

## Course Outline

### 1. COURSE INFORMATION

|                                        |                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                    |
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| <b>Session Offered</b>                 | Fall 2023                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                    |
| <b>Course Name</b>                     | Instrumentation & Control                                                                                                                                                                                                                                                                                  |                                                                                                                                                                    |
| <b>Course Code</b>                     | PROCTECH 2IC3                                                                                                                                                                                                                                                                                              |                                                                                                                                                                    |
| <b>Date(s) and Time(s) of lectures</b> | Wednesday 1:30 to 2:30pm<br>Friday 9:30 to 11:30am                                                                                                                                                                                                                                                         |                                                                                                                                                                    |
| <b>Program Name</b>                    | Process Automation Technology                                                                                                                                                                                                                                                                              |                                                                                                                                                                    |
| <b>Calendar Description</b>            | This course covers common pressure, level, temperature, and flow measuring systems that provide the basis to specify, design, construct, test and tune a control loop using a PID controller. A distributed control system is also introduced.<br>Lectures (three hours), one lab (three hours); one term. |                                                                                                                                                                    |
| <b>Instructor(s)</b>                   | Dr. Ahmed AbouArkoub<br><br>John Anger<br>Steve Eagle                                                                                                                                                                                                                                                      | E-Mail: arkouba@mcmaster.ca<br>Office Hours & Location: Monday 3:00pm to 4:00pm, online by appointment.<br>Email: angerjo@mcmaster.ca<br>Email: eagles@mcmaster.ca |

### 2. COURSE SPECIFICS

|                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |                                                                                                                                                            |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Description</b> | This course covers the terminology, concepts, principles and computations used by engineers and technicians to specify, analysis and maintain-instrumentation and control systems. It emphasizes practices in industry so that students learn what aspects of plant design and control are critical.<br>Practical examples are used for several common pressure, level, temperature and flow measuring systems. Approaches are presented for measurement selection, process/modification, control structure design and algorithm tuning to achieve good performance over a range of operation conditions. The sequence of the topics builds the student's ability to specify, design, construct, test and tune a control loop using a PID controller in multi-loop control design. |                                                                                                                  |                                                                                                                                                            |
| <b>Instruction Type</b>   | <b>Code</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Type</b>                                                                                                      | <b>Hours per term</b>                                                                                                                                      |
|                           | C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Classroom instruction                                                                                            | 39                                                                                                                                                         |
|                           | L                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Laboratory, workshop or fieldwork                                                                                | 39                                                                                                                                                         |
|                           | T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Tutorial                                                                                                         |                                                                                                                                                            |
|                           | DE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Distance education                                                                                               |                                                                                                                                                            |
|                           | <b>Total Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                  | 78                                                                                                                                                         |
| <b>Resources</b>          | <b>ISBN</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Textbook Title &amp; Edition</b>                                                                              | <b>Author &amp; Publisher</b>                                                                                                                              |
|                           | ISBN: 978-0-8269-3442-0<br>ISBN: 978-0-8269-3446-8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Instrumentation and Process Control, 6 <sup>th</sup> /7 <sup>th</sup><br><br>INSTRUMENTATION AND PROCESS CONTROL | Franklyn W Kirk, Thomas A W, Philip Kirk,<br><br>Online Lab Manual,<br>A. AbouArkoub,<br><a href="http://avenue.mcmaster.ca">http://avenue.mcmaster.ca</a> |
|                           | <b>Other Supplies</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Source</b>                                                                                                    |                                                                                                                                                            |
|                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |                                                                                                                                                            |

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Prerequisite(s)</b>          | ENG TECH 1MT3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Corequisite(s)</b>           | PROC TECH 2EE3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Antirequisite(s)</b>         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Course Specific Policies</b> | <p><b>ATTENDANCE:</b><br/>Regular attendance is expected for all classes. Aside from the obvious benefits to regular attendance, you are responsible for knowing test dates, assignment due dates, class changes, and other announcements made during class. Although classes missed due to illness and other extenuating circumstances are often unavoidable, absenteeism for these reasons should be kept to a minimum. Attendance in the lab is mandatory.</p> <p><b>Note:</b><br/>The students must prepare for each lab by studying before attending the lab. The time for experiments is limited and should not be wasted on reading the experiment for the first time in the lab.<br/>Post-lab reports:<br/>The students will work individual, as A or B. Each student must complete each lab report. However only one report for the group will be marked on alternating basis.</p>                                      |
| <b>Departmental Policies</b>    | <p>Students must maintain a GPA of 3.5/12 to continue in the program.</p> <p>In order to achieve the required learning objectives, on average, B.Tech. students can expect to do at least 3 hours of “out-of-class” work for every scheduled hour in class. “Out-of-class” work includes reading, research, assignments and preparation for tests and examinations.</p> <p>Where group work is indicated in the course outline, such collaborative work is mandatory.</p> <p>The use of cell phones, iPods, laptops, and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.</p> <p>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class.</p> <p>Instructor has the right to submit work to software to identify plagiarism.</p> |

