (or 3<sup>rd</sup> ed. 1996).
7. M.H. Hayes, *Digital Signal Processing*, 2<sup>nd</sup> ed. McGraw-Hill (Schaum's Outlines), 2012.  
**On Matlab for DSP:**
8. J.H. McClellan, R.W. Schafer and M.A. Yoder, *DSP First*, 2<sup>nd</sup> ed., Pearson, 2016.
9. V.K. Ingle and J.G. Proakis, *Digital Signal Processing using Matlab: A Problem Solving Companion*, 4<sup>th</sup> ed., Cengage Learning, 2017.

### Rules and Regulations (to be updated for each offering based on MUN policies):

**Academic Integrity and Professional Conduct:** Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at [www.engr.mun.ca/undergrad/academicintegrity](http://www.engr.mun.ca/undergrad/academicintegrity).

**The Memorial University of Newfoundland Code:** "All members of the Memorial University of Newfoundland Community, which includes students, faculty, and staff, shall treat others with respect and fairness, be responsible and honest, and uphold the highest standards of academic integrity."  
(<http://www.mun.ca/regoff/calendar/sectionNo=GENINFO-1502>)

**Faculty of Engineering Student Code of Conduct:** "Like Professional Engineers, engineering students are expected to behave in a professional manner at all times. Students are encouraged to conduct themselves in a manner consistent with the [PEG-NL Code of Ethics](#)." Read more at <http://www.engr.mun.ca/policies/codeofconduct.php>

**Safety:** Students are expected to demonstrate awareness of, and personal accountability for, safe conduct within the classroom and building. Take note of emergency exits. Students will immediately report any concerns regarding safety to the teaching assistant and/or professor.

**Inclusion and Equity:** Students who require physical or academic accommodations are encouraged to speak privately to the instructor so that appropriate arrangements can be made to ensure your full participation in the course. All conversations will remain confidential.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

**Student Assistance:** Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).



Faculty of Engineering and Applied Science

## Course Outline

ENGI9826

Winter 2020-2021

# ENGINEERING 9826: Advanced Control Systems

**Instructor** Dr. Siu O'Young  
**E-mail** [oyoung@mun.ca](mailto:oyoung@mun.ca)  
**Phone** 864-8345  
**Office Location** EN-3074  
**Office Hours** 10:00 - 2:00pm Wednesday

**PREFERRED METHOD OF CONTACT:** email

**SCHEDULE:** MWF 12:00 – 12:50 noon (concurrent with 7200) and W: 4:00-5:40pm (9826 specific)

### RATIONALE:

This is an introductory graduate level course aimed at exposing a novice to different theoretical areas in systems and controls. It will review both classical controls and modern controls and introduce optimal control for continuous-time dynamical systems, and discrete-event systems built upon automata theory. The course will also give a unified view of continuous-time dynamical systems and discrete-event systems as hybrid systems.

### REFERENCES:

- Luenberger, D.C., *Introduction to Dynamical Systems*, Wiley, 1979
- Nise, N. S., *Control Systems Engineering*, 7<sup>th</sup> Ed., Wiley, 2015
- Ogata, K., *Modern Control Engineering*, 5<sup>th</sup> Ed., Prentice Hall, 2009
- Williams, R. L. and D. A. Lawrence, *Linear State-Space Control Systems*, Wiley, 2007
- Belegundu, A.D. and T.R. Chandrupatla, *Optimization Concepts and Applications in Engineering*, Prentice-Hall, 1999
- Hopcroft, J.E. and J.D. Ullman, *Introduction to Automata Theory, Languages, and Computation*, 3<sup>rd</sup> Ed., Pearson, 2006
- Cassandras, C.G. and S. Lafortune, *Introduction to Discrete-Event Systems*, 2<sup>nd</sup> Ed., Springer, 2009
- Polderman, J.C. and J.C. Willems, *Introduction to Mathematical Systems Theory: A Behavioral Approach*, Springer, 1998

### MAJOR TOPICS:

- Dynamical Systems and Representations
- Classical Control Systems in Frequency Domain
- Modern Control Systems in Time Domain
- Optimal Control
- Behavioral Systems
- Discrete-Event Systems
- Hybrid Systems



Faculty of Engineering and Applied Science

## Course Outline

ENGI9826

Winter 2020-2021

---

### ASSESSMENTS:

- Assignments (20%)
- Midterm (20%)
- Project Presentation (15%)
- Final Project (45%)

### LAB SAFETY:

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

### ACADEMIC INTEGRITY AND PROFESSIONAL CONDUCT:

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at <http://www.mun.ca/engineering/undergrad/academicintegrity.php>

Students are encouraged to consult the Faculty of Engineering and Applied Science Student Code of Conduct at <http://www.engr.mun.ca/policies/codeofconduct.php> and Memorial University's Code of Student Conduct At <http://www.mun.ca/student/home/conduct.php>.

### INCLUSION AND EQUITY:

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

### STUDENT ASSISTANCE:

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).



## Proposal for a new graduate program

### Master of Applied Science in Software Engineering

Memorial University, St. John's, NL, Canada

<b>Name of the program</b>	Master of Applied Science in Software Engineering
<b>Degree name in short form</b>	M.A.Sc.SE
<b>Academic units offering the program</b>	Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science and Department of Computer Science, Faculty of Science
<b>Administrative home of the program</b>	Faculty of Engineering and Applied Science
<b>Proponents</b>	Dr. Cheng Li (licheng@mun.ca) and Dr. Sharene Bungay (cs-chair@mun.ca)
<b>Date</b>	October 19, 2021
<b>Tentative start of the program</b>	Fall 2022

## Contents

1	Executive summary.....	4
2	Description of the program.....	5
2.1	Name of the program.....	5
2.2	Graduate student profile.....	5
2.3	Learning outcomes.....	5
2.4	Key learning outcomes.....	5
2.5	Requirements for admission.....	6
2.6	Program overview.....	6
2.6.1	Core courses.....	6
2.6.2	Elective courses.....	6
2.6.3	Program schedule.....	7
3	Statement of Justification.....	7
3.1	Introduction.....	7
3.2	Contribution to strategic goals of the University.....	7
4	Market analysis.....	8
4.1	International and national comparison of related programs and unique attributes.....	8
5	Projected enrollment.....	10
6	Resource implications.....	10
6.1	Existing faculty resources.....	10
6.2	New faculty resources.....	12
6.3	Additional non-faculty resources.....	12
6.4	Administration of the program.....	12
7	Budget.....	12
7.1	Program expenses.....	13
7.2	Revenue.....	14
7.3	Payment schedule.....	14
	Appendix A: Library holdings evaluation.....	15
	Appendix B: Calendar regulations.....	16
	Appendix C: Course listings.....	17
	Core courses.....	17
	Elective courses.....	17

Faculty of Engineering and Applied Science

Master of Applied Science in Software Engineering

Appendix D: Consultation .....	18
Appendix E: Faculty CVs .....	19
Appendix F: Canadian university survey of undergraduate and graduate programs in software engineering.....	26



## Faculty of Engineering and Applied Science

### **1 Executive summary**

This proposal calls for the creation of the Master of Applied Science in Software Engineering program housed in the Faculty of Engineering and Applied Science at Memorial University, but jointly offered by the Department of Electrical and Computer Engineering (Faculty of Applied Science and Engineering) and the Department of Computer Science (Faculty of Science). Software is critical to most modern technologies. Given the expected and accelerated growth for professions related to software over the next decades, the development of software programs has become a priority for almost all major universities. The proposed program is in direct alignment with the strategic goals of the University regarding information and communication technologies. Further the proposed software engineering program has been designed with an internationally recognisable curriculum. The curriculum focuses on the fundamental aspects of the field, and is intended to attract local, national and international students who want to break into this emerging area. The establishment of the proposed software engineering program is not only timely but will also put Memorial University at the lead among the Atlantic Canadian universities. Specifically, the program is intended to yield advanced software engineers and architects to lead and facilitate information innovation and commercialization.

## **2 Description of the program**

The Master of Applied Science in Software Engineering (MAScSE) is a course-based Master's program intended for students with a computer science or computer engineering background who wish to upgrade their background to specialize in software engineering. The MAScSE is a four-term, course-based Master's program to be offered jointly by the Faculty of Science and the Faculty of Engineering and Applied Science. Graduates of the program will have knowledge and understanding of the core areas and methods of Software Engineering and will be ready to work in positions of software development, computer systems architecture and design, and distributed services. We foresee graduates working in both the private and public sectors locally in Newfoundland and Labrador and across Canada. We expect the program to attract students with a background in computer science, computer engineering and cognate areas.

The selection of core courses is intended to cover much of the required part of the Engineers Canada examination syllabus for Software Engineering<sup>1</sup> and the selection of electives is intended to cover some of the optional parts of the syllabus. It is not intended for the program to be accredited by Engineers Canada (note that Engineers Canada does not accredit graduate programs.) Students who complete the program may go on to register with a provincial regulator as a Professional Engineer; however completing the program is neither necessary nor sufficient to qualify for registration. The program distinguishes itself from the existing course option MSc in Computer Science and MASc in Computer Engineering by an increased focus on software engineering and adjunct topics and a decreased emphasis on other areas of computer science, digital design, and communications.

### **2.1 Name of the program**

The proposed name for the new program is Master of Applied Science in Software Engineering (MAScSE).

### **2.2 Graduate student profile**

Applicants should have a four-year undergraduate degree (or equivalent) in computer science, computer engineering or a cognate area. Applicants must meet the English Proficiency requirements described under Section 4 (General Regulations), Subsection 4.1.5 (English Proficiency Requirements) of the School of Graduate Studies Calendar. Admission will be competitive, selective, and based on overall academic performance.

### **2.3 Learning outcomes**

Students will graduate with a broad understanding of the main areas of Software Engineering as well as in-depth knowledge in some of these areas. Students will acquire practical experience through course projects, and by completing a substantial team capstone project.

### **2.4 Key learning outcomes**

By completing the proposed MAScSE program, it is expected that a graduate shall be able to:

---

<sup>1</sup> <https://engineerscanada.ca/sites/default/files/2021-04/Software-engineering-syllabus.pdf>

- Develop an in-depth understanding of software engineering methods and techniques in areas such as software quality assurance, software security, human-machine interfaces, software development and maintenance, project planning and management
- Build the skills to design and develop, implement, integrate, and maintain software and software related products.
- Refine and apply the skills necessary to develop and manage small-, medium-, and large-scale software systems with a primary focus on theory and foundational knowledge

## 2.5 Requirements for admission

Admission will be competitive, selective, and based on overall academic performance. The Chair of the Program in concurrence with Graduate Studies committees of the departments will oversee the admission process to ensure that the proper policies and regulations are followed and the best candidates are offered admission. The minimum requirements are:

- Applicants should have a four-year undergraduate degree (or the equivalent) in computer science or computer engineering (or cognate area).
- Applicants must meet the English Proficiency requirements described under Section 4 (General Regulations), Subsection 4.1.5 (English Proficiency Requirements) of the School of Graduate Studies Calendar.

## 2.6 Program overview

The program consists of 21 credit hours of core courses and 9 credit hours of elective courses (subject to the Chair of the Program's approval), either from the list below or an approved replacement.

### 2.6.1 Core courses

ENGI 9818	Software Fundamentals
COMP 6901	Applied Algorithms
COMP 6905	Software Engineering
ENGI 9867	Advanced Computing Concepts for Engineering
ENGI 9874	Software Design and Specification
SE xxx2	Software Verification and Validation
SE xxx1 <sup>†</sup>	Software Engineering Capstone
<sup>†</sup> Normally SE xxx1 will be taken in the final term	

### 2.6.2 Elective courses

COMP 6904 <sup>1</sup>	Advanced Computer Architecture
COMP 9861 <sup>1</sup>	High-Performance Computer Architecture
COMP 6908	Database Technology and Applications
COMP 6910	Services Computing, Semantic Web and Cloud Computing
COMP 6916	Security and Privacy or ENGI 9823 Computer Security
COMP 6921	Syntax and Semantics of Programming Languages

Faculty of Engineering and Applied Science

Master of Applied Science in Software Engineering

COMP 6922	Compiling Methods
COMP 6925 <sup>2</sup>	Advanced Operating Systems
ENGI 9875 <sup>2</sup>	Embedded and Real-Time Systems Design
COMP 6934	Introduction to Data Visualization
ENGI 9872	Digital Communications
ENGI 9876	Advanced Data Networks
ENGI 9869 <sup>3</sup>	Advanced Concurrent Programming
COMP 6903 <sup>3</sup>	Concurrent Computing
SE xxx3	Software Engineering Practice
AI xxx	Topics in Artificial Intelligence
<sup>1</sup> Students can take one of COMP 6904 or COMP 9861	
<sup>2</sup> Students can take one of COMP 6925 or ENGI9875	
<sup>3</sup> Students can take one of ENGI 9869 or COMP 6903	

### 2.6.3 Program schedule

Term	Core courses	Elective courses
Fall	ENGI 9818 (Software Fundamentals) COMP 6901 (Applied Algorithms)	
Winter	COMP 6905 (Software Engineering) ENGI 9867 (Advanced Computing Concepts for Engineering)	Elective (1)
Spring	ENGI 9874 (Software Design and Specification) SE xxx2 (Software Verification and Validation)	Elective (1)
Fall	SE xxx1 (Software Engineering Capstone)	Elective (1)

## 3 Statement of Justification

### 3.1 Introduction

With our lives lived increasingly utilizing varied technologies, software lies at the heart of technological function. With an increased reliance on modern, advanced technologies, there is an ever-increasing demand for specialists being able to develop software, understand and support computer systems architecture and design, and distributed services, tasks which are done by software engineers. Given the continuing demand for software engineers, and the expected accelerated growth of this profession over the next few decades, the development of a software engineering graduate degree has become a top priority for many major universities global. The development of a Master of Applied Science in Software Engineering program at Memorial University is therefore especially timely, poising Memorial as a national leader in this exciting field.

### 3.2 Contribution to strategic goals of the University

Memorial University's Strategic Plan notes that we must strive to be "A University for Our Province". With the increasing growth of technology companies in Newfoundland and Labrador (e.g., Verafin), producing highly skilled and highly trained software engineers allows the University to directly fulfill an industrial need. Further, Memorial's Strategic Research Plan, and specifically the "Information and Communication Technology" theme, specifically lists "software

engineering” as a priority area. The formation of a software engineering master’s program thus directly responds to the strategic research goals of the university.

