MECH 325 Syllabus
Mechanical Design I: Design with Mechanical Components

1 Overview

MECH 325 is a mechanical design course on machine components – sometimes called *machine design*. We hope that in studying machine design, you will develop a further appreciation for:

- the range of readily-available mechanical components for use in design
- the limitations of purely analytical models in capturing the behaviour of complex mechanical systems, and the importance of empirical models (codes, manufacturer's guidelines, etc.) derived from generations of design experience
- the iterative nature of the design process

2 Particulars

2.1 People and Places

There are two sections for this course. Each section will be taught in the same way using the same approach, the same materials and the same schedule.

	Section 101	Section 102
Instructor	Jon Mikkelsen	
Email	mikk@mech.ubc.ca	
Office	CEME 2208H	
Office hours	No set hours yet	
Lectures	Section 101: Tues 9:30-11:00 MCLD 202 Thu 14:00-15:30 CEME 1202	Section 102: Tues 11:00-12:30 MCLD 202 Thu 15:30-17:00 LSC 1003
Tutorials	T1A: Tues 14:00-15:30 SWNG 407 Thu 9:30-11:00 SCRF 1005 T1B: Tues 14:00-15:30 SWNG 409 Thu 9:30-11:00 SCRF 200 T1E: Tues 15:30-17:00 MCLD 220 Thu 9:30-11:00 SCRF 208	T1C: Tues 14:00-15:30 CHBE 103 Thu 11:00-12:30 SWNG 309 T1D: Tues 15:30-17:00 BUCH B318 Thu 11:00-12:30 FORW 519 T1F: Tues 15:30-17:00 MCLD 214 Thu 11:00-12:30 SWNG 105

TAs are assigned to teach tutorial sessions module by module.

2.2 Textbook

The required course text is Budynas, R.G., Nisbett, J.K., *Shigley's Mechanical Engineering Design* 11th Edition from McGraw Hill (either 9th Ed., 2010, or 10th Ed., 2014 can also be used). The book is available in the bookstore and will also be used in MECH 326 and MECH 328. **Note: the above text contains information in both SI and imperial units. If you choose to purchase an international edition instead, you will likely find it has SI units only and you will need to obtain copies of the imperial unit information (figures, tables, etc.) from a colleague (the exams are part open-book). Likewise, you may need to reference a colleague's text to ensure the page numbering is consistent.** For other reference materials relevant to this course, see the section at the end of this syllabus.

3 Course Aims and Objectives

Our overall aim of this course is to **provide students with the background and skills to be able to understand, analyze, and select mechanical components in typical engineering design scenarios.** The focus of the course is very much a practical one. While we do want you to understand the basic physics behind common mechanical components, this is not a course in designing the mechanical components themselves; this is a course in selecting and using the components in the scope of a larger design.

For each class of component studied, there is a common set of learning goals in that you should be able to:

- **Identify** and **classify** common types of each component
- **Describe** the component features and geometry using accepted terminology
- **Describe** the operating principles and typical applications of each type of component
- **Describe** the advantages and disadvantages of each component compared to other components that achieve similar function
- **Analyze** components in terms of accepted computational methods, standards, and codes
- **Compute** safety factors and/or expected life for components (where applicable)
- **Select** and **specify** appropriate components for a given design application
- **Evaluate** and/or **justify** the selection of components for a given design application

The course is divided into five modules, based on different classes of mechanical components. The specific objectives for each module are summarized below.

