SICHUAN UNIVERSITY PITTSBURGH INSTITUTE

ENGR0135 - Statics and Mechanics of Materials 1

Syllabus for 2016 Fall Term

Catalog Description

First of a two course sequence covering statics and strength of materials. Topics covered include: concurrent force systems, equilibrium, axial loading, stress, strain, deformation, moments, equivalent systems, centroids, centers of mass and distributed loads, free-body diagrams, equilibrium of rigid and deformable bodies, plane trusses, frames and machines, equilibrium in 3D, torsion and friction. Use is made of computers for problem solving. 3 credit hours.

Instructor

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Text

W. F. Riley, L. D. Sturges, and D. H. Morris, *Statics and Mechanics of Materials: An Integrated Approach,* 2nd Edition, John Wiley & Sons, Inc.

Learning Objectives

Chapter 1 General Principles

1. describe the scope of study of the 3 branches of the – the mechanics of rigid bodies, the mechanics of deformable bodies, and the mechanics of fluids.
2. express the scope of study of statics, kinematics and kinetics.
3. define Space, Time, Mass, Force, Particle, and Rigid body.
4. describe Newton's Laws of Motion.
5. describe the Law of Gravitation
6. explain the difference between mass and weight by relating to the law of gravitation
7. memorize the values of gravitational accelerations in ft/s^2 and m/s^2
8. list the fundamental quantities and their symbols in the US Customary System (US) units.
9. list the fundamental quantities, supplementary quantities and their symbols in the International System (SI) of Units
10. identify the derived quantities, their symbols and definition in both the US and the SI Systems
11. identify the symbols and special names of common derived units
12. work with the base units and derived units in both SI units and US units including conversions between these two systems
13. determine if an equation is dimensionally homogenous
14. describe errors and accuracy associated with physical data, physical model and engineering calculations
15. accurately round off calculation results to maintain accuracy consistency
16. describe the best practice in solving engineering mechanics problems.

Chapter 2 Concurrent Force Systems

1. define equilibrium
2. list the characteristics of a force
3. define and give qualities of a scalar
4. define and give qualities of a vector
5. define unit vector in an arbitrary direction, and in xyz coordinate system
6. express vector as a magnitude and direction
7. express vectors, 2-d and 3-d, in Cartesian component form
8. find the directional cosine of a 3-d vector
9. find a position vector in 3-d based on coordinates falling on a line
10. find a unit vector from a position vector
11. determine if a vector is a free vector, a sliding vector or a fixed vector.
12. explain the physical meaning of addition, subtraction and scalar product of vectors
13. perform basic vector calculations: addition, subtraction, and scalar product.
14. describe law of sines and law of cosine
15. identify the difference between contact forces and noncontact forces
16. explain in plain English the definition of distributed forces, concurrent forces, parallel forces, coplanar forces and collinear forces with examples
17. obtain the resultant of a concurrent force system – two forces or more – by using the law of sines and the law of cosines
18. resolve a force into 2 or more component forces in specified directions
19. resolve a 2-D and 3-D force into rectangular components
20. obtain the resultant of a concurrent force system – two forces or more – by using rectangular components

Chapter 3 Equilibrium: Concurrent Force Systems

1. define “particle”
2. determine when bodies of finite size can be treated as particles
3. describe the assumptions and constraints associated with the term “particles” used in statics construct a free body diagram for a body of interest
4. write the governing equations of equilibrium of a particle in x- and t-components
5. solve equilibrium equations of a 2-d or 3-d concurrent force system for unknown quantities
6. analyze a 3-d body system, determine the known and unknown quantities, construct a free body diagram
7. develop compatibility conditions to solve problems if the number of unknown exceeds the number of equilibrium equations.

