ME 2202: DYNAMICS OF RIGID BODIES

Section B, Fall 2026

Credit Hours:	3-0-3
Catalog Description:	Kinematics and kinetics of particles and rigid bodies in one, two, and three dimensions. Newton-Euler equations. Work-energy and impulse-momentum principles
Class Time and Location:	TuTh 9:30a-10:45a, Whitaker 1103
Instructor:	Dr. David E. Torello (He/Him/His), Eighth St. West Apartments, Office W011 Email: david.torello@me.gatech.edu
Office Hours:	Office hours will be conducted in-person. Time: TBD Location: Love Building 2nd floor atrium
Graders/TA's:	*Graders:* • TBD *Learning Assistants:* • TBD
Prerequisites:	COE 2001 Statics, PHYS 2211, and MATH 1502 or equivalent
Instruction Mode:	In-person
Textbook:	J. L. Meriam, L.G. Kraige, J. N. Bolton, Engineering Mechanics: Dynamics, 9th Edition, Wiley, 2018. ISBN: 978-1118885840
Online Videos:	Video links are provided in Canvas "Modules" tab and are also all available in the "Media Gallery" Canvas tab. Please note that there are some typos and errata that used to be published when the videos were hosted on Coursera which no longer are readily accessible. I will do my best to point them out when I see them. If there is a conflict between my course notes and the videos, default to my course notes unless otherwise instructed.

1. INTRODUCTION:

Welcome to ME 2202, Dynamics of Rigid Bodies! The purpose of this course is to provide you with the opportunity to learn and apply the fundamental principles of engineering dynamics. Dynamics is the study of **motion**, as contrasted to Statics, which is the study of forces and moments in equilibrium. While these appear to be vastly different subjects at first glance, they share many of the same fundamental concepts and mathematical operations. It is highly advised for students to make sure they are comfortable with their vector algebra from Statics, as we will move through that material quickly at the beginning of the class.

2. COURSE LEARNING OBJECTIVES

Learning objectives serve as guideposts for the knowledge and skills you will build as an engineer from this course. Each objective highlights a critical step in the process of solving problems pertaining to real-world dynamic systems. **Essentially, this course is about learning how things move and how engineers make sense of that motion.** By the end of the semester, you'll be able to describe and predict how particles and rigid bodies behave in both 2D and 3D, and you'll know how to use tools like Newton's laws, energy methods, and momentum principles to analyze motion. You'll get lots of practice sketching free-body diagrams, motion graphs, and other visual tools that help turn a real-world situation into a problem you can solve. Just as importantly, you'll learn how to simplify and make assumptions wisely, which are skills every engineer needs when dealing with complex systems. Throughout the course, you'll practice choosing the right approach for the problem at hand, interpreting your results, and explaining what they mean in the context of engineering design. By the end, you'll not only have the technical skills to tackle dynamics problems, but also the judgment to apply them in making sound engineering decisions.

1. Understand and Predict Motion of Solid Bodies
By the end of the course, students will be able to:

a. **Represent** the kinematics and kinetics of particles and rigid bodies undergoing planar and 3D motion.
b. **Apply** Newton–Euler equations, work–energy methods, and impulse–momentum relations to predict forces, moments, and motion.
c. **Model** motion using Cartesian, polar, and path coordinate systems as appropriate.

2. Develop Multi-Representation Problem-Solving Skills
By the end of the course, students will be able to:

a. **Construct and interpret** diagrammatic representations of mechanical systems, including free-body diagrams, state diagrams, impulse-momentum diagrams, and motion graphs to support problem solving.
b. **Translate** between physical motion, diagrammatic representation, and mathematical models across multiple coordinate systems.

3. Train Analytical Thinking Under Constraints
By the end of the course, students will be able to:

a. **Select and defend** the most appropriate analysis method (e.g., force-based, energy-based, or momentum-based) for a given problem context.
b. **Evaluate** modeling assumptions and justify their use.
c. **Identify** kinematic and kinetic constraints limiting the motion or forcing of a dynamic system.

4. Make Engineering Decisions Based on Dynamics Analyses
By the end of the course, students will be able to:

a. **Interpret** the results of dynamics problems to inform engineering design or performance evaluation.
b. **Compare** alternative solution methods and select the most effective approach for a given context.
c. **Communicate** the validity, limitations, and practical implications of analysis results.

