ES 226 – 04 STATICS

Statics provides an introduction to the analytical methods of engineering design by focusing on the analysis of force systems in equilibrium. Students are required to demonstrate proficiency in working with vector representations of forces, moments, and couples; drawing and analyzing free body diagrams; solving 2-D and 3-D equilibrium problems considering particles, rigid bodies, and structures; analyzing external and internal forces and moments in beam and frame structures; calculating the centroid and moments of inertia of composite cross-sections; and analyzing friction forces.

Prerequisite: MATH162 (Calc II) and PHYS131 (Newtonian Dynamics).

Professor: Anne Raich, Ph.D. 322 ACE raicha@lafayette.edu
330-5590 http://sites.lafayette.edu/raicha

Lecture: TTh 1:15 p.m. – 2:30 p.m., AEC 327
Office Hours: MW 3:00 - 4:30; T 3:00 - 4:00
Other times, if the door to my office is open, feel free to stop by and ask questions

Textbook: Hibbeler, R.C. (2006) Engineering Mechanics: Statics. 11th Ed., Prentice Hall, ISBN: 0132215004

Exam I: Tuesday, October 2nd, 2012 (Evening Exam – 7:00 pm to 9:00 pm)
Exam II: Tuesday, November 6th, 2012 (Evening Exam – 7:00 pm to 9:00 pm)
Final Exam: T.B.D.
Notes: For all exams you will be able to bring one page of handwritten notes (one-side only). The use of other notes or books during the exam will not be permitted. The final exam is comprehensive.

Grade Distribution: Homework: 15% Exam I: 25% Final Exam: 30%
Video HW Project: 5% Exam II: 25%

Final Grading Scale: $A \geq 92$; $92 > A- \geq 90$; $90 > B+ \geq 87$; $87 > B \geq 82$; $82 > B- \geq 80$; $80 > C \geq 70$; $70 > D \geq 60$; $F < 60$

Expected Workload:
This course requires what is called "*old-fashioned gumption*", as will many other engineering courses you encounter in your studies. There is a lot of homework assigned in the course. The main purpose of the homework is to help you learn the fundamentals of statics, and there is typically a strong correlation between effort on the homework and exam scores. You should expect to spend 8 to 12 hours each week solving homework problems, including reworking problems that you have trouble with (often these types of problems appear on the exams). Engineers are known for their intellectual curiosity and their willingness to work hard and these traits allow engineers to rise to leadership positions.

Learning Objectives:
Specific learning objectives are defined for each class. Learning objectives are tailored to let you know what skills and knowledge you are expected to learn. Therefore, the learning objectives directly define the skills and knowledge on which you will be tested in the exams. Full understanding of a learning objective is accomplished through in-class and out-of-class work (i.e. through notes, discussion, demonstrations, reading assignments, homework, and projects).

Attendance and Participation:
Regular and on-time class attendance *is required,* although no grade is assigned for attendance**.** Class participation is expected and provides an opportunity to ask *your* questions, which serve the class at large in learning the course material more thoroughly. You are responsible for all material covered in class, even if absent for authorized activities.

Academic Integrity Statement**:** "Students are expected to be honorable, ethical, and mature in every regard"
No form of scholastic misconduct will be tolerated. Academic dishonesty includes cheating, fabrication, falsification, plagiarism, copying homework from other students or from solutions, etc. It is the student's responsibility to comply with the *Lafayette College Student Handbook* (*http://*studentlife.lafayette.edu/files/2011/08/studenthandbook_1112.pdf) and to be familiar with the *Principles of Intellectual Honesty* (http://www.lafayette.edu/academics/honesty.pdf). Violations will be handled in accordance with the Procedural Standards in Disciplinary Proceedings outlined in the *Student Handbook*.

