Western University
Mechatronic Systems Engineering Program

MSE 3380B — Mechanical Components Design for Mechatronic Systems

COURSE OUTLINE – 2021-2022

Description: In this course, students will learn to design and specify mechanical components commonly used in mechatronic devices and systems. The design of critical components such as gears, shafts, bearings and fasteners is explored, and this knowledge will be complemented through the completion of three hands-on labs during the term. Students will apply this knowledge using engineering analysis tools to complete a mechatronic system design project.

Instructor: Dr. Aaron Price
ACEB 3457, 519-661-2111 ext. 86420, aaron.price@uwo.ca
Consultation hours: Thursdays, 9:30 AM – 10:20 AM via OWL's Zoom tool

Academic Calendar Copy: This course investigates the stress analysis, design, and selection of various mechanical components typically employed in mechatronic systems. Topics include advanced solid modeling, failure theory, and the analysis and design of gearing, shafts, bearings and fasteners.

Contact Hours: 3 asynchronous lecture hours per week, 9 total virtual laboratory hours, 2 tutorial hours per week (blend of asynchronous/synchronous), 0.5 course.

Antirequisite: MME 3380A/B.

Prerequisites: MME 2200Q/R/S/T or MSE 2200Q/R/S/T, MME 2202A/B or MSE 2212A/B, MSE 2202A/B, MME 3381A/B or MSE 3381A/B. Restricted to students enrolled in the Mechatronic Systems Engineering Program.

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.

CEAB Academic Units: Engineering Science 75%, Engineering Design 25%

Required Textbook: *Shigley's Mechanical Engineering Design* by R. Budynas and K. Nisbett, McGraw-Hill, 11th International Student edition. ISBN-13: 978-1-260-56999-5.

Required Software: MATLAB, SolidWorks.

Other Required References: Asynchronous lesson videos, laboratory manuals and supplementary information will be available via the course OWL site.

General Learning Objectives (CEAB Graduate Attributes):

Knowledge Base	A	Use of Engineering Tools	A	Impact on Society and the Environment	

Problem Analysis	A	Individual and Team Work	D	Ethics and Equity	
Investigation		Communication Skills	D	Economics and Project Management	
Design	A	Professionalism		Life-Long Learning	D

x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

Topics and Specific Learning Objectives:

1. Stress Analysis and Design of Mechanical Components (Shigley, Ch. 3) (PA2, PA3)

At the end of this section, students will be able to:

a. Calculate the normal and shear stresses present in a component due to axial, flexural and torsional loads.

b. Construct free-body, shear, bending moment and torsion diagrams for a given component loading and identify locations most critical for failure analysis.

c. Identify stress concentrations present in a specific component and determine the magnitude of the stress concentration.

d. Propose design changes to mitigate the presence of a stress concentration.

e. Evaluate contact stresses at the interface of spherical/cylindrical components.

2. Mechanical Fits (Shigley, §7-8) (PA2, PA3)

At the end of this section, students will be able to:

a. Identify the type of fit resulting from the assembly of two components with known geometries.

b. Compute the required dimensional tolerances to achieve a desired fit between two components.

c. Analyze the stresses present at the interface of an interference fit.

d. Assess if a given interference fit is capable of transmitting a specified torque without slipping.

3. Static Failure Theory and Fracture Mechanics (Shigley, Ch. 5) (PA2, PA3)

At the end of this section, students will be able to:

a. Select and apply an appropriate static failure theory to determine a component's factor of safety in service.

b. Implement static failure criteria to specify component design parameters.

c. Predict the onset of crack propagation using the theory of fracture mechanics.

d. Design a component for resistance to rapid crack propagation using fracture mechanics.

4. Fatigue Failure Theory and Design (Shigley, Ch. 6) (PA2, PA3)

At the end of this section, students will be able to:

a. Determine fatigue strength.
b. Determine fatigue safety factor.
c. Select design parameters for fatigue.
d. Determine fatigue safety factor for combined loading.
e. Sketch the failure locus for fatigue and static yield, and indicate the load line.
f. Predict cumulative fatigue life.

