

ENGPYHS 3L04
Engineering Metrology
Undergraduate Studies
Winter 2027
Course Outline

Current as of Thu 2026 08 13 16:06:44; see A2L for the most up-to-date version of this document

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Matt Minnick
BSB/B106
minnick@mcmaster.ca

Office Hours:
TBA

Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

See A2L for TA info

Contact the IA, Mohammadreza Shahzadeh <shahzm14@mcmaster.ca>, for any lab-related issues. For other matters, contact the course instructor.

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

The primary method of communication will be

1. Avenue To Learn (A2L, <http://avenue.mcmaster.ca/>) news postings for announcements - make sure to set your A2L email settings so it emails these to you.
2. MS Teams ("Course Forum") posts for questions about content or admin things anyone else might want to know about too.
3. Email for individual messages.

CLASS FORMAT

Course Dates: Mon 4 Jan - Wed 7 Apr 2027

Units: 4

Course Delivery Mode: All classes are in-person

Course Description: Introductory statistics for engineering, error analysis of experimental data, data visualization and curve fitting, hypothesis testing and making decisions, ANOVA, sensors for engineering measurements, noise and interference, instrument response and uncertainty, reliability, and selected topics in state-of-the-art technologies. Measurements include electromagnetic quantities, force, acceleration, angle, pressure, fluid flow, temperature, light, quantum metrology, and nuclear instruments.

Three lectures, one lab (three hours); second term

Prerequisite(s): Credit or registration in ENGPYHS 2A04, 2CD4, 2E04, and 2P04, and MATH 2Z03, 2ZZ3

The course is scheduled as follows:

- | | | | |
|----------------|------|---------------|-------------------------|
| • C01: lecture | MoWe | 08:30 – 09:20 | see Mosaic for location |
| | Fr | 10:30 – 11:20 | see Mosaic for location |
| • L01: lab | Tu | 14:30 – 17:20 | see Mosaic for location |

Lectures will be recorded and posted shortly afterwards on A2L via echo360. However, attending class regularly and working through problems along with peers and the instructor is your best path to success.

COURSE INTENDED LEARNING OUTCOMES

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

1. Perform statistics calculations
2. Explain how a variety of sensors determine various properties of the physical world, and the trade-offs of different types for the same property.
3. Select the best sensor for the application.
4. Develop and calibrate measurement systems to collect and analyze data.
5. Complete data analysis on measured data, including forming confidence intervals on measured results and curve fit parameters

ACCREDITATION LEARNING OUTCOMES

The Canadian Engineering Accreditation Board (CEAB) is a division of Engineers Canada and is responsible for accrediting undergraduate engineering programs across Canada. Accreditation by the CEAB ensures that the engineering programs meet a national standard of quality and cover essential educational requirements. Graduate Attributes are a set of qualities and skills that the CEAB expects engineering graduates to possess. These attributes are a benchmark for the learning outcomes of accredited engineering programs. This section lists the Graduate Attribute Indicators associated with some of the Learning Outcomes in this course.

The Graduate Attributes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's grade in the course.

Outcomes	Indicators
1. Perform statistics calculations	1.1 - Competence in Mathematics
2. Explain how a variety of sensors determine various properties of the physical world, and the trade-offs of different types for the same property.	3.1 Selects appropriately from relevant knowledge base to plan appropriate data collection methods and analysis strategies.
3. Select the best sensor for the application.	
4. Develop and calibrate measurement systems to collect and analyze data.	
5. Complete data analysis on measured data, including forming confidence intervals on measured results and curve fit parameters	3.2 Synthesizes the results of an investigation to reach valid conclusions

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>

LAB INFORMATION

In the labs, you will use electronic measuring equipment and sensors to measure properties of the physical world. You will collect most data with the arduino and analyze it in python, developing programs for each to complete these tasks. As such, you will need to bring your laptop computer equipped with the software to enable this. Note: if you only have USB-C ports, you'll need an adaptor to the rectangular USB-A 2.0.