#### 4 Market analysis

Recent years have seen accelerated growth in demand for software developers. The United States Bureau of Labour Statistics estimates a growth of 22% in the fields of Software Developers, Quality Assurance Analysts, and Testers from 2020-2030, “much faster than average”<sup>2</sup>. In Canada, there is expected to be a labour shortage for software engineers over the next 10 years, with an expected 27,500 new job openings and only 24,000 new job seekers available to fill these positions<sup>3</sup>. By province, job prospects for software engineers are fair to good (on a scale of limited, fair, and good), and while projections for Newfoundland and Labrador are not known, projections in the rest of Atlantic Canada are all good (the highest rating). Wages for software engineers are high, averaging around \$95,000 per year (\$45.67 per hour) in Canada<sup>3</sup> and \$110,140 per year (\$52.95 per hour)<sup>2</sup> in the United States. Overall, there is a pressing demand for graduates to enter this domain. The proposal of a course-based Master of Applied Science in Software Engineering at Memorial University is in direct response to the rapid developments of this field. As an exceptionally interdisciplinary field, it is worth mentioning that Memorial University already has considerable research expertise in software engineering, distributed among the departments of Electrical and Computer Engineering, Computer Science, and beyond. The consolidation of this expertise in a master program in software engineering will allow Memorial to fill this lacuna in skilled software engineers quickly. Additionally, by producing highly educated and skilled graduate students in software engineering with master’s degrees, we will help ensure that our graduates are prepared to enter the field at the top of the profession. The creation of a dedicated master’s program in software engineering can, therefore, be seen as a timely approach for structuring the training of the next generation of software professionals. Since the proposed course-based MAScSE program is intended to attract strong undergraduate students, we most notably expect to be able to offer a promising set of graduates to fulfill local industry demand in addition to growing local, national and international markets.

##### 4.1 International and national comparison of related programs and unique attributes

Most major Canadian universities offer software engineering programs, including the University of Toronto<sup>4</sup>, the University of Waterloo<sup>5</sup>, the University of Alberta<sup>6</sup>, and McGill University<sup>7</sup>. Notably, these programs are housed in both the department electrical and computer engineering (e.g., University of Toronto), the department of computer science (e.g., University of Alberta) and jointly between the two (e.g., McGill University). In Canada, fewer universities offer graduate

<sup>2</sup> U.S. Bureau of Labour Statistics (2021), <https://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm>

<sup>3</sup> Government of Canada (2019), <https://www.jobbank.gc.ca/marketreport/outlook-occupation/5485/ca>

<sup>4</sup> University of Toronto (2021), <https://www.ece.utoronto.ca/prospective-students/curriculum-streams/software-hardware/>

<sup>5</sup> University of Waterloo (2021), <https://uwaterloo.ca/future-students/programs/software-engineering>

<sup>6</sup> University of Alberta (2021), <https://www.ualberta.ca/computing-science/research/research-areas/software-engineering.html>

<sup>7</sup> McGill University (2021), <https://www.mcgill.ca/undergraduate-admissions/program/software-engineering-faculty-engineering>

## Faculty of Engineering and Applied Science

## Master of Applied Science in Software Engineering

programs in computer engineering with an optional specialization in software engineering, including Carleton University<sup>8</sup> and the University of Waterloo<sup>9</sup>. Globally, universities around the world<sup>10</sup> have started graduate programs in software engineering with a broad interpretation of the definition of the term “software engineer” and a wide variety of curricula, some focusing more on software and information systems, some centred on hardware and computer architectures related to software engineering, and others seeking a balance between the two, or allowing students the option to choose a specialization. Generally, depending on the focus of the program, software engineering graduate degrees are offered through either the Faculty of Engineering and Applied Science (e.g., department of Electrical and Computer Engineering), the Faculty of Science (e.g., the department of Computer Science), or jointly between the two. Many such programs are offered as a specialisation of existing programs in either faculty.

Given the rapid development in the field of software engineering, which is only expected to accelerate over the coming decade, and to leverage the current expertise at Memorial, we propose a Master of Applied Science in Software Engineering graduate program that is balanced between software and hardware, with a slightly stronger focus on software principals and theoretical fundamentals of software engineering. In proposing a program that is focused on the fundamental theoretical aspects of this field rather than specific areas of application, our prospective students will be appropriately prepared for the ever-evolving job market.

Out of 96 Canadian universities surveyed, there are presently 27 universities offering undergraduate degrees specifically in software engineering (or equivalent). Of those same 96 Canadian universities surveyed, ten are offering masters degrees in software engineering or related areas. A detailed survey of software engineering-related programs offered in Canadian universities are given in Appendix F: Canadian university survey of undergraduate and graduate programs in software engineering. In Alberta, the Universities of Alberta and Lethbridge offer options or specializations within existing Master of Science degrees, while the University of Calgary offers a one-year course-based Master of Software Engineering. In British Columbia, Simon Fraser University offers a related program resulting in a Master of Science in Professional Computer Science which is similar to the proposed MAScSE. In Nova Scotia, St. Mary’s University offers a one-year course-based Master of Science in Software Engineering. In Ontario, McMaster, Western and Wilfred Laurier Universities offer course-based Master of Software Engineering degrees, while Queen’s University offers a software engineering specialization with the Master of Science program. Finally, in Quebec, Concordia University and École de technologie supérieure offer course-based Master of Software Engineering degrees. Notably, among the Atlantic universities only St. Mary’s University offers a specific Masters degree in software engineering, “with a primary focus on quality, reliability, and maintainability<sup>11</sup>”. Memorial University, being a leader of Atlantic universities, is in the unique position of offering a Master of Applied Science in Software Engineering in which students can learn and apply the fundamental techniques from a

<sup>8</sup> Carleton University (2021), <https://carleton.ca/sce/graduate-studies/>

<sup>9</sup> University of Waterloo (2021), <https://uwaterloo.ca/graduate-studies-academic-calendar/engineering/department-electrical-and-computer-engineering/master-engineering-meng-electrical-and-computer-engineering>

<sup>10</sup> Texas State University, San Marco, Texas; University of Europe for Applied Sciences, Berlin, Germany; Innopolis University, Kazan, Russia; Torrens University, Australia; Ben-Gurion University of the Negev, Beersheba, Israel

<sup>11</sup> St. Mary’s University (2021), <https://www.stmarytx.edu/academics/programs/master-software-engineering/>

## Master of Applied Science in Software Engineering

theoretical foundation, jointly delivered by both the department of Electrical and Computer Engineering, and the department of Computer Science.

## 5 Projected enrollment

Table 1. Projected 5-year enrolment\*

Type/year	Year 1	Year 2	Year 3	Year 4	Year 5
FT enrolment	15	20	25	30	30
PT enrolment	-	-	-	-	-
Canadian enrolment	2	2	2	2	2
International enrolment	13	18	23	28	28
On-campus	15	20	25	30	30
Online	-	-	-	-	-
Thesis	-	-	-	-	-
Non-thesis	15	20	25	30	30
Total	15	20	25	30	30

\*Enrolment as of Fall semester of each year.

## 6 Resource implications

The Faculty of Engineering and Applied Science and the Faculty of Science, and in particular the departments of Electrical and Computer Engineering and Computer Science, have both the teaching and research expertise relevant to the core components of software engineering. Significant research involving software engineering is conducted in both faculties, and many faculty members have existing expertise that can contribute to the success of the program. In fact, the interest in software across the university can be used to enrich the program through, for example, the capstone project as well as enlarging the pool of elective courses.

The program requirements of proprietary software will be minimal because the program will leverage existing software (e.g., Matlab) and other open-source resources. However, students still need access to high performance computing facilities and, depending upon enrolment, the department's computer lab facilities may be overwhelmed. Should such an eventuality arise, a portion of the generated revenue would need to be directed to address this. Meanwhile, some alternatives have been sought. For example, the Centre for Health Informatics and Analytics of the Faculty of Medicine hosts a cluster with big data analysis capabilities, and students whose adviser holds an affiliation with the Faculty of Medicine may be granted access to the computing resources.

### 6.1 Existing faculty resources

Below a list of faculty members with teaching and research expertise relevant to the core components of software engineering is provided.

Name	Faculty	Description
Andrew Vardy	FEAS/Science	Swarm robotics and navigation
Octavia Dobre	FEAS	Wireless, optical and underwater communication
Cheng Li	FEAS	wireless communications and networking, communications signal processing, underwater communication and networking, and mobile ad hoc and wireless sensor networks

## Master of Applied Science in Software Engineering

Dennis Peters	FEAS	Software, ranging from introductory programming courses to advanced topics such as software engineering and concurrent programming
Thumeera Wanasinghe	FEAS	Autonomous robotics systems, multi-sensor data fusions, applied AI and machine learning, and digitalization and its socioeconomic impact.
Howard Heys	FEAS	Cryptography, digital hardware design, and communication networks.
Mohsin Jamil	FEAS	Advanced control systems, digital signal processing and machine learning, as well as advanced control systems, mechatronics, power electronics, power systems and instrumentation.
Ramachandran Venkatesan	FEAS	Parallel processing architectures and applications, error control coding, underwater communications, wireless communications, and optical communications.
Weimin Huang	FEAS	Mapping of oceanic surface parameters via high-frequency ground wave radar, X-band marine radar, and global navigation satellite systems.
Reza Shahidi	FEAS	Software engineering, theory of computation, digital signal processing and digital systems, incorporating machine learning, both from theoretical and practical standpoints
Sarah Power	FEAS	Brain-computer interfaces involving the classification/detection of mental states using non-invasively measured neural signals, signal processing and biomedical engineering
Cecilia Moloney	FEAS	Nonlinear signal and image processing methods, signal representations, and radar signal processing, ethics in engineering, problem solving in engineering, and methods for engineering discovery, signals and systems, probability and random processes, and communications
Siu O'Young	FEAS	Sense-and-avoid technology for remotely piloted aircraft systems ("drones")
Theodore Norvell	FEAS	Formal programming methods, semantics of programming languages, implementation of programming languages, automated verification of concurrent programs, design of programming languages, program animation, and visual programming languages
Stephen Czarnuch	FEAS	Intelligent, pervasive technologies based on autonomously tracking human motion using computer vision and machine learning.
Dave Churchill	Science	His research revolves around artificial intelligence, video games, and robotics.
Kartek Popuri	Science	Medical image analysis, machine learning, artificial intelligence and computer vision.
Alex Bihlo	Science	Numerical analysis and machine learning (deep learning) with applications to geophysical fluid dynamics



Faculty of Engineering and Applied Science

Master of Applied Science in Software Engineering

Matthew Hamilton	Science	Digital twin and virtual reality systems, including aspects such as vision/sensing, simulation/modelling, graphics/visualization and user interfaces.
------------------	---------	---

## 6.2 New faculty resources

The Department of Electrical and Computer Engineering is seeking two tenure-track faculty to support the delivery of the program.

## 6.3 Additional non-faculty resources

The proposed program will use some of the existing courses offered in the departments of Electrical and Computer Engineering and Computer Science. However, it will require of 3 new on-campus courses, additional sections to existing courses, and a capstone project as well as the teaching time to offer a comprehensive selection of elective courses.

## 6.4 Administration of the program

The proposed Master of Applied Science in Software Engineering program will be administered by the Dean of the Faculty of Engineering and Applied Science, who will appoint a Board of Studies (BoS) Chair. The Chair will struck the joint board with members from the Department of Electrical and Computer Engineering and the Department of Computer Science. The chair must work in conjunction with the department heads of Electrical and Computer Engineering and Computer Science or their representatives in all relevant matters concerning the program. The Board will meet regularly to deal with admissions, student progress reviews, changes to the curriculum and content, and review the regulations governing the program.

## 7 Budget

The proposed budget for the Master of Applied Science in Software Engineering (MAScSE) program is provided in Table 2 with different enrolment scenario. The budget of the enrollment is based on one local student from Newfoundland and Labrador (NL), one Canadian student (non-NL) and one international student each year, where the program fees and special fees of Canadian students will be lower than the international students, and the rest will be international students. As per the budget, program will have a break-even with about 25 - 30 students. With the strong demand in this subject area, it is expected that the program will reach its intended capacity within four years. Surplus of revenues will be used to support students through upgrades in technology as well as entrance scholarship, in-program scholarship, and bursaries for students.

As detailed in the market analysis, there is a high demand for the MAScSE program. However, in case of low enrolments, efforts will be taken to improve the intake by different recruitment strategies with available Memorial resources. The highly related but still complementary sister program (Master of Artificial Intelligence; MAI) as well as other existing course-based programs in the Faculty of Engineering and Applied Science and the Faculty of Science will provide a large pool to attract students from outside, and will serve as a large buffering zone in case one program experiences short term enrolment challenges.

Faculty of Engineering and Applied Science  
Master of Applied Science in Software Engineering

Table 2: Proposed budget for Master of Applied Science in Software Engineering

Type/year		Year 1	Year 2	Year 3	Year 4	Year 5
<b>Enrolments (students)</b>	International student	13	18	23	28	28
	Canadian student	1	1	1	1	1
	NL student	1	1	1	1	1
	<b>Total student</b>	<b>15</b>	<b>20</b>	<b>25</b>	<b>30</b>	<b>30</b>
<b>Revenue</b>	Program fees	138,810	187,140	235,470	283,800	283,800
	Special fees	294,270	395,680	497,090	598,500	598,500
	Other revenue					
	<b>Total Revenue</b>	<b>433,080</b>	<b>582,820</b>	<b>732,560</b>	<b>882,300</b>	<b>882,300</b>
	Revenue to MUN central account	138,810	187,140	235,470	283,800	283,800
	VP office fee (20% of gross)	58,854	66,967	99,418	119,700	119,700
	Revenue to FEAS and FS	235,416	316,544	397,672	478,800	478,800
<b>Expenditures (Instructional &amp; Administrative costs)</b>	Tenure-track professor (incl. benefits, 2 positions)	240,000	240,000	240,000	240,000	240,000
	Per-course instructor (3 positions)	17,284	17,284	17,284	17,284	17,284
	Teaching assistantships (5 positions)	6,719	6,719	6,719	6,719	6,719
	Administration support	34,287	34,287	34,287	34,287	34,287
<b>Expenditures (Materials, Supplies, and Recruitment costs)</b>	Course related materials, int'l scholarships and equipment (@\$2,000 per student)	30,000	50,000	50,000	60,000	60,000
	Recruitment expenses and travel expenses	10,000	10,000	10,000	10,000	10,000
	Recruitment agency commission (@2,568 per student)	33,380	59,058	59,058	71,896	71,896
	Entrance scholarship to Canadian student	5,000	5,000	5,000	5,000	5,000
<b>Total Expenditures</b>		<b>574,335</b>	<b>665,786</b>	<b>757,236</b>	<b>848,687</b>	<b>848,687</b>
<b>Net Balance</b>		<b>\$(141,255)</b>	<b>\$(82,966)</b>	<b>\$(24,676)</b>	<b>\$33,613</b>	<b>\$33,613</b>

### 7.1 Program expenses

The major part of the expenses is the salary portion of two tenure track faculty positions. It is highly necessary as software engineering is a fast growing area globally. It is hard to attract highly qualified candidates without such positions. Those faculty members are also expected to be actively engaged in research and graduate student supervision. Three per-course instructors are considered to complement additional teaching tasks. As per the Memorial regulations, 20% of the gross income will contribute to the Provost Office expenses. Other expenses include teaching

## Faculty of Engineering and Applied Science

### Master of Applied Science in Software Engineering

assistantship, faculty administration support, program related materials, equipment and scholarships, recruitment expense and travel expense, and recruitment agency commissions.