"I give you two examinations, one in trigonometry and one in honesty. I hope you pass them both, but if you must fail one, let it be trigonometry for there are many good people in this world today who cannot pass an examination in trigonometry, but there are no good people in the world who cannot pass an examination in honesty" – Madison Sarratt, Vanderbilt University

Class	Date		Tentative Topic (Subject to Change)	Required Reading for Class
1	T	8/28	Introduction/ Review of Vector Operations	Review of Chapter 1
2	R	8/30	Force Vector Resultants/ Resolving Force Vectors	2.1, 2.2, 2.3, 2.4
3	T	9/4	Free Body Diagrams/ Particle Equilibrium	3.1, 3.2, 3.3
4	R	9/6	Particle Equilibrium	3.1, 3.2, 3.3
5	T	9/11	3-D Cartesian Vector Operations	2.5, 2.6
6	R	9/13	Position Vectors, Vector Projections, Dot Product	2.7, 2.8, 2.9
7	T	9/18	3-D Particle Equilibrium	3.4
8	R	9/20	Moment of a Force – Scalar and Vector Formulations	4.1, 4.2, 4.3
9	T	9/25	Moments about an Axis / Couples	4.4, 4.5, 4.6
10	R	9/27	Force and Moment Resultants/Equivalent Systems	4.7, 4.8, 4.9
11	T	10/2	Simple Distributed Loading	4.10
	T	10/2	**EXAM I** (Evening Exam 7:00 pm – 9:00 pm)	Covers Classes 1 - 9
12	R	10/4	Supports, Reactions, Free Body Diagrams	5.1, 5.2, 5.3
	T	10/9	*Fall Break – No Class*	
13	R	10/11	2-D Rigid Body Equilibrium/Two Force Members	5.1, 5.2, 5.3, 5.4
14	T	10/16	Trusses – Method of Joints and Sections	6.1, 6.2, 6.3
15	R	10/18	Trusses – Method of Sections/ Zero-Force Members	6.3, 6.4
16	T	10/23	Trusses – Stability, Space, & Design	
17	R	10/25	Pulleys and Frames	6.6
18	T	10/30	Frames and Machines	6.6
19	R	11/1	Internal Forces - Beams, Frames, Machines	7.1, 7.2
20	T	11/6	Shear and Moment Diagrams/ Equations	7.2, 7.3
	T	11/6	**EXAM II** (Evening Exam 7:00 pm – 9:00 pm)	Covers Classes thru 18
21	R	11/8	Shear and Moment Diagrams/ Equations &Graphical	7.2, 7.3
22	T	11/13	Shear and Moment Diagram Practice	7.2, 7.3
23	R	11/15	3-D Rigid Body Equilibrium	5.5, 5.6, 5.7
24	T	11/20	3-D Rigid Body Equilibrium & Internal Forces	5.6, 5.7, 7.1, 7.2
	R	11/22	*Holiday Break – No Class*	
25	T	11/27	Basic Dry Friction/Wedges	8.1, 8.2, 8.3
26	R	11/29	Wedges & Centroids – Integration &Composite Bodies	8.3, 9.1, 9.2, 9.3
27	T	12/4	Centroids/Moments of Inertia	10.1, 10.2, 10.4
28	R	12/6	Moments of Inertia – Composite Areas	10.5
FINAL: TBA				

ABET Outcomes: This course focuses on ABET program outcome (a.), which involves applying math and science principles daily to perform analysis of systems in equilibrium including trusses, frames, and machines. Other outcomes addressed include (j.) and (k.), which involve discussing contemporary structural and mechanical systems, including bridges, buildings, and machines, in order to highlight their impact on the design profession and society, and providing opportunities to gain proficiency in the use of engineering tools and programs through completion of mini-projects.

Students with Disabilities**:** The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation or require assistance with academic concerns/accommodations, please contact the Office of the Dean of Studies (610-330-5080).

Federal Credit Hour Policy: The student work in this course is in full compliance with the federal definition of a four credit hour course. Please see the Lafayette College Compliance webpage (http://registrar.lafayette.edu/additional-resources/cep-course-proposal/) for the full policy and practice statement.

Software Used for this Class: To complete the course assignments, you are encouraged to use Excel, Matlab and other programs that are available on lab computers. As engineers you will always be looking for new tools to apply that make your life easier. How to use Goal Seek in Excel and how to use a TI-84 type calculator to solve matrices will be discussed in-class.

