ABEN 478/678 - Machinery Analysis & Design
3 credits, Spring 2022
Meets in **ABEN 208 & Service Center 101A** on Mon/Wed 1:00 PM – 1:50 PM (Lecture) and Mon: 2:00 – 4:50 PM (Laboratory)

Instructor and contact information:
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Office hours: T/W/F 2:00 PM – 5:00 PM and by appointment via an email

Bulletin description:
Principles of design, development, and testing of agricultural machines and machine systems. Applications of computer aided design (CAD) and Failure Mode and Effects Analysis (FMEA). (Also offered for graduate credit - see ABEN 678).
Prerequisites: ME 223 (and ME 221, ME 222).

Textbook: No textbook is assigned. The several copies of the references used in the class are available in ABEN 222 for student reference. Please keep these textbooks in ABEN 222.

Overview:

Agricultural and off-road machinery design and development includes both synthesis and analysis. Synthesis is the collection and building up of ideas into an over-arching concept such as the development of a large round baler or a combine. Analysis is the detailed study and selection of components. Both aspects are important to the successful development of machinery and equipment that provides value and function to the owner/user. Both aspects will be included in this course. However, the greatest area of study will be the analysis portion.

Components include but not limited with frames, parts, assemblies, bearings, springs, and so forth to form the final machine or piece of equipment. Fasteners can also be included.

Objectives:
Upon completion of the course, student will be able to:

1. to apply the fundamental principles used in machine design and analysis to meet design and customer specifications. (ABET 1, 6) [A, student outcomes 1 and 6 (Table 1)]

1.1 to apply engineering design fundamentals to make proper assumptions, carry out appropriate analyses, and draw upon different mechanical engineering domains in the analysis of joints, shafts, bearings, springs, gears, drives, and other components.

1.2 to demonstrate the ability how to design mechanical components based on the design analyses highlighted above.

2. to learn how to identify and quantify the design specifications and trade-offs for the selection and application of components, commonly used in the design of complete mechanical systems. (ABET 1, 6) [A, student outcomes 1 and 6 (Table 1)]

2.1 to take technical, economical, safety, quality, and other issues (such as environmental) into account when selecting and/or designing mechanical components.

3. to understand the variety of mechanical components available and emphasize the need to keep learning. (ABET 1, 6, 7) [A, C student outcomes 1, 6, 7 (Table 1)]

3.1 to seek and learn new material outside the class topics through the completion of open-ended tasks including homework, report, term paper, computer assignment, and/or project. The amount and depth of new material identified and used by the student are measurable indicators of the student's performance.

4. to identify, formulate, and solve engineering problems (ABET 4, 7) [C, student outcomes 4 and 7 (Table 1)]

5. to use techniques, skills, and modern engineering tools necessary for engineering practice. (ABET 2, 4) [A, B student outcomes 2 and 4 (Table 1)]

6. to write laboratory reports and make short presentations (ABET 3, 4) [B, C, student outcomes 3 and 4 (Table 1)].

Table 1. Program educational objectives and supporting student outcomes. *

Graduates are expected to have established themselves as practicing engineers who, within a few years of graduation:	
A	Successfully address emerging engineering challenges in the design or evaluation of machine systems, processing systems, and natural resources and environmental systems affecting the production of food, feed, and other biobased products. Technical learning outcomes include student outcomes (1), (2), and (6): 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics 2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
B	Effectively use professional communication, critical thinking, and interpersonal skills as team leaders and team members. Communicational learning outcomes include student outcomes (3) and (5): 3. an ability to communicate effectively with a range of audiences 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
C	Responsibly serve the public and their employers by participating in professional development and by maintaining the highest standard of professional ethics. Contextual learning outcomes include student outcomes (4) and (7): 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

***** See https://www.ndsu.edu/aben/about/abet_accredited/ for the current ABEN program educational objectives. See https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/ for information on ABET student outcomes 1-7, effective as part of the "Criteria for Accrediting Engineering Programs, 2021-2022."