Chapter 4 Stress, Strain, and Deformation: Axial Loading

1. explain the physical meaning of tension, compression, internal stresses, and internal forces
2. describe normal stress and shear stress in a section of a bar, both perpendicular and inclined to the axis of loading, under axial loading
3. define normal stress
4. define shear stress
5. describe the sign convention associated with normal stresses
6. Describe the average value, maximum value and the quantitative variation of normal stress and shear stress on a transverse cross section and inclined cross section.
7. find the plane(s) of maximum normal stress
8. find the plane(s) of maximum shear stress
9. Explain why a body subject to only axial loading can have a shear stress
10. describe punching shear and bearing shear and formulas to calculate their average values
11. calculate normal, shear, punching and bearing stresses in a force system.
12. explain deformation and strain accurately.
13. Explain the difference between displacements possible in rigid bodies and deformable bodies

14. describe the difference between axial strain and shearing strain including units used.
15. describe Hooke's Law, modulus of elasticity, and modulus of rigidity including the formula that defines each of them.
16. identify the elastic limit, yield point, yield strength and creep limit from a stress-strain diagram of a material.
17. explain ductility and the two quantitative indices commonly used to describe it.
18. explain Poisson's Ratio for uniaxial state of stress.
19. describe the effects of material composition, temperature and type of stresses – either compression or tension – on the stress-strain behavior of a material.
20. define thermal strain and coefficient of thermal expansion
21. calculate total normal strain of a material under applied loads.
22. find unknown forces, strains, stresses, and/or displacements for bodies subject to multiple axial loads, including cases where multiple materials are present
23. distinguish between thermal and mechanical strain and know what strain to use in Hooke's Law
24. define statical determinacy
25. determine when a static system is statically indeterminate.
26. solve for unknown forces, stresses, strains, displacements, etc. for static systems by using equilibrium and
    a. Hooke's law (the stress/strain relation)
    b. geometry of deformation/geometric constraints, and
    c. geometry of deformation/geometric constraints when thermal effects are present
27. describe factors of safety
28. apply factors of safety in calculations/designs
29. describe modes of failure and their governing properties including elastic failure, yielding and fracture.

Chapter 5 Equivalent Force/Moment Systems

1. explain the physical meaning of moments and its characteristics.
2. explain the Principle of Moments
3. express a moment about a point in vector form and in matrix form
4. express a moment about a line in vector form and in matrix form
5. apply the Principle of Moments to solve 2-D and 3-D problems.
6. describe the physical meaning of couples and their mathematical presentation
7. describe how a force apply on a body is equivalent to a force and a force-couple
8. apply the equivalent force-moment principle to solve static problems
9. explain the relationship between center of mass and center of gravity
10. describe first and second moments of mass and area qualitatively and mathematically
11. explain the relationship between centroids and center of mass and center of gravity
12. determine locations of centroid, center of mass and center of gravity of bodies.
13. compute location of centroid of composite bodies.
14. calculate the magnitude and location of a distributed load on structural members

Chapter 6 Equilibrium: Rigid and Deformable Bodies

1. explain external forces, internal forces, reaction forces and applied forces.
2. construct free body diagram
3. establish equations for 2-d equilibrium.
4. calculate unknown forces or other related unknowns through the use of equilibrium equations for a rigid body
5. determine static indeterminacy
6. apply equations of equilibrium to solve problems associated with deformable bodies
7. calculate the internal forces for simple 2D or 3D trusses using the method of joints or method of sections.
8. describe the variation of dry friction force from static equilibrium to impending motion
9. distinguish the difference of static friction and kinetic friction
10. perform static force analysis of rigid bodies in dry frictional contact
11. perform force analysis for flat belts and v-belt used in power transmission

12. Design simple structures to withstand a prescribed external loading, and to predict the deflection and failure load for the structure

Chapter 7 Torsional Loading: Shafts

1. draw a free body diagram for a circular bar subject to torsional loading
2. writing the equilibrium equations based on the free body diagram
3. define angle of twist
4. explain the linear relationship between shear strain and the distance from the center of the shaft
5. explain the relationship between longitudinal distance and the distance from the center of the shaft.
6. define polar second moment of areas
7. explain the linear relationship between shear stress, torsional moment, polar second moment of areas and the distance from the center of the shaft
8. calculate angle of twist
9. explain work of a force in plain English and express it mathematically
10. describe the conditions of positive, negative and zero work done be a force on a body.
11. explain work of a couple and express it mathematically
12. calculate the power transmitted by a shaft
13. properly select a shaft to safely and economically transmit a specified power thru torsional loading
    solve statically indeterminate problems involving torsional loads by aids of distortion equations (angle of twist)

Participation

Active participation in this course by all students is required and expected. Attendance for all lectures is strongly advised. Any student whose performance/attendance is unsatisfactory or not up to date will be notified by the College and may be dropped from the course for insufficient progress or participation.