#### 7.2 Revenue

The revenue for the program is generated based on the student's regular program fee plus the special fee. The regular fees of the program are \$9,666, \$7,434, and \$5,718 for international students, Canadian students, and Newfoundland students, respectively. The special fees of the program are \$20,282 for international students, and \$15,302 for Canadian and Newfoundland students.

#### 7.3 Payment schedule

Based on the proposed budget, a payment schedule (Table 3) is proposed where students need to pay a non-refundable deposit fee.

Table 3: Payment schedule

Type	Fee type	Deposit	Fall	Winter	Spring	Total
Local Student	Regular fee	\$1,000	\$1,906	\$1,906	\$1,906	\$5,718
	Special fee		\$7,651	\$6,651	\$0	\$15,302
Canadian Student	Regular fee	\$1,000	\$2,478	\$2,478	\$2,478	\$7,434
	Special fee		\$7,651	\$6,651	\$0	\$15,302
International Student	Regular fee	\$1,000	\$3,222	\$3,222	\$3,222	\$9,666
	Special fee		\$10,141	\$9,141	\$0	\$20,282

Faculty of Engineering and Applied

Master of Applied Science in Software Engineering

Science **Appendix A: Library holdings evaluation**

Faculty of Engineering and Applied Science  
 Master of Applied Science in Software Engineering

## Appendix B: Calendar regulations

### xxx. Regulations Governing the Degree of Master of Applied Science in Software Engineering

The Degree of Master of Applied Science in Software Engineering (MAScSE) is a four-term, course-based Master's program jointly offered by the Department of Computer Science and the Department of Electrical and Computer Engineering.

#### xxx.1 Qualifications for Admission

1. Admission is limited and competitive, and based on overall academic performance.
2. To be considered for admission, applicants shall normally hold a minimum second-class 4-year Bachelor's Degree in computer science, computer engineering or in a related discipline from a university of recognized standing.
3. To be eligible for consideration for admission applicants will meet the English Proficiency Requirements described under General Regulations, English Proficiency Requirements.
4. Admission to the program shall be upon acceptance by the Dean of Graduate Studies after recommendation by the Chair of the Program or either Head of the Departments of Computer Science or Electrical and Computer Engineering, along with a tentative program of study.

#### xxx.2 Degree Requirements

1. The degree program requires the completion of 30 credit hours.
  - a. 3 credit hours of a Capstone project course SE XXX1.
  - b. 18 credit hours by completing ENGI 9818, COMP 6901, COMP 6905, ENGI 9867, ENGI 9874, and SE xxx2.
  - c. 9 credit hours (three courses) to be selected from COMP 6904, 6908, 6910, 6916, 6921, 6922, 6925, 6934, ENGI 9807, 9869, 9876, 9877, SE xxx3, and AI xxx.

#### xxx.3 Evaluation

Students must obtain a grade of at least 65% in all program courses to receive credit for the course towards their program requirements. Any student who fails to receive 65% or more in a course must repeat the course in the case of core courses, or must either repeat or replace the course with another program course in the case of elective courses. Any student who receives a grade of less than 65% in two courses or in a repeated course will be required to withdraw from the program.

Faculty of Engineering and Applied Science

Master of Applied Science in Software Engineering

**Appendix C: Course listings***Core courses*

ENGI 9818	Software Fundamentals
COMP 6901	Applied Algorithms
COMP 6905	Software Engineering
ENGI 9867	Advanced Computing Concepts for Engineering
ENGI 9874	Software Design and Specification
SE xxx2	Software Verification and Validation
SE xxx1 <sup>†</sup>	Software Engineering Capstone
<sup>†</sup> Normally SE xxx1 will be taken in the final term	

*Elective courses*

COMP 6904 <sup>1</sup>	Advanced Computer Architecture
ENGI 9861 <sup>1</sup>	High-Performance Computer Architecture
COMP 6908	Database Technology and Applications
COMP 6910	Services Computing, Semantic Web and Cloud Computing
COMP 6916	Security and Privacy or ENGI 9807 Computer Security
COMP 6921	Syntax and Semantics of Programming Languages
COMP 6922	Compiling Methods
COMP 6925 <sup>2</sup>	Advanced Operating Systems
ENGI 9875 <sup>2</sup>	Embedded and Real-Time Systems Design
COMP 6934	Introduction to Data Visualization
ENGI 9872	Digital Communications
ENGI 9877	Cryptography
ENGI 9876	Advanced Data Networks
ENGI 9869 <sup>3</sup>	Advanced Concurrent Programming
COMP 6903 <sup>3</sup>	Concurrent Computing
SE xxx3	Software Engineering Practice
AI xxx	Topics in Artificial Intelligence

<sup>1</sup> Students can take one of COMP 6904 or COMP 9861<sup>2</sup> Students can take one of COMP 6925 or ENGI9875<sup>3</sup> Students can take one of ENGI 9869 or COMP 6903

Faculty of Engineering and Applied Science

Master of Applied Science in Software Engineering

## **Appendix D: Consultation**

## Appendix E: Faculty CVs

**Andrew Vardy** is a Professor jointly appointed to the Department of Computer Science and the Department of Electrical and Computer Engineering at Memorial University in St. John's, Canada. He completed degrees in electrical engineering (B.Eng., Memorial University, 1999), evolutionary and adaptive systems (M.Sc., University of Sussex, 2000), and computer science (Ph.D., Carleton University, 2005). His main research area is swarm robotics but he has also developed new techniques in visual robot navigation. He leads the Bio-Inspired Robotics (BOTS) lab which is focused on developing swarms of robots that can actively organize their environments, for example by sorting objects or cleaning a space.

**Octavia A. Dobre** received the Dipl. Ing. and Ph.D. degrees from the Polytechnic Institute of Bucharest, Romania, in 1991 and 2000, respectively. Between 2002 and 2005, she was with New Jersey Institute of Technology, USA. In 2005, she joined Memorial University, Canada, where she is currently a Professor and Research Chair. She was a Visiting Professor with Massachusetts Institute of Technology, USA and Université de Bretagne Occidentale, France. Her research interests encompass wireless, optical and underwater communication technologies. She has (co)authored over 400 refereed papers in these areas.

Dr. Dobre serves as the Editor-in-Chief (EiC) of the IEEE Open Journal of the Communications Society. She was the EiC of the IEEE Communications Letters, Senior Editor, Editor, and Guest Editor for various prestigious journals and magazines. She also served as General Chair, Technical Program Co-Chair, Tutorial Co-Chair, and Technical Co-Chair of symposia at numerous conferences.

Dr. Dobre was a Fulbright Scholar, Royal Society Scholar, and Distinguished Lecturer of the IEEE Communications Society. She obtained Best Paper Awards at various conferences, including IEEE ICC, IEEE Globecom, IEEE WCNC, and IEEE PIMRC. Dr. Dobre is a Fellow of the Engineering Institute of Canada, a Fellow of the Canadian Academy of Engineering, and a Fellow of the IEEE.

**Cheng Li** received his B. Eng. and M. Eng. degrees from Harbin Institute of Technology, Harbin, P. R. China, in 1992 and 1995, respectively, and his Ph.D. degree in Electrical and Computer Engineering from Memorial University, St. John's, Canada, in 2004. He is currently a Full Professor and Head of the Department of Electrical and Computer Engineering of Memorial University, St. John's, Canada. His research interests include wireless communications and networking, communications signal processing, underwater communication and networking, and mobile ad hoc and wireless sensor networks. He has (co)authored over 350 technical papers in his research areas.

Dr. Li is an IEEE Communications Society Distinguished Lecturer for the 2021-22 term. He is an associate editor of the IEEE Transactions on Communications, IEEE Internet-of-Things Journal, IEEE Network Magazine, and IEEE Systems Journal. He has served as the General Co-Chair of the ICNC'22, WINCOM'19, and AICON'19, and the TPC Co-chair for the ICNC'20, MSWiM'14, WiMob'11 and QBSC'10. He has served as a co-chair for various technical symposia/tracks of many international conferences, including IEEE GLOBECOM, ICC, and WCNC. He is the recipient of the best paper awards in various international conferences, including the IEEE Globecom'2017 and ICC'2010. Dr. Li is a registered Professional Engineer (P. Eng.) in Canada and is a Senior Member



of the IEEE and a member of the IEEE Communication Society, Computer Society, Vehicular Technology Society, and Ocean Engineering Society.

**Dennis K. Peters** is Professor and Associate Dean (Undergraduate Studies) for the Faculty of Engineering and Applied Science at Memorial University in St. John's, NL, Canada where he has been a member of Faculty since 1998. He earned the B.Eng. (Electrical) degree at Memorial University in 1990, before going to work in the high-tech industry at Newbridge Networks (now Alcatel) in Ottawa, Ontario. After two years in industry he returned to school, this time at McMaster University in Hamilton, Ontario where he completed the M.Eng. (Electrical & Computer) in 1995 and Ph.D. (Electrical & Computer Engineering) in 2000. His research involves applications of machine learning techniques to a variety of problems ranging from marine operations to oilfield characterization. He also studies techniques for design and verification of software and computer systems, with particular focus on high performance computing, simulation, real-time applications and parallel or distributed processing.

Dr. Peters is an active volunteer in the professional engineering community in Canada. He is a former Chair (2014-15) of the Board of Directors of the Professional Engineers and Geoscientists of Newfoundland and Labrador (PEGNL), and served (2008-2020) on the Canadian Engineering Qualifications Board (CEQB), including a term as Chair (2016-18). He was a member (2002-13) of the Registration Committee for PEGNL, including the last 7 years as Chair. He is a member (1999-present) of the executive committee for the Newfoundland and Labrador Section of the IEEE, including a term as Chair and several years as Student Branch Counselor. He has participated in accreditation visits for the Canadian Engineering Accreditation Board (CEAB) and has served on the organizational committees for local, national and international conferences.

His teaching activity is primarily in the area of software, ranging from introductory programming courses to advanced topics such as software engineering and concurrent programming.

**Thumeera Wanasinghe** received his B.Sc. (Hons.) and M.Sc. degree in Electronic and Telecommunication Engineering from the University of Moratuwa, Sri Lanka, in 2009 and 2011, respectively. He obtained his doctoral degree in Electrical Engineering from Memorial University of Newfoundland, Canada, in 2017. His masters' thesis focussed on electrical parametric modelling of human skin impedance spectroscopy in response to variations in blood glucose level, and his doctoral thesis focussed on autonomous multi-robot collaboration. After completing his doctoral degree, he joined the Memorial University of Newfoundland as a postdoctoral researcher. He led three industrial funded research projects exploring underwater image processing, 3D point-cloud processing, and opportunities and challenges of digitalization of extractive industries. He has completed several online certifications in data science, machine learning, deep learning, and self-driving cars during his postdoctoral study. Currently, he is an Assistant Professor (Teaching term) attached to the Department of Electrical and Computer Engineering, Faculty of Engineering and Applied Science, Memorial University of Newfoundland. His main research areas are autonomous robotics systems, multi-sensor data fusions, applied AI and machine learning, and digitalization and its socioeconomic impact. His teaching interests embrace but are not limited to the following areas: communications systems, electrical/ electronic/ digital circuits, signal processing, electromagnetic principles, autonomous robotic systems, control systems, machine learning, artificial intelligence, and data science.

**Howard M. Heys** obtained a B.E.Sc degree in electrical engineering in 1984 from the University of Western Ontario in London, Ontario, Canada, and a Ph.D. degree in computer engineering in 1994 from Queen's University, Kingston, Ontario, Canada. He worked for several years as a software designer in Ottawa and Toronto and is now a professor of Electrical and Computer Engineering at Memorial University. His current research interests include cryptography, digital hardware design, and communication networks. He has supervised or co-supervised 25 graduate student research theses and served on numerous conference program committees, as well as hosting and chairing the Conference on Selected Areas in Cryptography (SAC) twice at Memorial. His recent teaching activities have included introductory courses in digital logic, computer hardware foundations, and circuits and advanced courses in communication networks and cryptography.

**Mohsin Jamil** received a Bachelor of industrial electronics Engineering degree from NED University of Engineering and Technology, Karachi, Pakistan, in 2005. He received two master's degrees in electrical engineering from Dalarna University Sweden and the National University of Singapore in 2006 and 2008, respectively, with major in Automation and Control Engineering. He received his PhD degree in electrical engineering from the University of Southampton in 2012.

He is currently an assistant professor (teaching) and adjunct professor within the Department of Electrical and Computer Engineering at Memorial University of Newfoundland, Canada, since August 2019. Between 2016 and 2019, he worked in the Department of Electrical Engineering at the Islamic University of Madinah, Saudi Arabia. Between 2012 and 2016, He was working at the Robotics Department of the National University of Sciences and Technology (NUST), Islamabad, Pakistan. His teaching interest includes advanced control systems, digital signal processing and machine learning, as well as advanced control systems, mechatronics, power electronics, power systems and instrumentation. He also works in other multidisciplinary areas as well, such as process control, system identification, artificial intelligence, and machine learning.

He is the author and co-author of several IEEE publications in different journals and peer-reviewed conferences. He is the recipient of different awards and funding grants. He is a registered Professional Engineer in the Province of Newfoundland and Labrador, Canada. He is an associate editor of IEEE Access and a senior member of IEEE.

**Ramachandran Venkatesan** received the B.E. degree (Hons.) from Madurai University, Madurai, India, and the M.Sc.E. and Ph.D. degrees from the University of New Brunswick, Fredericton, NB, Canada, all in electrical engineering. He is a professor (emeritus) of computer engineering with Memorial University of Newfoundland, St. John's, NL, Canada, where he has been working since 1987. He worked in Industry as a welding research engineer for several years. He has held several academic administrative positions including the Chair of Electrical and Computer Engineering, the Associate Dean for Graduate Studies and Research, the Associate Dean for Undergraduate Studies, the Acting Dean, and the Dean Pro Tempore of Engineering. His research interests include parallel processing architectures and applications, error control coding, underwater communications, wireless communications, and optical communications. He is a Registered Professional Engineer.

**Weimin Huang** received the B.S., M.S., and Ph.D. degrees in radio physics from Wuhan University, Wuhan, China, in 1995, 1997, and 2001, respectively, and the M.Eng. degree in electrical engineering from the Memorial University of Newfoundland, St. John's, NL, Canada, in 2004. From 2008 to 2010, he was a Design Engineer with Rutter Technologies, St. John's. Since 2010, he has

been with the Faculty of Engineering and Applied Science, Memorial University of Newfoundland, where he is a Professor. He has authored more than 250 research articles.