3. TOPICS:

MOTION OF PARTICLES AND SYSTEMS OF PARTICLES

Module 1: Particle Kinematics – Position, velocity, and acceleration of particles
Module 2: Particle Kinetics – Newton-Euler equations
Module 3: Particle Kinetics – Work-kinetic energy theorem

PLANAR MOTION OF RIGID BODIES

Module 4: Planar Kinematics – Relative velocity and acceleration of rigid bodies
Module 5: Planar Kinematics – Relative velocity and acceleration of rigid bodies in moving reference frames
Module 6: Planar Kinetics – Newton-Euler Equations

Module 7: Planar Kinetics – Work-Kinetic Energy Theorem
Module 8: Planar Kinetics – Impulse Momentum Theorem

GENERAL MOTION OF RIGID BODIES

Module 9: General Kinematics of rigid bodies in 3D motion
Module 10: General Kinetics of rigid bodies in 3D motion

4. COURSE STRUCTURE:

This course will progress through the topics listed above in a logical order, starting with a treatment of the kinematics of particles and bodies approximated as particles, describing motion in mathematical terms. Then we will use this to help us analyze the kinetics of particles, or how particles react to external forces, using several modeling frameworks (Newton-Euler, Work-Kinetic Energy Theorem, and Impulse-Momentum Theorem). We will repeat this structure two more times, moving on to rigid bodies in planar motion (2-D problems of bodies with actual dimension), and finally ending in rigid body motion in 3-D problems. The last part of the course is particularly challenging, as several of our intuitions break down when forces and moments are applied in all three directions of space. In other words,… this is the fun stuff.

This course is all about getting you as much experience doing dynamics as possible. This section of ME 2202 will be taught in a *flipped classroom* mode, with lecture material being supplied in the form of online video modules. Class time will consist almost exclusively of working problems or discussing the finer points of details covered in the modules that I think are particularly important. If students have a common issue, we will stop class and have a mini lecture on that concept to clear up confusion, addressing challenging conceptual issues as they arise in the classroom. The flipped environment provides you with the ability to spend more time doing and applying concepts with guided help instead of alone in your living quarters, and this guided practice is what will help you understand this course practically and conceptually.

4.1. ATTENDANCE POLICY:

This course does not have mandatory attendance, but you will absolutely be responsible for material and activities that occur during class time, whether you are in attendance or not. Therefore, **attendance during class time is highly encouraged.** When you attend class, I expect you to treat both your fellow classmates and the teaching staff with respect. This means that you are expected to show up on time, participate fully and authentically with each assignment, and meet the criteria for satisfactory achievement outlined later in this syllabus. If you cannot make class, please let me know via email as soon as possible and we can discuss any issues that may arise.

4.2. COURSE SOFTWARE:

This course will utilize two major software platforms, all free of charge to students:

1. Canvas – This will be used to post learning aids, worksheets, and for course announcements. Additionally, all announcements made on Canvas are considered official course policy and **it is expected that you will check Canvas regularly and have email notifications enabled.**
2. Gradescope – This is where you will upload all submitted work for this course, so please be sure to familiarize yourself with this platform during the first week of the semester.

This course will NOT be utilizing Wiley Plus. If you decide to buy the textbook for this course, please do not buy any materials relating to Wiley Plus as that money will be wasted. That being said, this course is taught from the video modules, and they are **completely sufficient as a reference**; therefore, purchasing the course text is optional.

4.3. Course Grading Policies:

4.3.1. Specifications Grading

This course is graded based on your in-class worksheet assignments, a selection of review problems designed to test your understanding of major course concepts, and a final exam which is a review of the course material. The grading in this course is likely something you aren't used to – we are grading this course using **specifications grading**.

In specifications grading…

- Each assignment includes a clear list of specifications that we will use to evaluate the quality of your work and that reflect the learning outcomes for the material.
- Every assignment will receive one of three marks based on whether you have met the listed specifications – Success, Retry, or Incomplete.
- You will be able to resubmit **nearly** every assignment in the course at least once (more on that later).
- In this grading scheme, we will be able to spend more time giving you qualitative feedback. A large part of this course is reflecting on this feedback and using it to help you develop your skills.
- Completion of collections of material for a given topic denotes completion of a topic module. You must pass a certain number of modules to get an A, B, C, D, or F grade to be clearly enumerated later in this document.