5. Shaft Design and Analysis (Shigley, Ch. 7) (PA1, PA2, PA3, D1)

At the end of this section, students will be able to:

a. Analyze shafts for combined static loading.
b. Analyze shafts for combined fatigue loading.
c. Compute transverse and angular shaft deflections at critical locations.
d. Compute critical shaft speed.
e. Specify shaft key dimensions for a specified transmitted load.

6. Gearing Types and Load Analysis (Shigley, Ch. 13) (PA1, PA2, PA3, D1)

At the end of this section, students will be able to:

a. Compute forces in spur and helical gears.
b. Specify spur gear parameters based on kinematic requirements.
c. Interpret the key parameters for the design of helical gears.

7. Spur, Helical, Bevel and Worm Gear Design and Analysis (Shigley, Ch. 14 + 15) (PA1, PA2, PA3, D4)

At the end of this section, students will be able to:

a. Apply the Lewis equation for spur gear design.

b. Design sets of spur gears for bending and surface durability.
c. Analyze spur gears using AGMA standards to predict failure modes and lifetime.
d. Analyze helical gears using AGMA standards to predict failure modes and lifetime.

8. Rolling-Contact Bearing Selection and Analysis (Shigley, Ch. 11) (PA1, PA2, PA3)

At the end of this section, students will be able to:

a. Select a ball bearing for a specified service condition or application.

b. Select a cylindrical bearing for a specified service condition or application.
c. Compute the equivalent radial load given axial and radial load components.
d. Determine an equivalent radial load and select the appropriate bearing.
e. Compute the realized reliability of a prescribed bearing.

f. Predict the remaining life of a bearing in service.

g. Determine the rated load for tapered bearings.

h. Prescribe appropriate bearing lubrication and enclosures for a given application.

9. Thread Standards, Mechanics of Power Screws (Shigley, §8-1, 8-2 only) (PA2, PA3)

At the end of this section, students will be able to:

a. Identify standard thread dimensions.

b. Determine power screw torque & efficiency.

c. Identify if a given power screw is self-locking.

d. Determine power screw buckling risk (buckling is reviewed in Ch. 4).

10. Geometric Dimensioning and Tolerancing (Shigley, Ch. 20) (KB4)

At the end of this section, students will be able to:

a. Specify required tolerances and dimensions for components on design drawings according to specifications.

11. Flexible Mechanical Elements (Shigley, Ch. 17) (PA1, PA2, PA3, D4)

At the end of this section, students will be able to:

a. Prescribe appropriate flat belt tensions.
b. Calculate the flat belt safety factor for a given loading.
c. Select an appropriate flat belt width.
d. Determine V-belt power capacity.
e. Predict V-belt life.
f. Compute chain drive power capacity.
g. Determine the required chain length for a given application.

A. Assembly Lab (KB4, I3)

Upon completion of this laboratory exercise, students will:

a. Identify fundamental machine components.
b. Practice disassembly/reassembly of a complex machine.
c. Investigate different methods of fastening bolts to the correct torque.

B. Metrology Lab (KB4, I3)

Upon completion of this laboratory exercise, students will:

a. Use metrology tools to investigate manufacturing tolerances.
b. Interpret engineering drawings.
c. Investigate the function of standard mechanical fits.

C. Fatigue Lab (I2, I3)

Upon completion of this laboratory exercise, students will:

a. Investigate parameters associated with the estimation of fatigue life.
b. Estimate the fatigue life of a given component based on interpreted data.

D. Mechanical Components (KB4)

Upon completion of this course, students will be able to:

a. Identify the various machine components introduced throughout the course.

