ENGINEERING
McMaster-Mohawk
Bachelor of Technology
Partnership

McMaster University

Course Outline

1. COURSE INFORMATION

Session Offered	Fall 2023	
Course Name	Machine Health and Remote Monitoring	
Course Code	PROCTECH 4MH3	
Date(s) and Time(s) of lectures	C01: Tuesday 5:30PM – 6:20PM, and Wednesday 4:30PM – 6:20PM L01: Friday 8:30AM -11:20 AM (Odd Weeks, i.e. weeks 1, 3, 5,…..) L02: Friday 8:30AM -11:20 AM (Even Weeks, i.e. weeks 2, 4, 6,…..) L03: Friday 3:30PM -6:20 PM (Odd Weeks, i.e. weeks 1, 3, 5,…..) L04: Friday 3:30PM -6:20 PM (Odd Weeks, i.e. weeks 2, 4, 6,…..)	
Program Name	Automation Engineering Technology/Automotive and Vehicle Engineering Technology/Mechanical Engineering	
Calendar Description	This course covers machine monitoring using an electronic interface to a machines PLC and with Direct Machine Interface (DMI) modules, installation of noise and vibration sensor network and analysis of data from the sensors. It also covers, signal processing, mobile and remote monitoring through sensors, wired and wireless Local Area Networks, cloud, and the Internet of Things (IoT).	
Instructor(s)	C01: Tom Wanyama	E-Mail: wanyama@mcmaster.ca Office Hours & Location: Wednesday 2:00pm – 4:00pm, • Online (Microsoft Teams) • In-Person: ETB516
	L01: Oluwaseun Folorunso L02: Oluwaseun Folorunso L03: Oluwaseun Folorunso L04: Oluwaseun Folorunso	E-Mail: foloruno@mcmaster.ca

2. COURSE SPECIFICS

Course Description	This course covers the knowledge and tools in the field of remote monitoring of the health of industrial machines, mainly through vibration analysis. The course starts with a brief introduction to the broad field of machine condition monitoring, including methods other than vibration analysis, as applied to the efficient maintenance of operating machines without disturbing their normal operation. Benefits and shortfalls of condition-based maintenance over other maintenance methods such as run to failure are covered. While this course covers all the most common machine condition monitoring technologies, it focuses on: (1) the measurement and analysis of vibration signals from operating machinery; (2) application of machine learning in machine condition monitoring; and (3) application of IoT and IIoT technologies in remote machine health monitoring.		
Instruction Type	**Code**	**Type**	**Hours per term**
	C	Classroom instruction	39
	L	Laboratory, workshop or fieldwork	18
	T	Tutorial	
	DE	Distance education	
		Total Hours	57
Resources	**ISBN**	**Textbook Title & Edition**	**Author & Publisher**

	Other Supplies	Source
	Lecture notes, slides and videos	Avenue to Learn
Prerequisite(s)	ENGTECH 4EE0 and registration in level IV of Automation Engineering Technology program or the Automotive and Vehicle Engineering Technology program; or registration in level IV of Mechanical Engineering program.	
Corequisite(s)	*None*	
Antirequisite(s)	*None*	
Course Specific Policies	**Missed Work:** Make up of missed work will only be allowed if the work is covered by MSAF. **Lab Attendance:** Laboratory attendance is compulsory. A mark of zero will be allocated for missed laboratory experiments. Students shall only attend labs during the time assigned to their lab sections.	
Departmental Policies	Students must maintain a GPA of 3.5/12 to continue in the program. 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. Where group work is indicated in the course outline, such collaborative work is mandatory. 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. 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. Instructor has the right to submit work to software to identify plagiarism.	
3. SUB TOPIC(S)		
Week 1	**Introduction to Machine Health and Remote Monitoring** Definitions, Motivation for Machine Health and Remote Monitoring, Maintenance Methods	
Week 2 Week 3	**Machine Health Monitoring Technologies** Introduction to machine health monitoring technologies (current, voltage, vibration, noise etc). Machine Condition monitoring strategies, (Route-based, process monitoring, permanently installed – noise and vibration) transmitters, DC data analysis	Assignment 1: Machine Health Monitoring. - Due end of week 4
Week 4	**Machine Health Data Analysis** Definitions, Rectification Error (RE), Reducing the effects of RE in determination of Peak, Peak-to-Peak, and RMS Values.	
Week 5	**Machine Health Data Analysis** Data Analysis using Numerical Methods, Drifting, Reducing the effects of Drifting in Vibration Dynamics Analysis, Determination of Peak and Peak-to-Peak, and RMS Values of Vibration Velocity and Displacement.	Assignment 2: Machine Health data Analysis - Due end of week 6

Mid-term Recess: Monday, October 9 to Sunday, October 15, 2023		
Week 6	**Introduction to Signal Processing** Introduction to signal processing, signal processing methods: Kurtosis, Wavelets Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform	
Week 7	**Machine Health Signal Processing** Introduction, Applying FFT on real (Vibration) signals, Meaning and Processing of FFT Y and X-Axis Values, Spectral Leakage and Aliasing, Windowing.	Assignment 3 Machine Heath Signal Processing and Vibration Dynamics Analysis - end of week 9
Week 8	**Machine Health Signal Processing** Peak, Peak-to-Peak, RMS, and Phase Values (For vibration - Acceleration, Velocity, and Displacement)	
Week 9	**Fault diagnosis** Introduction to Fault Diagnostics, Fault Diagnostics using Vibration, Gear faults, Misalignment, Bearing faults etc	Assignment 4 FFT due end of week 11
Week 10	**Application of IoT and IIoT in machine health monitoring** Introduction, Implementation of Remote Machine Health Monitoring using IoT and IIoT Technologies	
Week 11	**Application of IoT and IIoT in machine health monitoring** Implementation of Remote Machine Health Monitoring using integrated IoT and IIoT Technologies	
Week 12	**Application of AI in Machine Health Monitoring** Introduction to application of AI in Machine Health Monitoring, Multivariant Statistics, The Mahalanobis Distance, Feed-Forward ANN, Autoencoder ANN	
Week 13	**Course Review** Review of course material in preparation for final examinations.	
Classes end: December 6, 2023 Final Examination Period: Friday, December 8 to Thursday, December 21 All examinations MUST be written during the scheduled examination period.		
List of experiments		
Lab 1	Using Sensor Networks in Vibration Data Collection	
Lab 2	Using IoT technology to Support Remote Machine Health Monitoring	
Lab 3	FFT Fundamentals	
Lab 4	Acquisition of FFT and Raw Vibration Data	

4. ASSESSMENT OF LEARNING *including dates*	**Weight**
Assignments	20%
Mid-term test	20%
Labs	20%
Final examination (tests cumulative knowledge)	40%
TOTAL	**100%**
Percentage grades will be converted to letter grades and grade points per the University calendar.	

5. LEARNING OUTCOMES

1. Design condition monitoring systems for typical machines, including hardware selection and measurement system setup.
2. Program vibration analysis systems to implement signal analysis, and to extract fault symptoms of machines.
3. Diagnose typical machine faults based on the output of signal processing tools.
4. Understand, select, and apply mathematical and AI tools for the analysis and integration of machine health data (e.g. Fourier Analysis and Artificial Neural Network).
5. Produce reports and communicate analysis results of machine condition monitoring.
6. Apply Internet of Things (IoT) concepts to machine health monitoring.

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

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.

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.