Textbooks:

- Myszka, David H., 2012. Machines & Mechanism – Applied Kinematic Analysis 4th ed. ISBN 13: 978-0-13-272973-4
- Martin, G. H. 2002. Kinematics and Dynamics of Machines 2nd ed. Waveland Press, Inc., Long Grove IL. ISBN-1
- Srivastava, A. K., C. E., Goering, and R. P. Rohrbach. 1993. Engineering Principles of Agricultural Machines. ASABE, St. Joseph, MI.

Required student resources:

Students are expected to have daily access to the course Blackboard website for access to course announcements, assignments, project, including the on-line sources, and other reading materials. **A personal computer (laptop) with MATLAB/Simulink installed is needed.**

Assignment Overview and Policy

- **10 in-class unannounced pop-up quizzes** based on in-class covered materials, reading assignments, and self-study exercises. Out of 10 quizzes, **randomly chosen 5 quizzes** will be graded. **No make-up** quizzes allowed, except for a prior justification and approval of the instructor at least 24 hours before the class.
- **10 lab reports** based on the learned outcomes from industry visits, and collected data from the laboratory materials. Lab reports of graduate students will be in a higher standard than the ones of undergraduate students.
- **Tests**. There will be two in-class tests: **Test 1** on Week 6 and **Test 2** on Week 12/13. Prior to tests, there will be pre-test reviews of the questions included in Tests. For a **make-up exam**, the instructor's approval for any excusable justification at least 48 hours before the test date is needed as described in NDSU policy 333: https://www.ndsu.edu/fileadmin/policy/333.pdf
- **One team project (no report) and presentation** for undergraduate students **(ABEN478)**
- **One individual project with a 6-page long research paper** for graduate students (**ABEN 678**)
- **Self-study homework** assignments based on covered and additional learning materials.
- **Due dates** for assignments and lab reports will be announced with the assignments. Late assignments will be accepted with a 10% penalty per NDSU class day, but will not be accepted after solutions are posted/handed out/discussed in class.
- **Active participation** during in-class discussions is strongly encouraged. Note that you will earn extra credits by actively participating in-class discussions.

Table 2. Course Outline of Topics/Events (Tentative):

Week	Topics/Events
Week 1: 01/10 -01/14	Introduction. Course Overview, Design Process; Materials – Material Properties, Materials Selection, Combined Loading
Week 2: 01/17-01/21	Mechanisms. Vectors: Position/Displacement
Week 3: 01/24-01/28	Mechanisms. Vectors: Position/Displacement, Velocity **Laboratory Work # 1**
Week 4: 01/31-02/04	Mechanisms. Vectors: Velocity, Acceleration Mechanism Design Analysis. Four – bar Mechanisms **Laboratory Work # 2**
Week 5: 02/07-02/11	Mechanism Design. Slider-Crank Shaft Mechanism **Laboratory Work # 3**
Week 6: 02/14-02/18	Load and Stress Analysis: Equilibrium and Free Body Diagrams, Shear Force and Bending Moments, etc. Review of week 1-5 materials: **Test 1**
Week 7: 02/21-02/25	Fatigue Failure Resulting from Variable Loading, Fatigue Strength and Endurance Limits **Laboratory Work # 4**
Week 8: 02/28-03/04	Fluctuating Stresses and Influence of Non-Zero Mean Stress, Combination of Loading Modes **Laboratory Work # 5**
Week 9: 03/07-03/11	Shafts and Shaft Components: Shaft Materials, Shaft Layout, Shaft design for Stress, Deflection Considerations, Critical Speeds for Shafts **Laboratory Work # 6**
Week 10: 03/14-03/18	**Spring Break**
Week 11: 03/21-03/25	Shafts and Shaft Components: Shaft Materials, Shaft Layout, Shaft design for Stress, Deflection Considerations, Critical Speeds for Shafts **Laboratory Work # 7**
Week 12: 03/28 – 04/01	Gears: Types of Gears, Gear Trains. Gears: Force Analysis, Spur and Helical Gears, Bevel and Worm Gears, Selection of Gears **Laboratory Work # 8**
Week 13: 04/04 – 04/08	Gears: Types of Gears, Gear Trains. Gears: Force Analysis, Spur and Helical Gears, Bevel and Worm Gears, Selection of Gears Review of week 7-12 materials: **Test 2**
Week 14: 04/11 -01/15	Screws, Fasteners, and the Design of Nonpermanent Joints **Laboratory Work # 9**
Week 15: 04/18-04/22	Thread Standards and Definitions, Threaded Fasteners, Joints, Bolt Strength Design Project Case Studies **Laboratory Work # 10**
Week 16: 04/25-04/29	Rolling Contact Bearings and Lubrication: Bearing Types, Bearing Life, Bearing Life, Rating Life, Selection of Bearings Project presentation planning
Week 17: 05/02-05/06	Clutches, Brakes, and Flywheels, Flexible Mechanical Elements Project presentation planning