The motivation here is simple – shift the focus of learning and work effort from "getting points" to the material itself, encouraging learning the material according to the more concrete idea of ***skill competency***. What I am saying is this: "If you pass this assignment, I'm comfortable that you know this material to a degree that you can use it as a practicing engineer in later courses as well as your career." What is not stressed here is mastery – that comes with far more experience and continual, life-long learning.

4.3.2. Assignment Types:

4.3.2.1. In-class Worksheets

There is a famous saying by librarian and learning science pioneer John Dewey (not Melvil Dewey of Dewey Decimal System… the other Dewey):

> *Give [students] something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results."*

Most class periods involve giving you something to do - working problems in the form of in-class worksheets. These problems are meant to serve as introductions to the material discussed in the modules and a brief mini lecture for that day. **These worksheets are the primary means through which you will interact with the material, and it is expected that you will approach them with rigor and effort.** They are meant to be solvable during the class period, but they will be due online via Gradescope **at the end of the week (11:59p Friday).** Each worksheet will have listed specifications for a passing grade. It is important to stress that these are learning tools, and thus *complete* correctness is not a required passing specification. **No late in-class worksheets will be accepted without prior instructor authorization.**

You will be given detailed feedback on your work if necessary. From this feedback, you will be permitted to resubmit your worksheets according to the resubmission schedule shared in this document (§ 3.3.4.2). **My expectation is that everyone will pass 100% of the worksheets.** I understand that things come up and life can be difficult. The grade breakpoints allow for missing a small number of worksheets for whatever reasons may arise.

4.3.2.2. Review Problems and Midterms

Your skill in the subject of each module will be assessed by a review problem that summarizes the module content. While review problems are summary problems that cover the relevant information of the topic module, very few subjects in this course are standalone… they often leverage most of the content that has come before. Thus, while the module content is the focus of the problem, most problems will use material from previous modules. In this way, review problems reflect real-world problems.

This course will feature **three** midterm exams which each consist of **three** review problems. Midterm 1 will have three review problems, one each for modules 1, 2 and 3. The same format will apply to midterms 2 and 3, each covering modules 4 through 6 and 7 through 9, respectively. The required number of passing review problems is listed later in the final grade matrix at 3.3.5. Midterms will be conducted in class on the days outlined in the course schedule document.

4.3.2.3. FINAL EXAM

There will be a final exam in this class. Per the Georgia Tech final examination rules, you are hereby informed that the exam will take place. This exam will be administered in accordance with GT policies for scheduling conflicts. **Note that personal trips, previously bought flights, cruises, etc. will not be accommodated**. Requests for alternate exam accommodation must be received as soon as the conflict is discovered by the student. We trust that you will be honest with us in the application of this policy.

The grading of the final exam is a little different than other course deliverables:

1. **The final exam is opt-in**. You may decide not to take it and keep your current grade.
2. If you choose to take the final exam, it will be graded on a letter scale (the only such deliverable in the course). Your final grade for the course will depend on the outcome of your final grade as follows:
    a. If you get a **higher** grade on the final than your current grade based on your number of passing modules, your grade will be **raised by one letter grade** (B to A, C to B, etc.)
    b. If you get the **same** letter grade on your final as you currently have, there will be **no change to your grade.**
    c. If you get a **lower** grade on the final than you currently have, your grade will be **lowered by one letter grade** (A to B, B to C, etc.)

4.3.3. PASSING GRADES

All assignments will have a clear threshold for passing. In no case will passing require perfection, but it will require complete work that displays sufficient rigor. Passing indicates competency in the skills and knowledge appropriate for the specific assignment, and some assignments will separately define and address conceptual and numerical categories of mistakes. Conceptual mistakes are flaws in the core learning objectives at the heart of an assignment (e.g., you decided to use Newton-Euler to solve a collision problem instead of applying the Impulse-Momentum Theorem, misinterpreted 'plastic' vs. 'elastic' collision, etc.), while numerical mistakes affect the assignment quality but do not disrupt your basic understanding of the topic (e.g. poor arithmetic like 2+2=5, also known as a "Torello Special"). In general, assignments and review problems must contain **no more than one conceptual mistake and/or two numerical mistakes** to receive a passing grade. Additionally, all submitted assignments in this course must be scanned neatly, and work must be arranged clearly. **We will not penalize for poor handwriting, but we will absolutely assign a non-passing grade to submissions that lack professionalism**. Get your thumbs out of the scan.