Evaluation and Grading

The course consists of a three-hour lecture per week. Homework will be assigned at the end of each class and the explanations or solutions will be given at the beginning of the next class. Students are expected to do the homework after class. Class participation, quizzes and the final examination will evaluate student progress. There are a total of 6 units that comprise this course. For units 1-5, a quiz will be administered after the unit is completed. Each quiz grade is valued at 10% of the grade for this course. In addition to the 5 quizzes, there will be a final exam, which will constitute the remaining 50% of the course grade. Upon successful completion of this course, the student will earn 3 credits.

Administration

There will be an URL for the official course web site. You will be informed of the web site when it is set up.

In addition to all of the information contained in this handout, the official web site is also the place to find contact information for instructors and teaching assistants, homework

assignments, solution sets for homework assignments and midterm examinations, and assorted other useful downloadable items.

Final grades for the course will be assigned as follows:

Final Score	Letter Grade
98–100	A+
92–98	A
90–92	A-
88–90	B+
82–88	B
80–82	B-
78–80	C+
72–78	C
70–72	C-
68–70	D+
62–68	D
60–62	D-
0–60	F

Each student's final grade will be determined based on the following contributions:

Assessment Method	Percent of Final Grade
Homework Assignments	10%
Team Quizzes	10%
3 Term Test	30%
2 Design Problems	20%
Final Examination	30%

- There are weekly homework assignments that are normally due each Wednesday. Only three problems from each assignment will be graded. Copies of solutions to all assigned problems will be made available online at the official course web site.
- The three term tests and the final examination will be closed book, closed notes. An official formula sheet will be provided during the examinations (and is also available at the official course web site).
- Each design problem will be allocated approximately one lecture hour. The specific instructions for the study, solution, and submission of the various design problems will be included in the respective assignments.
- The final examination for Section 1 and Section 2 will be on Monday, January 9th, from 9:10 to 11:00 A.M. and 2:00 to 3:50 P.M., respectively. The location of the examination will be specified later.

Tentative Schedule

Week	Dates	Topic	Reading Assignment Sections	Homework Assignment Due
1	9/5 9/9	Introduction Concurrent Force Systems	1.1 – 1.7 2.1 – 2.7	
2	9/12 9/16	Equilibrium of Concurrent Force Systems Axial Loading: Stress	3.1 – 3.4 4.1 – 4.3	Homework #1
3	9/19 9/23	Axial Loading: Strain Axial Loading: Deformation	4.4 4.5 – 4.7	Homework #2
4	9/26 9/30	(quiz #1) Axial Loading: Deformation Axial Loading: Design	4.8 – 4.9 4.10 – 4.11	Homework #3
5	10/3 10/7	Recess ***National Holiday***		
6	10/10 10/14	Test 1 Design Problem 1	**(actual covered 5.6 – 5.11)**	
7	10/17 10/21	Equivalent Systems Centroids, Centers of Mass, and Distributed Loads	5.6 **(reviewed take home Quiz problems)** 5.7 – 5.8 (and examples of 5-7-5-11), Test 1 on 10/18	Homework #5
8	10/24 10/28	Centroids, Centers of Mass, and Distributed Loads	5.9 – 5.11 (6-1, 6-2, 6-3), Design Problem 1	Homework #6
9	10/31 11/4	Test 2 Free-body Diagrams	6.1 – 6.2 (6－3, 6－4, 6－5)	
10	11/7 11/11	Equilibrium of Rigid and Deformable Bodies	6.3 Test 2 then 6－6,	Homework #7 a
11	11/14 11/18	Equilibrium of Rigid and Deformable Bodies Frames and Machines	6.3 (6－7 to 6－8) and 6.4 – 6.5 Design problem 2)	Homework #7 b
12	11/21 11/25	Plane Trusses	6.6 (6－9, 7－2)	Homework #8
13	11/28 12/2	Equilibrium in 3D Friction	6.7 6.8 – 6.9 (7－4, 7－5, 7－6)	Homework #9
14	12/5 12/9	Test 3 Design Problem 2	Test 3 Design Problem 2	

15	12/12 12/16	Torsion	7.1 – 7.4 （7－7，7－8） Review 0f test 3	Homework #10
16	12/19 12/23	Torsion	7.5 – 7.8 （Final Review）	Homework #11
17	12/26 12/30	Catch-up Review	Final Exam	
18	1/2 1/6	Final Examination		