Course Outline (F2022)

ELE829: System Models and Identification

Instructor(s)  
Dr. Gosha Zywno [Coordinator]  
Office: ENG463  
Phone: (416) 979-5000 x 556105  
Email: gzywno@ryerson.ca  
Office Hours: Wednesdays, 1:00 -4:00 pm (Virtual)

Calendar Description  

Prerequisites  
ELE 639

Antirequisites  
None

Corequisites  
None

Compulsory Text(s):  
1. ELE829: Course Notes, M.S. Zywno, 2022. The notes are available from the secure course website, (login at https://my.ryerson.ca) as PDF downloadable files.  

Reference Text(s):  

Learning Objectives (Indicators)  
At the end of this course, the successful student will be able to:  

1. Demonstrates competency in developing mathematical models for deterministic systems (dynamic processes) and for stochastic systems (noise). Uses relevant computer simulation software - MATLAB System Identification Toolbox. Identifies and carries out steps required in performing a successful model identification procedure. Evaluates the effect of uncertainty in model parameters. (2b)  
2. Applies the tools for system identification to a real-time servomotor system, including obtaining experimental data. Selects appropriate analytical model for the real-time servomotor system, and verifies the model by comparing to experimental results. (3a)  
3. Selects appropriate analytical model for the real-time servomotor system, and verifies the model by comparing to experimental results. Assesses accuracy of the results obtained from the real-time servomotor system, verifying experimental data and explaining sources of possible discrepancies (non-linearity). (3b)
4. Designs data collection experiments for diagnostics and identification of the model, selects appropriate model structure (BJ model) and noise filter function, and appropriate Least Squares Algorithm. (4b), (4a)
5. Evaluates the quality of the derived system and noise models by validating against a set criteria, then improves the design until the model is validated. (4c)
6. Demonstrates proficiency in the use of high-performance engineering modeling and analysis software, including System Identification Toolbox, in this course, and for subsequent engineering practice by completing and demonstrating to the professor the required simulation and analyses to perform system and noise model diagnostics, identification and verification. (5a)
7. Helps other team members, and accepts help, on technical and team issues. Demonstrates capacity for team leadership while respecting others roles. Evaluates team effectiveness and plans for improvements. (6b)
8. Produces a professionally prepared technical report using appropriate format, grammar, and citation styles, with figures and tables chosen to illustrate points made, with appropriate size, labels and references in the body of the report. Reports are graded on correctness, completeness, grammar, quality of graphics and layout. (7a)
9. Responds appropriately to verbal questions from instructors, formulating and expressing ideas, using appropriate technical terminology this is assessed through comprehensive lab interviews by instructors. (7b)
10. Demonstrates an understanding of project management principles, applying them both to the individual final project and to group tutorials. These include: negotiating the project scope, managing the deadlines, decomposing projects into key tasks and allocating responsibilities and resources according to deadlines. (11b)

NOTE: Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).

<table>
<thead>
<tr>
<th>Course Organization</th>
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<tbody>
<tr>
<td>3.0 hours of lecture per week for 13 weeks</td>
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<tr>
<td>1.0 hours of lab per week for 12 weeks</td>
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<tr>
<td>0.0 hours of tutorial per week for 12 weeks</td>
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<thead>
<tr>
<th>Teaching Assistants</th>
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<tbody>
<tr>
<td>Shahab Ghorbani, MASc., PhD Candidate, <a href="mailto:shahab.ghorbani@ryerson.ca">shahab.ghorbani@ryerson.ca</a></td>
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<tr>
<th>Course Evaluation</th>
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<tr>
<td><strong>Theory</strong></td>
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<tr>
<td>Course Activities (Individual/Group) 20 %</td>
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<tr>
<td>Final Project Report (Individual) 40 %</td>
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<tr>
<td><strong>Laboratory</strong></td>
</tr>
<tr>
<td>Lab/Tutorial Project (Group) #1 9 %</td>
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<tr>
<td>Lab/Tutorial Project (Group) #2 9 %</td>
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<tr>
<td>Lab/Tutorial Project (Group) #3 9 %</td>
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<tr>
<td>Lab/Tutorial Project (Group) #4 13 %</td>
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<tr>
<td><strong>TOTAL:</strong> 100 %</td>
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**Note:** In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both "Theory and Laboratory" components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the "Course Evaluation" section above for details on the Theory and Laboratory components (if applicable).
Course evaluation is ongoing and semester-long, and includes both group work (lab/tutorial reports) and individual effort (final project). All reports include simulations. The course professor verifies all individual codes submitted with the final report. If the execution of the code does not support claims in the report, the project will receive a non-negotiable and significant reduction in the grade.