Sometimes students run out of time or get so stuck that, without help, they cannot proceed with a problem. If you submit a work product that does not represent a good-faith effort to provide a complete problem solution, your work will be marked "incomplete". No feedback will be provided in these cases, but you will still have a chance to resubmit your work should you decide to try again. I encourage you to start work early and ask questions during class or office hours to avoid this circumstance.

4.3.4. REGRADING, RESUBMITTING, AND RETAKING

4.3.4.1. REGRADING

Regrading specifically refers to when you believe we have made an error in grading, not resubmission of an assignment. Regrading is important to us because we believe that correctly grading your work is our responsibility and a sign of respect for you. If you would like us to regrade an assignment, please do the following:

All regrades must be submitted **via Gradescope** to the course instructor (Dr. Torello) no later than one week after feedback on that assignment is returned to you. You must include in the request a reason you would like a regrade. That reason should clearly identify the specification(s) you think we made a mistake on, as well as where in the assignment we should look. Note that if you wish to request a regrade, the entire assignment will be regraded.

4.3.4.2. RESUBMITTING

Resubmitting specifically means submitting an updated version of your work based on feedback provided after an initial grading assessment. Resubmitting is an especially important part of this course – **you are not expected to get your worksheets correct on your first attempt**. Many students view this as failing, but this could not be further from the truth. By attempting to do your best work and receiving feedback from the teaching team, you will learn how your original attempt was flawed conceptually and will be able to revise not only your on-paper submission but also the scaffold of connections and ideas in your head. This is a crucial part of this course and should be expected for all in-class worksheets. **As such, you will be able to resubmit all worksheets assigned in this course**.

Before discussing resubmission guidelines, I want to be clear about something. **As a general policy, the due dates and times listed on Canvas and Gradescope are completely final.** There is a large window available to you for all submissions in this course, and it is expected that you will budget the time necessary to collect, edit, clean, organize, and scan your work in your workflow. **Something submitted even one-tenth of a second beyond the due date is considered late** – if I am submitting a grant online to the NSF grant applications portal and the server gives the cutoff as 12a on Monday, it will not accept anything submitted after 12:00:00a on Monday. It is up to me to have things ready with a safety factor, as it is up to you to have your submissions ready with a safety factor.

If something goes horribly wrong and you lose internet or there is some sort of other server-side glitch, I will require proof that you submitted on time in the form of screenshots or confirmation emails. **I will not acknowledge any claims not supported with concrete evidence**. Every faculty has their pet peeves… this one is mine.

All worksheets may be resubmitted on Gradescope within the period between the first submission and the "late submission" deadline indicated for each assignment. Your initial submission will be graded and returned to you a few days after your first submission, at which point you will be able to ask questions about your work, revise it, and resubmit based on the feedback from the course graders. **You must detail what corrections you made so that graders understand what you were asked to fix from your previous submission**. This is the primary learning loop in this class – **Attempt, Submit, Reflect, Revise**. This is how most learning occurs; we are just pulling that loop out into plain relief and making it the focal point of the course. Take it seriously and you will see profound growth.

4.3.4.3. RETAKING

Review problems represent the culmination of your studies in a module, and all preparations should be made to pass them on the first attempt. However, it is important to understand that growth is just as much part of testing as any other learning activity, **and as such you will have the opportunity to retake a limited number of review problems that you do not pass the first time**. Your review problems will be graded in the same way as worksheets with feedback provided and a pass (P)/no pass (NP) mark will be assigned. If you receive an NP, you will be **eligible to attempt a similar problem again** on a later testing day to be assigned based on when the midterm is returned. It is

highly encouraged that you carefully study the feedback given to you on your first submission in preparation for later attempts. Please remember that review problems are meant to be a solo effort, and any collaboration, communication, or shared work on these problems is an express violation of the Academic Honor Code and will be grounds for immediate reporting to the Office of Student Integrity. Any review problems submitted to sites such as Chegg and Course Hero will immediately be requested for take down and we will request the information of the user who uploaded the work. This is extremely serious, and I will take it extremely seriously. Yes, I have a Chegg account.

Y**ou will be able to reattempt one review problem per midterm exam**. Remember – this is not the same exact problem, but a problem of the same type which means you will need to study to make sure you are ready. In total you can reattempt up to three problems in the course, and I will not allow you to bank a reattempt from a previous exam to use on a later exam. This is honestly for my benefit – grading this way is an IMMENSE effort and drain, and I need to give you all the chance to demonstrate your knowledge while I stay sane. I will explain the retake process when it first comes up in the course.

4.3.5. Topic Modules and Grading Scale

In total, this class has ~25 lessons during which we will have assigned worksheets (1 worksheet per lesson), 10 review problems, and a final exam. You will receive a final letter grade based on the collection of passing work you submit using the following scale. **You must satisfy the requirements of both columns to receive the corresponding letter grade.**

Table 1: The code phrase is "Issac Newton was a total jerk."

Grade	In-class Worksheets		Review Problems
A	• No more than 2 non-passing worksheets	AND	• 9 passing review problems • Final Exam Grade*
B	• No more than 3 non-passing worksheets	AND	• 8 passing review problems • Final Exam Grade*
C	• No more than 4 non-passing worksheets	AND	• 7 passing review problems • Final Exam Grade*
D	• No more than 5 non-passing worksheets	AND	• 6 passing review problems • Final Exam Grade*
F	• > 5 non-passing worksheets	AND	• < 6 passing review problems • Final Exam Grade*

5. Generative AI Usage Policy

Artificial intelligence (AI) tools such as ChatGPT, Copilot, or similar platforms are becoming increasingly common in engineering practice. In this course, AI may be used to **support your learning**, but never as a substitute for it. There is a lot to say about this topic, many arguments around which I am sure you've heard numerous times. Perhaps the best overall summary that I've encountered of the topic and the effects that generative AI usage has on learning is the following: https://www.recurse.com/blog/191-developing-our-position-on-ai. Using the arguments clearly presented in the linked article, the following guidelines clarify how AI fits course expectations. And because I'm a child of the 90's, you get to bear the brunt of my 90's vocabulary. In this course, we make RAD[1] (groans appropriate) use of AI tools:

Responsible

[1] This comes from a faculty colleague of mine, Dr. Todd Fernandez, in BME. You can blame him for the dad joke.

- You are expected to use AI thoughtfully and critically. Generated work must always be reviewed, verified, and understood by you. Submitting answers that you cannot explain will be treated as a breach of academic expectations.
- At times, you may be asked to complete assignments without AI assistance to preserve essential learning opportunities. Be prepared to work in both "AI-assisted" and "AI-free" modes.
- AI should enhance your problem-solving skills, not replace them. Always maintain ownership of your reasoning and final product.

Allowed

- AI may be used as a study partner or tutor. For example, to clarify concepts, suggest approaches, provide examples, or help with debugging code.
- It is acceptable to use AI for repetitive or routine coding tasks, provided you fully understand and can explain the resulting code.
- You may experiment with AI to compare problem-solving strategies, check your thinking, or generate practice problems.

Disclosed

- Any use of AI in assignments, projects, or written work must be **explicitly acknowledged**. This includes noting which tool you used, what prompts or queries you entered, and how you incorporated the output into your work.
- Transparency is required whether AI output was correct, partially useful, or misleading. Sharing both successes and failures promotes honesty and supports the learning community.

Summary: You may use AI tools in this course when doing so helps you learn, provided your work remains your own, you can fully explain it, and you clearly disclose AI involvement.

6. Academic Honor Code:

I expect full compliance with Georgia Tech's Academic Honor Code. Please read and understand this document if you have not already done so. You are allowed to work in groups on all worksheets, but all work you submit must be written in your own hand. Review problems are to be your own work and no collaboration will be allowed. Any cases of cheating or violations of the honor code will be reported to the Office of Student Integrity (OSI). Please refer to the honor code here: http://osi.gatech.edu/content/honor-code.