His research interests include the mapping of oceanic surface parameters via high-frequency ground wave radar, X-band marine radar, and global navigation satellite systems. Dr. Huang has been a Technical Program Committee Member. He serves as a regular Reviewer for more than 60 international journals and a Reviewer for many IEEE international conferences, such as RadarCon, the International Conference on Communications, IEEE Global Communications Conference, IEEE Geoscience and Remote Sensing Society, and Oceans. He was a recipient of the Postdoctoral Fellowship from the Memorial University of Newfoundland. In 2017, he was a recipient of the Discovery Accelerator Supplements Award from the Natural Sciences and Engineering Research Council of Canada. He was a recipient of the IEEE Geoscience and Remote Sensing Society 2019 Letters Prize Paper Award. He has served as the Technical Program Co-Chair for the IEEE Newfoundland Electrical and Computer Engineering Conference in 2012 and 2013. He is an Area Editor of the IEEE Canadian Journal of Electrical and Computer Engineering, an Associate Editor of IEEE Access, an Editorial Board Member of Remote Sensing, and a Guest Editor of IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

**Reza Shahidi** received the Bachelor of Mathematics degree (Joint Honours Computer Science and Pure Mathematics) from the University of Waterloo, Waterloo, ON, Canada, in 1998, and the M. Eng. and Ph.D. degrees in computer engineering from the Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St. John's, NL, Canada, in 2003 and 2008, respectively.

He was a Postdoctoral Fellow from 2008 to 2009 with the University of British Columbia, Vancouver, BC, Canada, where he conducted research on seismic imaging, after which he spent several years working in industry in radar signal and image processing. In 2019, he was appointed as an Adjunct Professor with the Electrical and Computer Engineering Department, Faculty of Engineering and Applied Science, Memorial University, where he holds a multi-year NSERC Discovery Grant to conduct research into ocean parameter spectrum extraction from HF radar data. His research interests include signal and image processing, machine learning, algorithm design, HF and X-band radar, and vehicular networks. Before being appointed Teaching Assistant Professor with the ECE Department at MUN in December 2020, he was Product Development Lead with Seamatica Aerospace, St. John's, NL, Canada, and has roughly a decade of industrial research and development experience. As Teaching Assistant Professor, and prior to that, Dr. Shahidi has taught courses in Software Engineering, Theory of Computation, Digital Signal Processing and Digital Systems. He has introduced and incorporated machine learning, both from theoretical and practical standpoints, when teaching graduate courses in Advanced Computing Concepts and Concurrent Programming over the past year. He is the author or co-author of approximately 50 peer-reviewed journal and conference publications in prestigious venues and has supervised/co-supervised several graduate students both at the University of British Columbia and Memorial University.

**Sarah Power** received the B.Eng. degree from Memorial University and the M.A.Sc. and Ph.D. degrees from the University of Toronto. She is an assistant professor, joint-appointed to the Department of Electrical and Computer Engineering and the Division of Community Health and

## Master of Applied Science in Software Engineering

Humanities. Broadly, her research interests lie in biomedical signal processing and the application of machine learning to medical, rehabilitation, and human factors problems. Her main research focus is in the area of brain-computer interfaces, which involves the classification/detection of mental states (e.g., mental workload, fatigue, attention, affective state, task proficiency) using non-invasively measured neural signals (e.g., EEG). Her current teaching activities are primarily in the areas of signal processing and biomedical engineering.

**Cecilia Moloney** is a faculty member at Memorial University where she is a Professor of Electrical and Computer Engineering. She is a member of the Radar Remote Sensing Laboratory (RRSL), with research interests that include nonlinear signal and image processing methods, signal representations, and radar signal processing. In addition, she is a founder of the MetaKettle Project, a legacy project of the NSERC/Petro-Canada Chair for Women in Science and Engineering, Atlantic Region that she held at Memorial University in 2004-2009. The MetaKettle Project promotes and conducts research in transformative pedagogy for science and engineering; her recent contributions have addressed aspects of ethics in engineering, problem solving in engineering, and methods for engineering discovery. Dr. Moloney has taught courses at undergraduate and graduate levels in the Signals and Systems stream of courses (e.g. Engi 9821, Digital Signal Processing), in probability and random processes (e.g. Engi 9825, Random Signals), and in communications (e.g. Engi 9871, Information Theory and Coding). To the courses she teaches she brings the technical knowledge and pedagogical insights she has honed over her academic career, from the classroom and from her research and outreach initiatives.

**Siu O'Young** is a Professor in Electrical and Computer Engineering at Memorial University. He has a Ph.D. in Electrical Engineering from the University of Waterloo. His current research focus is on sense-and-avoid technology for remotely piloted aircraft systems ("drones"). He is active in the RTCA SC228 committee for US detect-and-avoid standards and is a member of the TSO Mirror Committee on Unmanned Aircraft Systems for the Standards Council of Canada. He also has more than 20 years of business experience in mentoring high-tech start-ups and in accessing capital.

**Theodore S. Norvell** is a Professor of Computer Engineering at Memorial University, where he has been a faculty member for 26 years. His research has included formal programming methods, semantics of programming languages, implementation of programming languages, automated verification of concurrent programs, design of programming languages, program animation, and visual programming languages. He has taught courses in computing theory, software design, software development, concurrent programming, algorithms, data structures, discrete math, formal methods, digital logic, operating systems, and more, and he has developed software including "The Teaching Machine" (with Michael Bruce-Lockhart). He has supervised numerous undergraduate capstone projects including, most recently, aspects of the Killick-1 satellite, has supervised numerous capstone projects for course-based masters students, and has supervised or co-supervised 16 thesis-based students.

**Stephen Czarnuch** is an Associate Professor in Biomedical Engineering at Memorial University. He received his B.Eng. and Mgmt. and M.A.Sc. degrees in Electrical and Computer Engineering from McMaster University, and his Ph.D. in Biomedical Engineering from the Institute of Biomaterials and Biomedical Engineering at the University of Toronto in 2002, 2005, and 2014, respectively. Following a short post-doctoral appointment at Memorial University, he was appointed

to the Faculty of Engineering and Applied Science at Memorial in 2015. He currently holds or has held 12 grants as PI (including grants from CIHR and NSERC) and 8 grants as CI (including CIHR and SSHRC). He is currently supervising or has supervised 4 doctoral and 6 masters students, 15 research assistants, mentored 4 medical residents and over 40 undergraduate senior engineering students. He has extensive experience developing intelligent technologies for vulnerable populations by implementing a holistic, user-centered design philosophy centered on identifying user needs and evaluating health outcomes. His research is inherently interdisciplinary, lying at the intersection of engineering, computer science, medicine, gerontology, rehabilitation, psychology, and sociology. Specifically, he seeks to develop relevant, accessible, acceptable and adoptable patient-oriented technological interventions based on autonomously tracking human motion using computer vision. Further, he emphasizes the evaluation of their efficacy by connecting academic research with providers and patients in a real-world context. His technical focus is on machine learning, deep learning, and computer vision.

**Dave Churchill** – David Churchill is an Associate Professor of Computer Science at Memorial university, and runs the MUN AI and games lab. His research revolves around artificial intelligence, video games, and robotics.

**Karteek Popuri** is currently an Assistant Professor at the Department of Computer Science at Memorial University of Newfoundland. He got his Bachelor of Technology degree in Chemical Engineering at the Indian Institute of Technology (IIT) Madras, and his Master's degree in chemical engineering from the University of Alberta. He received his PhD degree in Computing Science from the University of Alberta. Dr. Popuri's research interests are broadly in the areas of medical image analysis, machine learning/artificial intelligence and computer vision.

**Alex Bihlo** is an Associate Professor and Canada Research Chair in Numerical Analysis and Scientific Computing in the math department, and cross-appointed with the computer science department. His research is on numerical analysis and machine learning (deep learning) with applications to geophysical fluid dynamics. I am teaching courses on numerical analysis, deep learning and reinforcement learning. I am also supervising several students in this research direction.

**Matthew Hamilton** holds a PhD in Computing Science from the University of Alberta in Canada, as well as an undergraduate degree in Pure Mathematics/Computer Science from Memorial University. He is author and co-author of multiple scientific and engineering articles and patents. Dr. Hamilton is currently and an Assistant Professor of Computer Science at Memorial University and President of Birch Scientific. Previously, he has worked in industrial research as a Holographic Rendering and CODEC R&D Engineer at Avalon Holographics and Senior Research Scientist, NSERC/Research and Development Corporation-NL Postdoctoral Industrial R&D Fellow at GRI Simulations, specializing in oil and gas virtual reality environments (simulation development, computer graphics, and data visualization) as well as computational aspects of developing a 3D display (rendering, codec development and display perception).

His research centers around developing digital twin and virtual reality systems, including aspects such as vision/sensing, simulation/modelling, graphics/visualization and user interfaces. He has particular interest in application of vision and computer graphics towards holographic 3D displays. He is interested in capture of real-world holographic imagery for live cinematic capture, visual modelling for games and digital twins and robotic vision in terms of processing and compression.

Master of Applied Science in Software Engineering

He also works on applying machine learning to digital twin systems for automating decision-making (e.g. in radiology), recognition of novel patterns and data-driven simulation of physical aspects of digital twin systems.

**Appendix F: Canadian university survey of undergraduate and graduate programs in software engineering**

<b>Alberta</b>	<b>City</b>	<b>Undergrad.</b>	<b>Grad.</b>
Athabasca University	Athabasca	No	No
Concordia University of Edmonton	Edmonton	No	No
MacEwan University	Edmonton	No	No
Mount Royal University	Calgary Springbank	No	No
The King's University	Edmonton	Yes	No
University of Alberta	Edmonton	Yes	Yes
University of Calgary	Calgary	Yes	Yes
University of Lethbridge	Lethbridge	No	Yes
<b>British Columbia</b>			
Capilano University	North Vancouver	No	No
Emily Carr University of Art + Design	Vancouver	No	No
Kwantlen Polytechnic University	Surrey	No	No
	Langley		
	Richmond		
	Cloverdale		
Royal Roads University	Victoria	No	No
Simon Fraser University	Burnaby	Yes	Yes
	Surrey		
	Vancouver		
The University of British Columbia	Vancouver	No	No
	Kelowna		
Thompson Rivers University	Kamloops	Yes	No
Trinity Western University	Langley	No	No
	Prince George		
	Terrace		
	Fort St John		
University of Northern British Columbia	Quesnel	No	No
	Gitwinksihkw		
	Abbotsford		
University of the Fraser Valley	Abbotsford	No	No
University of Victoria	Victoria	Yes	No
Vancouver Island University	Nanaimo	No	No
<b>Manitoba</b>			
Brandon University	Brandon	No	No
Canadian Mennonite University	Winnipeg	No	No
St Paul's College	Winnipeg	No	No
The University of Winnipeg	Winnipeg	No	No
Université de Saint-Boniface	Winnipeg	No	No
University of Manitoba	Winnipeg	No	No
<b>New Brunswick</b>			
Mount Allison University	Sackville	No	No
St Thomas University	Fredericton	No	No
Université de Moncton	Moncton	Yes	No

## Master of Applied Science in Software Engineering

	Edmundston		
	Shippagan		
University of New Brunswick	Fredericton	Yes	No
	Saint John		
<b>Newfoundland &amp; Labrador</b>			
Memorial University of Newfoundland	Corner Brook	No	No
	St John's		
<b>Nova Scotia</b>			
Acadia University	Wolfville	No	No
Cape Breton University	Sydney	No	No
Dalhousie University	Halifax	Ye	No
Mount Saint Vincent University	Halifax	No	No
NSCAD University	Halifax	No	No
Saint Mary's University	Halifax	No	Yes
St Francis Xavier University	Antigonish	No	No
Université Sainte-Anne	Pointe-de-l'Église	No	No
University of King's College	Halifax	No	No
<b>Ontario</b>			
	Sault Ste Marie		
Algoma University	Brampton	No	No
	South Porcupine		
Brescia University College	London	No	No
Brock University	St Catharines	No	No
Carleton University	Ottawa	Yes	No
Huron University College	London	No	No
King's University College	London	No	No
Lakehead University	Thunder Bay	Yes	No
	Orillia		
Laurentian University	Sudbury	Yes	No
	Barrie		
McMaster University	Hamilton	Yes	Yes
Nipissing University	North Bay	No	No
OCAD University	Toronto	No	No
Ontario Tech University	Oshawa	Yes	No
Queen's University	Kingston	Yes	Yes
Redeemer University	Ancaster	No	No
Royal Military College of Canada	Kingston	No	No
Ryerson University	Toronto	No	No
St. Jerome's University	Waterloo	No	No
Trent University	Peterborough	Yes	No
	Oshawa		
University of Guelph	Guelph	No	No
University of Ottawa	Ottawa	Yes	No
University of St Michael's College	Toronto	No	No
University of Sudbury	Sudbury	No	No
	Toronto		
University of Toronto	Mississauga	Yes	No
	Scarborough		



University of Trinity College	Toronto	No	No
University of Waterloo	Waterloo	Yes	No
University of Windsor	Windsor	No	No
Victoria University	Toronto	No	No
Western University	London	Yes	Yes
Wilfrid Laurier University	Waterloo	No	No
	Brantford		
York University	Toronto	Yes	No
<b>Prince Edward Island</b>			
University of Prince Edward Island	Charlottetown	No	No
<b>Québec</b>			
Bishop's University	Sherbrooke	No	No
Concordia University	Montreal	Yes	Yes
École de technologie supérieure	Montreal	Yes	Yes
École nationale d'administration publique	Québec	No	No
HEC Montréal	Montréal	No	No
Institut national de la recherche scientifique	Québec	No	No
McGill University	Montreal	Yes	No
Polytechnique Montréal	Montreal	No	No
Université de Montréal	Montréal	No	No
Université de Sherbrooke	Sherbrooke	No	No
	Longueuil		
Université du Québec	Québec	No	No
Université du Québec à Chicoutimi (UQAC)	Chicoutimi	No	No
Université du Québec à Montréal (UQAM)	Montréal	Yes	No
Université du Québec à Rimouski (UQAR)	Rimouski	No	No
Université du Québec à Trois-Rivières (UQTR)	Trois-Rivières	No	No
Université du Québec en Abitibi-Témiscamingue (UQAT)	Rouyn-Noranda	No	No
Université du Québec en Outaouais	Gatineau	No	No
Université Laval	Québec	Yes	No
Université TÉLUQ	Québec	No	No
<b>Saskatchewan</b>			
Campion College	Regina	No	No
	Regina		
First Nations University of Canada	Saskatoon	No	No
	Prince Albert		
Luther College	Regina	No	No
St Thomas More College	Saskatoon	No	No
University of Regina	Regina	Yes	No
University of Saskatchewan	Saskatoon	No	No

# ENGI 9818 Software Foundations

## Course Information Sheet

Memorial University of Newfoundland

2021 Fall

**Instructor** Theodore Norvell, EN-3064 until Sept. 22 CSF-4117 after Sept. 22, 864-8962.

**Times** MWF 11:00–12:00. Lab: Monday 13:00–15:00 or possibly Thursday 11:00 to 13:00

**Location** CSF-2112 when it is ready. Until then, Wednesday and Friday are in EN 4034. I don't know where we will be on Monday. If the lab is on Thursdays it will be in EN-3000/3029 until CSF-2112 is ready. First lab will be on Thursday Sept 9 at 11:00 in EN-3000/3029.