Module	Objectives: by the end of this module, you should be able to…
Module 1: Transmission Components Part 1 (gears and power screws)	• Identify common types of gears and describe their uses • Describe gear geometry using accepted nomenclature • Describe the importance of the involute profile of gear teeth • Describe the common materials/methods for forming gear teeth and explain how those methods influence gear selection and performance • Analyze a gear train in terms of kinematics, torque transmission, and reaction forces/moments • Determine safety factors in bending and contact for spur and helical gears using AGMA standards • Describe the operation of power screws and cite typical applications • Describe thread geometry for common types of power screws • Calculate friction, torque, and power requirement for various power screw applications • Specify an appropriate gear train or power screw for a given design application
Module 2: Transmission Components Part 2 (flexible drives)	• Describe the principal types of belts and their uses • Size flat-belts, V-belts, timing belts, roller chains, wire, and metal bands for given applications • Select an appropriate flexible drive element for a given application
Module 3: Connecting Elements 1 (bushings, bearings and shaft accessories)	Bushings and Bearings: • Identify types, uses, and characteristics of journal bearings • Describe the operating principles and selection criteria for hydrodynamic, hydrostatic bearings, and boundary-lubricated bearings • Size a boundary-lubricated bearing for a given application • Identify types, uses, characteristics, and selection criteria for rolling element bearings • Determine bearing life (under non-steady radial and thrust loads) for a given application based on manufacturer data • Specify an appropriate rolling element bearing for a given application • Specify an appropriate mounting arrangement for bearings on a shaft Shaft Accessories: • Identify shaft accessories: keys, pins, splines, etc. • Analyze shaft for stress concentrations caused by accessories • Identify shaft coupling components: U-joints, lock-nuts, retaining rings, etc.

Module 4: Connecting Elements 2 (springs, threaded fasteners)	Springs: • Identify different types of springs and describe their use • Develop an understanding of the physics of springs and how it provides the basis for spring design • Describe the design process for compression springs • Apply compression spring design process for fatigue loading Threaded Fasteners: • Identify types, uses, and characteristics of threaded fasteners • Describe characteristics of threads using accepted terminology • Determine the stiffness of a bolted joint • Describe the strength of a bolt, and identify the strength from published tables • Compute the effect of adding an external load to a bolted joint • Relate bolt torque to bolt tension • Describe the importance of preload in a bolt; compute preload in a statically loaded tension joint • Determine fatigue life for bolts with unsteady loads • Analyze bolted and riveted joints in shear • Design a bolted joint
Module 5: Energy Transduction (pneumatic and hydraulic systems	• Identify the main types of pneumatic and hydraulic systems • Recognize hydraulic symbols and components • Analyze fluid power circuits • Analyze pneumatic systems • Design a fluid power system

4 Schedule

The approximate course schedule, tutorials, assignments, and other special activities, are shown below. (This is a rough guide, subject to change as we progress through the course.)

Module	Day	Class Topic	Tutorial
0: Course Introduction	Sep 3	Imagine Day – No Class	
	Sep 5	Course intro and warm-up exercises	None
1: Transmission Elements 1	Sep 10	Gear intro	None
	Sep 12	**RAP Quiz 1**. Gear forces and kinematics	None
	Sep 17	Gears stress; power screw introduction	Gear trains
	Sep 19	Power screw analysis	Gear forces
2: Transmission elements 2	Sep 24	**RAP Quiz 2**; flexible drive intro	Gears stress
	Sep 26	**Assignment 1 debriefing****; Belts and flex drives	Work time*
	Oct 1	V-belts and chains	Flex drives
	Oct 3	Toothed belts, wire, metal bands	Flex drives
3: Connecting Elements 1	Oct 8	**RAP Quiz 3**; Intro: bearings and shaft accessories	Flex drives
	Oct 10	**Assignment 2 debriefing**; Bushings	Work time*
	Oct 15	Rolling contact bearing intro	Bushings
	Oct 17	Bearing analysis, Midterm Review	Bearings
	Oct 22	**Midterm Exam**	None
	Oct 24	Shaft accessories	None
4: Connecting Elements 2	Oct 29	Shaft accessories	Shaft accessories
	Oct 31	**RAP Quiz 4**: Springs and Fasteners	Work time*
	Nov 5	Extension/torsion springs	Compress. Springs
	Nov 7	Intro: Threaded fasteners	Other springs
	Nov 12	Threaded fastener analysis	Fastener intro
	Nov 14	Bolt patterns; shear loading; welding intro	Bolt fatigue/shear
5: Energy Transduction	Nov 19	**RAP Quiz 5**; Energy Transduction	Work time*
	Nov 21	Assignment #3 debrief; Fluid systems intro	Hydraulic systems
	Nov 26	Fluid Systems	Fluid power
Review	Nov. 28	Review	Work Time*

The final exam will be held during the exam period, Dec. 3-18, 2019 (TBD).

* "**work time**" = time in tutorial to work on assignment; unless noted, the TA will be present to answer questions and provide assistance as requested.

** "**Assignment debriefing**" = assignments are due at the start of class on dates indicated. Various in-class activities will be used for discussion and peer-review.