<table>
<thead>
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<th>Examinations</th>
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<td>Course evaluation is ongoing and semester-long, and includes both group work (lab/tutorial reports) and individual effort (final project). All reports include simulations. The course professor verifies all individual codes submitted with the final report. If the execution of the code does not support claims in the report, the project will receive a non-negotiable and significant reduction in the grade.</td>
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Other Evaluation Information

Course activities are part of the ongoing and semester-long evaluation: there are graded activities in every week of classes (on top of scheduled tutorial/lab reports). The graded activities include both individual assessments (D2L quizzes), homework assignments and computer simulations on the application of theory learned, which are then demonstrated to the professor in class.

Other Information

Teaching Methods

Lectures and Tutorials will be conducted in person. Students will have access to course materials on D2L. Students will be required to complete D2L Quizzes and Homework Assignments using upload features of D2L. All tutorials and final project reports have to be uploaded to D2L. Zoom teleconferencing software will be used for individual consultation, office hours, and individual student simulation presentations.

Other Information

Students will learn to work MATLAB System Identification Toolbox in the tutorial session with the help of course TA.

### Course Content

<table>
<thead>
<tr>
<th>Week</th>
<th>Hours</th>
<th>Chapters / Section</th>
<th>Topic, description</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>3</td>
<td>Goals for the course and course logistics. Overview: terminology, objectives, introduction to modern identification procedures (diagnostics, identification, validation), types of models. Data Collection - PRBS signal. Introduction to Matlab System Identification Toolbox. Introduction to Tutorial # 1. Review - frequency response, Bode plots for conventional modeling. (References: Course Notes Chapters 1, 2, 3).</td>
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<tr>
<td>Week 2</td>
<td>3</td>
<td>Modeling: Non-parametric models in frequency domain: SPA, ETFE. Review: Transfer function models, conversion between continuous and discrete representations, sampling. Modeling - simple Box-Jenkins model structures: OE Model (deterministic process, white noise). Diagnostic tools in frequency domain - summary. Activity # 1 due. (References: Course Notes Chapters 1, 2, 3).</td>
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<td>Week 4</td>
<td>3</td>
<td>Diagnostic tools in time domain – summary. Review of matrix algebra. Introduction to Least Squares methods. Robustness of parametric models, The</td>
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<td>Week 6</td>
<td>3</td>
<td>Validation for OE Model: Residue whiteness testing - Chi-Square tests, Confidence Intervals. Full examples of OE Model Identification and Validation. Hands-on simulations and group work. (References: Course Notes Chapter 6).</td>
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<tr>
<td>Week 8</td>
<td>3</td>
<td>Hands-on simulations and group work - Activity # 6 due. Summary of all diagnostic tools for all Box-Jenkins models: non-parametric time and frequency domain models, Auto- and Partial Auto-Correlation functions. References: Course Notes Chapter 6, 7, 8).</td>
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<td>Week 9</td>
<td>3</td>
<td>Hands-on simulations and group work- Activity # 7 due. Refining BJ model: ACF, PACF and CCF checks. Complete Validation for BJ Model: Residue whiteness testing - Chi-Square tests, Confidence Intervals. Activity # 8 (D2L Quiz) due. (References: Course Notes Chapter 6, 7, 8).</td>
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<td>Week 10</td>
<td>3</td>
<td>Hands-on simulations and group work - Activity # 9 due. Review - designing data collection experiment, model structure selection, complete diagnostics, structure revisions and final model validation. Examples of a full system identification procedure. (References: Course Notes Chapter 6, 7, 8).</td>
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<td>Week 11</td>
<td>3</td>
<td>Hands-on simulations and group work - Activity # 10 due. Overview of the Final Project (individual): &quot;Black Box&quot; System Identification of two systems (OE and PEM structures). Questions and answers regarding the project. (References: Course Notes Chapter 6, 7, 8).</td>
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<td>Week 12</td>
<td>3</td>
<td>Hands-on simulations and group work. Questions and answers regarding the final project, active consultation on final project computer simulations. Activity # 11 (D2L Quiz) due. (References: Course Notes Chapter 6, 7, 8).</td>
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Questions and answers regarding the final project, active consultation on final project computer simulations. Final Project due on December 6. (References: Course Notes Chapter 6, 7, 8).