Do you know if you are an active/reflective, a sensing/intuitive, a visual/verbal, and a sequential/global learner?
Check out your personal learning style by taking the online quiz at http://www.engr.ncsu.edu/learningstyles/ilsweb.html.
Read more about your learning styles http://www4.ncsu.edu/unity/lockers/users/f/felder/public/ILSdir/styles.htm

Learning Outcomes: This course that teaches students the basics of mechanics of non-deformable bodies in order to prepare them for future analysis and design courses and for professional practice. By the end of this course you should be able to:

- Draw correct free-body diagrams for 2D or 3D rigid bodies and particles under any system of forces.
- Investigate the equilibrium of 2D and 3D rigid bodies and particles under any system of forces.
- Analyze external support reactions and internal forces/moments in truss, frame, and machine systems.
- Identify zero force, two force and three force members in truss, frame, and machine systems.
- Analyze axial, shear and moment internal forces in beams and frames and Draw beam shear and moment diagrams.
- Identify surface friction forces and Analyze different applications including friction forces (sliding, rolling & tipping).
- Solve for the centroid and moment of inertia for any composite cross-section and object.

Homework Policy:

● Homework is generally assigned after each class and is collected at the beginning of next class meeting, unless otherwise specified. Late homework is accepted **only** by making a **prior** arrangement with the Prof. either during office hours or by email, subject to Lafayette College Dean's Excuse Policy outlined in section 7.3.2 of the Faculty Handbook - Class Attendance

● This class emphasizes developing problem solving skills. The use of free body diagrams is also emphasized. All homework must be submitted on engineering paper in an organized, professional manner with clear handwriting. Neatness does count - messy, unorganized problem solutions will result in lower grades. The following should be provided for the homework: A brief problem statement for each problem indicating the result requested; clear sketches and complete free body diagrams; description of the analysis steps and calculations made; checks that your answers are reasonable, and underlining or boxing your final answer(s).

● Unless otherwise stated, all homework in this class is expected to be individual work. Copying the work of others, including homework, is in violation of the College's Principles of Intellectual Honesty, which can be accessed at http://www.lafayette.edu/academics/honesty.pdf. You may discuss the homework assignments with other students; however all work submitted must be your own. It is your responsibility to properly acknowledge the source of ideas and facts received from others, including from other students, posted solutions, and solution manuals. If you discuss problems with other students, list their names on your homework. A student who commits academic dishonesty is subject to a range of penalties, including suspension or expulsion.

● To request re-grading, attach a signed statement to your work that details where you feel you lost points and submit it to the professor within one week after the homework or exam has been returned.

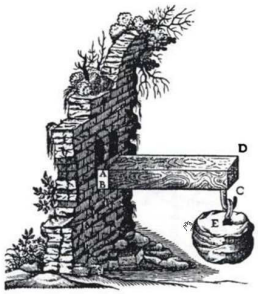
● Sample HW extension request email and response email:

Subject: Re: Request for HW Extension

```
----- Original Message -----
From: "Galileo Galilei" <galileig@lafayette.edu>
To: raicha@lafayette.edu
Sent: Thursday, October 27th, 1638 1:14:23 PM
Subject: Request for HW Extension

Hi Prof. Raich,
I would like to request an extension for the HW due Thursday, October 27th. I will turn this HW in by Thursday, November 3rd.
(Not sure about my understanding of beam bending - is it wrong that I am assuming that the beam rotates about the base of its
support point and there is uniform tension across the entire beam section?)
Thanks,
Galileo Galilei

Hi Galileo,
Sure, no problem with the HW extension. Don't worry, Antoine Parent in 75 years (1713) figures out beam theory correctly.
Thanks,
Prof. Raich
```



Galileo's Cantilever Beam

Design Mini-Projects: The mini-projects allow teams of two or three students to apply the analysis skills they have learned and to gain design experience in the selection of structural systems, synthesis of design alternatives and investigation of design performance tradeoffs. Details for each mini-project, including project deliverables and due dates, is provided during the semester.

Video Demo Homework Project:

● Student teams of two or three will select a problem from the Hibbeler textbook (Chapters 3 – 8) and produce a short video that serves to demonstrate how to set-up and solve the problem. Useful video elements include discussing the type of problem being solved, using drawings or physical models, performing a demonstration, and discussing similar problems solved by the methods.

● This project can be completed anytime during the semester, but must be turned in by 5:00 pm on Friday, Nov. 30th, 2012. Digital video cameras can be checked out by students at the library and video editing software is available. Video editing tutorial sessions are also available thru the library.

● Projects will be graded for accuracy of solution presented, clarity of explanation, creativity, and use of figures and/or models. Physical demonstrations can either be shown in the video or proposed demos can be described for future use.

Useful Web-based Tutorial Sites: There are only a few fundamental concepts in Statics; but many, many, many problems to apply them to. The more problems you think about solving or try to solve, the better you will become at recognizing how to solve new problems. Additional examples are provided at these sites:

Statics eCourse: https://ecourses.ou.edu/ **Visual Mechanics**: http://www.drsoftware-home.com/vismech/index.html

MecMovies: http://web.mst.edu/~mecmovie/ **Statics Visualizer (Trusses)**: CEE Software Folder or free download

Learning statics as an engineer is similar to getting a driver's license as a teenager.
It is essential, it allows you to head out on your own, and it helps you get a "date to the big dance" (i.e. job/grad school)

Engineers Have Attitude:

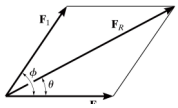
In addition to focusing on picking up the basic knowledge and developing the technical skills required to solve engineering problems, such as problem solving, critical thinking, teamwork, and communication skills, there is another goal of all engineering courses. This is to promote an **"engineering attitude"**. The characteristics of having a strong engineering attitude are accepting mistakes, having common sense, patience, ethics, high standards, confidence, persistence, curiosity, and flexibility, and understanding that there is not always a single right answer. Students with an engineering attitude possess a well-founded confidence in their ability to solve both routine and novel technical problems.

Those on top of the mountain did not fall there – Anon

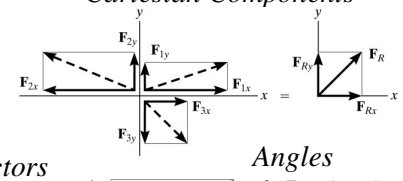
PARTICLE EQUILIBRIUM

↑VECTOR OPERATIONS

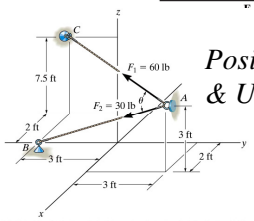
Resultant



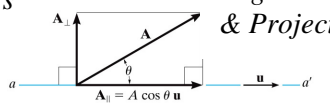
Cartesian Components



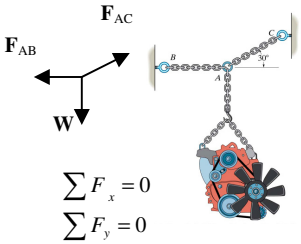
Position & Unit Vectors



Angles & Projections

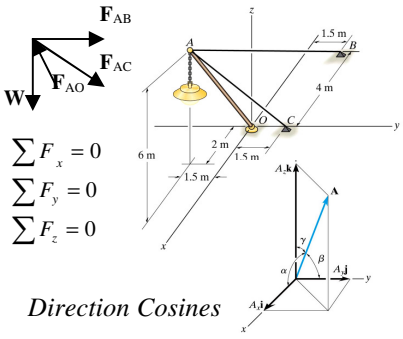


2-D EQULIBRIUM



$$\sum F_x = 0$$
$$\sum F_y = 0$$

3-D EQUILIBRIUM



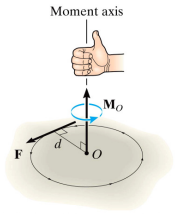
$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum F_z = 0$$

