Text: *Engineering Mechanics: Dynamics* (1st Edition); Benson H. Tongue and Daniel T. Kawano; John Wiley & Sons; 2016; ISBN: 978-1-119-345510 (this ISBN is for the loose-leaf version of the text plus access to WileyPLUS which is required for the course). Other versions which do not include WileyPLUS access are the Loose-leaf version, ISBN 978-1-119-44444-2, and the E-book version, ISBN 978-1-119-32205-4.

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TA(s): None assigned as of August 21, 2019

Grading policies: *Homework*

- There will be weekly problem assignments.
- Most of the assignments will be delivered through WileyPLUS—the online teaching and learning platform associated with the text.
- The assignments may vary in the number of problems, but all assignments will be equally weighted.
- You are encouraged to form study groups and teach one together. Piazza has been enabled for this course so you may discuss problems and share ideas asynchronously.
- Helping one another does not extend to copying someone else's work, allowing someone else to copy your work, doing assigned work (whether it be homework or a quiz) for someone else, or allowing someone else to do the assigned work for you.
- Late homework loses 50% of the original value per day that it is late so homework submitted two or more days late earns a score of 0.

Quizzes

- There will be weekly quizzes based on the homework assignments.
- These quizzes will typically pose a scenario similar to those found in the the homework followed by a set of True/False, Multiple Choice, and/or Fill-in-the-Blank style questions about the situation. The emphasis of the questions will be on how the behavior of the system is affected by the various parameters of the problem (e.g., does the final speed increase or decrease if the value of an angle is increased). Numbers will rarely appear in either the problem statement or the answers.
- The quizzes will post on BlackBoard immediately after class on the day homework is due and will remain available until the end of the next class. If homework is due on Monday or Wednesday, you will have 48 hours to complete the associated quiz. Quizzes that post on Friday will be available for 72 hours.
- USC's Academic Integrity policy will be strictly enforced and the *slightest* hint that the work you submit is not entirely your own will result in a report to SJACS proposing an F on the quiz for all those involved.
- If you fail to take the quiz before it is due, you may ask for an extension provided you do so before noon on the day the quiz was due. All such requests will be considered on a case-by-case basis.

Exams

- There will be two equally weighted in-class exams — the first approximately midway through the term and the second on the day and time scheduled for the final. The first exam will focus on particle motion and the second exam will focus on rigid body planar motion.

Final grade calculation

- The exams are equally weighted and will provide 50% of your grade.
- The quizzes are equally weighted and the average quiz score will provide 40% of your grade.
- The homework assignments are equally weighted and the homework average will provide 10% of your grade.

Background

Many students consider the study of dynamics to be one of the most challenging subjects in the entire engineering curriculum because it combines many topics that are typically studied in isolation and brings them together in one arena in which all of the topics are important. Think of the things you must know. . . You have real objects with real shapes and sizes so you must be ready to apply the principles of geometry and trigonometry. As the objects move through the space-time continuum, differential equations are used to describe how the parameters of motion vary with time. Since these objects move in 3-dimensional space, vectors are needed to talk about the various components. Finally, these equations need to be manipulated and solved simultaneously which requires a knowledge of algebra and linear algebra. Entire branches of mathematics have been developed specifically to talk about dynamic systems.

If you are looking for someone to blame for this course, look no further than Isaac Newton (1643-1727) and his seminal work, *Philosophiæ Naturalis Principia Mathematica* (often referred to simply as *The Principia*). This entire course is based upon Newton's observation that the force applied to a particle is proportional to the change in the linear momentum of the particle. Simple mathematical operations (like vector arithmetic), basic geometry, some algebra, and straight-forward applications of differential and integral calculus lead directly to everything else covered in the course. Not coincidentally, Newton is also responsible (along with Gottfried Wilhelm von Leibniz) for the branch of mathematics known as calculus.

If you want more people to fault, you can attribute geometry to Archimedes (287-211 BC) and his colleagues in Ancient Greece; algebra to Muhammad ibn-Musa al-Khwarizmi (780-850 AD); most modern mathematical notation, calculus texts, and the extension of Newton's work to rigid bodies to Leonhard Euler (1707-1783); the importance of the equal sign to Joseph Fourier (1768-1830); and vector analysis to Josiah Willard Gibbs (1839-1903).

Learning objectives and outcomes

This course covers elementary particle and rigid body dynamics — the study of how particles and rigid bodies respond to applied forces and/or torques. Although you should have some background in this subject from an earlier course in physics, this course provides a framework for the application of the principles of dynamics to much more complex systems than those you encounter in typical entry-level physics courses. Despite providing a framework for approaching more complex problems, this course is still limited in scope because we will deal almost entirely with greatly simplified systems using idealized elements and restricting ourselves to systems for which the resulting differential equations can be easily solved.