Week 18: 05/09-05/13	Project Presentation

Disclaimer

The course outline is subject to change.

Participation: active participation during the class is strongly encouraged. By actively participating in in-class discussions and problem-solving steps, you can earn extra credits that will be added to your grades on Quizzes and Tests.

Grade Distribution – ABEN478

Your grade in this course will be based on the following point breakdown.

Assessment	Number	Point Value	Total Points
Quiz	10	1	10
Test 1	1	15	15
Test 2	1	15	15
Lab Report (Lab Procedures, *Data presentation,* Executive Summary)	10	2.5	25
Course Project	1	25	25
Presentation of Project Results	1	10	10
Total Course Points			**100**

Grade Distribution for ABEN 678

Your grade in this course will be based on the following point breakdown.

Assessment	Number	Point Value	Total Points
Quiz	10	1	10
Test 1	1	15	15
Test 2	1	15	15
Lab Report (Lab Procedures, *Results and Discussion*, Executive Summary)	10	1.5	15
Course Project	1	25	25
Research Paper	1	10	10
Presentation of Project Results	1	10	10
Total Course Points			**100**

Grades will follow the standard NDSU grading scale:

A: 100-90% B: 80-89% C: 70-79% D: 60-69% F: <60%

Attendance: According to NDSU policy 333 - https://www.ndsu.edu/fileadmin/policy/333.pdf, attendance in classes is expected. *Your attendance and full participation is expected,* through class-room discussions, volunteering answers to questions, asking appropriate questions, thoughtful evaluation of a team oral presentation, evaluating of team member's participation in project, and by helping to create a spirit of cooperation within the class. The mode of instruction is face-to-face. You are required to attend lectures, project, and lab demonstrations in-person. However, there will be a zoom option for lectures only if you get sick and need to quarantine because of COVID. You must notify me at least an hour before class because I expect to see you in-person, especially during project demonstrations.

Students who exceed two absences for the semester should provide documentation of a valid excuse, such as from a medical professional or advisor of an NDSU student organization, to avoid a grade penalty of 2 point per unexcused absence.

Mask Guidance: Masks will be required in all classroom settings whether such classes are credit, non-credit, training sessions, etc. Faculty members who are able to maintain social distance from students may remove their masks during the class for purposes of being more easily heard. In addition, individuals should feel authorized to kindly ask other people who are visiting their workspace (*e.g.,* offices, cubicles, etc.) to wear a mask. (Sources: https://www.osha.gov/coronavirus/safework, https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html, https://www.health.nd.gov/ndhelps).

Students with Special Needs and/or Circumstances: Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor and contact the Disability Services Office as soon as possible. Recorded lectures will be made available. Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.

COE Honor Pledge: "On my honor I will not give nor receive unauthorized assistance in completing assignments and work submitted for review or assessment. Furthermore, I understand the requirements in the College of Engineering Honor System and accept the responsibility I have to complete all my work with complete integrity. Students who are suspected of academic dishonesty may not withdraw from the course in which dishonesty is suspected while the case is under review by the Honor Commission (NDSU Policy 335, 5b)."

Last updated: August 19, 2021