**Office hours** Wednesday and Friday at 2:00 – subject to change. In my office (see above). Appointments can be made for other times. You are welcome to knock on my office door anytime and if it's not a bad time, I'll be happy to talk.

**Mail** For anything concerning the course, please use the Brightspace “Course Mail”; I am user “theo”. For all other matters use regular email “theo@mun.ca” — please send from your MUN email address.

**TA** Ahmadi Mehrnaz (as far as I know)

**Web page** <http://www.engr.mun.ca/~theo/Courses/swf/> and for some things the Brightspace page.

## Description

Computer Software Foundations covers fundamental topics in computer software design and construction such as: design by contract, procedures, procedural abstraction and recursion; error handling; data structures, invariants, representation relations, and data abstraction; interfaces, inheritance of interface, inheritance of behaviour, inheritance of implementation, overriding, dynamic dispatch, and polymorphic code; simple patterns such as iterators; genericity; event-driven code; higher-order programming.

## Textbook

Barbara Liskov and John Guttag, *Program Development in Java: Abstraction, Specification, and Object-Oriented Design* Addison-Wesley Professional, 2000.

- This book is available only as an e-book or used.

## References

Cay Horstmann, *Core Java(TM) 2, Volume I-Fundamentals*, 11th ed., Prentice Hall PTR, 2020, or 9th ed., 2009. (9th edition available electronically from the library. See course web page.) What we really need is the 12 edition, but it is not yet published.

The Java Language Specification, Java SE 16 Edition, online at <https://docs.oracle.com/javase/specs/>  
 Bertrand Meyer, *Object-Oriented Software Construction*, 2nd ed., Prentice Hall, 1997.

## 1 Software

Java 16 or 17 JDK (or later)

Eclipse for Java Developers 2021-06 version. Or your favourite IDE. But it must support the Java 16 JDK.

Git

Optionally, SourceTree from Atlassian.

## Evaluation Scheme with *Tentative* Dates

<b>Midterms</b>	25%	Oct. 13 and Nov. 15
<b>Assignments</b>	25%	
<b>Labs</b>	10%	
<b>Final</b>	30%	TBA
<b>Float</b>	10%	(Better of midterms (combined) & final)

## Other Information

- If you are forced to isolate during the term, let me know. I will do my best to ensure that you can continue to participate.
- All the above is subject to change in case of a lock-down or other expected or unexpected crap.

- Late assignments and projects will not be accepted without prior arrangement or documented justification.
- Any complaints about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the exam.
- Academic dishonesty will, as a minimum, result in a mark of zero for the offending work. Academic dishonesty will be reported to the Associate Dean. Academic dishonesty includes copying from another student's work or allowing another student to copy from one's own work, consulting with any unauthorized person during an examination or test, using unauthorized aids, and presenting the ideas or works of another as one's own. If you have any doubt about whether something constitutes academic honesty, consult with the instructor. I am getting really freaking pissed off about cheating, so don't do it.
- Asking questions is strongly encouraged.
- Comments, suggestions and constructive criticisms are always welcome.

# COMP 6901 -- Applied Algorithms Fall 2020

[Announcements](#) | [Course information](#) | [Assignments and tests](#) | [Lecture notes](#)

## Course information

The course information below is **very tentative!** The way the lectures/tests are done and the marking scheme, in particular, are likely to change depending on everybody's availability, enrolment, software licenses and other factors.

Instructor: [Antonina Kolokolova](#)

Instructor office hours: TBA. Also on Zoom.

Additionally, we will be using discussion boards on [Brightspace](#).

We will be using [Brightspace \(formerly: known as D2L\)](#) for assignment submissions, tests, grades, announcements, etc. The assignments, slides and videos of lectures will also be posted here. The Brightspace shell for our course should be available shortly to all registered students; if you cannot register/access Brightspace after the first week of classes, please let me know.

Textbook: There will be no official textbook for this course. We will mostly follow *J. Kleinberg, E. Tardos. Algorithm Design*, but you do not need to buy it.

Reference books:

- J. Kleinberg, E. Tardos. Algorithm Design.
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. Introduction to Algorithms

We will also use other materials such as research papers.

See the [lecture notes from the previous run of this course](#) for more information.

**Marking scheme:** (tentative!): 4 assignments 15% each, and two tests 20% each. The last test is likely to be scheduled during the last week of classes.

**Description:** The goal of this course is to study both classical and advanced algorithm design techniques with emphasis on real-world applications. We will cover greedy algorithms, dynamic programming, backtracking, network flows as well as more advanced algorithms and techniques (time permitting). Time permitting, we will consider randomized, parallel and distributed algorithms, and/or streaming algorithms.

**Prerequisites:** This course assumes proficiency in the core subjects of computer science: programming, discrete math, and basic data structures/algorithms. In particular, I will assume that you can read and write proofs, know basic probability theory and combinatorics, know basic data structures and algorithm complexity analysis, can read and write pseudocode, and can program fluently in some programming language. Check our undergraduate courses COMP 1001, COMP 1002 and COMP 2002, and make sure you are comfortable with the material covered there; this should take care of most of the skills you need to succeed in COMP 6901.

**Policy on collaboration:** The work you submit must be your own. You may discuss problems from assignments with each other; however, you should prepare written solutions alone, and do not interact with anybody except the instructor while doing tests and online exercises. Plagiarism is a serious academic offense and will be dealt with accordingly. When in doubt, check [How to avoid Plagiarism](#)



# Computer Science 6905

## Software Engineering

### Fall 2020

Department of Computer Science

**Instructor:** Dr. Adrian Fiech  
**Virtual Office Hours:** During the scheduled class time (Monday, Wednesday and Friday 2:00 p.m. – 3:00 p.m.)  
**e-mail:** Brightspace (D2L) email: [afiech@online.mun.ca](mailto:afiech@online.mun.ca)

Please note that you **cannot** email to a Brightspace “online.mun.ca” email address from an outside address (such as “mun.ca” or “gmail.com”), nor can you email from a Brightspace “online.mun.ca” email address to an outside address. Thus, Brightspace “online.mun.ca” email addresses can only be used within the Brightspace environment. The course number **must** be included in the subject line of any emails to the instructor or the instructional staff.

Course information (e.g., assignments, labs, quizzes, lecture notes, announcements, grades, etc.) can be found on Brightspace (D2L).

**Course Prerequisite:**  
Undergraduate Software Engineering course.

**Course Summary:**  
This course starts with review of the basic skills necessary for a developer to function in a software engineering context (chapters 1-3). Next, we focus on methods and technologies that enable developers to specify, design and implement complex systems (chapters 4-8). Finally (student presentations, chapters 12-16), we learn methods and technologies that support the control, assessment and implementation of changes throughout the development of a system.

**Textbook:**  
*Object-Oriented Software Engineering: Using UML, Patterns, and Java™* (3<sup>rd</sup> Edition) by Bernd Bruegge, Allen H. Dutoit, Prentice Hall; ISBN-10: 0136061257; ISBN-13: 978-0136061250.

**Evaluation:**  
The final grade in this course will be determined as follows:

Assignment (28. September – 16. October)	20%
Presentations (due 19. October)	15%
Oral Midterm Exam (21./22./23. October)	35%
Project (26. October – 4. December)	30%

Your final mark can be no more than your midterm exam mark plus 15%!  
 The passing mark for a graduate course is 65%. **To pass this course you must obtain at least 50% on the midterm exam!**

**Lecture Time:** No live lectures; **asynchronous** delivery via notes and presentation slides.

**Tentative Course Schedule:**

Dates	Chapter(s)	Topics(s)
09. September – 11. September	1	Introduction to Software Engineering
14. September – 18. September	2 3	Modeling with UML Project Organization and Communication
21. September – 25. September	4 5	Requirements Elicitation Analysis
28. September – 02. October	5 6 7	Analysis System Design: Decomposing the System System Design: Addressing Design Goals
05. October – 09. October	7 8	System Design: Addressing Design Goals Object Design: Reusing Pattern Solutions
12. October – 16. October (MIDTERM BREAK - 12-13. October)		Review
19. October – 23. October		Presentations and <b>Midterm Exam</b>
26. October – 04. December		Project

**Notes on Assignment/Project/Presentation:**

- Assignment and Project will require programming using the Eclipse IDE. We will be using a GIT repository for group collaboration.
- Your submissions should be uploaded in the correct format, and in the correct folder, using Brightspace's **Assessment/Assignments** tool (instructions will be given on the first assignment). Be aware that the files you submit for evaluation should be uploaded on or before the due date and much before the cut off time. Even if you are late by a few seconds you will not be allowed to submit your work; hence you should try to upload the files 15 minutes before the cut off time since your system clock is not synchronized with CITL's system clock and the cutoff time is based on CITL's system clock. Please note that if your file has been correctly uploaded, you will get a confirmation receipt from the **Assessment/Assignments** tool. If you do not receive this receipt, please contact the CITL Support team (<https://www.citl.mun.ca/support/>). Your instructor will not be able to help you in this regard. It is **very important** to remember that what is not uploaded, cannot be marked. It is your responsibility to make sure that the **correct** files are actually uploaded, so please **do** check for the confirmation that your files have been uploaded.
- Material submitted for grading must be your group's original work. Copying someone else's work or allowing your work to be copied is a serious breach of university regulations and ethics. **Any and all copied material will receive the mark of 0%. If your assignments are quite similar then it can be construed as copying.** Please see the University Calendar - University Regulations - General Academic Regulations (Undergraduate) - **6.12 Academic Misconduct**.

## Oral Midterm Exams:

- The exams will be scheduled on the 21., 22. and 23. October. Your (30 minutes) time slot will be decided at the beginning of October.

## Student support:

- Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within the scope of the University Policies for the Accommodations for Students with Disabilities ([www.mun.ca/policy/site/policy.php?id=239](http://www.mun.ca/policy/site/policy.php?id=239)). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).
- Help with a variety of Online Learning issues, such technical support, etc., is available by contacting the **CITL Support Centre** via phone (1-866-435-1396, or locally at 709-864-8700), online chat (when available) or via their ticketing system. This contact information is available at: <https://www.citl.mun.ca/support/>
- Please note that Memorial University offers a broad range of supports. For a more comprehensive list of student supports and resources, please check out the following links:
  - <https://www.mun.ca/munup/support/>
  - <https://www.mun.ca/main/students.php>
  - <https://www.munsu35.ca/resource-centres/>

## Other:

- If, for special circumstances (such as medical or bereavement) you miss a deadline for a grade item, notify your instructor as soon as possible, providing any related documentation (if documentation is required). Failure to do this can result in a mark of 0% for that work. Please refer to the **current University policy** regarding medical notes and the information to be in them. For more information, please see the University Calendar - University Regulations - General Academic Regulations (Undergraduate) - **6.7.5 Exemptions from Parts of the Evaluation** and **6.15 Appeal of Decisions**, or consult the Registrar's Office. If your reasons for the missed work are acceptable, then your instructor may suggest an alternative evaluation scheme.
- Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar.
- Note that your instructor prefers to use Brightspace (D2L) email for course correspondence. Please send any emails to **afiech@online.mun.ca** address **within** Brightspace. Also, please include **[COMP6905]** in the subject line. Official email correspondence within the university **must** be via a valid Memorial University email account.
- The lectures and displays (and all material) delivered or provided in COMP 6905 - Software Engineering by Professor Fiech, including any visual or audio recording thereof, are subject to copyright owned by Professor Fiech. It is prohibited to record or copy by any means, in any format, openly or surreptitiously, in whole or in part, in the absence of express written permission from Professor Fiech any of the lectures or materials provided or published in any form during or from the course.



# ENGL. 9867 - Advanced Computing Concepts for Engineering

Memorial University of Newfoundland

Winter 2021

**Instructor** Reza Shahidi, EN-3060, Phone TBD.

**Email** For course-related email, please use [online.mun.ca](mailto:online.mun.ca); user name “rshahidi”, or [advancedcoco@reza.courses](mailto:advancedcoco@reza.courses). For all other email, please use [rshahidi@mun.ca](mailto:rshahidi@mun.ca).

**TAs** Zhao Zhenxin

**Lectures (Virtual)**

Mondays, Wednesdays, Fridays 11:00–11:50 WebEx (through BrightSpace)

**Tutorials (to be held as needed)**

Thursdays 12:00–12:50 EN-1000

**Office Hours** By appointment or Tuesday 11:00am to 12:00noon.

**Suitable for** Graduate students in Computer Engineering or Computer Science or undergraduates in Computer Engineering interested in a somewhat theoretical course.

**Web page** <http://online.mun.ca> and possibly <http://advancedcoco.reza.courses>

**Textbook** Parts of: Theodore S. Norvell, *Theories of Computation*. Current draft. Available at the course web-site.

**References** • Thomas Sudkamp, *Languages and Machines*, 3rd Ed., Addison-Wesley, 2005.

- Feldman and Harel, *Algorithmics: The Spirit of Computing*, 3rd Ed., Addison Wesley, 2004.
- Eric Hehner, *a Practical Theory of Programming*, current edition, 2019. <http://www.cs.toronto.edu/~hehner/aPToP/>
- Shalev-Shwartz and Ben-David, *Understanding Machine Learning: From Theory to Algorithms*, Cambridge University Press, 2014.
- Burkov, *The Hundred-Page Machine Learning Book*, Publisher: Andriy Burkov, 2019.

**Outline** The course looks at a number of important questions from four general areas of computing theory: Theory of programming, formal language theory, computational complexity theory and machine learning.

- Theory of Programming. *How do I describe a computational problem? How do I derive a program (or system) to solve a given problem. Does my program (or system) actually solve the problem it is meant to solve?*
  - Specification
  - Design synthesis
  - Verification
  - Documentation
- Formal Language Theory. *What kinds of computers are there? Which kinds of computers can solve which problems? Are there problems that no computer can solve? How can we finitely describe complex infinite sets such as the inputs to a computer program or the sentences in a human language?*
  - Finite machines
  - Regular expressions
  - Transducers and statecharts
  - Context free grammars
  - Computability and uncomputability
- Computational Complexity Theory. *How efficient is my algorithm? Is it maximally efficient for the problem? How hard are problems?*

- $O$ ,  $\Omega$ , and  $\Theta$
- Complexity of algorithms
- Complexity of problems – upper and lower bounds, average and worst-case complexity
- The class **NP**
- The class **NP**-complete and polynomial time reductions
- Machine Learning. *What is learning? When do we need machine learning? What are the different types of machine learning?*
  - Formal Learning Model
  - Computational Complexity of Learning
  - Support Vector Machines, Kernel Methods, Nearest Neighbour Algorithms
  - Artificial Neural Networks (Shallow vs. Deep Learning)

It turns out that the answers to these questions have considerable engineering utility. The course deals with both the theory and the application of the theory.

### Evaluation and approximate schedule

Assignments	15%	About 5. Times TBA.
Term paper / presentation	20%	Paper April 9. Presentations start March 29.
Midterm	10%	Feb 26
Midterm	10%	Mar 19
Final	30%	TBA
Better of midterms & final	10%	
Better of Term paper & assignments	5%	

### Other Information

- Late assignments will **not** be accepted without prior arrangement or documented justification. Missed tests will require a note from a medical doctor or a nurse practitioner.
- Any questions about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the exam.

