EME 150B  Winter 2014

Mechanical Design

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office hours: Weds. 2:00–4:00 pm

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office hours: time & place to be announced

lectures: T 8:00–9:50 am & R 8:00–8:50 am, 55 Roessler

discussion: R 9:00–9:50 am, 55 Roessler

Synopsis: In this course we shall investigate basic principles governing the
design, selection, and use of mechanical components, and their integration
into mechanical systems. Among the components that we study are springs,
fasteners, gears and gear trains, journal bearings, rolling–contact bearings,
and shafts and couplings. In each case, we shall be concerned with issues of
strength and load–carrying ability, possible failure modes, expected service
life, and statistical considerations. Design principles for mechanical systems
will be illustrated by practical design projects during the course of the class.
1 prerequisites

EME 150A (and all classes that are required for it) is an essential prerequisite for this class. If you have not taken EME 150A, you cannot take EME 150B. Familiarity with the basic concepts of load and stress analysis, static and fatigue failure theories, etc., will be assumed in EME 150B.

2 textbook

The required text for this course is Shigley’s *Mechanical Engineering Design* (McGraw–Hill, 9th edition). EME 150B covers (a subset of) Part 3 of this book. Parts 1 and 2 were covered in EME 150A.

3 syllabus

The following is an outline of the topics that we shall cover:

- **mechanical design**
  - teamwork & design projects
  - design creativity & methodology
  - mechanical components & systems
  - design for a given service life

- **gears & gear trains**
  - speed reduction & torque amplification
  - taxonomy and applications of gear types
  - spur gears — geometry & nomenclature
  - involute teeth and conjugate action
  - pitch circles, tooth numbers, speed ratios
  - pressure angle, interference, contact ratio
  - analysis of gear trains & train ratios
  - kinematics of planetary gear trains
  - helical, bevel, and worm gears
  - gear–tooth strength analysis

1 lecture

2 weeks
rolling–contact bearings
taxonomy of rolling–contact bearings
statistical approach to service life
static & dynamic load ratings
estimation of bearing service life

journal bearings
phenomenology of friction
fluid friction — viscosity
lubricated journal (sliding) bearing
Petroff equation for unloaded bearing
dimensionless Sommerfeld number
charts for design of loaded bearings
heat balance for journal bearings
journal vs. rolling–contact bearings

DC motors
electromechanical power conversion
the permanent–magnet DC motor
torque–speed operating line
motor start–up and stall torques
gear ratios for inertia matching

mechanical springs
helical compression springs
spring dimensions & nomenclature
spring stiffness & natural frequency
stress in helical compression springs
fatigue loading of compression springs
design of helical torsion springs
spring design/selection methodology

fasteners
analysis of bolted joints
specification of the pre–load
fatigue loading of bolted joints
static failure modes for joints
load factors for bolted joints
shafts and couplings

design methodology for shafts
axial & angular location of components
static loading — bending & torsion
analysis of fatigue loading for shafts
dynamic instability: whirling of shafts
rigid and flexible shaft couplings

4 exams

There will be two exams — an in–class midterm, and a comprehensive final. No make–up exams will be given — if you have a legitimate reason (medical condition, etc.), corroborated by written documentation, arrangements may be made in exceptional circumstances for you to take the exam somewhat earlier, or for a missed exam to not count towards your grade.

5 project

The design and analysis of mechanical systems will be illustrated by means of a class project. In this project you will design, manufacture, and test a device that meets demanding functional requirements using limited resources. You will work in teams, to be set up during class. Teamwork is a key aspect of real–world engineering, and each member is expected to participate diligently. At the conclusion of the project, you will have the opportunity to evaluate your team–mates contributions, and these peer evaluations will be taken into consideration in determining individual grades. The project will also involve class presentations and design reviews, and the preparation of a final project report. Due dates will be announced in class.

6 homeworks

Homeworks will be assigned on Thursdays, and are due at the beginning of class on the following Thursday (no late homeworks will be accepted). Solution sets for the homeworks will be posted after the due date.
Homeworks are to be completed on your own — you may consult with classmates about conceptual aspects of a problem, but all written work (whether in scrap or final form) must be your own. You must not consult with former students from this class, or in any way use solution sets from prior years.

7 discussions

The discussion sections will cover problem-solving, clarification of material covered in the lectures, homeworks, and exams, and planning for the course project. Since the project is an integral part of the course, attendance at the discussion sections is required.

8 grading policy

Penalties may be imposed on homeworks, project reports, and exams for lack of neatness, legibility, or clear organization of your work. The honor code is in effect with regard to exams, homeworks, and projects. Your mature and responsible adherence is expected — violations will be taken very seriously.

9 course grade

Exams, projects, and homeworks contribute to your overall grade as follows:

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<tbody>
<tr>
<td>homeworks</td>
<td>12%</td>
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<tr>
<td>midterm exam</td>
<td>16%</td>
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<tr>
<td>final exam</td>
<td>36%</td>
</tr>
<tr>
<td>design project</td>
<td>36%</td>
</tr>
<tr>
<td>total</td>
<td>100%</td>
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10 additional reading

There are many other texts that have the same scope as Shigley and Mischke — you may wish to consult one or more of them:


Finally, for both fun and enlightenment, I recommend: