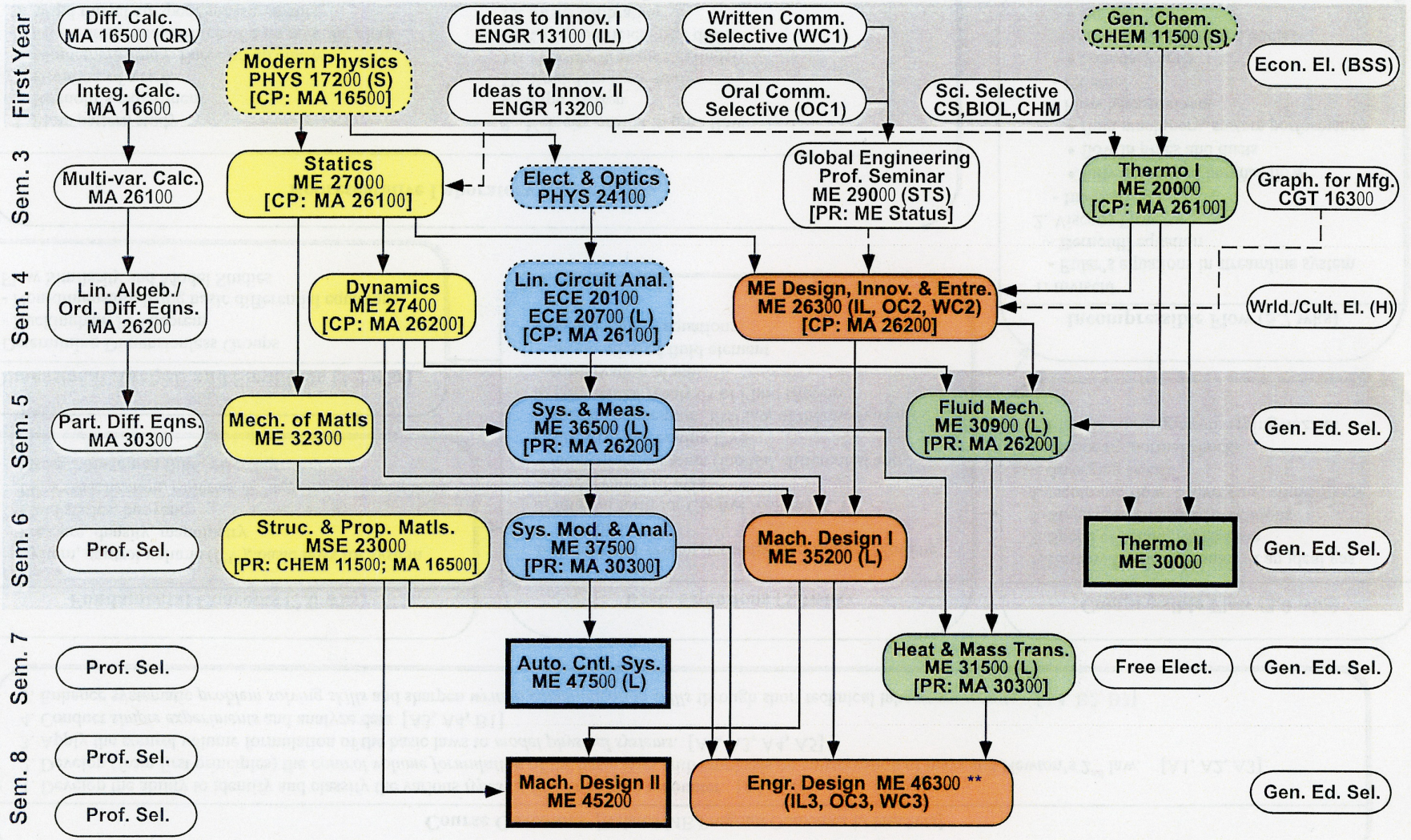
Mechanical Engineering - Program Map



**ME 463 must be taken in the last semester before receiving a degree

ME 27000 Basic Mechanics I
Fall 2019

Instructor	*Lecture time/room*	*Office/phone*	*Email*
Yangfan Liu	MWF 8:30-9:20/PHYS 223	ME 3061K/49-66714	liu278@purdue.edu
Jim Jones	MWF 9:30-10:20/ME 1130	ME 2200/49-45691	jonesjd@purdue.edu
Fabio Semperlotti	MWF 11:30-12:20/PHYS 223	ME 3061P/49-45974	fsemperl@purdue.edu
Luize Vasconcelos	MWF 12:30-1:20/EE 170	ME 3179/476-6944	lscalcod@purdue.edu
Chuck Krousgrill	MWF 3:30-4:20/ME 1130	ME 3061G/49-45738	krousgri@purdue.edu
Yutong Xue	MWF 4:30-5:20/ME 1130	ME 3061J/NA	xue46@purdue.edu
Morgan Murphy	TR 9:00-10:15/ME 1130	NA	r32mt5@purdue.edu

OH: MWF 3:30-4:20 pm

Course Blog: *https://www.purdue.edu/freeform/statics/*

A course blog is made available to you for the semester. This blog contains threaded a discussion component where you can seek assistance from fellow students in all sections of ME 270 as well as assist other students in answering their questions. In addition, the blog contains links to all material related to the course, including: course syllabus, homework problem statements, homework problem video solutions, solution videos for over 300 lecturebook examples, material for exam preparation, and any additional information that your instructor will make available to you during the semester. It is recommended that you use threaded discussions on this blog for discussions with your colleagues in the course. The blog is preferable to something like GroupMe, since on the blog, instructors and TAs can become involved in the blog discussions for providing helpful direction on problem solving, whereas this is not possible on GroupMe. We ask that you follow two simple rules. One, be courteous to the other people using the blog, and, two, please do not provide complete solutions for homework problems in your blog discussions.

→ discussion

Course materials

Course Lecturebook

Highly encouraged to have a new book

ME 270 utilizes a workbook-style textbook (a "lecturebook"): "*Statics: A Lecturebook, 2nd edition*" by Krousgrill, Rhoads and Gibert. The lecturebook includes all of the necessary reading material for the course, including a large number of example problems and material that is supported by the course blog. The lecturebook and course blog complement each other in providing you support in the course.

Course Description

Vector operations, forces and couples. Free body diagrams, equilibrium of particles and rigid bodies. Distributed forces. Centers of gravity and centroids. Friction. Trusses, frames, and machines. Internal reactions resulting from axial, shear, torsional, and bending loading. Stress and strain analyses and elementary failure criteria.

Prerequisites/Concurrent Prerequisites

Prerequisites: MA 166 Analytical Geometry & Calculus II; PHYS 172 Modern Mechanics
Concurrent Prerequisites – ENGR 132 Transforming Ideas to Innovation II; MA 261 Multivariate Calculus

Course Outcomes

1. Develop an understanding of static equilibrium and stresses in statically-determinate structures and how to apply them to engineering systems.
2. Learn a systematic approach to problem solving.
3. Foster effective mathematical and graphical communication skills.

Classroom Environment (Not Applicable to Distance Students)

We wish to encourage a professional classroom environment based on basic courtesy and mutual respect. To help achieve this environment, please arrive to class on time and come prepared to fully participate in class discussions. Please do not *sleep* in class, *text*, read the *Exponent*, work on *other assignments*, or *leave class early* without permission (unless you are feeling ill). Such behaviors are disrespectful to the instructor and fellow classmates, and can disrupt the learning process.

Homework

Homework (HW) must be submitted by 11:59pm (EST) on the due date (i.e., homework assigned in a particular class is due at 11:59pm on the day of the next class period, unless otherwise posted). Please post your HW on Gradescope on the appropriate HW link using a **single** PDF file (you will be asked to prescribe which page(s) each problem is on in Gradescope). Late HW will not be accepted without a personalized excuse (i.e., a generic PUSH note is not sufficient). Please review your homework submission **after** it has been uploaded onto Gradescope to ensure that all work has been properly submitted. If for some reason you have problems posting your HW on Gradescope, please email the grader the PDF of your HW before the 11:59pm deadline with an explanation. If you have a problem converting your HW into a single PDF format, take a legible picture of your HW and email to the grader. Each of these accommodations should be rare occurrences. Students will be given two free HW scores in case they miss an assignment or suddenly become ill. Opportunities for additional HW extra credit may also be made available by your instructor. Homework solutions will be posted on the blog shortly after they are due. Graders will strive to have your assignments graded by the class period following submission. If you are unable to submit the work on-time due to circumstances outside of your control, you may submit your work to your instructor with written documentation of the circumstances for consideration.

Scanning submission issues ↓

Grader: Yashna Shine : yshine@purdue.edu

Quizzes (not applicable to off-campus students)

A number of quizzes may be given throughout the semester to assist students in keeping up on the course material. The goals of the quizzes are to encourage student-to-student participation on group quizzes, and help students identify gaps in their understanding of the basic mechanics principles on longer, individual quizzes. No make-up quizzes will be given.

Exams

There will be two midterm exams and one final exam. Contact your instructor immediately if you are not able to make it to an exam. You will need documentation to support an excused absence from an exam. In the case of an excused absence on an exam, your final exam will count as your score for the exam you missed. Instructors will strive to have exams graded and returned within one week of the exam date.

Grades (In-Class Students)

Homework	10%
Quizzes	5%
Exams 1 and 2	25% or 60%
Final Exam	60% or 25%

If you score better on the average of Exams 1 and 2 than you do on the Final, the average of these Hour Exams will count as 60% and the Final will count as 25% of your final grade.

If you score better on the Final Exam than on the average of Exams 1 and 2, the final will count as 60% and the average of the Hour Exams will count as 25% of your final grade.

Distance Students

Homework	15%
Exams 1 and 2	25% or 60%
Final Exam	60% or 25%

Grades will be assigned on an absolute scale as follows: A+ $\geq$ 97; 97 > A $\geq$ 93; 93 > A- $\geq$ 90, 90 > B+ $\geq$ 87; 87 > B $\geq$ 83; 83 > B- $\geq$ 80; 80 > C+ $\geq$ 77; 77 > C $\geq$ 73; 73 > C- $\geq$ 70; 70 > D+ $\geq$ 67; 67> D $\geq$ 63; 63 > D- $\geq$ 60, F < 60. **No sweeping exam or final curves will be administered.** Students are strongly encouraged to attend all classes and complete all assignments to the best of their ability.

Deadline to Collect Graded Work

Electronically stored assignments, such as those uploaded to Blackboard or Gradescope will be retained until the end of the semester, after which they may be deleted. Final exams will be held until 30 days into the next regular semester to give students a reasonable period to retrieve their final exams. After that time, any remaining final exams may be discarded appropriately. Students are strongly encouraged to collect their graded work in a timely fashion to have it available for future use. Details are available at: https://engineering.purdue.edu/ME/Academics/Undergraduate/recordRetentionPolicy

Tutorial Room (not applicable to off-campus students)

Assistance with any questions will be available daily M-F 8:30-5:30pm in the ME 270 Tutorial Room. The ME 270 Tutorial Room is located in ME 2138 (labeled Tutorial Room 2) in the Gatewood Wing of the ME Building (almost directly above the classroom). The Tutorial Room will have TAs available during the hours of operation to answer any questions you may have concerning homework problems, old exam problems, or other conceptual questions you may have as well as ample table space to sit down and work on homework with your peers. We strongly encourage you to take advantage of this valuable resource.

Academic Honesty

Faculty and students working together can promote a fair and positive academic environment. All students are expected to conduct themselves in an ethical manner. Students are permitted to discuss homework assignments together, but should do their own work when preparing a problem solution (i.e., copying from a solution manual, an on-line resource such as Chegg, or another student's work is explicitly prohibited). Also, remember aiding and abetting others also a form of cheating. Specifically, posting or allowing other students to see your completed assignments is a common form of aiding and abetting others and is explicitly prohibited. Finally, the use of GroupMe sites are discouraged. Rather, we encourage students to discuss homework on the ME 270 blog following the rules established for the blog. When students use GroupMe sites it raises suspicions about what they are hiding and lead to accusations of cheating. Likewise, all exams are to be completed without unauthorized assistance. Any student caught cheating on an assignment or exam will receive disciplinary action, up to and including receiving a grade of "F" for the course. In addition, documentation of the infraction will be forwarded to the Office of the Dean of Students (ODOS), which may result in additional disciplinary sanctions, up to and including separation from the University (specifically suspension or expulsion). All of us are equally responsible for ensuring a fair and positive environment. If you become aware of any dishonest activities, please report the infractions to me (anonymously if you prefer) and we will investigate the concerns. If there is sufficient evidence of academic dishonesty, we will take disciplinary action. Finally, remember if you are complicit in assisting a peer to cheat, you are equally guilty. Please take to heart Purdue's Honor Pledge:

Using blog for discussion ⇓ no solution posting

"As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Academic Integrity Statement: http://www.purdue.edu/purdue/about/integrity_statement.html
Code of Student Conduct: http://www.purdue.edu/studentregulations/student_conduct/regulations.html
Reports of cheating can be submitted through the ODOS website *(purdue.edu/odos)*, by phone at 765-494-8778 or by email at integrity@purdue.edu.

Class Attendance (Not applicable to Distance Students)

Students are expected to attend every class period for which they are enrolled. If a student misses class due to illness, additional time for assignments can be permitted only if the student has a personalized note from a physician on or immediately prior to the date of the absence (i.e., a generic PUSH note is not sufficient). When an absence can be anticipated (interviews, scheduled doctor's appointment, etc.), students are responsible for notifying instructors well in advance of the absence. In

such cases, students are expected to work ahead and submit their homework prior to the scheduled absence. Occasionally, other emergency absences (e.g., family emergency, bereavement, etc.) may be necessary. Students need to submit the proper documentation as soon as possible to be eligible to request accommodation for missed work. The link below is the official University policy on class attendance: http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

ME Exam Calculator Policy

The **only** exam calculators that are permitted to be used during exams are the **TI-30XIIS** and the **TI-30Xa**. Students retain the freedom to use their calculator of choice for on homework, labs, and projects, but are encouraged to practice using their exam calculator to make sure they fully understand its functionality. The use of any unauthorized calculators during an exam will be deemed an academic dishonesty infraction. Students who violate this policy are subject to sanctions from the instructor, up to and including, a failing grade in the course, as well as be reported to the Office of the Dean of Students for University-level sanctions, which could include probation, suspension, or even expulsion from the University. Any questions about this policy should be addressed to your instructor.

Copyrighted Materials

Please note that the ME 270 Lecturebook, assignments, exams, quizzes, etc. are copyrighted materials and should not be sold, bartered to others, or posted on-line without the expressed written consent of the authors. Similarly, notes taken in class are considered to be "derivative works" of the instructor's presentations and materials and likewise should not be sold or bartered or posted on the internet without consent. Students are permitted to use their notes, assignments, exams and quizzes etc. for individual and/or group study or other non-commercial purposes reasonably rising up from enrollment in the course or the University generally.

Course Evaluations

During the last week of the semester, you will be provided an opportunity to evaluate this course and your instructor. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have about a week to complete this evaluation. Your participation in this evaluation is an integral part of this course. Your feedback is vital to improving education at Purdue University. We strongly urge you to participate in the evaluation system. Your instructor may provide some modest incentive (extra credit) for your participation, but may require you to provide documentation that you have completed the survey (e.g., a screen shot showing completion).

Grief Absence

Occasionally, students experience a death in their family and are entitled to a time of bereavement according to University regulations. In such cases, students are strongly encouraged to contact the Office of the Dean of Students for assistance in documenting the incident and contacting all of their instructors. The official regulations regarding the University Grief Policy can be found at the following link: https://www.purdue.edu/odos/sac/grief-absence-policy-for-students/

Campus Emergencies

In the event of a major campus emergency (e.g., severe weather, active shooter, etc.), course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. The School of Mechanical Engineering will provide details regarding access to information online and any additional procedures that may be needed as soon as they are available or can be obtained by contacting the instructors or TAs via mail or phone. You are expected to read your @purdue.edu email on a frequent basis.

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity. For details of Purdue's policy go to the following link: http://www.purdue.edu/policies/facilities-safety/iva3.html

Students with Disabilities

If you have a disability that requires special academic accommodation, please make an appointment to speak with your instructor within the first week of the semester in order to discuss any adjustments and bring your accommodation letter from the Disability Resource Center. It is important that we are informed about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications. If a student does not notify their instructor well in advance about the need for accommodations, there may not be time to arrange some accommodations.

Nondiscrimination Policy

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. For details, see the link below: http://www.purdue.edu/dfa/consumerinfo/nondiscrimination.php

Counseling and Psychological Services (CAPS) Information

Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at (765) 494-6995 and http://www.purdue.edu/caps/ during and after hours, on weekends and holidays, or through its counselors physically located in the Purdue University Student Health Center (PUSH) during business hours.

ME 27000
BASIC MECHANICS I

→ Statics

Course Outcomes [Related ME Program Outcomes in brackets]

1. Develop an understanding of *static equilibrium* and *stresses in statically determinate structures* and how to apply them to engineering systems. [A1, A2]
2. Learn a systematic approach to *problem solving*. [A2]
3. Foster effective mathematical and graphical *communication skills*. [B1]

Statics of Rigid Bodies
(9 wks)

Stresses in Statically-Determinate Structures
(6 wks)

Fundamentals (2 wks)

1. Newton's Laws
2. Vector algebra; vector components
3. Position, unit and force vectors
4. Dot product
5. Cross product
6. Moment of a force about a point

Static Equilibrium (5 wks)

1. Equilibrium of a particle
2. Support reactions and free body diagrams
3. Static indeterminacy and partial constraints
4. 2-D and 3-D static equilibrium
5. Trusses
   - method of joints
   - method of sections
6. Frames and machines
7. Dry friction
   - Coulomb's Laws
   - Systems with friction
   - Sliding or tipping
   - Wedges

Equivalent Systems (2 wks)

1. Determination of the resultant of concurrent forces
2. Equivalent force/couple systems
3. Centroid and center of mass
   - by composite parts
   - by integration
4. Surface loadings
   - line loads
   - pressure distributions
5. Fluid statics
   - rectangular surfaces

Introduction of Stress and Strain in Materials (1 wk)

1. Basic definitions of stress and strain
2. Mechanical properties of materials
3. Shear stress and strain

Stress Analysis (5 wks)

1. Stress due to axial loading
2. Shear stress due to torsion
3. Shear force and moment diagrams
4. Second area moments for beams
5. Flexural stresses in beams
6. Stress analysis of beams

ME 270 – Basic Mechanics I

Fall 2019

Period		Date	Topic	Reading	Homework
			STATICS		
1	M	Aug. 19	Introduction, Unit Conversions	1.A-F	H1.A, H1.B
2	W	Aug. 21	Position, Unit, and Force Vectors	2.A-B	H2.A, H2.B
3	F	Aug. 23	Dot Product	2.A-E	H3.A, H3.B
4	M	Aug. 26	Particle Equilibrium (2-D)	3.A-F	H4.A, H4.B
5	W	Aug. 28	Particle Equilibrium (3-D)	3.A-F	H5.A, H5.B
6	F	Aug. 30	Moment About a Point	1.D,4.A-B	H6.A, H6.B
B	M	Sep. 2	**Labor Day**		
7	W	Sep. 4	Force Couples, Equivalent Systems	5.A-B	H7.A, H7.B
8	F	Sep. 6	Free Body Diagrams; Equilibrium of Rigid Bodies (2-D)	4.C-D	H8.A, H8.B
9	M	Sep. 9	Equilibrium of Rigid Bodies (2-D)	4.E-G	H9.A, H9.B
10	W	Sep. 11	Equilibrium of Rigid Bodies (3-D)	4.E-G	H10.A, H10.B
11	F	Sep. 13	Equilibrium of Rigid Bodies (3-D)	4.E-G	H11.A, H11.B
12	M	Sep. 16	Distributed Loading	5.D	H12.A, H12.B
13	W	Sep. 18	Centers of Mass of Centroids: By Composite Parts	5.C	H13.A, H13.B
14	F	Sep. 20	Centers of Mass of Centroids: By Integration	5.C	H14.A, H14.B
15	M	Sep. 23	Fluid Statics: Buoyancy	5.E-G	H15.A, H15.B
R	W	Sep. 25	**Review for Exam 1**		
E	Th	Sep. 26	**EXAM 1 (6:30 – 7:30 PM); (Covers Lectures 1-15)**	Ch. 1-5	None assigned
B	F	Sep. 27	**NO LECTURE**		
16	M	Sep. 30	Fluid Statics: Hydrostatic Loads	5.E-F	H16.A, H16.B
17	W	Oct. 2	Fluid Statics: Hydrostatic Loads	5.E-G	H17.A, H17.B
18	F	Oct. 4	Friction: General	6.A-B	H18.A, H18.B
B	M	Oct. 7	**OCTOBER BREAK**		
19	W	Oct. 9	Friction: Slipping-Tipping	6.C	H19.A, H19.B
20	F	Oct. 11	Friction: Flat Belts	6.D	H20.A, H20.B
21	M	Oct. 14	Friction: Wedges	6.E-G	H21.A, H21.B
22	W	Oct. 16	Trusses: Method of Joints	7.A-C	H22.A, H22.B
23	F	Oct. 18	Trusses: Method of Sections	7.E	H23.A, H23.B

Statics of Rigid Body

Statics of rigid body

Stress analysis

Period		Date	Topic	Reading	Homework
24	M	Oct. 21	Trusses: Zero-Force Members	7.C-I	H24.A, H24.B
25	W	Oct. 23	Frames and Machines: Simple Systems	8.A-D	H25.A, H25.B
26	F	Oct. 25	Frames and Machines: Simple Systems	8.A-D	H26.A, H26.B
R	M	Oct. 28	**Review for Exam 2**	Ch. 6-8	None assigned
E	Tu	Oct. 29	**EXAM 2 (6:30 – 7:30 PM); (Covers Lectures 16-26)**		
B	W	Oct. 30	**NO LECTURE**		
27	F	Nov. 1	Internal Force/Couple Analysis	9.A	H27.A, H27.B
28	M	Nov. 4	Shear Force and Bending Moment Diagrams (Pt. Loads)	9.B	H28.A, H28.B
29	W	Nov. 6	Shear Force and Bending Moment Diagrams (Dist. Loads)	9.B	H29.A, H29.B
30	F	Nov. 8	Shear Force and Bending Moment Diagrams (Graph. Meth.)	9.B-E	H30.A, H30.B
31	M	Nov. 11	Stress-Strain Curves; Axial Stress and Strain	10.A-F	H31.A, H31.B
32	W	Nov. 13	Axial Stress and Strain; Factor of Safety	10.A-F	H32.A, H32.B
33	F	Nov. 15	Shear Stress and Strain; Direct Shear	11.A-D	H33.A, H33.B
34	M	Nov. 18	Shear Stress Due to Torsion in Circular and Tubular Shafts	11.E	H34.A, H34.B
35	W	Nov. 20	Shear Stress Due to Torsion in Circular and Tubular Shafts	11.E, F	H35.A, H35.B
36	F	Nov. 22	Flexural Stresses in Beams	12.A	H36.A, H36.B
B	M	Nov. 25	Flexural Stresses in Beams	12.A	H37.A, H37.B
B	W	Nov. 27	**THANKSGIVING**		
37	F	Nov. 29	**THANKSGIVING**		
38	M	Dec. 2	Second Moments of Area: By Composite Parts	12.B	H38.A, H38.B
39	W	Dec. 4	Second Moments of Area: By Integration	12.B, D	H39.A, H39.B
R	F	Dec. 6	**Review for Final Exam**	Ch. 1-12	Practice Exams
E			**FINAL EXAM (details to be announced); (Covers Lectures 1-39)**		

Coding: Integer = Lecture number; B = Break; E = Exam; R = Review lecture.
Homework numbers correspond to lecture numbers. Review lectures do not increase counter. Homework is due the class period after it is assigned.

TEXTS
ME 270 textbook ("Statics: A Lecturebook", 2nd Edition, Fall 2019).

ME 270 BLOG
You will automatically be added to the blog once you have registered for ME 270. Once you have access to the blog, you can adjust your email settings to receive all, some or none of the posting, as according to your preference.

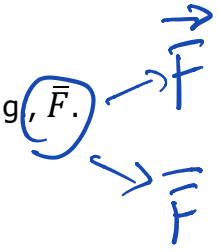
Your Name (Last, First, Middle) Problem Number Date

Given: concise statement (in your own words) of the information given.

Find: concise statement (in your own words) of the information sought.

Solution:

- Draw a schematic (where appropriate, a free body diagram) of the system and label appropriate coordinate axes. Use a straight edge whenever possible.
- State mathematical formulation of basic laws or definitions to be used.
- State your initial assumptions.
- Beginning with the basic equations, carry through the analysis, simplifying as far as possible before substituting in numbers.
- Substitute in numerical values (using a consistent set of units) to obtain numerical answers.
- Check your answers to be sure that they are reasonable.
- Label your answers and include appropriate units with the answers.
- Use "over bar" notation for all vectors appearing in your solution; e.g., $\bar{F}$.



NOTE:

[1] Work problems directly on the sheet to be turned in. Give all the details of calculations.

[2] Neat work will help in avoiding careless errors (Mars Climate Orbitor).

[3] Use Engineering Grid Paper for all homework problems.

[4] One problem per page working on just the light side of the paper.

[5] Make sure your name, problem number, date, etc. appears on all pages.

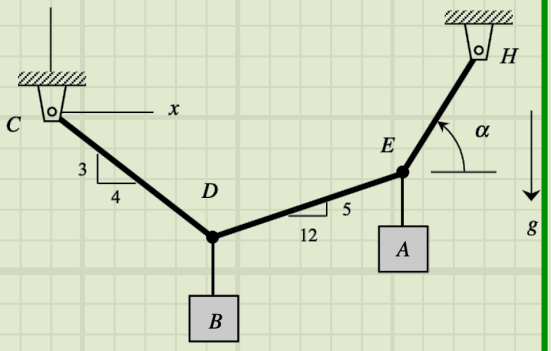
Your Full Name	Problem H3.B	Date

Given: Blocks A and B each have a weight of W and are supported with the cable system shown.

Find: If the system is in static equilibrium,

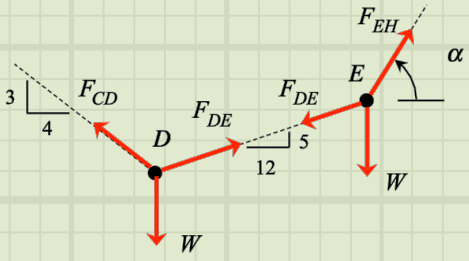
a) determine the tensions in cables CD and DE, and

b) determine the angle α.



Solution:

Free body diagrams (FBDs):



From the FBD of D:

$$\sum F_x = -\frac{4}{5}F_{CD} + \frac{12}{13}F_{DE} = 0 \;\Rightarrow\; F_{CD} = \frac{15}{13}F_{DE}$$

$$\sum F_y = \frac{3}{5}F_{CD} + \frac{5}{13}F_{DE} - W = 0 \;\Rightarrow\; \left[\frac{3}{5}\left(\frac{15}{13}\right) + \frac{5}{13}\right]F_{DE} = W \;\Rightarrow\; F_{DE} = \frac{13}{14}W$$ ← F_{DE}

$$\Rightarrow\; F_{CD} = \frac{15}{13}F_{DE} = \frac{15}{13}\left(\frac{13}{14}W\right) = \frac{15}{14}W$$ ← F_{CD}

From the FBD of E:

$$\sum F_x = -\frac{12}{13}F_{DE} + F_{EH}\cos\alpha = 0 \;\Rightarrow\; F_{EH}\cos\alpha = \frac{12}{13}\left(\frac{13}{14}W\right) = \frac{6}{7}W$$

$$\sum F_y = -\frac{5}{13}F_{DE} + F_{EH}\sin\alpha - W = 0 \;\Rightarrow\; F_{EH}\sin\alpha = W + \frac{5}{13}\left(\frac{13}{14}W\right) = \frac{19}{14}W$$

Dividing the above two equations gives:

$$\frac{F_{EH}\sin\alpha}{F_{EH}\cos\alpha} = \frac{6W/7}{19W/14} \;\Rightarrow\; \tan\alpha = \frac{12}{19} \;\Rightarrow\; \alpha = \tan^{-1}\left(\frac{12}{19}\right) = 32.3°$$ ← α

Lec 1

INTRODUCTION

Learning Objectives

1. To introduce and define the subject of *mechanics*.

2. To introduce *Newton's Laws*, and to understand the significance of these laws.

3. The review *modeling, dimensional consistency*, *unit conversions* and *numerical accuracy* issues.

4. To review basic *vector algebra* (i.e., vector addition and subtraction and scalar multiplication).

Definitions

Mechanics: Study of forces acting on a rigid body

a) *Statics* - body remains at rest

b) *Dynamics* - body moves

Definitions

Mechanics: Study of forces acting on a rigid body

a) Statics – body remains at rest

b) Dynamics – body moves

Newton's Laws

3 eqn's, 3 eqn's

First Law: Given *no net force*, a body at rest will remain at rest and a body moving at a constant velocity will continue to do so along a straight path $(\sum \bar{F} = \bar{0}, \sum \bar{M} = \bar{0})$

When $\bar{a} = 0$ ↔ remain rest / moving at constant $\bar{v}$

Second Law: Given a *net force* is applied, a body will experience an acceleration in the direction of the force which is proportional to the net applied force $\sum \bar{F} = m\bar{a}$.

Third Law: For each action there is an *equal and opposite* reaction $\bar{F}_{AB} = -\bar{F}_{BA}$

Models of Physical Systems

Develop a model that is representative of a physical system

Particle: a body of infinitely small dimensions (conceptually, a point).

Rigid Body: a body occupying more than one point in space in which all the points remain a fixed distance apart.

Deformable Body: a body occupying more that one point in space in which the points do not remain a fixed distance apart.

Dimensional Consistency

If you add together two quantities,

$$x = C_1 v + C_2 a$$

these quantities need to have the same dimensions (units); e.g., if x, v and a have units of (L), (L/T) and (L/T^2), then C_1 and C_2 must have units of (T) and T^2 to maintain dimensional consistency.

Many times algebraic errors in analysis lead to dimensional inconsistency. *Use dimensional consistency as a check on your algebra.*

Unit Conversions

Use a logical process in your unit conversions. For example, to convert 60 mph to ft/sec:

$$\frac{miles}{60\,hour} \times \frac{hour}{3600s} \times \frac{5280ft}{mile} = 88\frac{ft}{s}$$

Accuracy of Numerical Answers

Say that you do the following calculations:

$$z = \frac{x}{y} + t$$

Say that you have used four significant digits for x and y but only two significant digits for t. The numerical value of z will not have more than two significant digits (and likely less than two).

Examples of Significant Figures:

385.1	four significant figures
38.51	four significant figures
0.03851	four significant figures
3851×10^{7}	four significant figures
7.04×10^{-4}	three significant figures
25.5	three significant figures
0.51	two significant figures
0.00005	one significant figures
27.855	five significant figures
8.91×10^{4}	three significant figures
2200	May have two, three or four significant figures depending on the accuracy of the measurement that obtained the number. Where such doubt may exist, it is better to write the number as 2.2×10^{3} to show two significant figures; or as 2.20×10^{3} to show three significant figures.
55	two significant figures
55.0	three significant figures. The zero is significant in this case, since it is not otherwise needed to show proper location of the decimal point.

3 SF { 3.14 / 2.00

Retention of Significant Figures

1. In recording measured data, only one doubtful digit is retained, and it is considered to be a significant figure.

2. In dropping figures that are not significant, the last figure retained should be increased by 1 if the first figure dropped is 5 or greater.

3. In addition and subtraction, do not carry the result beyond the first column that contains a doubtful figure. For example,

$$\begin{array}{r} 11.3 \\ +\ 31.43 \\ \hline 42.73 = 42.7 \end{array}$$

(the 3 in the hundredth's place is insignificant since the 11.3 figure can only be measured to the closest tenth).

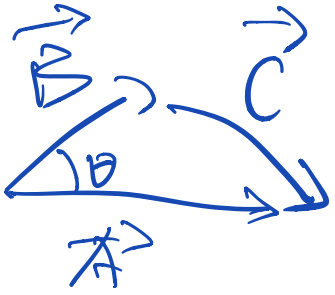
4. In multiplication and division, carry the result to the same number of significant figures that there are in the quantity entering into the calculation that has the least number of significant figures. For example,

$$\begin{array}{r} 15.5 \\ \times\ \ 5.4 \\ \hline \end{array}$$

Note: Unless stated otherwise, we shall retain three significant figures (unless one or more digits are lost through additions; for example, 90.2 - 90.1 = 0.1). Thus, given a dimension of 2 ft, assume it is actually 2.00 ft.

Vectors

Vectors are characterized by both a magnitude and direction. Examples of vectors: position, velocity, acceleration, force, moment.



Vectors add by the parallelogram law. For example.

$$\bar{A} = \bar{B} + \bar{C}$$

Says that vector $\bar{A}$ has the same magnitude and direction as the sum of vectors $\bar{B}$ and $\bar{C}$

More the tail of $\bar{C}$ to the head of B. $\bar{A}$ is then found by connecting tail of $\bar{B}$ to the head of $\bar{C}$.

See the text for the mechanics of adding and subtracting vectors and for multiplying a scalar with a vector.

Law of Cosines:

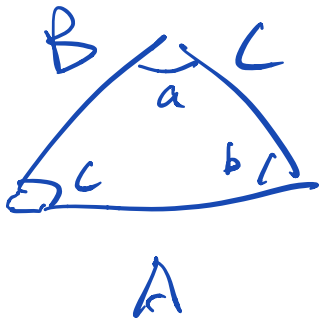
$$C = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$

Length (Scalar: magnitude only)

Need numerical solutions for most of the examples & HWs

Law of Sines:

$$\frac{A}{\sin a} = \frac{B}{\sin b} = \frac{C}{\sin c}$$



History of Mechanics

Three divisions:

1. Mechanics of Rigid Bodies
2. Mechanics of Deformable Bodies
3. Mechanics of Fluids

Aristotle (384-322 BC) – first to investigate the statics of levers and the first to develop some of the first theories of dynamics

Archimedes (287-212 BC) – explained the lever fulcrum and the theory of buoyancy

da Vinci (1452-1519) – continued Archimedes work on levers and developed a theory on moments for 3-D bodies

Brahe (1546-1601) – developed accurate astronomical measurements

Kepler (1571-1630) – developed laws of planetary motion

Stevinus (1548-1620) – conceived the laws of equilibrium and the parallelogram law for vector addition

Galileo (1564-1642) – studied projectile motion and took strong stance against natural philosophers and the Catholic Church

Descartes (1596-1650) – developed Cartesian coordinate system and the theory of virtual work

Hooke (1635-1703) – Developed theory of elasticity (Hooke's Law)

Newton (1642-1727) – Invented calculus (with Gottfried Leibniz) and wrote the Mathematical Principles of Natural Philosophy, the foundation for Newton's Laws of Motion and classical mechanics

Newton laid the foundation for future contributors like Euler, Lagrange, Cauchy, Kolmogorov, and many others.