### 3. SUB TOPIC(S)

| Module | Activity Type                                                                                                   | Assignments                                                                   | Resources Bank                                                                                                                                                                                      |
|--------|-----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Week1  | Introduction to Instrumentation-Control & Instrument Drawing (ISA Standard)                                     | -Review <b>Lab 1</b>                                                          | -Lecture-1 Introduction-Control and I.S.A Standard (Instrument Drawing)<br>-Chapter 1, 2, & 3                                                                                                       |
| Week2  | Pressure (Pressure Transmitters & Switches, Principles), Instrumentation calibration and operation in processes | - <b>Quiz-1</b> Intro to Instrumentation<br>-Review <b>Lab 2</b>              | -Lecture-2A Pressure Measurements-part A (Fundamentals), 2B (Mechanical-Devices), and 2C (Electronic-Sensors)<br>-Lecture-3A Fundamentals of Instrumentation Calibration<br>-Chapter 9, 10, 11, &12 |
| Week3  | Level Measurements- Fundamentals (Open Vessels)                                                                 | - <b>Quiz-2</b> Pressure Measurements and calibration<br>-Review <b>Lab 3</b> | -Lecture-3B Pneumatic Systems<br>-Lecture 4A Level Measurements-Fundamentals                                                                                                                        |

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| Week4                                                                                                                                                                                                                                              | Level and Density Measurements-(Closed Vessels, Installation)                                                            | - <b>Quiz-3</b> Level System open-tanks.<br>-Review <b>Lab 4</b><br>-Midterm review                                     | -Lecture 4B Level Measurements- Electronic Devices<br>-Lecture-4C Level and Density Measurements-Practical                           |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapter 13, 14, 15 & 17<br>-Practices A                                                                                             |
| Week5                                                                                                                                                                                                                                              | Temperature part 1; (Introduction, Mechanical, & Resistance Thermometer).                                                | - <b>Quiz-4</b> Level System closed-tanks.<br>-Review <b>Lab 5</b> .<br><b>MidTerm Test 1(Oct 6<sup>th</sup>)</b>       | -Lecture-5A Temperature Measurements-RTDs Electrical Thermometers<br>-Lecture-5B Temperature-Fundamentals                            |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapter 4, 5, & 6                                                                                                                   |
| Week6                                                                                                                                                                                                                                              | Temperature part 2; (TCs, types, range calculation)                                                                      | - <b>Quiz-5</b> Temperature measurements “Mechanical/RTD”<br>-Review <b>Lab 6</b>                                       | -Lecture-5C Temperature Measurements-TCs<br>-Lecture-5D Temperature Measurements-Radiations<br>-Temperature TC Calibration-Practical |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapter 6, 7, & 8                                                                                                                   |
| Week7                                                                                                                                                                                                                                              | Introduction to Industrial Control, system diagrams.                                                                     | -Review <b>Quizzes 1 to 5</b><br>-Review <b>Lab 7</b>                                                                   | -Lecture-6A Instrumentation Signals and Transmissions<br>-Lecture-6B Process Control-Introduction                                    |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapter 29, 31, 34                                                                                                                  |
| Week8                                                                                                                                                                                                                                              | Control of continuous process, (basic theory of P, I & D controllers, open loop systems).                                | - <b>Quiz-6</b> Temperature measurements “TC”<br>-Review <b>Lab 8</b>                                                   | -Lecture-6C Process Control-Open and Close loop responses                                                                            |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapters 35 & 36                                                                                                                    |
| Week9                                                                                                                                                                                                                                              | Control loops systems, part1 (close loop single-element, ON/OFF control), examples Level and Flow control loops.         | - <b>Quiz-7</b> Introduction to Industrial Control and system diagrams<br>-Review <b>Lab 9</b><br>-Midterm review       | -Lecture-6C Process Control-Open and Close loop responses<br>-Control System-Matlab simulator, Dynamic Tuning                        |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapters 36 & 37<br>-Practices B                                                                                                    |
| Week10                                                                                                                                                                                                                                             | Control loops systems, part2, PID controller characterization, step response, tuning and close loop dynamic performance. | - <b>Quiz-8</b> PID controller, open loop system<br>-Review <b>Lab 10</b><br><b>MidTerm Test 2(Nov 17<sup>th</sup>)</b> | -Lecture-6C Process Control-Open and Close loop responses<br>-Control System-Matlab simulator, Dynamic Tuning                        |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapter 36 & 37                                                                                                                     |
| Week11                                                                                                                                                                                                                                             | Multi-element control and systems performance, PID controller actions.                                                   | - <b>Quiz-9</b> PID controller, closed loop system                                                                      | -Lecture-6D Process Control-Multi elements system                                                                                    |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         |                                                                                                                                      |
| Week12                                                                                                                                                                                                                                             | Flow measurements<br>-Principle and application, differential flowmeters<br>-Turbine, Ultrasound, and Mass-flowmeters    | - <b>Quiz-10</b> Controller tuning and Multi-element systems<br>-Final-exam review                                      | -Lecture-7 Flow Measurements                                                                                                         |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapters 18 & 19<br>-Chapters 20 & 21<br>-Practice Questions Final                                                                  |
| Week13                                                                                                                                                                                                                                             | Process Control Applications, “Boiler Control”                                                                           | - <b>Final Exam review</b>                                                                                              | -Lecture-8-Process Applications and safety                                                                                           |
|                                                                                                                                                                                                                                                    |                                                                                                                          |                                                                                                                         | -Chapters 46 & 47<br>-Practice Questions Final                                                                                       |
| Midterm Recess: Monday, October 9 to Sunday, October 15<br>Classes end: Wednesday, December 6<br>Final examination period: Friday, December 8 to Thursday, December 21<br>All examinations MUST be written during the scheduled examination period |                                                                                                                          |                                                                                                                         |                                                                                                                                      |