E. Team Design Project (D1, D4, CS3, ET2)

Upon completion of this project, students will be able to:

a. Design the mechanical power transmission components for a mechatronic system
b. Effectively communicate their design through engineering reports and drawings
c. Demonstrate proficiency with SolidWorks solid modelling software

Evaluation:

Course Component	Weight
Quizzes	15%
Laboratory	15%
Team Design Project	35%
Final Examination	35%

Quizzes: Three 30-minute online quizzes will be held during the tutorial period on January 26th, February 23rd and March 16th. Quizzes are limited open book, and only simple nonprogrammable calculators are allowed.

Laboratory: Lab groups will be scheduled to participate in virtual lab sessions running throughout the term. There are 3 labs in total covering metrology, assembly, and fatigue. Pre-lab exercises must be completed prior to the lab session, and lab reports must be submitted at the conclusion of the lab session.

Team Design Project: The team design project consists of a final report due at 5:00 PM on April 9th. Reports must be submitted electronically via OWL. A project description including a detailed grading rubric for each deliverable will be posted on the course OWL site.

Final Examination: The final examination will take place during the regular examination period. The final exam will be three hours long, limited open book. Only simple, nonprogrammable calculators are allowed. Permissible textbook annotations will be explicitly described in the lecture, and also posted on the course OWL site.

Course Policies: The following course-specific policies will be enforced throughout the course:

Laboratory sessions:

- Participation in all laboratory sessions is mandatory.
- Students who join 30 min after the scheduled lab time or miss the lab without a legitimate reason will be given a one-time only chance to conduct the lab (at a rescheduled time) with 50% penalty. Any reoccurrence will count as a missed lab.
- Students who miss a lab with academic consideration are required to reschedule the lab by contacting the TA responsible for the laboratory. Failure to do so will result in a zero mark for that lab.
- A minimum mark of 50% in each laboratory exercise, with a minimum average of 60% across all laboratory exercises is required to pass the course.

Quizzes:

- The quiz component of the grade will be comprised of all three quiz marks.

- No make-up quiz options will be offered regardless of the circumstances for which the quiz was missed.
- Missing a quiz without academic consideration will result in a mark of zero for that quiz.
- Missing one quiz with academic consideration will increase the weight of the remaining two quizzes to 7.5% each.
- Missing two or more quizzes with academic consideration will automatically shift the weight of the missed quizzes into the final examination.
- Missing two or more quizzes without academic consideration will result in failure of the course.

Project:

- The default assumption is that everyone contributes equally to the team effort, and hence all students will receive the same grade for the project components.
- Peer evaluation: Each student may elect to specify the contributions made by each member of their team, including his/herself in the event that contributions are not deemed equitable. Individual grades will be adjusted for each student based on self and peer evaluation as required.
- A minimum of 60% must be obtained on the project in order to pass the course.
- Late submissions will be penalized by 2^{n+1}%, where n is the number of days past the set due date. Weekends count as a single day. Any deliverables submitted more than 5 days late will not be accepted. Work submitted after the last day of classes will not be accepted and will receive a grade of 0 automatically.

Final examination:

To obtain a passing grade in the course, a mark of 60% or more must be achieved on the final examination. A final examination mark < 60% will result in a final course grade of 48% or less.

If the above conditions are not met, your final grade cannot be greater than 48%. Students who have failed this course (i.e., final average < 50%) must repeat all components of the course.

Use of 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 improper use of English. Additionally, poorly written work with the exception of the final examination 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.

Attendance: All classes, laboratories, and tutorials are mandatory unless otherwise stated. Any student who, in the opinion of the instructor, has not engaged sufficiently in class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the program, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Academic Consideration for Student Absences: Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the term, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-

reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams),
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are *not* met, students will need to provide a Student Medical Certificate if the absence is medical in nature or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. **All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.**

Western University's policy on Consideration for Student Absences is detailed here:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Consideration_for_absences.pdf

and information pertaining to the Student Medical Certificate (SMC) is detailed here:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

Religious Accommodation: Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their course requirements will be affected by a religious observance. Additional information is given in the Western Multicultural Calendar:

https://multiculturalcalendar.com/ecal/index.php?s=c-univwo

Cheating and Plagiarism: Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. 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.