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>L/T/A</th>
<th>Description</th>
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| 2-3  | 2     | Tutorial 1: Diagnostic Tools in Frequency Domain and Simple Model identification - OE Model (2 sessions)  
Part 1 - Non-Parametric Models in Frequency Domain as Diagnostic Tools.  
Part 2 - Simple Model Identification using OE Model.  
Part 3 - Conventional Parametric Model from Frequency Response Data. |
| 4-5  | 2     | Tutorial 2: Diagnostic Tools in Time Domain and Simple Model identification - OE Model (2 sessions)  
Part 3 - Conventional Parametric Model from Frequency Response Data.  
Week 4: Tutorial 1 Report due/Tutorial 1 Quiz online. |
| 6-7  | 2     | Tutorial 3 - Stochastic Noise Models - Identify structure of four different noise models (2 sessions)  
Week 6: Tutorial 2 Report due/Tutorial 2 Quiz online. |
| 8-10 | 3     | Tutorial 4 - Simple System Identification of a Real-Life System – Servomotor (3 sessions)  
Part 1: Obtaining Experimental Frequency and Time Domain Responses from the Servomotor.  
Part 2: Model Identification and Comparisons with Nominal Values Model.  
Week 8: Tutorial 3 Report due/Tutorial 3 Quiz online.  
Week 11: Tutorial 4 Report due/Tutorial 4 Quiz online. |

Policies & Important Information:

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on the Senate website

1. In accordance with the Policy on TMU Student E-mail Accounts (Policy 157), Toronto Metropolitan University (TMU) requires that any electronic communication by students to TMU faculty or staff be sent from their official university email account;
2. Any changes in the course outline, test dates, marking or evaluation will be discussed in class prior to being implemented;
3. Assignments, projects, reports and other deadline-bound course assessment components handed in past the due date will receive a mark of ZERO, unless otherwise stated. Marking information will be made available at the time when such course assessment components are announced.
4. Familiarize yourself with the tools you will need to use for remote learning. The Continuity of Learning Guide for students includes guides to completing quizzes or exams in D2L or Respondus, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.

5. The University has issued a minimum technology requirement for remote learning. Details can be found at: https://torontomu.ca/covid-19/students/minimum-technology-requirements-remote-learning. Please ensure you meet the minimum technology requirements as specified in the above link.

6. Toronto Metropolitan University COVID-19 Information and Updates (available https://www.torontomu.ca/covid-19/students) for Students summarizes the variety of resources available to students during the pandemic.

7. Refer to our Departmental FAQ page for information on common questions and issues at the following link: https://www.ecb.torontomu.ca/guides/Student.Academic.FAQ.html.

**Missed Classes and/or Evaluations**

When possible, students are required to inform their instructors of any situation which arises during the semester which may have an adverse effect upon their academic performance, and must request any consideration and accommodation according to the relevant policies as far in advance as possible. Failure to do so may jeopardize any academic appeals.