In the past I have had several students find answers to problems on Chegg, Course Hero, etc. and submit those to me. I am extremely familiar with these solution sets (as are my graders), and if we suspect you of submitting copied work then you will immediately be referred to OSI, as I refuse to handle the process of cheating disputes without official backup. I will not make any exceptions to this policy.

7. Disability Services and Course Accommodations:

The Georgia Institute of Technology has policies regarding disability accommodation, which are administered through the Office of Disability Services (http://disabilityservices.gatech.edu/). If you require special accommodations (ADAPTS), please notify me ASAP.

Additionally, we all need some accommodations in education because we each learn differently. Those accommodations might include video captions, a low distraction place to think during class, or extra time on certain assignments. We are committed to supporting accommodations when it is at all feasible. **Asking for help when you need it is an important life and engineering skill. It is also a skill that we want to help you develop through this course.**

8. Diversity, Equity, and Inclusion:

The teaching team expects our classroom and virtual spaces to be a place where you, and everyone else, are treated with respect. Our class will welcome individuals of all backgrounds, beliefs, bodies, and identities both visible and invisible. All members of this class are expected to cooperate in the creation of a respectful, welcoming, and inclusive environment for every other member of the course. If there are things the teaching team or others have done to degrade that environment we encourage you to bring them to our attention and we will work to correct them. By including this statement, we mean to express our values as your instructor and supporting teaching staff members. While many of us are used to entering spaces (physical or otherwise) where we automatically feel welcome, not everyone experiences that. For many reasons, explicitly stating that people are welcome, and how we want to make them feel welcome is valuable to the learning environment we want to create.

9. Safe Zone:

I am a member of a Safe Zone Ally community network and am committed to listening and supporting you in a safe and confidential manner. As a Safe Zone Ally, I can help you connect with resources to address problems you may face that interfere with your ability to engage in academic and social pursuits on campus as it relates to issues of sexual orientation, gender identity, and other elements of your identity and life experience. Our goal is to help you be successful and to maintain a safe and equitable campus. If we or someone else can help you, our door is open.

Similarly, the teaching team will gladly use an alternate name or gender pronoun of your choice. Please advise us of this preference as early as possible so that we may make appropriate changes to our records. At your preference, we will use preferred names publicly or privately.

ABET Course Objectives:

Objective 1: To teach students the basic principles underlying the dynamics of rigid bodies in planar and 3D motion.

- **1.1** Students will demonstrate an understanding of Newtonian-Eulerian physics and basic equations underlying kinematics and kinetics of rigid bodies in 2D and 3D motion.

Objective 2: To educate students to identify, formulate and solve engineering problems in rigid body dynamics.

- **2.1** Students will demonstrate the ability to isolate rigid bodies and to draw clear and appropriate free body diagrams.
- **2.2** Students will demonstrate an ability to identify kinematic and kinetic knowns and unknowns.
- **2.3** Students will demonstrate an ability to identify and effectively account for kinematic constraints such as rolling and/or sliding, and their kinetic consequences.
- **2.4** Students will demonstrate that they can apply and combine the appropriate principles referred to in Objective 1 to the solution of problems.
- **2.5** Students will demonstrate that they can combine the appropriate principles referred to in Objective 1 to the solution of problems.
- **2.6** Students will demonstrate that they can determine the mass moments and products of inertia for arbitrary rigid bodies.
- **2.7** Students will demonstrate that they can calculate the principal coordinates and the principal moments of inertia for arbitrary rigid bodies.

Objective 3: To introduce students to the concepts of work-energy and impulse-momentum for rigid body systems.

- **3.1** Students will demonstrate an understanding of work-energy principles as applied to rigid bodies in 2D and 3D motion.
- **3.2** Students will be able to evaluate the kinetic energy of rigid bodies as well as the potential energy associated with gravity and spring forces.
- **3.3** Students will demonstrate an understanding of conservation laws for momentum and energy.
- **3.4** Students will demonstrate an ability to apply impulse-momentum relations where appropriate.

3.5 Students will demonstrate that they can utilize coefficient of restitution data in the solution of impact problems in rigid-body dynamics.