- Unless otherwise specified, assignments are to be done individually.
- Academic dishonesty will, as a minimum result, in a grade of zero for the offending work, and will be reported to the Associate Dean. Academic dishonesty includes copying, allowing your work to be copied, unauthorized working in groups, and failing to correctly cite sources. If you have any doubt about whether something constitutes academic honesty, consult with me. See section 4.12 of the School of Graduate Studies regulations for more information. <http://www.mun.ca/regoff/calendar/sectionNo=GRAD-0029>
- Asking questions is strongly encouraged. If you have a question, it is likely that others have the same question. Please ask questions during class, not after.
- Comments, suggestions and constructive criticisms are always welcome.

## **The Memorial University of Newfoundland Code**

All members of the Memorial University of Newfoundland Community, which includes students, faculty, and staff, shall treat others with respect and fairness, be responsible and honest, and uphold the highest standards of academic integrity.

### **Expectations of Student Conduct**

Engineering students are expected to behave in a professional manner at all times. Memorial has two sets of rules which deal with inappropriate behaviour by students. The first set deals with academic offences such as cheating (<http://www.mun.ca/regoff/calendar/sectionNo=GRAD-0029>), while the other set deals with non-academic offences such as disruptive behaviour in class (see <https://www.mun.ca/student/supports-and-resources/respectful-campus/student-code-of-conduct.php>). The penalties can be severe, the severest being expulsion from the University. It is strongly recommended that students read and follow these rules.



Faculty of Engineering and Applied Science

## Course Outline ENGI-9874

Spring 2021

### ENGI-9874: Software Specification and Design

<b>Instructor</b>	Ebrahim Karami	<b>TA</b>	Mehrnaz Ahmadi
<b>E-mail</b>	ekarami@mun.ca	<b>E-mail</b>	mehrnaza@mun.ca
<b>Phone</b>	709-219-1633	<b>Phone</b>	

Preferred method of communication: MUN email.

**SCHEDULE:** Lecture: MWF 10:00-10:50 am, online room in D2L.

#### RESOURCES:

##### Required Textbooks:

1. Bernd Bruegge and Allen H. Dutoit, Object-Oriented Software Engineering Using UML, Patterns, and Java, 3<sup>rd</sup> ed., Prentice Hall, 2010.
2. Robert C. Martin, Agile Software Development, Prentice Hall, 2003.

##### Optional Resources:

- Martin Fowler, UML Distilled, 3rd ed, Addison Wesley, 2004, ISBN 0-321-19368-7.
- Cay Horstmann, Core Java(TM) 2, Volume I—Fundamentals, 11th ed., Prentice Hall PTR, 2020, or 9th ed., 2009. (9th edition available electronically from the library. See course web page.)
- Craig Larman, Applying UML and Patterns, 2nd ed., Prentice Hall PTR, 2002.
- Erich Gamma et al, Design Pattern
- Booch et al., The UML User Guide
- Rumbaugh et al, The UML Reference Manual Freeman and Freeman, Head First Design Patterns

##### MAJOR TOPICS:

- Introduction, Methodologies
- The UML notation
- Requirements Elicitation, Analysis/Design
- Analysis
- System Design
- Case Study



Faculty of Engineering and Applied Science

## Course Outline ENGI-9874

Spring 2021

### ASSESSMENT:

	Weight	Approximate date
<b>Assignments</b>	<b>15%</b>	-
Assignment 1	5%	June 14
Assignment 2	5%	July 5
Assignment 3	5%	July 26
<b>Midterms</b>	<b>20%</b>	
Midterm 1	10%	June 18
Midterm 2	10%	July 16
<b>Project</b>	<b>35%</b>	TBA
<b>Final Exam</b>	<b>30%</b>	TBA

**Course Materials on D2L:** This course will use D2L for online rooms, exams, the distribution of course materials, such as class presentations, assignments, solutions, and other information as pertinent, as well as for occasional email notices to the whole class. Materials will be posted as we progress through the course.

### Exams:

There will be two midterm exams during the class time. Deferred tests can be permitted only if the student proves his/her inability to take the test for very serious reasons, such as sickness. Evaluations outside regular class periods require approval of the Associate Dean of Undergraduate Studies.

**Calculator Policy:** In order to ensure fair assessment of students' understanding of course materials, there is a restriction on the calculators which can be used during the tests and exam. Basic scientific calculators can be used in the tests and exam which have none of the following capabilities: graphing, text memory, programmability. Similarly, the use of notebook computers, tablets, or other communicating devices such as cell phones or smartphones will be prohibited during the tests and exam. If you are uncertain, please check ahead of time with the instructor or TA prior to the tests or exam to be sure that the calculator you plan to use complies with the calculator policy.

---

### The Required Fine Print – Please read and observe

#### Academic Integrity and Professional Conduct:

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at [www.engr.mun.ca/undergrad/academicintegrity](http://www.engr.mun.ca/undergrad/academicintegrity).

**The Memorial University of Newfoundland Code:** “All members of the Memorial University of Newfoundland Community, which includes students, faculty, and staff, shall treat others with respect and fairness, be responsible and honest, and uphold the highest standards of academic integrity.” (<http://www.mun.ca/regoff/calendar/sectionNo=GENINFO-1502>)



Faculty of Engineering and Applied Science

**Course Outline**  
**ENGI-9874**

Spring 2021

**Faculty of Engineering Student Code of Conduct:** “Like Professional Engineers, engineering students are expected to behave in a professional manner at all times. Students are encouraged to conduct themselves in a manner consistent with the PEG-NL Code of Ethics.” Read more at <http://www.engr.mun.ca/policies/codeofconduct.php>

**Safety:** Students are expected to demonstrate awareness of, and personal accountability for, safe conduct within the classroom and building. Take note of emergency exits. Students will immediately report any concerns regarding safety to the teaching assistant and/or professor.

**Inclusion and Equity:** Students who require physical or academic accommodations are encouraged to speak privately to the instructor so that appropriate arrangements can be made to ensure your full participation in the course. All conversations will remain confidential.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

**Student Assistance:** Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).

**ADDITIONAL INFORMATION:**

**Team Project:** A major part of this course is the term project. Carefully read the following points with respect to the project:

- Projects will be undertaken by teams of no more than two students.
- Teams must define their own projects.

**MISCELLANEOUS NOTES:**

- Submitted materials are due by 11:59pm on the due date. Late materials will not be accepted without prior arrangement or documented justification.
- Any complaints about marks, addition, recording etc., or special circumstances (e.g., illness, bereavement) must be brought to my attention before the final report deadline.
- Academic dishonesty will, as a minimum result in a grade of zero for the offending work and may be reported to the Dean for treatment through the prescribed formal process. Academic dishonesty includes copying, allowing your work to be copied, and failing to cite sources. Refer to the relevant information available through Memorial University.
- Questions related to the course are strongly encouraged.
- Constructive comments, suggestions and criticisms are always welcome.



Science and Engineering

Course Outline  
SE xxx2

Spring 2023

## SE xxx2 Software Verification and Validation

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https://TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	SE xxx2 Software Verification and Validation covers validation of requirements, verification of software via both dynamic analysis (testing) and static analysis. Verification is covered at the unit, integration, system, and acceptance levels. Techniques such as Test Driven Development, peer review, manual and automated proof will be covered. Traceability from requirements to implementation is covered.		
<b>Schedule</b>	<b>Lecture</b> MTuWThF TBDtime–TBDTime TBDplace		
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

### 1 Learning goals

The goal of the course is to introduce the student to concepts and techniques of requirements validation and design verification for software systems and systems that include software.

This will include techniques for validation of systems requirements in including prototyping, review, writing of acceptance tests, modelling and checks for completeness, consistency, and determinism. Students should learn concepts of defects, errors, faults, hazards, and failures. And they should learn techniques for verifying that software has a low or zero defect rate. These techniques include software and system testing from unit testing to acceptance testing. They also include static analysis techniques that can prove the absence of classes of defects and program proofs that ensure that the software meets its formal requirements.

Students should learn how to integrate validation and verification into software development processes including agile processes. Concepts covered will include peer review, test driven and behaviour driven development, defensive programming, regression testing, fault injection, code coverage, trace-ability, developer testing, and separate quality assurance teams.

### 2 Major Topics

- Requirements Validation
- Unit, integration, systems, and acceptance testing.
- Static analysis.
- Proofs of correctness.
- BDD, TDD, Peer review, regression testing.
- Coverage, trace-ability.



### 3 Assessment

<b>Assignments (5)</b>		10%
<b>Quizzes (4)</b>		40%
<b>Project and presentation</b>	15%	<b>Final Exam</b> 35%

### 4 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

### 5 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

### 6 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.



Science and Engineering

Course Outline  
SE xxx1

Fall 2021

## SE xxx1 Software Engineering Capstone

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https:TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	<p><b>Software Engineering Capstone</b> will normally be taken in the final two semesters of the program.</p> <p>The project involves the design and analysis of a significant piece of software. Students will be work in teams and each team will be supervised by one of the course instructors. The project will also have a client who may be the same as the supervisor. Teams will consist of 3 to 5 students working together in a coordinated fashion. Effective collaboration and organization of the team and the work is an important aspect of the course.</p> <p>The course is only available to students in the Masters of Software Engineering</p>		
<b>Schedule</b>	<b>Lecture</b>	MWF TBDtime–TBDTime	TBDplace
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

### 1 Assessment

Each team is assessed according to the following scheme

Component	Mark
Progress Report 1	15%
Progress Report 2	15%
Presentation	20%
Final Report	50%

Each student's mark will be determined not only by their team mark, but also according to their individual effort and contribution as assessed by the instructors and by their peers.

### 2 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the

teaching assistant, staff technologist, and professor.

### 3 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

### 4 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.

Computer Science 6908  
Fall 2020

**Course Name:** Database Technology and Applications

**Class Time:** 3:30pm – 4:45pm, T, Th

**Instructor:** Jian Tang

**Office Hours:** 2:15pm – 3:15pm, T, Th, or by appointment

**Textbook:** “Database Management Systems”, 3<sup>rd</sup> Ed., Raghu Ramkrishnan, Johannes Gehrke, McGraw – Hill Education, ISBN: 0-07-246563-8 (E-copy available from the web)

**Reference:** “Fundamentals of Database Systems”, 7<sup>th</sup> ED, Ramez Elmasri, Shamkant B. Navathe, Pearson Education Ltd, ISBN 13: 978-1-292-09761-9 (E-copy available from the web)

**Objectives:** To introduce students to database processing, database management systems and database design considerations. Additional topics covered include the theory and methodologies essential for the relational database design, implementation and management under the corporation as well as web application environment.

**Prerequisites:** COMP 3725 or COMP 2004, and COMP 3754 or COMP 2007

**Representative topics:**

A review of relational data model

Concepts and notations

SQL

Nested SQL

Embedded SQL

Database applications on web

Client-server architecture of web applications

HTML

Python

Queries using relational algebra

Storage organizations

Hardware aspects

Storing files on a disk

Operations of files

Index structures

Hashing

B+-tree

A review of FD and normal forms

Relational decomposition and dependency preservation

Lossless joins

Query processing

Implementation of select, project and join

Cost analysis of implementation schemes

Overview of transaction management

The ACID property

- Transactions and schedules
- Problems caused by concurrent executions
- Problems caused by aborted transactions
- Serializability and recoverability
- Concurrency control
  - Lock-based concurrency control
  - 2PL
  - Timestamp-based concurrency control
- Crash recovery
  - The log
  - Checkpointing
  - Redo phase
  - Undo phase

Course Schedule (for reference only, subject to change)

week	date	Content
1	Sept. 10	Introduction, review of relational model
2	Sept. 15, 17	SQL and nested SQL
3	Sept. 22	Database in web applications, HTML, Python
3	Sept. 24	Relational algebra
4	Sept. 29, Oct. 1	Relational algebra
5	Oct. 6, 8	Storage organization, B+ tree
6	Oct. 12 – 13	Mid-term break, no class
6	Oct. 15	Hash
7	Oct. 20	Query processing and implementation:25 mins
7	Oct. 22	Review, query processing and implementation
8	Oct. 27	Review, query processing and implementation
8	Oct. 29	FD and normal forms
9	Nov. 3, 5	FD and normal forms, LJ and DP
10	Nov. 10	LJ and DP
10	Nov. 12	Transaction, concurrency control
11	Nov. 17	Concurrency control
11	Nov. 19	Crash recovery
12	Nov. 24, 26	Crash recovery
13	Dec. 1	Crash recovery
13	Dec. 3	Crash recovery, review

## Evaluations and schedules\*

title	coverage	weight	due date
Assignment 1	RD, SQL, relational algebra	4%	Oct. 1
Assignment 2	Relational algebra, storage organization, B+ tree	4%	Oct. 15
Assignment 3	Hash, query processing	4%	Nov. 3
Assignment 4	FD and normal forms	4%	Nov. 17
Assignment 5	Tran. magt, con. control and crash recovery	4%	Dec. 3
Project1	Database application on the web	12%	Oct. 9
Project2	Implementation of relational algebra with B+tree	23%	Nov. 23
Final	full coverage	45%	To be determined

\*The due dates may change depending on the progress of the classes.

\*Project1 is an individual project. Project2 is a group project with at most two members.

\*Assignments and projects are designed to be the independent work of each student (and each group for the group project). Word-to-word copying (including superficial modification) is an academic offence. Identical copies will receive zero for both copies.

**Method of Lecture Delivery:** The entire course will be taught online throughout the semester. A combination of synchronous and asynchronous delivery will be used for the lectures. In most cases, I will give live lectures at the assigned time-slots. Depending on the circumstances, however, I may post the pre-recorded lectures on or before the assigned class time. When this happens, I will inform you in advance.

- A statement of Memorial University's commitment to accommodation of students with disabilities:

Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within the scope of the University Policies for the Accommodations for Students with Disabilities([www.mun.ca/policy/site/policy.php?id=239](http://www.mun.ca/policy/site/policy.php?id=239)). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).

- A statement regarding academic integrity:

Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar.

# COMP 6910

Fall 2016

## Services Computing, Semantic Web and Cloud Computing

### Course objectives / description

This course will cover the fundamental concepts and technologies behind services computing, semantic Web and cloud computing. Services Computing deals with all aspects relating to services, including creation, registration, discovery, composition and delivery. The core concept behind Semantic Web is the representation of data in a machine-interpretable way. Ontologies facilitate the means to realize such representation. Cloud Computing advocates the concept that any computation can be done anywhere and at anytime. Scalability, elasticity, security and confidentiality are important requirements

### Course outline (Topics include the following):

- The Principles of Services and Services Computing;
- Service-Oriented Architecture (SOA);
- Web Ontology Language;
- Web Services Publishing and Discovery;
- Semantic Service Selection;
- Co-ordination Frameworks for Web Services;
- Transaction Concepts;
- Service Management;
- Overview of Cloud Computing;
- Security, Privacy and Trust Management Issues for Cloud Computing;

### Prerequisites / background required

Introductory courses in Databases, Computer Architecture and Operating Systems (equivalent to COMP 3754 and COMP 3725) are required.

