30.105: Machine Elements Design

Term 6, 2021

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Goal: Learn application of engineering and design principles to ensure machine elements remain within operational limits while yet providing the necessary system level machine performance against requirements.

Text:

Juvinall, R. & K. Marshek, *Fundamentals of Machine Component Design*, Wiley.

Electronic versions of any edition are acceptable. Reading assignments will be given each week. In order to gain greater benefit from the lectures, you must complete the assigned reading before coming to class. Even a superficial first reading the night before the class period will improve your comprehension and retention of the material covered. Your performance in this course will rely on how well you assimilate the assigned reading. You also will be tested on assigned reading material that may not be covered during meeting times.

References:

- Arthur G. Erdman, George N. Sandor and Sridhar Kota. *Mechanism Design: Analysis and Synthesis Vol I.* 4th Edition, Prentice Hall, 2001.
- J. M. McCarthy and G. S. Soh. *Geometric Design of Linkages.* 2th Edition, Springer, 2010.
- Robert L. Norton. *Machine Design: An Integrated Approach.* 5th Edition, Pearson, 2014.

Prerequisites:

30.001: Structures and Materials.

Course Description: This subject provides advanced knowledge for designing key machine elements and mechanisms such as bearing, shafts, gears, and springs. It also provides analytical, heuristic and case-based knowledge to make machines as integrated systems of machine elements. Emphasis is on use of core engineering knowledge, including mechanics and materials, along with design principles to ensure the machine elements remain within operational limits while yet providing the necessary system level machine requirements. Students will work in small groups to analyze and size machine elements.

Learning Objectives:

Develop an understanding of the principles and approaches to

- Describe and quantify the metrics for key machine elements such as bearing, springs, gears, and shafts.
- Apply core engineering principles in the design of machine elements.
- Understand and implement system level analysis approaches to machine element design.
- Apply basic concepts of experimentation, measurement, and data analysis to machine design.
- Synthesize the above objectives in a real-world machine design context.

Measurable Outcomes:

At the end of the course, a student should be able to

- Identify, define, and formulate in quantitative terms, design problems for machine elements.
- Apply core subject engineering knowledge (such as mechanics, materials, systems and dynamics and mathematics) in machine element design problems.
- Define and apply the metrics for machine elements and the metrics that characterize the overall machine behavior.
- Implement computer design and simulation tools in the design of machine elements.
- Understand how to integrate machine elements into a machine with specified function.
- Define, quantify, and measure the overall factor of safety of a complex machine.

Pedagogy: The course will include instructor lead discussions and breakout group activities in the laboratory discussions. The reverse engineering project is structured to apply concepts learnt in class to address machine design problems within the EPD Pillar tracks. This is a 12 unit subject, which means that the overall weekly time commitment is, on average, approximately 12 hours. Workload is composed of cohort based learning sessions (5.0 hr.), and individual self-study or project time (7 hr.) per week.

Attendance: Class attendance is ***required***. Your class participation grade will be reduced for each unexcused absence after the first such absence. A roll sheet will be distributed occasionally during cohort sessions to record attendance. If you have a legitimate excuse for missing class, please contact the course instructors before the date you intend to be absent.

Grading:

Component	**Total**
Assignments	15%
Reverse Engineering Project	30%
Midterm Exam	25%
Final Exam	25%
Misc. (class participation, class work etc.)	5%
Total	100%

All assignments must be turned in on time. Assignments will not be accepted/graded after the due date/time. Do not attempt to hand-in late assignments, unless you have *prior* approval of the faculty. Verbatim copying of any material that you submit for credit is a serious academic offense and will result in penalties and perhaps failing the course.

Exams(s):

- Midterm - November 5, 2021 (2:30 pm to 4.30 pm)
- Final Exam - December 15, 2021 (1:00 pm to 3:00 pm)

Course Materials: eDimension will be used for announcements, course handouts, and other information.

Formal Reviews: If you feel that part of an assignment (homework, lab report, or exam) was graded in error, you may request a formal review of the work. You have 7 days after your work is returned to submit for a formal review. After the 7-day period, the grade will not be changed. Only formal requests for review will be considered. To obtain a review, you must submit to me a *typed* cover sheet that has your full name, student number, date, and description of the assignment that you want reviewed. You must explain *in* what you feel was incorrect and why you feel like you should have gotten a better score. Staple the questionable assignment to the cover sheet. During a review, the *entire* assignment will be evaluated, not just the issue with which you were concerned. Thus, a formal review may possibly result in a lower overall score.

IMPACT ON SUBSEQUENT COURSES IN CURRICULUM:
This course makes use of courses on technical engineering analysis subjects by applying the analysis principles of past courses and providing motivational case studies and contextual examples. This course prepares for the capstone design course 1.400 and 1.401 by providing

technical understanding of designing machine elements for proper operation and failure prevention when used in a machine designed as a part of the capstone course.

IES ACCREDITATION PROGRAM OUTCOMES ACHIEVED:

This course contributes to the following Program Outcomes and SLOs for EPD

- SLO#1: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
- SLO#2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
- SLO#3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- SLO#4: Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
- SLO#5: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.
- SLO#8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
- SLO#9: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
- SLO#10: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- SLO#11: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.