5 Course Format

5.1 Team-Based Learning

MECH 325 will be presented in a team-based learning (TBL) format.[1] This format will be familiar to those who have taken the MECH 2 design sequence. In a conventional lecture-based course, basic information is gained in the classroom, skill development begins in tutorials, and challenging problems are tackled outside of class, with little input from the instructor. Moreover, numerous studies show that students retain less than 20% of the content presented a conventional lecture, suggesting it is not a particularly effective use of time. The philosophy with TBL is to make better use of the student and instructor time by switching where various learning activities take place:

- Initial exposure to material is gained out of class through reading assignments
- Key points are reinforced by the instructor using mini-lectures, and then exercises and active learning take place in the classroom and the tutorial room
- Realistic, challenging problems are completed by students in and out of class, and conclude with debriefings and discussions by the instructor in class.

This ensures you see the course material multiple times and in multiple different ways. The other important aspects of TBL are the Readiness Assurance Process (RAP) quizzes following the readings, and the formation of diverse, heterogeneous teams.

5.2 Readiness Assurance Process

The Readiness Assurance Process (RAP) is a technique in team-based learning. It is used to ensure that students are familiar with background information on a topic so that class time can be used more effectively. The steps in the RAP in class are:

- Individual RAP quiz: an individual multiple-choice test based on a general understanding of material from assigned readings
- Team RAP quiz: the same multiple-choice test as conducted by individuals but this time taken as a team
- Feedback: immediate feedback by instructor to ensure all students understand the material before proceeding with more advanced topics

5.3 Team Structure

Teams of approximately six or seven students will be formed prior to the course. The teams are set up within the roster of the tutorial sections. The objective in team formation is to ensure maximum heterogeneity in the teams and to give everyone an opportunity to work with a diverse range of other people.

6 Evaluation and Grading Structure

Many of the activities will be evaluated with a single mark assigned per team but with each student still individually responsible for the material. There will also be individual evaluations; all exams will be done as individuals. The elements that contribute to the final course grade are

[1] Michaelsen, Larry K., Arletta Bauman Knight & L. Dee Fink. "Team-Based Learning." Stylus Publishing, Sterling, 2004.

shown below. The instructor reserves the right to adjust or modify the course grading as necessary.

Item	No.	Weight	Team or Individual*
RAP Quizzes (individual)	5	7.5%	I
RAP Quizzes (team)	5	7.5%	T
Homework	4	10%	I
Team Assignments	2	15%	T
Midterm exam	1	20%	I
Final exam	1	40%	I

The team component of your grade will be subject to a peer assessment (using the *iPeer* software), which is designed to prevent people from letting the team carry them along without they themselves contributing. Each person will be asked to recommend an allocation of the team marks to all other team members and to provide reasons for their recommendation. Each student's scores they receive from the peer evaluations will be averaged to create a multiplier to scale the team scores in order to determine each student's final grade. There will be a "dry run" peer assessment early in the course so that you will be able to identify any issues early and make changes to how your team is functioning. The iPeer schedule is as follows:

- iPeer 1: due Oct 7
- iPeer 2: due Nov 10
- iPeer 4: due Dec 3

In order to pass the course, you must:

- Achieve an overall course grade of at least 50%
- ***Achieve an average grade of at least 50% on the combined midterm and final exam grade (each weighted as shown above)***

7 Additional Reference Material

Collins, J.A., *Mechanical Design of Machine Elements and Machines: A Failure Prevention Perspective*, Wiley, New Jersey, 2003.

Esposito, A., *Fluid Power with Applications,* 5th Edition. Prentice-Hall, New Jersey, 2000

Mott, R.L., *Machine Elements in Mechanical Design*, 4th Edition. Prentice-Hall, New Jersey, 2004.

Norton, R.L., *Machine Design: An Integrated Approach*, 3rd Edition. Prentice-Hall, New Jersey, 2006.

Spotts, M.F., Shoup, T.E., Hornberger, L.E., *Design of Machine Elements*, 8th Edition. Prentice-Hall, New Jersey, 2004.

Sullivan, J.A., *Fluid Power: Theory and Applications*, 4th Edition. Prentice-Hall, New Jersey, 1998.

Ugural, A.C., *Mechanical Design: An Integrated Approach,* McGraw-Hill, Toronto, 2004.