COURSE SCHEDULE

Labs begin on week 2 of the course and run every week until the final week (12 lab weeks total).

Lectures run every week including the first week.

Weekly schedule of lecture topics is as follows. Labs cover topics found in the previous lecture week. See A2L for a detailed description of suggested lab activity to attempt in each week to demonstrate the competencies.

1. Course intro, Metrology, basic lab skills, and statistics
 - a. Metrology:
 - i. Sensors, actuators, instruments, and transducers
 - ii. Understanding errors in engineering measurements
 - b. Basic Statistics; random errors in measurements, mean, standard deviation, sample and parent distribution
 - c. Basic lab skills:
 - i. Arduino voltage measurement
 - ii. Serial communication to python
 - iii. Printing data from serial port to python output
 - iv. Saving data in an array
 - v. instrument calibration
2. Electrical Transduction and Uncertainty as Probabilities
 - a. Standard error
 - b. reporting results, rounding, and significant figures
 - c. Binomial, Poisson, and Gaussian distributions
 - d. Confidence limits and error bars
 - e. Voltage measurement
 - f. Dealing with error from binning
 - g. Plotting a Gaussian fit to histogram data
3. Resistance Measurement and error propagation
4. Thermal metrology
5. Force and dimensional metrology, live plotting
6. Photometry, PWM, least squares curve fitting and the error matrix
7. Curve fitting continued, dynamic response, and hysteresis errors
8. Magnetometry
9. Tachometry, Servo control, advanced serial communication, Fast Fourier Transform
10. Poisson statistics and radiation metrology
11. Flow metrology, Hypothesis testing and the Student's T distribution
12. Monte Carlo methods, mathematical proofs, and the SI system of units
13. Review & Summary

REQUIRED/OPTIONAL MATERIALS AND FEES

COMPUTER:

Students should have a laptop computer (needed for in-person practical test exercises) capable of simultaneously running a python IDE, web browser, and MS Word (Windows machines are recommended). You will be required to use this in-class and during labs.

SOFTWARE:

Arduino IDE, Python and some python IDE (e.g., Anaconda distribution using spyder), MS Word (2007 or newer).

REFERENCE TEXTS:

-[Required] Course notes (free online via A2L)

-[Required] Measurements and their Uncertainties by Ifan G. Hughes & Thomas P. A. Hase (available through McMaster library e-reserves)

Recommended Additional Texts (Optional):

1) A.J. Wheeler, Introduction to Engineering Experimentation (3rd edition, Pearson, 2010).

2) J.P. Holman, Experimental Methods for Engineers (8th edition, McGraw-Hill, 2012).

3) J.G. Webster and H. Eren, Measurement, Instrumentation, and Sensors Handbook (2nd edition, CRC Press, 2014).

COURSE ASSESSMENT DETAILS

This course will assess you using competency based assessment (CBA). To achieve a passing grade, you must demonstrate achievement of all essential competencies, and any subsequent competencies will increase your grade from there. Competencies are as follows:

1. Essential Competencies (must achieve all of these to pass)
2. Subsequent Competencies (can further increase grade once passing)

Achieving a competency involves two steps:

1. Achieving a perfect score on an A2L quiz covering the competency, and THEN
2. Demonstrating your mastery of the competency in the lab (assessed by a TA).

Lab demos of competencies will involve some combination of answering (without notes) questions similar to those on the online quiz and showing your development and use of a measurement system in the lab. The exact requirements will vary for different competencies and is explained under the competency details document found on A2L.

Grade matrix:

Each of the 10 essential competencies is worth 5%, completing all 10 is necessary to achieve a passing grade of 50%.

Completing each additional competency thereafter is worth 2% additional grade.

All supplementary competencies must be achieved in order.

GRADING SCALE

The McMaster 12 Point Grading Scale

Grade	Equivalent Grade Point	Equivalent Percentages
A+	12	90-100
A	11	85-89
A-	10	80-84
B+	9	77-79
B	8	73-76
B-	7	70-72
C+	6	67-69
C	5	63-66
C-	4	60-62
D+	3	57-59
D	2	53-56
D-	1	50-52
F	0	0-49

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

It is your responsibility to regularly check both the course Teams page and A2L for updates and announcements.

Competency-based assessment is mastery learning that is necessarily "at your own pace" to some extent, meaning that rather than strict deadlines for assessments, you will have access to as many demo opportunities as we can give you and multiple attempts at those demos; this means no MSAF is needed for extensions, because you've been pre-allocated not only extensions but *additional attempts* at work. That said, we expect that you will regularly attend lectures and attempt to work through labs at the pace of the suggested lab schedule in the competency details spreadsheet. Falling a bit behind on course work and demonstrating a week or two late isn't usually a problem, but falling behind too far or falling behind at the end of the course will eliminate your chance to demonstrate competencies during the available demo periods, reducing your final grade. In an effort to prevent too many students from falling too far behind, there will be a cap on the number of competencies you can demo during the final 5 weeks of the course to no more than 3 competencies per week, so plan ahead accordingly. Additionally, demos will be first-come-first-serve so if you are not ready to demo at the start of the lab period you may end up not being able to demo that week if too many other students get in the queue ahead of you.

GENERATIVE AI

Though it's not recommended, students may freely use generative AI in this course so long as the use of generative AI is referenced and cited following citation instructions given in the syllabus. Use of generative AI outside assessment guidelines or without citation will constitute academic dishonesty. It is the student's responsibility to be clear on the expectations for citation and reference and to do so appropriately.

The reason it's not recommended is that our objectives here are to learn the skills and concepts of the problems we're tackling (code you prepare is really just there for *you* to learn the key concepts by doing it!) For that reason, we're providing a lot of support for you with problems in class and labs, and setting up assessments that encourage you to go through the steps of solving them yourself. Remember to think about what you've done and why each step works; if you try to present code that's totally different than how we've been solving things in class because you departed substantially from the course techniques with the help of generative AI, we may not be able to follow your solution enough to grant you marks.

APPROVED ADVISORY STATEMENTS

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics and the Faculty of Engineering are committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the [Equity and Inclusion Office](#).

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](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. 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.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

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.

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.

ACADEMIC ADVISING

Academic Advisors are available to assist you with any problems or questions you may have. This includes course selections, changes to your enrolment, McMaster Student Absence Form (MSAF), Religious, Indigenous, or Spiritual Observances (RISO) forms, exams, taking courses at another university (for credit at McMaster), Petitions for Special Consideration, and much more. Below is the contact information for the Office of the Associate Dean (Academic) in the Faculty of Engineering:

JHE-Hatch 301

<https://www.eng.mcmaster.ca/programs/academic-advising>

(905) 525-9140 ext. 24646

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the [Student Wellness Centre](#).

REQUESTS FOR RELIEF FOR MISSED ACADEMIC WORK

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](#)". An abbreviated version is provided below.

The University recognizes that students periodically require relief from academic work due to extenuating circumstances. Students seeking relief for missed academic term work are expected to read the **McMaster Student Absence Form Policy**. The Policy aims to manage these requests by taking into account the needs and obligations of students, instructors and administrators. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in their course. Any concerns regarding the granting of relief should be directed to the Faculty Office.

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three (3) calendar days:**
 - Use the [McMaster Student Absence Form](#) (MSAF) on-line self-reporting tool. No further documentation is required.
 - Students may submit requests for relief using the MSAF once per term.
 - An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
 - The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
 - The MSAF cannot be used for academic work that has already been completed or attempted.
 - An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
 - The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. **For medical or personal situations lasting more than three (3) calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**
 - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
 - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

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.

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.