Western University
Department of Mechanical & Materials Engineering

MME 4459b – Advanced CAE: Manufacturing Technologies

COURSE OUTLINE - 2019-2020

CALENDAR DESCRIPTION:

This course is an introduction to modern computer aided manufacturing technologies. Topics include subtractive technologies, such as computer-numerically controlled (CNC) machining, as well as additive technologies used for rapid prototyping purposes.

COURSE INFORMATION:

Instructor: Professor R. Tutunea-Fatan
Office: ACEB 3462; Phone 519-661-2111, ext. 88289
E-mail: rtutunea@eng.uwo.ca

Lectures: Wed. 3:30 pm – 4:20 pm (ACEB 1415)
Thu. 1:30 pm – 2:20 pm (ACEB 1420)

Labs: Section 002: Mon. 2:30 pm – 4:20 pm (SEB 1028)
Section 005: Tue. 8:30 am – 10:20 am (SEB 1028)
Section 006: Wed. 10:30 am – 12:20 am (SEB 1028)
Section 008: Thu. 2:30 pm – 4:20 pm (SEB 1028)
Section 003: Fri. 9:30 am – 11:20 am (SEB 1028)
Section 007: Fri. 12:30 – 2:20 pm (SEB 1028)
Section 004: Fri. 2:30 am – 4:20 am (SEB 1028)

PREREQUISITES:

MME 3379A/B or MSE 3301A/B

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you will be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

CONSULTATION HOURS:

By advance notice via email (preferred) or drop in.

ACCREDITATION UNITS:

Engineering Science = 100%

TOPICS:

1. Introduction to computer-assisted manufacturing technologies
   - Generalities on computer-assisted manufacturing
   - Subtractive and additive manufacturing processes*
2. Subtractive manufacturing: computer numerically-controlled (CNC) machining
   - Historical notes on CNC machining
   - Conventional vs. NC vs. CNC machining
   - Word address programming (G-code)
   - Milling operations
   - CNC position and motion control systems
   - Shop activities
   - CNC machining centers

- Computer-aided part programming (CAM)

3. Additive manufacturing (AM)*
   - Historical notes on AM
   - Generic AM process
   - Types of AM processes
   - Software issues for AM
   - Practical applications of AM
   - CNC machining vs. AM

* AM topics make up approximately 10-15% of course content.

LEARNING OUTCOMES

Upon the successful completion of the course, students will:

- Understand, assess and apply the advantages and limitations of the subtractive and additive manufacturing processes
- Know how to use and operate CNC machines and FDM 3D printers in order to fabricate geometries of a certain/limited complexity
- Evaluate and implement setups and workholding methods that allow a fast, accurate and safe generation of the intended geometry
- Select cutting tools and process parameters that are in agreement with machine tool available and surfaces/material being cut
- Use computer-aided manufacturing (CAM) software to generate tool paths to be followed by the CNC machine and/or 3D printer
- Read and troubleshoot NC programs written in standard G-code format
- Evaluate and decide among different 3D building options available when fabricating a part through FDM 3D printing
- Generate FDM 3D printer-specific command programs/codes
- Apply "design for manufacturability" (DFM) principles in routine design tasks
- Observe the principles of a safe working environment

CONTACT HOURS: 2 lecture hours/week, 2 laboratory hours/week, 0.5 course

RECOMMENDED TEXTBOOKS:

Valentino J.V., Goldenberg J., *Introduction to Computer Numerical Control (CNC),* 5th Edition, Prentice Hall, 2013

Gibson I., Rosen D.W., Stucker B., 3D Printing: Technology, Applications, and Selection, CRC Press, 2018

EVALUATION: The final course grade will be determined according to the following weighting scheme:

Assignments	15%
Projects	35%
Final examination (closed book)	50%

Course assignments and projects will be handed out and collected according to the following *tentative* schedule:

Evaluation Format	Weight	Effort Type	Assigned	Due
Assignment 1	5%	Individual	Week of Jan. 27	Week of Feb. 10
Assignment 2	5%	Individual	Week of Feb. 24	Week of Mar. 9

Evaluation Format	Weight	Effort Type	Assigned	Due
Assignment 3	5%	Individual	Week of Mar. 16	Week of Apr. 6
Project 1	10%	Team	Week of Jan. 13	Week of Jan. 27
Project 2	15%	Team	Week of Feb. 3	Week of Mar. 9
Project 3	10%	Team	Week of Mar. 16	Week of Apr. 6

