

Western University
Faculty of Engineering
Mechatronic Systems Engineering Program

MSE 3380B — Mechanical Components Design for Mechatronic Systems

Course Outline 2017–18

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
SEB 3026A, 519-661-2111 ext. 86420, aaron.price@uwo.ca
Consultation hours: Thursdays, 10:00 – 11:00 AM or by appointment.

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 lecture hours, 0.75 laboratory hours, 1.5 tutorial hours, 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, 10th edition. ISBN-13: 978-0073398204.

Required Software: MATLAB, SolidWorks, Siemens NX, EAGLE, Carbide Motion, Carbide Create, FlatCAM.

Other Required References: 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

Notation: 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)

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)

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)

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)

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)

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)

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

- a. Compute forces in spur, helical, bevel and worm 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 (Shigley, Ch. 14 + 15)

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.
- e. Analyze bevel gears using AGMA standards to predict failure modes and lifetime.
- f. Analyze worm gears using AGMA standards to predict failure modes and lifetime.

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

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)

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. Review of Geometric Dimensioning and Tolerancing (Shigley, Ch. 20)

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)

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.

In general, students will be expected to be able to identify the various components they have been exposed to throughout the course.

Evaluation:

Course Component	Weight
Quizzes	15%
Laboratory	15%
Team Design Project	25%
Final Examination	45%

In order to pass the course, the following requirements must be met:

- A minimum mark of 50% in each laboratory exercise, with a minimum average of 60% across all laboratory exercises. This means that attendance in each laboratory period is mandatory. Your teaching assistant will sign your lab report as testimony to your attendance. You will only be allowed to make up for a missed laboratory if you have a valid excuse (e.g., doctor's note submitted to and recognized by Undergraduate Services).
- A minimum mark of 50% on the project.
- A minimum mark of 60% on the final exam.

If these 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.

Note that, the efforts of the team on the major project constitute a quarter of the grade for this course. Each student will be asked to specify the contribution made by each member of the team, including his/herself. Team grades may be adjusted for each student based on self and peer evaluation.

Quizzes: Three 30-minute quizzes will be held during the tutorial period on January 24th, February 14th and March 7th. Quizzes are limited open book, and only simple nonprogrammable calculators are allowed.

Laboratory: Lab groups will be scheduled to attend lab sessions running throughout the term. There are 3 labs in total covering fabrication (SEB 3101), metrology (SEB 1076), and assembly (SEB 1076). Students will be required to purchase a components kit that includes the parts to fabricate an Arduino-compatible motor controller shield (1 kit is required per lab group). All other components required for the lab will be provided. Pre-lab exercises must be completed prior to the lab session, and lab reports must be submitted at the conclusion of the lab session. Lab measurement worksheets will be provided via OWL and must be printed in advance of the lab session.

Team Design Project: Deliverables for the team design project consist of an interim report due at 5:00 PM on March 23rd and a final report due at 5:00 PM on April 6th. 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 be 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.

Late Submission Policy: All assigned work is due at the start of class or laboratory period, as appropriate. 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.

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, is absent too frequently from 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.

Absence Due to Illness or Other Circumstances: Students should immediately consult with the instructor or program Director if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see the attached “Instructions for Students Unable to Write Tests or Examinations or Submit Assignments as Scheduled”). The student should seek advice from the instructor or program Director regarding how best to deal with the problem. Failure to notify the instructor or program Director immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, see the relevant section of the Academic Handbook:

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

For more information concerning accommodations for religious holidays, see the relevant section of the Academic Handbook:

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

Missed Midterm Examinations: If a student misses a midterm examination, the exam will not be rescheduled. The student must follow the Instructions for Students Unable to Write Tests and provide documentation to their program within 24 hours of the missed test. The program will decide whether to allow the reweighting of the test, where reweighting means the marks normally allotted for the midterm will be added to the final exam. If no reasonable justification for missing the test can be found, then the student will receive a mark of zero for the test.

If a student is going to miss the midterm examination for religious reasons, they must inform the instructor in writing within 48 hours of the announcement of the exam date or they will be required to write the exam.

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

Use of Electronic Devices: Turn off all sound for pagers and cell phones. Students may use laptops, tablet computers, or smart phones *only* to access the course OWL site or PressWestern during lectures and tutorials. Use of *nonprogrammable* calculators *only* is permitted during quizzes and examinations. No other electronic devices may be used at any time during lectures, tutorials, or examinations.