### Evaluation

Assignments	40 %
Midterm	20 %
Project	40%



**References / reading list**

- Services Computing, Liang-Jie Zhang, Jia Zhang and Hong Cai, Springer, 2007, ISBN 978-3-540-38281-2.
- Service Computing Concepts, Methods and Technology, Zhaohui Wu, Shuiguang Deng and Jian Wu, Morgan Kaufmann, ISBN 978-0-12-802330-3, 2015.
- Service-Oriented Computing Semantics, Processes, Agents, Munindar Singh and Michael N. Huhns, Wiley, 2004, ISBN 978-0-470-09148-7.
- Cloud Computing Principles and Paradigms, (ed) Raj Kumar Buyya, James Broberg and Andrej Goscinski, John Wiley & Sons, 2011, ISBN 978-0-470-88799-8.
- Cloud Computing Methodology, Systems and Applications, (ed) Lizhe Wang, Rajiv Ranjan, Jinjun Chen and Boulem Benetallah, CRC Press, 2012, ISBN 978-1-4398-5641-3.
- Web Services – Concepts, Architectures and Applications, G. Alonso, F. Casati, H. Kuno, and V. Machiraju, Springer, 2004, ISBN 978-3-642-07888-0.

## COMP 6922 : Compiling Methods Winter 2018

**Objectives:** This course provides theoretical foundations for compiler design. Emphasis is on practical mechanisms of lexical and syntax analyses. Classical compiler writing tools (LEX and YACC) are included as example implementations of some compiling methods.

**Required background:** Practical knowledge of programming in a high-level language is assumed. Some background in formal languages, automata theory and computer organization (machine-level programming) is needed.

### Evaluation:

Assignments	25 %	<b>Note:</b> All assignments are expected to be worked out individually; no credit is given for assignments which are considered identical.
Project	25 %	
Final examination	50 %	

### Outline:

- Overview of formal grammars and formal languages (and in particular, context-free grammars and languages) with basic properties and some grammar transformations
- Definition of programming languages, lexical, syntax and semantics analyses of programming languages
- Recursive-descent parsing, code generation, error-recovery
- Finite automata and scanning; LEX
- General top-down and bottom-up parsing
- Bottom-up parsing, LR(k), SLR(k) and LALR(k) parsers, YACC
- Top-down parsing, LL(k) parsers
- Attribute grammars, inherited and synthesized attributes, attribute evaluation, examples

### References:

- A.V. Aho, M.S. Lam, R. Sethi, J.D. Ullman, "Compilers - principles, techniques, and tools" (3-rd ed.); Addison-Wesley Longman 2006 (ISBN 0-321-48681-1)
- K. Cooper, L. Torzon, "Engineering a compiler"; Elsevier Science 2007 (ISBN 1-55860-698-X, 1-55860-699-8).
- A. Meduna, "Elements of compiler design"; Auerbach Publ. 2008 (ISBN 1-4200-63233-5).
- T.A. Mogensen, "Introduction to compiler design"; Springer-Verlag London 2011 (ISBN 978-0-85729-828-7).
- S. Muchnick, "Advanced compiler design and implementation"; Academic Press 1997 (ISBN 1-55860-320-4).
- A.T. Schreiner, H.G. Friedman, "Introduction to compiler construction with UNIX"; Prentice-Hall 1985 (ISBN 0-13-474396-2)

**Directory:** [www.cs.mun.ca/courses/cs6922](http://www.cs.mun.ca/courses/cs6922) or `/local/pub/cs/cs6922`

**Instructor:** Dr. W.M. Zuberek, office: EN-2028, tel. 864-4701, email: [wlodek@mun.ca](mailto:wlodek@mun.ca)

Please review carefully and retain this document for future reference.

**First important thing you must do, and do it immediately:**

Send me an email, with subject header: COMP 6925 my mun email address. Then I will be able to include your email address in my address book.

All future correspondence, including your assignments etc., will be done via email.

CS6725      Advanced Operating Systems      Fall 2018  
Instructor: Ashoke Deb      email: ashoke@mun.ca      Office: EN2026

Recommended Reading:

- *Operating System Design, The XINU Approach*, Comer
- *Operating System Concepts*, Silberschatz et. al.
- *Operating Systems – Internals and Design Principles*, Stalling
- *Principles of Concurrent Programming*, Ben-Ari
- *Modern Operating Systems*, Tanenbaum et al.

Grading Scheme:

- There are no exams
- The evaluation will be based on the following:

- One semester-long group project: worth 60% (More about group project later.)
- Two assignments (to be done independently): worth 40%

**NOTE:**

- When sending email, please prefix subject with CS6725:
- For making appointments, send me an email, but give enough lead time.

Students are required to attend lectures, and maintain a complete and accurate copy of the class notes.

The process of writing the class notes is half the study! Also, please refer to the University Calendar articles 6.8.3 and 6.11.

The assignments are due on the due date, approximately a week to 10 days from the date assigned.

Due dates are strictly final, and assignments are due in class.

Assignments submitted outside the class will not be accepted.

**Class Policy:**

*Please turn off and put away all communication devices while in class.*

No hw will be given on the last two weeks of classes; but a previously assigned hw may be due during that time. The span of more than one hw may overlap in time, ie. a new hw may be assigned before the previous one is due.

**All assignments must be done totally independently (or within the group, if it is a group project). Students collaborating, or copying, in part or in whole, will receive zero as grade!!!!!!!!!!!!**

Programming projects can be done in any language of your choice. No programming language will be covered in this course.

Please (a) submit your work, in a brown envelop, properly labeled; (b) submit your work in class, before the lecture begins; (c) work submitted outside the class, and not on due date, will not be accepted; (d) due dates are final, and are not extended.

**OFFICE HOURS:** Office hours are by appointment. Please send me an email with subject header: COMP 6925 Can i make an appointment to see you.

I do not have a cell phone, and do not check my email after hours, or weekends, or holidays.

So, please give a lead time, say a couple of days, for a response.

## COURSE SYLLABUS - FALL 2021

### COMPUTER SCIENCE 4304: DATA VISUALIZATION

### COMPUTER SCIENCE 6934: INTRO TO DATA VISUALIZATION

---

Instructor: Terrence Tricco (he/him)

Email: tstricco@mun.ca

Office: ER-6031

Lectures: 11:00 - 11:50am M-W-F (Three 50 minute lectures per week.)

Lecture Room: EN-2006

Office Hours: 1:00 - 3:00pm on Mondays (or by email appointment)

4304 Pre-requisites: COMP 2001, COMP 2002, Statistics 2500 or Statistics 2500

### **Instructional Continuity**

Welcome back to campus. All lectures in this course will be taught both in-person and through recorded video posted online to Brightspace. The recorded lectures will be a duplicate of the in-person lecture. You can choose which mode of learning you prefer.

Masks are currently required on campus. If this policy changes during the term, it is still recommended to wear a mask even if not required. There will be different levels of comfort and anxiety for mask use. Please be respectful of everyone in the class.

Should there be disruption to in-person lectures over the course of the term by other health directives or the overall situation connected to Covid-19, then instruction will continue through the online videos according to the course schedule.

### **Course Objectives**

Data visualization is the art of creating images based on data. Visualizations enable users to explore, understand, and extract insights from data in an efficient way. This course will be centred on data visualization for data science, and will cover three broad topics. One will be the tools of data visualization, specifically Jupyter notebooks and Python visualization libraries. A second topic will be standard types of visualizations for different types of data. The third topic will be on the theoretical aspects of data visualization, such as viewer perception and rules of thumb for good visualizations.

### **Course Outline**

- Data Visualization Tools
  - Jupyter Notebooks and Python
  - Pandas data library

- Matplotlib, Seaborn and Plotly visualization libraries
- Vector graphics (svg), Rasterization
- Interactivity
- Standard Visualisation Types
  - Relational: Line plots, Scatter plots, Bubble plots, Heat maps
  - Categorical: Bar plots, Histograms, Box plots, Radar charts
  - Hierarchical: Pie charts, Venn diagrams
  - Multi: Scatterplot matrix
  - Spatial: Choropleth, Contour plots, Kernel density estimation
  - Data reduction: t-SNE, Principal component analysis
- Data Visualisation Theory
  - Planning and design process
  - Human perception
  - Colour theory
  - Elements of style
  - Rules of thumb, pitfalls to avoid

## Evaluation

There will not be any in-person evaluation. The final grade in the course will be determined as follows:

• Assignments (8)	<b>50%</b>
• Course Project	<b>50%</b>
○ Project Proposal	(10%)
○ Project Submission and Code	(25%)
○ Video Presentation	(15%)

## Recommended Reading (Optional)

There is no required textbook for this course. The following textbooks are only recommended for further reading on course topics.

A. Kirk, *Data Visualisation: A Handbook for Data Driven Design*, 2nd Edition, Sage, 2019.

T. Munzner, *Visualization Analysis & Design*, CRC Press, 2014.

R. Spence, *Information Visualization: An Introduction*, 3rd Edition, Springer, 2014.

## Memorial University Policies

Memorial University of Newfoundland is committed to supporting inclusive education based on the principles of equity, accessibility and collaboration. Accommodations are provided within

the scope of the University Policies for the Accommodations for Students with Disabilities ([www.mun.ca/policy/site/policy.php?id=239](http://www.mun.ca/policy/site/policy.php?id=239)). Students who may need an academic accommodation are asked to initiate the request with the Glenn Roy Blundon Centre at the earliest opportunity ([www.mun.ca/blundon](http://www.mun.ca/blundon)).

Students are expected to adhere to those principles which constitute proper academic conduct. A student has the responsibility to know which actions, as described under Academic Offences in the University Regulations, could be construed as dishonest or improper. Students found guilty of an academic offence may be subject to a number of penalties commensurate with the offence including reprimand, reduction of grade, probation, suspension or expulsion from the University. For more information regarding this policy, students should refer to the University Regulations for Academic Misconduct (Section 6.12) in the University Calendar.





Faculty of Engineering and Applied Science

Course Outline  
ECE7400 / ENGI 9869

Spring 2021

## ECE 7400 / ENGI 9869 (Advanced) Concurrent Programming

<b>Instructor</b>	Dr. Reza Shahidi rshahidi@mun.ca Phone number: 864-2617 EN-3060	<b>TA(s)</b> Sidra Anwar and Dharar Samir sidraa and sdharar @mun.ca
<b>Office Hours</b>	By appointment	
<b>Website</b>	<a href="https://online.mun.ca/">https://online.mun.ca/</a>	
<b>Communication</b>	E-mail is the preferred form of communication. If you need to discuss something confidential, please use the mail system in D2L or email me at rshahidi@mun.ca.	
<b>Calendar Entry</b>	<b>ECE 7400 Concurrent Programming</b> (same as the former ENGI 7894) surveys parallel and distributed architectures and examines patterns of concurrent program design; correctness of concurrent programs: safety and liveness properties, proof of properties; synchronization using locks, semaphores, and monitors; communication using message passing and remote procedures; parallelization for high-performance computation and advanced topics such as scientific applications, distributed systems, model checking, and transaction processing.	
<b>Other Requirements</b>	Counter-Requisites: the former ENGI 7894 or the former ENGI 8893	
<b>Prerequisites</b>	ECE 5400 or the former ENGI 5892 or the former ENGI 6892, ECE 6500 or the former ENGI 6861	
<b>Schedule</b>	<b>Lecture</b> Tue/Thu 10:30–11:45 am	Virtual (WebEx via D2L)
<b>Textbook</b>	<i>The Art of Multiprocessor Programming (Second Edition)</i> by Maurice Herlihy, Nir Shavit, Victor Luchangco, Michael Spear. (Morgan Kaufmann, Sept 2020). Paperback: ISBN: 978-0-124-15950-1, Ebook: 978-0-123-91406-4.	
<b>References</b>	<ul style="list-style-type: none"> <li>• <i>Java Concurrency in Practice</i>, by Brian Goetz et al. (Addison-Wesley Professional, 2006). Paperback. ISBN: 978-0-321-34960-6, E-Book. ISBN: 978-0-132-70225-6.</li> <li>• <i>The Little Book of Semaphores</i>, by A. Downey, (Green Tea Press, 2008). E-book available from <a href="http://www.greenteapress.com/semaphores/downey08semaphores.pdf">http://www.greenteapress.com/semaphores/downey08semaphores.pdf</a></li> <li>• <i>Concurrent Programming in Java: Design Principles and Patterns, second edition</i>, by Doug Lea, (Addison-Wesley Professional, 1999). Paperback. ISBN: 978-0-201-31009-2.</li> </ul>	

## 1 Major Topics

- Overview of Concurrent/Distributed/Parallel Programming
- Processes and Synchronization
- Concurrency Semantics
- Locks and Mutexes
- Deadlock and Starvation
- Semaphores
- Monitors
- Barriers and Futures
- Advanced Java concurrency features
- RPC/Rendezvous
- Concurrent Data Structures
- Introduction to GPU Programming
- Introduction to Cuda and OpenCL
- Examples of GPU algorithms/implementations
- Concurrency Issues in Real-time O/S programming/Internet of Things
- Parallel Algorithms
- Parallel Programming and Scientific Programming (MPI)
- OpenMP/vectorization (SSE/MMX)
- Designing Concurrent Programs with UML
- Other concurrent/parallel languages (e.g., Haskell, Go, Scala)

## 2 Course Description

The course content will be delivered through lectures (virtual) and assigned readings. Assessment will be in the form of five assignments, two midterm exams, a project (including report and presentation, only for ENGI 9869) and a final exam.

### 2.1 Lectures

Questions during lectures are welcome. Student participation in active learning exercises during class time is required.

### 2.2 Website

I will be using Desire2Learn (D2L) as the course websites for ECE 7400/ENGI 9869. Apart from responding to e-mails I have received, **D2L will be my sole means of contact with you.** As such, I recommend that you log in to check for messages or announcements at least once a day. Should you have any problems using D2L, please contact their technical support—I have no ability to access or fix your account or solve your problems.

Naturally, any personal questions pertaining to your grades, absences, lateness, etc., should be sent directly to me via the website's e-mail functionality rather than posting on the discussion board.

## 2.3 Absences and Lateness

Absences during any of the scheduled assessment (tests and exams) may be excused for valid medical reasons or bereavement in accordance with university policy. You are responsible for providing appropriate documentation.

