Eng Phys 3L04
Engineering Metrology: Fundamentals and Applications

Undergraduate Studies
Fall 2020/21
Course Outline

CALENDAR/COURSE DESCRIPTION

Statistics for engineering measurements, error analysis of experimental data, sensors for pervasive engineering measurements, radiation detectors (thermal, optical, nuclear), noise and interference, instrument response and uncertainty, signal conditioning, data communications, reliability and safety, introduction to feedback and control, and selected topics in state-of-the-art technologies.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): Registration in Level III or above of any Engineering Physics program

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. H.K. Haugen
ABB-428
haugenh@mcmaster.ca
ext. 23335

Office Hours:
By appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

TBA	**TBA**	**TBA**	**Office Hours:** By appointment

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca/

The course is offered via a combination of online (asynchronous) and virtual (synchronous) mechanisms. Details on the mechanisms for the live (synchronous) sessions will be announced upon the beginning of the semester.

COURSE INTENDED LEARNING OUTCOMES

By the end of this course, students should be able to:

i. Work with relevant statistics and error analysis at a level expected of a first introduction to engineers.
ii. Demonstrate knowledge of a wide range of measurement techniques and technologies relevant to industrial detection, monitoring, and control; as well as where to apply them
iii. Be able to identify the main sources of noise and interference in measurements, and propose viable options for improving measurement results.
iv. Be able to make the relevant connections between a wide range of measurement techniques and the underlying fundamental physics.
v. Understand the basic aspects of feedback and control, and the main engineering aspects of stability
vi. Work hands-on with data acquisition from a range of different sensor types, and clearly reports key results
vii. Be able to assess various aspects of the scientific and engineering literature.

MATERIALS AND FEES

Required Texts:
EP 3L04 custom courseware.
"Measurements and Their Uncertainties", Ifan Hughes and Thomas Hase (Oxford, 2010)

Recommended Additional Texts:
"Measurements and Data Analysis for Engineering and Science", 4th Edition, Patrick Dunn and Michael Davis (CRC Press, 2018)
"Mechatronics", 7th Edition, William Bolton (Pearson, 2018)
"The Art of Electronics", 3rd Edition, Paul Horowitz and Winfield Hill (Cambridge University Press, 2015)
"Feedback Systems: An Introduction for Scientists and Engineers", Karl Åström and Richard Murray (Princeton University Press 2008)
"Engineering Signals and Systems", Fawwaz Ulaby and Andrew Yagle (Michigan Publishing, 2018)
"Image Processing for Engineering", Andrew Yagle and Fawwaz Ulaby (Michigan Publishing, 2018)

Calculator:
A scientific calculator is required.

Other Materials:
Laboratory take-home kits are available from the Campus Store.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 4 live sessions per week
- Experiments are done at home, but regular laboratory help sessions will be available. Details will be provided during the semester.
- 6 assignments (approximately)
- Brief preparatory work submissions (roughly weekly)
- Quizzes (roughly weekly)
- Final exam (please refer to the assessment table)

COURSE OVERVIEW

This section outlines the general strategy for Engineering Physics 3L04 in fall 2020. It should be noted that this represents the tentative plan for the coverage of material, and we will undoubtedly make some adjustments as we proceed through the semester. The central goal of the course is to consider a wide range of physical principles, engineering mathematics, and technologies which are relevant to engineering measurements. With the recent elimination of Eng Phys 2W03, a considerable emphasis will now be placed on statistics and error analysis. This fall, with the combination of online and virtual delivery, a much lower priority will be placed on a traditional lecture format than was the case in recent years. In fact, our prep work category serves to encourage you to do some reading ahead of time, so that we are ready in live sessions to spend a lot of our time in an interactive mode.

The following is an outline of some of the main resources which we plan to utilize, but note that there are also journal articles from the scientific and engineering literature which will form a basis for our studies.