Use of Personal Response Devices (“Clickers”): Personal Response Devices (“clickers”) enable instructors to gauge class comprehension by asking structured questions during the lesson, to which you may respond by entering the appropriate response on a clicker device. In this course, we will make use of PressWestern's iClicker (<https://www.iclicker.com/>) software to enable the use of students’ own mobile devices such as smartphones, tablets and laptops as virtual clickers. Individual responses will be collected and displayed as an anonymized graph at the front of the room. If the instructor chooses, these responses may also be saved for future analysis. In this course, virtual clickers will primarily be used to promote engagement during the lessons, and participation is therefore not mandatory (but strongly encouraged). These activities also serve to provide you with formative feedback on your understanding of the course material. Although clickers may be used in the classroom for polling opinions and/or collecting some types of personal data (e.g. Have you ever encountered a tapered roller bearing?), such responses will not become part of your academic record and will not contribute to the assessment of your grade. Such non-academic data will either be recorded anonymously or not at all. Finally, any data gathered using personal response systems will not be used for research purposes without the express written consent of the student.

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.

INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

IF, ON MEDICAL OR COMPASSIONATE GROUNDS, YOU ARE UNABLE TO WRITE TERM TESTS OR FINAL EXAMINATIONS OR COMPLETE COURSE WORK BY THE DUE DATE, YOU SHOULD FOLLOW THE INSTRUCTIONS LISTED BELOW. YOU SHOULD UNDERSTAND THAT ACADEMIC RELIEF WILL NOT BE GRANTED AUTOMATICALLY ON REQUEST. YOU MUST DEMONSTRATE TO YOUR DEPARTMENT (OR THE UNDERGRADUATE SERVICES OFFICE) THAT THERE ARE COMPELLING MEDICAL OR COMPASSIONATE GROUNDS THAT CAN BE DOCUMENTED BEFORE ACADEMIC RELIEF WILL BE CONSIDERED. DIFFERENT REGULATIONS APPLY TO TERM TESTS, FINAL EXAMINATIONS AND LATE ASSIGNMENTS. PLEASE READ THE INSTRUCTIONS CAREFULLY. (SEE THE 2017 UWO ACADEMIC CALENDAR).

A. GENERAL REGULATIONS & PROCEDURES

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or exam that is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097. Otherwise, you will report to your department office to request relief.
3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.
4. Documentation must be provided as soon as possible. If no one is available in your Department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.
5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. TERM TESTS

1. If you are in first year and you are unable to write a term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.
2. If you are an upper year student and you are unable to write a term test, inform your instructor PRIOR to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief. Otherwise, you will report to your department office to request relief.
3. Be prepared to provide supporting documentation to the Department Chair and/or the Undergraduate Services Office (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. **N.B.** The approval of the Chair or the Undergraduate Services Office is required when rescheduling term tests.

C. FINAL EXAMINATIONS

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, sleeping in, misreading timetable and travel arrangements.
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

N.B. It is the student's responsibility to check the date, time and location of the Special Examination.

D. LATE ASSIGNMENTS

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Associate Dean if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4.
 - i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean. Documentation is mandatory.
 - ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean.

E. SHORT ABSENCES

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. EXTENDED ABSENCES

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You may want to seek advice from the academic counsellor in your Department or Ms. Karen Murray in the Undergraduate Services Office, if you are in first year.

G. DOCUMENTATION

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.**

In Case of Serious Illness of a Family Member: Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

In Case of a Death: Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

For Other Extenuating Circumstances: If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

H. ACADEMIC CONCERNS

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).
2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**
3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your academic counsellor.

Calendar References: Check these regulations in your 2017 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness: <http://westerncalendar.uwo.ca/2017/pg117.html>
Academic Accommodations for Students with Disabilities: <http://westerncalendar.uwo.ca/2017/pg118.html>
Academic Accommodations for Religious or Holy Days: <http://westerncalendar.uwo.ca/2017/pg119.html>
Course Withdrawals: <http://westerncalendar.uwo.ca/2017/pg157.html>
Examinations: <http://westerncalendar.uwo.ca/2017/pg129.html>
Scheduling of Term Assignments: <http://westerncalendar.uwo.ca/2017/pg135.html>
Scholastic Offences: <http://www.westerncalendar.uwo.ca/2017/pg111.html>
Student Medical Certificate: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf
Engineering Academic Regulations: <http://www.westerncalendar.uwo.ca/2017/pg1442.html>

Note: These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

Drop Deadlines:

First term half course (i.e. "A" or "F"):	November 5, 2017
Full courses and full-year half courses (i.e. "E", "Y" or no suffix):	November 30, 2017
Second term half or second term full course (i.e. "B" or "G"):	March 7, 2017

Contact Information:

Undergraduate Services Office:	SEB 2097	Telephone: (519) 661-2130	E-mail: engugrad@uwo.ca
Dept. of Chemical and Biochemical Engineering & Green Process Engineering:	TEB 477	Telephone: (519) 661-2131	E-mail: cbeugrad@uwo.ca
Dept. of Civil and Environmental Engineering:	SEB 3005	Telephone: (519) 661-2139	E-mail: civil@uwo.ca
Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering:	TEB 279	Telephone: (519) 661-3758	E-mail: eceugrad@uwo.ca
Dept. of Mechanical and Materials Engineering:	SEB 3002	Telephone: (519) 661-4122	E-mail: mmeundergraduate@uwo.ca