1. **Academic Consideration Requests for missed work** (e.g. missing tests, labs, etc) - According to Senate Policy 134, Section 1.2.3, if you miss any exams, quizzes, tests, labs, and/or assignments for health or compassionate reasons you need to inform your instructor(s) (via email whenever possible) in advance when you will be missing an exam, test or assignment deadline. When circumstances do not permit this, you must inform the instructor(s) as soon as reasonably possible". In the case of illness, a Toronto Metropolitan Student Health Certificate, or a letter on letterhead from an appropriate regulated health professional with the student declaration portion of the Student Health Certificate attached. For reasons other than illness, proper documentation is also required (e.g. death certificate, police report, TTC report). ALL supporting documentation for illness or compassionate grounds MUST be submitted within three (3) working days of the missed work." NOTE: You are required to submit all of your pertinent documentation through the University's online Academic Consideration Request system at the following link: prod.apps.ccs.ryerson.ca/senateapps.

2. **Religious, Aboriginal and Spiritual observance** - If a student needs accommodation because of religious, Aboriginal or spiritual observance, they must submit a Request for Accommodation of Student Religious, Aboriginal and Spiritual Observance AND an Academic Consideration Request form within the first 2 weeks of the class or, for a final examination, within 2 weeks of the posting of the examination schedule. If the requested absence occurs within the first 2 weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these forms should be submitted with as much lead time as possible in advance of the absence. Both documents are available at www.torontomu.ca/senate/forms/relobservforminstr.pdf. If you are a full-time or part-time degree student, then you submit the forms to your own program department or school;

3. **Academic Accommodation Support** - Before the first graded work is due, students registered with the Academic Accommodation Support office (AAS - prod.apps.ccs.ryerson.ca/senateapps) should provide their instructors with an Academic Accommodation letter that describes their academic accommodation plan.

**Virtual Proctoring Information (if used in this course)**

Online exam(s) within this course may use a virtual proctoring system. Please note that your completion of any such virtually proctored exam may be recorded via the virtual platform and subsequently reviewed by your instructor. The virtual proctoring system provides recording of flags where possible indications of suspicious behaviour are identified only. Recordings will be held for a limited period of time in order to ensure academic integrity is maintained and then will be deleted.

**Access to a computer that can support remote recording is your responsibility as a student.** The computer should have the latest operating system, at a minimum Windows (10, 8, 7) or Mac (OS X 10.10 or higher) and web browser Google Chrome or Mozilla Firefox. You will need to ensure that you can complete the exam using a reliable computer with a webcam and microphone available, as well as a typical high-speed internet connection. Please note that you will be required to show your Toronto Metropolitan University OneCard prior to beginning to write the exam. In cases where you do not have a Toronto Metropolitan University OneCard, government issued ID is permitted.

Information will be provided prior to the exam date by your instructor who may provide an opportunity to test your set-up or provide additional information about online proctoring. Since videos of you and your environment will be recorded while writing the exam,
please consider preparing the background (room / walls) so that personal details are not visible, or move to a room that you are comfortable showing on camera.

**Academic Integrity**

Toronto Metropolitan University's [Policy 60](https://www.torontomu.ca/senate/policies/pol60.pdf) applies to all students at the University. Forms of academic misconduct include plagiarism, cheating, supplying false information to the University, and other acts. The most common form of academic misconduct is plagiarism - a serious academic offence, with potentially severe penalties and other consequences. It is expected, therefore, that all examinations and work submitted for evaluation and course credit will be the product of each student's individual effort (or an authorized group of students). Submitting the same work for credit to more than one course, without instructor approval, can also be considered a form of plagiarism.