Term coursework topics:

- Assignment 1: Manual part programming
- Assignment 2: Machining process parameters
- Assignment 3: Motion control systems
- Project 1: Manual part programming
- Project 2: CAM software-assisted part programming
- Project 3: CNC machining vs. AM of complex surfaces

COURSE POLICIES The following course-specific policies will be enforced throughout the course:

Course projects/laboratory sessions

- All three course projects are hands-on machining and/or 3D printing projects to be completed during the timetabled laboratory sessions.
- Due to the nature of the hands-on projects, *lab session changes (in any of the weeks of the term) are not permitted*. The structure of each team (to be determined in the first lab session) will remain the same for the entire duration of the course. Each team will complete the assigned project at its own speed and its own approach, such that 'jumping' between teams and lab sessions does not make any (educational) sense.
- The hands-on component of the project will be carried out during laboratory sessions as follows: three lab sessions for Project 1 (including the first safety/demo week), five lab sessions for Project 2 and three lab sessions for Project 3.
- Due to the high load of the CNC laboratory as well as limited amount of TA hours available for the course, non-timetabled laboratory sessions cannot be provided. Because of this, each group will have to complete the hands-on component of the project (*i.e.*, machine the required part) during the allotted timetabled lab sessions. If the project will not be completed in the allotted number of laboratory sessions, appropriate project mark penalties will have to be applied.
- Conversely, if a group will complete the hands-on component of the project in a number of sessions that is smaller than the allotted number, then group members are allowed to be absent from the rest of sessions that are allotted to that particular project (however, the supervising TA should be notified about group intention to be absent from the remainder of project-specific laboratory sessions). However, please note that – due to the inherent pacing of the course material – subsequent roll forward of the course project timelines are not possible. In other words, while each project will be assigned/announced/distributed on the same day for the entire class, its earlier completion is possible/allowed.

- Laboratory session attendance is mandatory, the only allowed exceptions being sessions that are missed with academic consideration (*i.e.*, approved by Engineering Undergraduate Services).
- No make-up lab sessions can be offered since each lab session will be virtually different from the previous one (the project will continuously progress during the allotted weekly lab sessions).
- If a certain lab session is missed with academic consideration, the student is advised to agree with his/her group members ways to compensate for missed project work. If no consensus is reached, the instructor might decide to penalize the student who has missed a lab session.
- If more than *one* lab session allotted to a certain project is missed *with academic consideration*, individual penalties will likely be applied on the corresponding project mark. The amount of mark penalty will be established by the course instructor.
- If a certain lab session is missed *without academic consideration*, individual penalties will be applied on the corresponding project mark. The penalties to be applied are increasing in severity as follows: at the first unjustified lab absence, the penalty on the project mark will be proportional with the percentage of one lab session out of the total number of lab sessions allotted to the project (*i.e.*, 33% for Project 1 and 3 and 20% for Project 2). After two unjustified lab absences a penalty of 50% of the entire project mark (worth of 35% of the final course grade) will be applied. Three unjustified lab absences are equivalent with course failure.

Final examination

- Final examination will be closed book (all required formulas will be provided).
- Only non-programmable calculators will be allowed during the final examination.
- If a minimum of 50% is not obtained on the final examination, the student cannot receive a final mark greater than 48%.

UNITS: Metric and US customary.

ENGLISH: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests and examinations for the improper use of English. Additionally, poorly written work with the exception of final examinations may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

CLASSROOM DEMEANOR: The instructor is committed to providing a respectful learning environment for all students involved in this course. This is a collective responsibility of the instructor and students, and therefore students partaking in this course agree to abide by this criterion. This includes arriving at lectures on time, and acting in a professional manner during class.

ATTENDANCE: Any student who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with

the permission of the Dean, the student will be debarred from taking the regular examination in the course.

CHEATING: University policy states that cheating, including plagiarism, is a scholastic offense. The commission of a scholastic offence is attended by academic penalties which might include expulsion from the program. If you are caught cheating, there will be no second warning. (see Scholastic Offence Policy in the Western Calendar.

SSD: Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

NOTE: Students who have failed an Engineering course (i.e. < 50%) must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted for grading by the student in subsequent years.