All required papers may be subject to submission for textual similarity review to commercial plagiarism-detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Scholastic offences are taken seriously, and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Online Etiquette: Some components of this course will involve online interactions. To ensure the best experience for both you and your classmates, please honour the following rules of etiquette:

- please "arrive" to class on time
- please use your computer and/or laptop if possible (as opposed to a cell phone or tablet)
- ensure that you are in a private location to protect the confidentiality of discussions in the event that a class discussion deals with sensitive or personal material
- to minimize background noise, kindly mute your microphone for the entire class until you are invited to speak, unless directed otherwise
- please be prepared to turn your video camera off at the instructor's request if the internet connection becomes unstable
- unless invited by your instructor, do not share your screen in the meeting

The course instructor or teaching assistant will act as moderator for the class and will deal with any questions from participants. To participate please consider the following:

- if you wish to speak, use the "raise hand" function and wait for the instructor to acknowledge you before beginning your comment or question
- remember to unmute your microphone and turn on your video camera before speaking
- self-identify when speaking
- remember to mute your microphone after speaking (unless directed otherwise)

General considerations of "netiquette":

- keep in mind the different cultural and linguistic backgrounds of the students in the course
- be courteous toward the instructor, your colleagues, and authors whose work you are discussing
- be respectful of the diversity of viewpoints that you will encounter in the class and in your readings. The exchange of diverse ideas and opinions is part of the scholarly environment. "Flaming" is never appropriate.
- be professional and scholarly in all online postings. Cite the ideas of others appropriately.

Note that disruptive behaviour of any type during online classes, including inappropriate use of the chat function, is unacceptable. Students found guilty of Zoom-bombing a class or of other serious online offenses may be subject to disciplinary measures under the Code of Student Conduct.

Online Proctoring Notice: Quizzes and examinations in this course will be invigilated using Zoom. You will be required to keep your camera on for the entire session, present your student card for identification purposes, and share your screen with the invigilator if asked to do so at any time during the exam. The exam session will not be recorded.† More information about the use of Zoom for invigilation is available in the Online Proctoring Guidelines at the following link: https://www.uwo.ca/univsec/pdf/onlineproctorguidelines.pdf.

Completion of this course will require you to have a reliable internet connection and a device that meets the system requirements for Zoom. Information about the system requirements is available at the following link: https://support.zoom.us/hc/en-us.

†Note that Zoom servers are located outside Canada. If you would prefer to use only your first name or a nickname to login to Zoom, please discuss this with your instructor in advance of the test or examination.

Policy on Repeating All Components of a Course: Students who are required to repeat an Engineering course 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 by the student for grading in subsequent years.

Internet and Electronic Mail: Students are responsible for regularly checking their Western e-mail and the course web site (https://owl.uwo.ca/portal/) and making themselves aware of any information that is posted about the course. If the student fails to act on information that has been posted on these sites and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

While email is a useful tool for coordinating office hour appointments or for simple clarifications, an in-person meeting is recommended to address more complex questions. Please make an appointment to discuss any personal, academic, group work or controversial issues in person, especially any concerns that you might have about your grades. Dr. Price will check email Monday through Friday during normal office hours; you can expect a response within 24 hours during the workweek. Over weekends and holidays Dr. Price will not be checking email regularly, so plan accordingly. Due to increased demand, emails sent after 4:00 PM the day before the exam may not be responded to before the exam.

Accessibility: 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 519-661-2111 ext. 82147 for any specific question regarding an accommodation.

Support Services: Office of the Registrar, http://www.registrar.uwo.ca/

Student Development Centre, http://www.sdc.uwo.ca/

Engineering Undergraduate Services, http://www.eng.uwo.ca/undergraduate/

USC Student Support Services, http://westernusc.ca/services/

Students who are in emotional/mental distress should refer to Mental Health @ Western, http://www.health.uwo.ca/mental_health/, for a complete list of options about how to obtain help.