EME 150B   Winter 2014

Mechanical Design

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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 — 1 lecture

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

gears & gear trains — 2 weeks

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

rolling–contact bearings 1 weeks

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

journal bearings 1 weeks

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 1 week

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 1.5 weeks

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 1.5 weeks

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 1 week

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 evaulate 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:

homeworks	12%
midterm exam	16%
final exam	36%
design project	36%
total	100%

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:

- A. D. Deutschman, W. J. Michels, and C. E. Wilson,
  Machine Design: Theory and Practice,
  Macmillan (1975).
- K. S. Edwards and R. B McKee,
  Fundamentals of Mechanical Component Design,
  McGraw–Hill (1991).
- R. C. Juvinall and K. M. Marshek,
  Fundamentals of Machine Component Design,
  Wiley (1991).
- R. L. Norton,
  Machine Design: An Integrated Approach,
  Prentice–Hall (1998).
- R. M. Phelan,
  Fundamentals of Mechanical Design (3rd ed.),
  McGraw–Hill (1970).
- M. F. Spotts,
  Design of Machine Elements (6th ed.),
  Prentice–Hall (1985).

Finally, for both fun and enlightenment, I recommend:

- J. L. Adams, *Conceptual Blockbusting: A Guide to Better Ideas* (2nd edition), Norton (1979).
- M. J. French, *Invention and Evolution: Design in Nature and Engineering*, Cambridge University Press (1988).
- H. Petroski, *Design Paradigms: Case Histories of Error and Judgement in Engineering*, Cambridge University Press (1994).
- H. Petroski, *To Engineer is Human: The Role of Failure in Successful Design*, St. Martin's Press (1985).