1. **Overview of Measurement Systems** [Chapter 6, "Measurement Systems: Sensors and Transducers" in the book "Measurement and Data Analysis for Engineering and Science" by Patrick Dunn and Michael Davis, 4th edition (CRC Press, 2018)]

2. **Statistics and Error Analysis***** ["Measurements and Their Uncertainties", by Ifan Hughes and Thomas Hase; and the CCW section, Chapter 8 of "Statistics: A Guide to the Use of Statistical Methods in the Physiccal Sciences", by R.J. Barlow; as well as various on-line resources and from the literature]

3. **Pervasive Measurements in Engineering – Flow, Pressure, Temperature, and Mechanical**
   - Flow measurements [based on various resources outside of CCW]
   - Pressure (including vacuum) [based on various resources outside of CCW]
   - Thermodynamics and Temperature Measurements [based on Chapter 8 from "Experimental Methods for Engineers" by Holman, and sections of Chapter 9, "Measuring Pressure, Temperature, and Humidity", Wheeler and Ganji, "Introduction to Engineering Experimentation"]
   - Mechanical and Electrical Actuation [Chapters 8 and 9 in "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" (6th Edition), by William Bolton (2015)]

4. **Physics and Technology of Ultrasound** [based on "Ultrasound Measurement", by Coursey, Chapter 49 of "Measurement, Instrumentation, and Sensors Handbook", Webster and Eren, CRC (2014), and various resources outside of CCW]

5. **Dynamic Behaviour of Measurement Systems** [based on Chapter 11 of "Introduction to Engineering Experimentation" by Wheeler and Ganji (Prentice Hall, 2010)]

6. **Two selected aspects of telecom technology** [based on "Optical Fiber Communications" by Keiser]
   - Optical receiver operation (including consideration of signal-to-noise)
   - Digital link (technical) budgets

7. **Optical Fiber Sensors** [based on resources outside of CCW; and on selected material from Chapter 9, "Measuring Pressure, Temperature, and Humidity", in the book by Anthony Wheeler and Ahmad Ganji, "Introduction to Engineering Experimentation" (Prentice Hall, 2010)].

8. **Radioactivity** [based on resources outside of CCW; and "Radioactivity Measurement", by Coursey, Chapter 80 of Part VIII of "Measurement, Instrumentation, and Sensors Handbook", Webster and Eren, CRC (2014)]

9. **Detectors – Electromagnetic Radiation and Nuclear Particle Radiation** [based on Chapter 12 "Thermal and Nuclear Radiation Measurements" in the book "Experimental Methods for Engineers" by Holman (McGraw Hill, 2012); as well as selected resources from the literature.

10. **Measurement and Applications of Infrared Radiation** [based on selected resources from the literature]

11. **Feedback and Control – A Brief Introduction** [based on Chapter 8, "The Control Subsystem" of "Feedback and Control for Everyone", by Albertos and Mareels, as well as articles from the literature]

12. **Telemetry** [based on "Telemetry", by Albert Lozano-Nieto, Chapter 90 of Part IX of "Measurement, Instrumentation, and Sensors Handbook"; Edited by John Webster and Halit Eren, CRC Press (2014)]

13. **Two Common Technical Issues** [based on Chapter 1, "The Interference Problem" in the book "Noise Reduction Techniques in Electronic Systems", and on Chapter 20, "Thermal Control", by Philip Hobbs; as well as selected other sources outside of CCW]
    - The basis of interference and noise issues in measurements
    - Thermal effects

14. **Reliability and Safety** [Chapter 1 in "Practical Reliability Engineering"; and "Aerospace Engineering on the Back of an Envelope", Alber (Springer, 2012); as well as selected resources from the literature];
    - Basic ideas on reliability
    - Selected safety considerations

ASSESSMENT

Component	Weight #1	Weight #2
Assignments † (6 are planned)	35%	35%
Brief Lab Reports (4 or 5)	15%	15%
Prep work	15%	15%
Quizzes	15%	15%
Optional short project (end of term)	5%	0%
Special final assignment in lieu of exam (in exam time)	15%	20%
Total	100%	100%

† *Note*: *There are bonus questions on all of our assignments. If your total term assignment score exceeds 100%, then the additional marks will be carried forward toward your final course mark.*

ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes 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
[i]	1.1, 1.3, 2.3
[ii]	1.3, 1.4, 2.1, 4.3
[iii]	1.3, 2.2, 2.3, 4.3
[iv]	1.2, 3.1
[v]	1.3
[vi]	5.1, 5.2, 5.3, 7.1, 7.2, 7.3
[vii]	12.1

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

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 is 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.

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

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:
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.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (Avenue to Learn) for updates and announcements.
2. Late penalties will be indicated on the posted assignments and other course deliverables.
3. In the case of the preparation work and the quizzes, we will exclude a couple of your worst scores in computing the final category scores. Details will be announced after the semester begins.

SUBMISSION OF REQUEST 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".

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three 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 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 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.