By the end of this course, you will be able to:

1. draw the Free Body Diagrams (FBD) of particles acting under the influence of applied forces;
2. recognize a non-rotating or rotating frame of reference in which the path of a particle is simple to describe;
3. select a coordinate system in which the position, velocity, acceleration, and jerk of a particle are easy to express;
4. recognize constraints on the motion of a particle;
5. combine the equations of motion and constraints into a set of equations sufficient to solve for all of the unknown quantities;
6. apply the separation-of-variables method to solve simple differential equations involving the motion of single particles;
7. predict the motion that results from a particular set of forces applied to a particle;
8. extend items 1-7 above to systems of particles;
9. relate the position, velocity, acceleration, and jerk of one location on a rigid body to that of another location on the same or another rigid body; and
10. extend items 1-7 above to one or more rigid bodies.

Course outline

This section contains a weekly plan for the semester. While not fixed in stone, this schedule roughly illustrates what we'll be discussing each week and the work you'll be expected to complete. We may not follow the exact sequence of topics in the text — depending on class progress, we might jump ahead at some points during the term or return to earlier material at other points — but this is the outline we will try to follow. We will start with single particles and examine their kinematics, their motion as described by Newton's Laws, and how Newton's Laws lead to relationships between impulse and momentum and between work and energy. We will then introduce multiple particles and see how Newton's Laws and the relationships between impulse and momentum and between work and energy change when multiple particles are involved. Finally, we'll introduce the concept of a rigid body and see what happens to those same Newton's Laws and the relationships between impulse and momentum and between work and energy change when rigid bodies are involved.

Week-by-week schedule

You should note that the number of class meetings per week is not constant due to various holidays. Labor Day, Fall Recess, and Thanksgiving all affect the Fall schedule since the weeks of Labor Day and Fall Recess contain only two class meetings and the week of Thanksgiving has but a single meeting. These lost lecture days may affect what we can cover on those weeks — if so, we'll make appropriate adjustments as we go.

In the table that follows: Column 1 contains the week of the term; Column 2 contains the reading material for the week; Column 3 briefly describes the topics that will be discussed in class that week; and Column 4 identifies the problem assignment for the week. *You are expected to have completed the reading assignment before the lectures on those topics start.*

Week	Reading assignment	Lecture topics	Problem set
1	*Text: Ch. 1, Ch. 2 (§2.1)* *Bb: vector review handout* *Bb: Separation of Variables handout*	*Nomenclature; ideal systems; problems solvable by SoV* [$\ddot{s} = \ddot{s}(t)$, $\ddot{s}(s)$, *or* $\ddot{s}(\dot{s})$]*;* *rectilinear motion*	*Problem set #1*
2	*Text: Ch. 2 (§2.2-5)* *Bb: coordinate systems handout*	*Curvilinear motion; Cartesian, intrinsic, cylindric, and spherical coordinate systems*	*Problem set #2*
3	*Text: Ch. 2 (§2.5-6)*	*Relative and constrained motion*	*Problem set #3*
4	*Text: Ch. 3 (§3.1-3)* *Bb: systems of particles handout (§1-2)*	$\boldsymbol{F} = m\boldsymbol{a}$ *for single particles*	*Problem set #4*
5	*Text: Ch. 3 (§3.4, 7)* *Bb: particle collision handout*	*Linear impulse/momentum;* *particle impacts*	*Problem set #5*
6	*Text: Ch. 3 (§3.5-6)*	*Angular impulse/momentum;* *central force motion*	*Problem set #6*
7	*Text: Ch. 4 (§4.1-4)* *Bb: conservative forces handout*	*Work/energy; power;* *conservative forces;* *potential energy*	*Problem set #7*
8	*Text: Ch. 5 (§5.1-6)* *Bb: systems of particles handout (§3)*	*Closed systems of particles;* *force, energy, and momentum*	*Problem set #8*
9	*Text: Ch. 6 (§6.1-2)*	*Rigid body planar kinematics;* *abs. and rel. vel./acc.;* *Joints/contact conditions*	*Problem set #9*
10	*Text: Ch. 6 (§6.3-5)*	*Rotating frames*	*Problem set #10*
11	*Text: Ch. 7 (§7.1-3)* *Bb: rigid body motion handout (§1-3)* *Bb: centers and centroids handout*	$\boldsymbol{F} = \dot{\mathbf{L}}$ *and* $\boldsymbol{M}_O = \dot{\mathbf{H}}_O$ *for rigid bodies in planar motion;* *2-D constrained motion*	*Problem set #11*

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Week	Reading assignment	Lecture topics	Problem set
12	*Text: Ch. 7 (§7.4)* *Bb: rigid body motion handout (§4)*	*Impulse/Momentum for rigid bodies in planar motion;* *Rigid body impact*	*Problem set #12*
13	*Text: Ch. 7 (§7.5)* *Bb: rigid body work/energy handout*	*Work/Energy for rigid bodies in planar motion*	*Problem set #13*
14	*Text: Ch. 8 (§8.1-4)*	*3-D kinematics;* *3-D kinetics*	*Problem set #14*
15		*Catch up, review, etc.*	
16	*Study days and* *Final exam*		