**List of experiments**

|                                    |                                                                         |
|------------------------------------|-------------------------------------------------------------------------|
| Lab 1 (Sep 11 <sup>th</sup> )      | Lab orientation, lab procedure and Introduction                         |
| Lab 2 (Sep 18 <sup>th</sup> )      | Low Pressure–Manometers and High Pressure-Deadweight Testers Standards  |
| Lab 3 (Sep 25 <sup>th</sup> )      | Calibration of Electronic DP Transmitter                                |
| Lab 4 (Oct 2 <sup>rd</sup> )       | Hydrostatic level measurement                                           |
| Lab 5 (Oct 16 <sup>th</sup> )      | RTDs and R/I Transmitters, calibration                                  |
| Lab 6 (Oct 23 <sup>th</sup> )      | Thermocouples Temperature Transmitters, calibration                     |
| Lab-review (Oct 30 <sup>st</sup> ) | Lab-test review                                                         |
| Lab-test (Nov 6 <sup>th</sup> )    | Lab-test                                                                |
| Lab 7 (Nov 13 <sup>th</sup> )      | LabVolt Process System Familiarization, Process Dynamic-Characteristics |
| Lab 8 (Nov 20 <sup>st</sup> )      | PI Controller Open Loop system, dynamic performance                     |
| Lab 09 (Nov 27 <sup>th</sup> )     | Level-Process, Closed Loop Control System                               |
| Lab 10 (Dec 4 <sup>th</sup> )      | Makeup / Pressure-Process, Closed Loop Control                          |

Note that this structure represents a plan and is subject to adjustment term by term.  
 The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes.

| <b>ASSESSMENT OF LEARNING *including dates*</b>                                                    | <b>Weight</b> |
|----------------------------------------------------------------------------------------------------|---------------|
| Mid-Term tests, (Test 1 Oct 6 <sup>th</sup> and Test 2 Nov 17 <sup>th</sup> )                      | 20%           |
| Lab Reports                                                                                        | 25%           |
| Lab Test (Nov 6 <sup>th</sup> )                                                                    | 10%           |
| Assignments/Projects                                                                               | 10%           |
| Final examination (tests cumulative knowledge)                                                     | 35%           |
| <b>TOTAL</b>                                                                                       | <b>100%</b>   |
| Percentage grades will be converted to letter grades and grade points per the University calendar. |               |

**5. LEARNING OUTCOMES**

|                                                                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Describe various process control loops, their functions and correctly use the technical terms and symbols involved in control system.                                       |
| 2. Explain the use of various pressure, level, temperature and flow measuring system commonly encountered in process control.                                                  |
| 3. Select, install and use various pressure, level, temperature, flow measuring devices and perform calibration of instruments for such measurements.                          |
| 4. Demonstrate the mathematical representation of combined control action of a PID controller, calculate input and output signal for various measuring systems.                |
| 5. Perform basic process control calculation, explain steady-state and dynamic phenomena and use several different tuning strategies to effectively tune a process controller. |

## 6. COURSE OUTLINE – APPROVED ADVISORY STATEMENTS

### ANTI-DISCRIMINATION

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

[http://www.mcmaster.ca/policy/General/HR/Discrimination Harassment Sexual Harassment-Prevention&Response.pdf](http://www.mcmaster.ca/policy/General/HR/Discrimination%20Harassment%20Sexual%20Harassment-Prevention&Response.pdf)

### ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty: The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

### AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, other software, etc.). For more details about McMaster’s use of Turnitin.com please go to [www.mcmaster.ca/academicintegrity](http://www.mcmaster.ca/academicintegrity).

### COURSES WITH AN ON-LINE ELEMENT

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

### ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

### COMMUNICATIONS

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.
- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.

Check the McMaster/Avenue email and course websites on a regular basis during the term.

#### • CONDUCT EXPECTATIONS

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

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

### ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

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

### REQUESTS FOR RELIEF FOR MISSED ACADEMIC TERM WORK

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

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

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

#### **COPYRIGHT AND RECORDING**

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

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

#### **EXTREME CIRCUMSTANCES**

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