## 3 Learning Outcomes

Upon successful completion of this course, the student will be able to:

	<b>Learning Outcomes</b>	<b>Methods of Assessment</b>
1	Recognize and explain various common parallel and distributed architectures	Assignments, Midterms, Final Exam
2	Recognize and explain various common patterns of concurrent program design	Assignments, Midterms, Final Exam
3	Analyse concurrent programs to determine if they satisfy appropriate safety and liveness properties	Assignments, Midterms, Final Exam
4	Design solutions to problems using shared memory concurrent techniques including locks, barriers, semaphores, and monitors.	Assignments, Midterms, Final Exam
5	Design solutions to problems using distributed memory concurrent techniques such as message passing and remote procedure calls.	Assignments, Midterms, Final Exam
6	Design and analyse solutions to computational problems using both data and task parallelization and modern programming tools.	Assignments, Midterms, Final Exam
7	Appreciate the impact of choice of programming language on concurrency.	Assignments, Midterms, Final Exam

## 4 Assessment

### 4.1 ECE 7400

Assignments (5 in total, due May 25, June 8, June 29, July 13, July 27)	30%
Midterm 1 (June 10)	15%
Midterm 2 (July 22)	15%
Final Exam	40%

### 4.2 ENGI 9869

Assignments (5 in total, due May 25, June 8, June 29, July 13, July 27)	20%
Midterm 1 (June 10)	10%
Midterm 2 (July 22)	10%
Course Project	20%
Final Exam	40%

No calculators may be used on the exams or tests.

Any questions about marks (addition, recording, etc.) or special circumstances (illness, bereavement, etc.) must be brought to my attention before the final exam. No reconsideration of marks other than the final exam will be made after the day before the exam date.

### 4.3 Midterms

There will be two in-class midterm examinations. They are worth 15% each for ECE 7400 students and 10% each for ENGI 9869 students.

Needless to say, the midterms are individual tests.

### 4.4 Course Project (only grad section)

There will be a course project only for ENGI 9869, worth 20% of the term mark for that course on a topic chosen by the student and agreed to by the instructor. A presentation will be given by each ENGI 9869 student as well as a report prepared on the agreed-upon topic. These will be due during the last week of lectures.

### 4.5 Final Exam

The final examination will be worth 40% of the term mark for both ECE 7400 and ENGI 9869.

The 'safelabs' option was passed to the class, elide the Lab Safety statement.

## 5 Academic Integrity and Professional Conduct

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at <http://www.mun.ca/engineering/undergrad/academicintegrity.php>.

Students are encouraged to consult the Faculty of Engineering and Applied Science Student Code of Conduct at <http://www.mun.ca/engineering/undergrad/academicintegrity.php> and Memorial University's Code of Student Conduct at <http://www.mun.ca/student/conduct/>.

## 6 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

## 7 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.



Faculty of Engineering and Applied Science

Course Outline  
ENGI 9875

Winter 2020–21

## Engineering 9875: Real-time and embedded systems design

<b>Instructor</b>	Jonathan Anderson jonathan.anderson@mun.ca (709) 864-2715 EN-3028	<b>TA(s)</b>	Mahya Soleimani Jadidi msoleimanija@mun.ca
<b>Office Hours</b>	Tuesdays 1600–1700		
<b>Website</b>	<a href="http://memorialu.gitlab.io/Engineering/ECE/Teaching/operating-systems/website">http://memorialu.gitlab.io/Engineering/ECE/Teaching/operating-systems/website</a>		
<b>Communication</b>	All communication should be via email, Webex or in person: D2L mail may not be checked.		
<b>Calendar entry</b>	9875 Embedded and real-time system design examines real-time process scheduling; memory and device management; I/O communications; real-time systems; operating system and hardware concurrency issues; kernel architectures; device drivers; and a survey of available real-time operating systems and embedded platforms.		
<b>Schedule</b>	Lecture	MWF 0900–0950	online
	Lab	Mon 1400–1650	EN-1038B (remote)
<b>Credit value</b>	3 credit-hours	<b>Lab hours</b>	(at least) four 3-hour sessions per semester
<b>Textbook</b>	–		
<b>References</b>	<i>Operating Systems: Three Easy Pieces</i> , Remzi and Andrea Arpaci-Dusseau, <a href="http://www.ostep.org">http://www.ostep.org</a> , v1.00. <i>The Design and Implementation of the FreeBSD Operating System (2nd Edition)</i> , K McKusick, G V Neville-Neil and R N M Watson, 2014.		

### 1 Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. explain how operating systems mediate between applications and hardware,
2. synthesize correct low-level software in C,
3. synthesize simple OS primitives with concurrency,
4. explain the unique constraints of real-time and embedded systems and implications for their design and
5. design software to take advantage of efficient OS primitives.

### 2 Assessment

<b>Assignments (5 of 6)</b>	20%	The final assignment will be <b>due in the last two weeks of classes</b> , so it will be assigned <b>before the last two weeks of classes</b> pursuant to §6.7.3 of the Calendar.
<b>Labs (5)</b>	15%	You <b>must complete all labs</b> to complete Engineering 9875.
<b>Quizzes</b>	20%	
Tentative dates: Jan 19, Feb 9, Mar 9, Mar 22		
<b>Project</b>	15%	The project will include a proposal, presentation and report.
<b>Midterm exam</b>	10%	
Tentative date: Feb 19		
<b>Final Exam</b>	20%	Exams will be closed-book; online proctoring will be used.

## 3 Topic details

### 3.1 Processes, privilege and system calls

- **Recall:** microprocessors, virtual memory
- OS and computing history
- Processes
- Privilege: modes and rings
- Filesystem abstractions
- System calls
- Memory allocation
- Traps, interrupts and interrupt handling

### 3.2 Process co-ordination and shells

- **Review:** Unix files and system calls
- Process control
- Shells
  - Environment variables
  - Pipes and pipelines
  - Shell scripting
- Inter-process communication
- `init(8)`

### 3.3 Kernels, scheduling and threading

- **Review:** concurrency
- Kernel architectures and data structures
- Scheduling
  - Process models
  - Scheduling policies
  - Multiprocessing
- Threading
  - Multithreading
  - User- and kernel-level threads
  - Thread scheduling

### 3.4 Memory management

- **Review:** virtual memory
- Memory management hardware
  - segmentation
  - paging
- Paging policies

### 3.5 Files, filesystems and protection

- **Review:** filesystem abstractions
- Unix permissions, MAC policies and capabilities
- Filesystem implementation
- FAT filesystems
- Copy-on-write filesystems

### 3.6 Networking essentials

- Berkeley sockets
- Internet Protocol
- TCP/IP
- DHCP and PXE
- NFS

### 3.7 Busses, I/O and device drivers

- **Review:** memory and I/O interfacing
- Data busses and modern chipsets
- Polling, programmed I/O and DMA
- I/O buffer strategies
- Device drivers
- Asynchronous I/O

### 3.8 Real-time and embedded systems

- **Review:** assembly programming and interrupts
- Embedded systems
- System-on-chip designs
- Early OS boot
- Bootloaders
- Real-time scheduling
  - Periodic scheduling and RMS
  - Aperiodic scheduling
  - Priorities and priority inversion

## 4 Academic Integrity and Professional Conduct

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at <http://www.mun.ca/engineering/undergrad/academicintegrity.php>.

Students are encouraged to consult the Faculty of Engineering and Applied Science Student Code of Conduct at <http://www.mun.ca/engineering/undergrad/academicintegrity.php> and Memorial University's Code of Student Conduct at <http://www.mun.ca/student/conduct>.

## 5 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

## 6 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.

## ENGINEERING 9876: Advanced Data Networks

Instructor	Dr. Cheng Li	Teaching Assistants	Xiaohang Zhao
E-mail	<a href="mailto:licheng@mun.ca">licheng@mun.ca</a>	E-mail	xiaohangz@mun.ca
Phone	864-8972	Phone	
Office Location	EN-4012	Office Location	EN-4031
Office Hours	Wed. 2:00-4:00	Office Hours	Thur. 2:00-4:00

Website      D2L course page

**Communication**      *Email, course website, and bulletin board on the website.*

### COURSE DESCRIPTION:

*This course includes the fundamental concepts, protocols, analysis and modelling techniques, architectures, and applications pertaining to data communications networks.*

### PREREQUISITES:

It is expected that students have had an introductory course in computer networks. If a student does not have this background, the onus is on the student to fill in the necessary background for the various areas of the course. The introductory reference texts listed below are a good foundation for developing this background.

### SCHEDULE:

LECTURE: Tuesday and Thursday 10:30-11:45 am, Room: online  
TUTORIAL: There will be 2-3 tutorial sessions, which will be mostly used to review mid-term exam papers and cover additional lecture materials. Time and venue will be determined during the term.

### CREDIT VALUE:

3 credits

### RESOURCES:

#### TEXT BOOK

- S. Keshav, *An Engineering Approach to Computer Networking*, Addison-Wesley, 1997. (Note: second edition will be available soon).

#### COURSE NOTES

- Lecture notes will be available through online or will be handed out in class for most lectures.

### REFERENCES

#### Introductory

1. A. Leon-Garcia and I. Widjaja, *Communication Networks: Fundamental Concepts and Key Architectures*, 2nd ed., McGraw Hill, 2004.
2. W. Stallings, *Data and Computer Communications*, 8th ed., Prentice-Hall, 2007.
3. A. Tanenbaum, *Computer Networks*, 4th ed., Prentice-Hall, 2003.



Intermediate

4. W. Stallings, *High-Speed Network and Internets: Performance and Quality of Service*, 2nd ed., Prentice-Hall, 2002.

Advanced

5. D. Bertsekas and R. Gallager, *Data Networks*, 2nd ed., Prentice-Hall, 1992.  
+ many, many others (eg. books focussed on networks, the Internet, network security, etc.).

**MAJOR TOPICS:**

The topics will include, but not be limited to:

- *Introductory Concepts*
  - network topologies, communication architectures
- *Elements of Communication Protocols*
  - packet formats, flow control, error control, protocol analysis
- *Packet Switching*
  - datagram vs. virtual circuit
- *Queuing Theory*
  - M/M/1, M/D/1, and other queues
- *Scheduling*
  - scheduling strategies for best-effort and guaranteed-service connections
- *Routing*
  - distance-vector and link-state routing strategies for packet switching
- *High Speed Switching Architectures*
  - sampling of switch fabric architectures such as broadcast bus, Batcher-Banyan, and Balanced Gamma networks
- *Security* (time permitting)
  - symmetric key and public key encryption, authentication, digital signatures
- *5G Networks* (time permitting)
  - properties, applications and enabling technologies
- *Wireless Sensor Networks* (time permitting)
  - an introduction to wireless sensor networking technologies, challenges, and applications

**LEARNING OUTCOMES:**

Upon successful completion of this course, the student will be able to:

- Understand the basic concepts of data communication architectures and protocols.
- Able to analyze the performance of a network using probability tools and queuing theory
- Understand networking techniques including scheduling, routing, and switching
- Understand data network applications

**ASSESSMENT:**

		<b>Approximate Due Dates</b>
Project:	30 %	
Midterm 1:	15 %	(Oct. 19, 2021, tentative)
Midterm 2:	15 %	(Nov. 16, 2021, tentative)
Final exam:	40 %	

Please note that the two midterm examinations will be in-class tests, tentatively scheduled for Tuesday, October 19 (10:30 am-12:00 pm) and Tuesday, November 16 (10:30 am-12:00 pm).

**PROJECT:**

There will be one major project in the course. The nature of the project will be a survey of a topic in an area applicable to the course. The project deliverables are:

- (1) project title, due Friday, Sept. 24
- (2) project proposal (1 page), due Friday, Oct. 1
- (3) seminar (15~20 minutes), presentation schedule starting from the week of Nov. 22
- (4) paper (~25-30 pages 1.5 line spaced), due Friday Dec. 3

**The project must be new work produced by the student and must not be the repetition of a project from a previous course or other context. Also, although the project will represent a survey of work by other researchers, the organization and wording of your final report must be entirely original. Work that contains any amount of copied material will be given a mark of zero.**

**PROBLEM SETS:**

The course will have several problem sets designed to reinforce the topics covered in the lectures. No marks will be given for the problem sets.

**ACADEMIC INTEGRITY AND PROFESSIONAL CONDUCT:**

Students are expected to conduct themselves in all aspects of the course at the highest level of academic integrity. Any student found to commit academic misconduct will be dealt with according to the Faculty and University practices. More information is available at [www.engr.mun.ca/undergrad/academicintegrity](http://www.engr.mun.ca/undergrad/academicintegrity).

Students are encouraged to consult the Faculty of Engineering and Applied Science Student Code of Conduct at <http://www.engr.mun.ca/policies/codeofconduct.php> and Memorial University's Code of Student Conduct at <http://www.mun.ca/student/conduct>.

**LAB SAFETY:**

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

**INCLUSION AND EQUITY:**

Students who require physical or academic accommodations are encouraged to speak privately to the instructor so that appropriate arrangements can be made to ensure your full participation in the course. All conversations will remain confidential.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

**STUDENT ASSISTANCE:**

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at [www.mun.ca/student](http://www.mun.ca/student).



Science and Engineering

Course Outline  
SE xxx3

Fall 2023

## SE xxx3 Software Engineering Practice

<b>Instructor</b>	Prof. X x@mun.ca (709) 864-TBD EN-TBD	<b>TA(s)</b>	TBD
<b>Office Hours</b>	TBD		
<b>Website</b>	https://TBD		
<b>Communication</b>	TBD		
<b>Calendar Entry</b>	SE xxx2 Software Engineering Practice introduces the student to software development processes, practices, and tools. It includes software project management using agile processes; development tools and practices; deployment, operations, and dev-ops.		
<b>Schedule</b>	<b>Lecture</b> MTuWThF TBDtime–TBDTime TBDplace		
<b>Credit Value</b>	3 credits		
<b>Textbook</b>	TBD, AUTHOR, ED, PUB (YEAR).		

### 1 Learning goals

### 2 Major Topics

- Requirements engineering
- Software project management
- Practices and tools
- Operations and development-perations

### 3 Assessment

<b>Assignments (5)</b>	10%
<b>Quizzes (4)</b>	40%
<b>Project and Presentation</b>	20%
<b>Final Exam</b>	30%

### 4 Lab Safety

Students are expected to demonstrate awareness of, and personal accountability for, safe laboratory conduct. Appropriate personal protective equipment (PPE) must be worn (e.g. steel-toed shoes, safety glasses, etc.) and safe work practices must be followed as indicated for individual laboratories, materials and equipment. Students will immediately report any concerns regarding safety to the teaching assistant, staff technologist, and professor.

## 5 Inclusion and Equity

Students who require accommodations are encouraged to contact the Glenn Roy Blundon Centre, <http://www.mun.ca/blundon/about/index.php>. The mission of the Blundon Centre is to provide and co-ordinate programs and services that enable students with disabilities to maximize their educational potential and to increase awareness of inclusive values among all members of the university community.

The university experience is enriched by the diversity of viewpoints, values, and backgrounds that each class participant possesses. In order for this course to encourage as much insightful and comprehensive discussion among class participants as possible, there is an expectation that dialogue will be collegial and respectful across disciplinary, cultural, and personal boundaries.

## 6 Student Assistance

Student Affairs and Services offers help and support in a variety of areas, both academic and personal. More information can be found at <http://www.mun.ca/student>.