Suspiscions of academic misconduct may be referred to the Academic Integrity Office (AIO). Students who are found to have committed academic misconduct will have a Disciplinary Notation (DN) placed on their academic record (not on their transcript) and will normally be assigned one or more of the following penalties:

1. A grade reduction for the work, ranging up to an including a zero on the work (minimum penalty for graduate work is a zero on the work);
2. A grade reduction in the course greater than a zero on the work. (Note that this penalty can only be applied to course components worth 10% or less, and any additional penalty cannot exceed 10% of the final course grade. Students must be given prior notice that such a penalty will be assigned (e.g. in the course outline or on the assignment handout);
3. An F in the course;
4. More serious penalties up to and including expulsion from the University.

The unauthorized use of intellectual property of others, including your professor, for distribution, sale, or profit is expressly prohibited, in accordance with Policy 60 (Sections 2.8 and 2.10). Intellectual property includes, but is not limited to:

1. Slides
2. Lecture notes
3. Presentation materials used in and outside of class
4. Lab manuals
5. Course packs
6. Exams

For more detailed information on these issues, please refer to the [Academic Integrity policy](https://www.torontomu.ca/senate/policies/pol60.pdf) and to the Academic Integrity Office website (https://www.torontomu.ca/academicintegrity).

**Academic Accommodation Support**

Toronto Metropolitan University acknowledges that students have diverse learning styles and a variety of academic needs. If you have a diagnosed disability that impacts your academic experience, connect with Academic Accommodation Support (AAS). Visit the [AAS website](https://www.torontomu.ca/senate/policies/policies/aas政策.pdf) or contact [aasadmin@ryerson.ca](mailto:aasadmin@ryerson.ca) for more information.

Note: All communication with AAS is voluntary and confidential, and will not appear on your transcript.

**Important Resources Available at Toronto Metropolitan University**

1. [The Library](https://www.torontomu.ca/senate/policies/policies/library政策.pdf) provides research [workshops](https://library.torontomu.ca/ask) and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the Library's virtual research help service at [https://library.torontomu.ca/ask](https://library.torontomu.ca/ask) to speak with a librarian.

2. [Student Life and Learning Support](https://www.torontomu.ca/senate/policies/policies/studentlifeandlearningpolicy政策.pdf) offers group-based and individual help with writing, math, study skills, and transition support, as well as [resources and checklists to support students as online learners](https://www.torontomu.ca/senate/policies/policies/studentlifeandlearningpolicy政策.pdf).
3. You can submit an Academic Consideration Request when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the Senate website and select the blue radial button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request.

Please note that the Provost/Vice President Academic and Deans approved a COVID-19 statement for Fall 2022 related to academic consideration. This statement will be built into the Online Academic Consideration System and will also be on the Senate website (www.ryerson.ca/senate) in time for the Fall term:

Policy 167: Academic Consideration for Fall 2022 due to COVID-19: Students who miss an assessment due to cold or flu-like symptoms, or due to self-isolation, are required to provide a health certificate. All absences must follow Senate Policy 167: Academic Consideration.

Also NOTE: Policy 167: Academic Consideration does allow for a once per term academic consideration request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. If the absence is more than 3 days in duration and/or is for a final exam/final assessment, documentation is required. For more information please see Senate Policy 167: Academic Consideration.

4. TMU COVID-19 Information and Updates for Students summarizes the variety of resources available to students during the pandemic.

5. TMU COVID-19 Vaccination Policy.

6. If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The Remote Learning guide for students includes guides to completing quizzes or exams in D2L Brightspace, with or without Respondus LockDown Browser and Monitor, using D2L Brightspace, joining online meetings or lectures, and collaborating with the Google Suite.

7. Information on Copyright for students.

8. At Toronto Metropolitan University (TMU), we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line**: 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk**: 24/7 hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE**: 24/7 access to confidential support through counsellors via My SSP app or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- Centre for Student Development and Counselling: 416-979-5195 or email csdc@ryerson.ca
- Consent Comes First - Office of Sexual Violence Support and Education: 416-919-5000 ext: 553596 or email osvse@ryerson.ca

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the Toronto Metropolitan University Mental Health and Wellbeing website.