

Classical Mechanics

Instructor: Dr. Jim Drachenberg (jld00a@acu.edu)

About the Course

Classical mechanics is a story of three different *but equivalent* perspectives: Newtonian, Lagrangian, and Hamiltonian mechanics. We will apply these perspectives to a number of fascinating problems and be blown away by deep insights into the nature of our universe, e.g. the amazing connection between symmetries and conservation laws. We will use these perspectives to dabble in rocket science, celestial mechanics, rigid body dynamics, and computational physics. *I am excited to learn with you, this semester!*

Course number and title: PHYS 371 – Classical Mechanics

Credit hours: 3

Semester and year: Fall 2020

Meeting time and place: Tuesdays and Thursdays, 8-9:20 AM.

Face to Face: Engineering and Physics Labs at Bennett Gymnasium (BEN) 219.

For your convenience, here is a [link to the ACU campus map](#).

Online: [Google Meet](#), Meeting Code: classical

Prerequisites/corequisites: Undergraduate level PHYS 220 Minimum Grade of D or Undergraduate level PHYS 120 Minimum Grade of D. Corequisite: MATH 361.

Catalog description: Vector methods of static systems of forces, couples and moments, particle dynamics, rigid body dynamics, work, kinetic and potential energy, momentum and the conservation laws, and Hamilton and Lagrangian methods.

Intended audience: Junior engineering and physics majors.

About the Teacher

Instructor: Dr. Jim Drachenberg, Associate Professor

Office location: Onstead Science Center (OSC) 123A

Phone number(s): (325) 674-6150

Email address: jld00a@acu.edu. You may also contact me through the Canvas course.

Office hours/Contact expectations: MTWF 10:00 – 11:00 AM or by appointment. I welcome virtual appointments on [Google Meet](#), meeting code: drach_officehours

Mission Statements

ACU Mission: The mission of Abilene Christian University is to educate students for Christian service and leadership throughout the world.

College Mission: The College of Arts and Sciences endeavors to educate students for worldwide Christian service and leadership through programs of study and other learning experiences that blend a liberal arts education with professional and career education. The college offers a broad spectrum of programs in the arts, humanities, social sciences, behavioral sciences, natural sciences, and mathematics as well as professional and pre-professional programs. Many courses in the college are designed to provide a unique liberal arts education from a Christian perspective to students of all majors throughout the university.

Department Mission: ACU undergraduate engineering and physics majors pursue a deeper understanding of the physical world through theory, application, analysis and practical design. Their education comes under the mentorship of dedicated Christian engineers who bring a variety of experiences and backgrounds to the table and who guide students as they develop technical knowledge and skills the professional practice skills that prepare them for engineering careers. At ACU, we admire God's handiwork in the laws of the universe and seek to understand and apply those principles to solve big problems while improving the lives of people around the world.

Unique Christian Perspective:

"He has made everything appropriate in its time. He has also set eternity in their heart, yet so that man will not find out the work which God has done from the beginning even to the end."

—Ecclesiastes 3:11

Classical Mechanics is an upper-level course that digs deeper into the physical laws that govern the motion of objects in our world. We begin to grapple with the realization that realistic problems are messy. Even the simplest departures from the ideal render exact solutions impossible. Could there be in this a lesson on the nature of sin and the necessity of redemption by grace rather than the works of humanity?! As our reflections on the universe mature, we come to the realization that even the symmetries we observe have profound implications for physical law. If we believe that the laws of nature do not change with time—the cornerstone of the scientific method—then we must accept that the energy and matter comprising our universe have been the same throughout all of time. Our eyes turn to God, Who set eternity in our hearts. We grapple with the limitations of our discipline, which can only address what has been created. The creative act itself lies beyond our grasp. Yet, for we of faith, the realization of our limitations is freedom. We cannot reach the Divine ourselves. But God brings us to Himself as His children and there our existence is fulfilled beyond what this physical world can offer.

Course Content

Outline of topics:

- Newton's Laws of Motion
- Projectiles
- Momentum and angular momentum
- Energy
- Oscillations
- Calculus of variations
- Lagrange's equations
- Two-body central force problems
- Mechanics in non-inertial reference frames
- Rotational motion of rigid bodies
- Coupled oscillators and normal modes
- Hamiltonian mechanics

Format of Class

Format of Class: Come to class prepared to engage and ask questions! Learning is most effective—and *certainly more fun!*—when there is active discussion between you, your peers, and me. To facilitate this, I expect you to complete the assigned reading and watch the pre-lecture recording, *before coming to class*. In class, we will focus on working problems together and on the portions of material, where I believe you most need my help. While I come prepared, ***I always welcome your feedback***, e.g. office hours, e-mail, or Canvas discussions, on what specifically you would like me to cover.

On-line: When we must meet on-line, we will use [Google Meet](#), code: classical. We will meet during our normal class time and do our best to recreate the face-to-face experience. In light of this, it is extremely important that you continue to come prepared by completing the readings and viewing pre-lecture recordings.