Direction Cosines

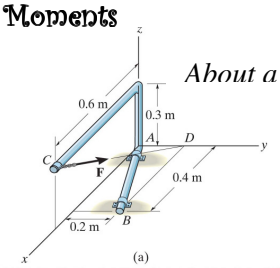
RIGID BODY EQUILIBRIUM

Moments

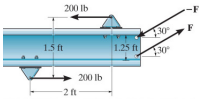
About a Point



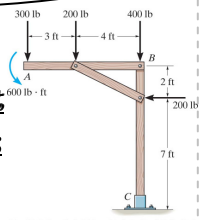
About a Line



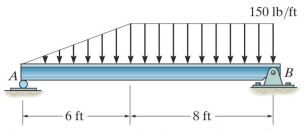
Couple



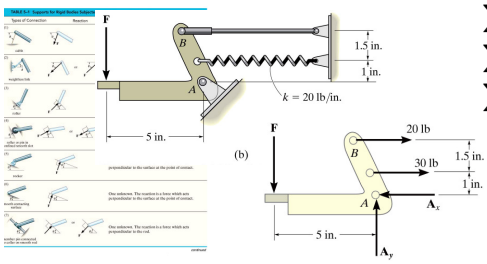
Equivalent Systems



Distributed Loads



2-D RIGID BODY FBDS

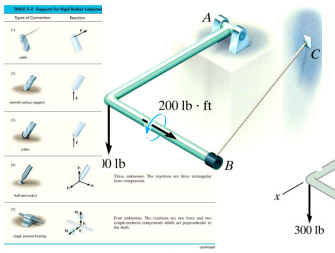


$$\sum F_x = 0$$
$$\sum F_y = 0$$
$$\sum M_{pt} = 0$$

Drawing a FBD

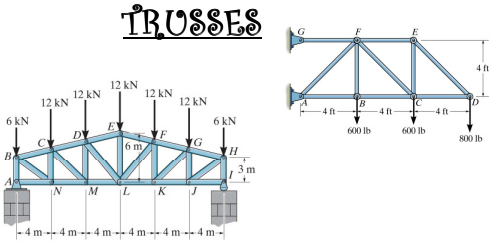
"Free" the body from its surroundings and "*Expose*" the forces acting on it *"Show"* all forces/moments (external loads, reactions, internal forces) on the FBD

3-D RIGID BODY FBDS

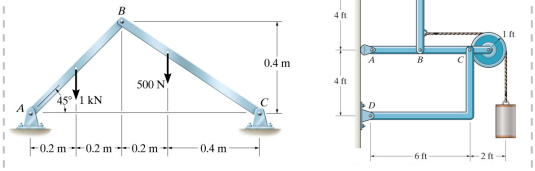


$$\sum \mathbf{F} = 0$$
$$\sum \mathbf{M}_{pt} = 0$$

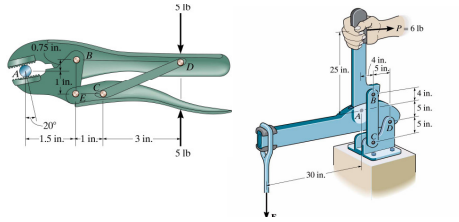
TRUSSES



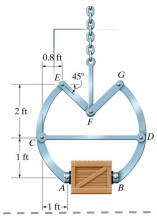
FRAMES



MACHINES

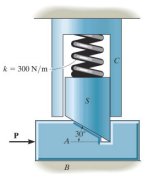


Friction

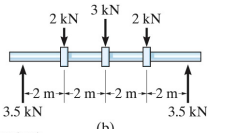


Impending Motion

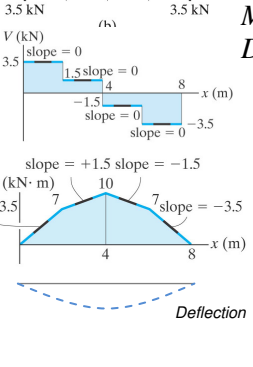
Wedges



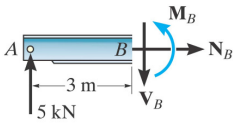
Internal Forces



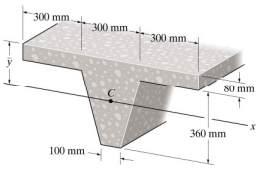
Shear & Moment Diagrams

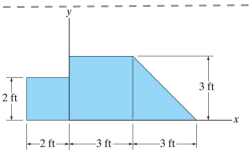


Section Cuts



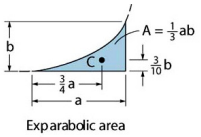
Centroids





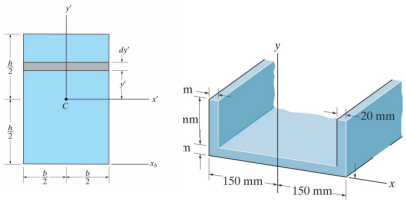
Composite Sections

Integration



Exparabolic area

MOMENT OF INERTIA



Parallel Axis Theorem

"Nothing is particularly hard if you divide it into small jobs" – Anon