Instructional Materials

Textbook: Classical Mechanics by John Taylor

Other materials:

- We will be using [Google Colab](#) for writing simple scripts for numerical calculation. These computation techniques will immediately give you a leg up on the competition in industry or graduate school, so please take full advantage of this unique empowerment opportunity!
- Pre-lecture recordings and lecture slides are posted in Canvas
- My videos can also be accessed from my [YouTube channel](#)

Learning Outcomes

Course goal and competencies: Students will understand how to apply the Newtonian, Lagrangian, and Hamiltonian methods to problems in classical physics. Students will be able to apply simple PYTHON scripts to obtain numerical solutions to problems that cannot be solved in closed form.

Assessment and Grading

Assessment activities: Your course grade will be determined from homework assignments, exams, an independent project, and the cumulative final exam.

Approximate weights are as follows:

Exams (2)	20% each for a total of	40%
Homework		20%
Independent project		20%
Final Exam		20%

Final grade calculation:

Range of Points	Final Letter Grade
90%-100%	A
80%- 89%	B
70%-79%	C
60%-69%	D
Below 60%	F

Rules for discussing grades: Please respect the privacy of your peers and do not pressure your classmates to discuss their grades with you. I welcome the opportunity to discuss any of your grades. Grades are considered set two weeks after the grades have been posted to Canvas. Any objection must be received prior to conclusion of the two-week period, otherwise I will assume you consent to the posted grade.

Independent Project: Pick a chapter (other than 13) from Part II of Taylor to study on your own and write a 2 to 3-page report. Then, prepare a media presentation of your topic, e.g. compile a set of PowerPoint lecture slides, create a video, record a podcast, craft an artistic rendering, etc. Finally, typeset in Word or LaTeX a “solution manual” for 10 problems from the end of your chapter. Your project grade will be determined from

1. **Proposal:** In one page, discuss the topic, scope, justification, and deliverable.
2. **Progress Report:** Submit a 2-3-page report on the progress of your project. Describe any changes from the original proposal.
3. **Rough Draft:** Submit a rough draft for *peer review*. By this point, you should have a complete *draft* of your report and solution manual. Media presentations should be sufficiently complete or described so as to receive useful feedback. Submit your materials for review by your peers. In turn, I will assign you two projects to review. After receiving peer comments, give responses indicating what—if anything—you chose to do. Your score will be determined by the quality of your draft and of the feedback you give to your peers.
4. **Final Draft:** Your completed project, incorporating the feedback of your peers.

University Policies

ADA Compliance Policy:

Abilene Christian University is dedicated to removing barriers and opening access for students with disabilities in compliance with ADA and Section 504 of the Rehabilitation Act. The Alpha Scholars Program facilitates disability accommodations in cooperation with instructors. In order to receive accommodations, you must be registered with Alpha Scholars Program, and you must complete a specific request for each class in which you need accommodations. If you have a documented disability and wish to discuss academic accommodations, please email alpha@acu.edu call their office directly at 325-674-2667.

Academic Integrity Policy:

Academic integrity is defined as academic work completed as assigned for each class by the individual or group responsible for the work. Violations of academic integrity and other forms of cheating involve the intention to deceive, mislead, or misrepresent and therefore, are a form of lying. Such actions are contrary to behavioral norms that flow from the nature of God. Academic misconduct includes, but is not limited to, the following: 1) Failure to give credit to sources used in a work in an attempt to present the work as one's own, 2) Submission of papers or projects obtained from another source (e.g., research service or club paper file) as one's own, and 3) Falsifying information orally or in writing. Academic misconduct may result in, but is not limited to, a zero on the assignment and/or an F in the course. Additionally, the department chair, Dean of your school, and the Dean of Student Life will be notified. See the full university policy, including how to appeal a decision, by following [this link](#).

Anti-Harassment Policy:

As a professor, one of my responsibilities is to help create a safe learning environment on our campus. I also have a mandatory reporting responsibility related to my role as a professor. It is my goal that you feel able to share information related to your life experiences in classroom discussions, in your written work, and in our one-on-one meetings. I will seek to keep the information you share private to the greatest extent possible. When I am not able to keep your information confidential, I will only share it with responsible administrators on campus who can provide you with services and resources. I am required to share with the Title IX Coordinator information regarding sexual misconduct or harassment, dating or domestic violence or stalking that you report to me. If you would prefer to share information in a confidential setting, I encourage you to speak with someone in the [ACU Counseling Center](#). All of your options are available for review by clicking on the link to ACU's [policy](#).

Course Policies

Attendance/tardiness: Daily attendance is *essential*, in both face-to-face and virtual settings. If you must be absent, notify me **beforehand**. If you cannot, contact me, as soon as possible, to let me know the reason. Attendance will be considered in your final grade at my discretion. Regardless of absence, you are responsible for the material. If absent from an exam, your grade will be zero unless I grant prior approval. You must be on-time to class. Persistent tardiness is grounds for a reduction in your overall grade.

Participation: Participation in class is critical for you, your peers, and for me to be the effective instructor you deserve. Participation will be considered in your final grade assessment at my discretion. Misconduct in class will not be tolerated. Mistreatment of others, including breach of verbal decorum, is grounds for removal from class. Refer to the [ACU student handbook](#) for more information on such policies.

On-line Decorum: Just as you treat people with respect in the classroom, I expect you to extend that respect to on-line forums, as well. Exercise the Golden Rule with liberality and give each other the benefit of the doubt, when possible.

Dress Code: Please follow the student guide. If you aren't sure, don't wear it. Respect your classmates. I reserve the right to ask you to remove hats, e.g. during exams.

Homework: Submit legible work of professional quality, well-enough organized that you have an inkling of what you were thinking when you review it, later! Assignments must be submitted on time. Late assignments may be returned ungraded with a score of zero.

Exams: Make-up exams will be administered only for university-approved absences (e.g. university-sponsored activity), provided you furnish me with written notification and documentation prior to the absence. There will be no make-up final exam.

Collaboration: Collaboration is strongly encouraged! HOWEVER, it is still critical for you to “own” material. Assistance should be limited to verbal help. Do not take written information from others. This will help you think independently after receiving assistance. Excellent performance on homework correlated with poor performance on exams is one indicator you are receiving too much help.

Drop Policy: All university policies and deadlines must be followed.

Technology use: Cell phones, laptops, iPods, or other electronic devices are not allowed in face-to-face class unless we use them corporately. If I determine your electronic device is disturbing the class or distracting you or others, whether in a face-to-face or virtual setting, you will be dismissed. If such distractions become a pattern, I will not hesitate from further action, including expulsion from the course.

Academic Integrity: DO. NOT. CHEAT. All university policies concerning academic misconduct—including plagiarism and cheating—apply implicitly to all assessment activities whether or not it is explicitly stated on the assignment. Additionally, I expect you to report academic misconduct if you witness it. ***Failure to report academic dishonesty is considered academic dishonesty, at my discretion.*** Do not discuss quizzes or exams with anyone who has yet to take them. Please consult me for assistance on homework! However, assignments submitted in your name must reflect your original work. Copying the work of anyone, past or present, is a violation of Academic Integrity and will lead to disciplinary action including but not limited to loss of credit, course grade reduction, and automatic course failure.

Chegg: Use of Chegg or any similar website, e.g. that works assignments for you, *for any reason whatsoever*, is prohibited! As a violation of academic integrity, such use is subject to all penalties listed above and is furthermore grounds for immediate dismissal from the course.

Calendar

Refer to Canvas Calendar for the most up-to-date information. Modules are already in place for each week's activity. Please, also, refer to the [university academic calendar](#) for key dates relevant to our campus.

DATE	TOPICS COVERED	CHAPTERS
08/25	Newton's Laws of Motion	1
08/27	Newton's Laws of Motion & Projectiles and Charged Particles	1 & 2
09/01	Projectiles and Charged Particles & Momentum and Angular Momentum	2 & 3
09/03	Momentum and Angular Momentum	3
09/08	Energy	4
09/10	Energy	4
09/15	Energy & Oscillations	4 & 5
09/17	Oscillations	5
09/18	<i>Independent Project Proposal Due</i>	
09/22	Oscillations & Calculus of Variations	5 & 6
09/24	Calculus of Variations & Lagrange's Equations	6 & 7
09/29	Lagrange's Equations	7
10/01	Lagrange's Equations	7
10/06	Lagrange's Equations & Two-body Central Force Problems	7 & 8
10/08	Two-body Central Force Problems	8
10/13	Exam 1 (Chapters 1-7)	
10/15	Two-body Central Force Problems	8
10/16	<i>Independent Project Progress Report Due</i>	
10/20	Mechanics in Non-inertial Reference Frames	9
10/22	Mechanics in Non-inertial Reference Frames	9
10/27	Mechanics in Non-inertial Reference Frames	9
10/29	Rotational Motion of Rigid Bodies	10
11/03	Rotational Motion of Rigid Bodies	10
11/05	Rotational Motion of Rigid Bodies	10
11/06	<i>Independent Project Rough Draft Due</i>	
11/10	Rotational Motion of Rigid Bodies	10
11/12	Rotat. Motion of Rigid Bodies & Coupled Oscillators and Normal Modes	10 & 11
11/13	<i>Independent Project Peer Review Due</i>	
11/17	Coupled Oscillators and Normal Modes	11
11/19	Coupled Oscillators and Normal Modes	11
11/24	Exam 2 (Chapters 8-10)	
11/26	Thanksgiving Break (no class)	
12/01	Virtual Meeting: Hamiltonian Mechanics	13
12/03	Virtual Meeting: Hamiltonian Mechanics	13
12/04	<i>Independent Project Final Report Due</i>	
12/10	Final Exam (Chapters 1-11 & 13), 8:00-9:45 AM	