PHYS 304: Mechanics

Units: 4

Term—Day—Time:

- ➢ **Fall 2022**
- ➢ **Tuesdays and Thursdays from 8.00 am to 9.50 am**
- ➢ **Two 110 minutes classes per week, 15 weeks**

Location:

- ➢ **In-Person: GFS 118 (Grace Ford Salvatori Hall)**
- ➢ **And Online (live session):** **https://usc.zoom.us/j/92198379756** **(check our Blackboard page for the passcode)**

Instructor:

- ➢ **Dr. Marcin Abram**
- ➢ **e-mail: mjabram@usc.edu**

Teaching Assistant:

- ➢ **Chunyu Tan**
- ➢ **e-mail: chunyuta@usc.edu**

Students Hours (also known as Office Hours):

- ➢ **Wednesday 5-6 pm**
- ➢ **Online: https://usc.zoom.us/j/8934576028 (check the meeting passcode on our Blackboard page)**
- ➢ **Everybody is welcome!**
- ➢ **Drop-in, drop-out style. It means you don't have to make an appointment. Just join the session and ask your questions.**

Piazza:

- ➢ **https://piazza.com/usc/fall2022/phys304/home**

Course Description

Physics 304 is an intermediate-level course in classical mechanics, the study of the dynamics of macroscopic objects, which can range in size from a few microns to the scale of planets and stars. This class can also be seen as a first course in the canon of theoretical physics. It is also your gateway to study quantum mechanics (PHYS 438). The official USC prerequisites for PHYS 304 are Physics 151 or 161 and Math 245. We'll make heavy use of concepts from single-variable and multivariable calculus, as well as differential equations, right from the start. The goal is to build on ideas from introductory mechanics while developing a range of new math skills. The topics include free and driven oscillations, the calculus of variations, Lagrangian mechanics for free and constrained systems, Hamiltonian mechanics, rotational dynamics, general relativity, and chaotic systems.

Learning Objectives

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

1. Describe (quantitatively and qualitatively) the dynamics of macroscopic objects.
2. Describe physical systems using Lagrangian and Hamiltonian formulations of mechanics.
3. Apply single-variable and multivariable calculus to solve a range of classical physics problems, including free and driven oscillators, free and constrained systems of particles, systems in noninertial reference frames, etc.
4. Discuss modern advances in classical physics (e.g., nonlinear dynamical systems, chaos theory, etc.).

Prerequisite(s)

I have constructed the course with the understanding that you have completed (or you are familiar with the content of):

★ Either PHYS 151 (Fundamentals of Physics I: Mechanics and Thermodynamics) or PHYS 161 (Advanced Principles of Physics I), and

★ MATH 245 (Mathematics of Physics and Engineering I).

Co-Requisite(s) or Concurrent Enrollment

None.

Recommended Preparation

To succeed with this class, review the information from:

★ Introduction to Physics (mostly the sections devoted to mechanics; however, some basic knowledge about electric and magnetic fields will be handy too).

★ Calculus (you should be able to solve single-variable and multivariable equations).

★ Mathematical Analysis (you should be able to solve simple integrals and know methods of solving linear differential equations).

★ Algebra (you should be fluent with complex numbers and matrix calculus; you should be able to calculate eigenvalues and eigenvectors).

Course Notes

This course will be comprised of:

- ★ lectures,
- ★ weekly quizzes (short take-home conceptual assignments),
- ★ weekly problem sets (longer quantitative questions),
- ★ a student project (discussed below), and
- ★ a final exam.

The course will ordinarily be taken for a letter grade. Documents, including lecture notes, homework assignments will be distributed online via the course Blackboard site.

You are expected to buy/rent just one book, "Classical Mechanics" by John R. Taylor. All other required or recommended readings will be available free of charge either from the USC libraries, https://libraries.usc.edu/, or they will be uploaded to the Blackboard site of our class.

Description and Assessment of Assignments

Weekly problem sets

Each Thursday, I will publish a problem set. Those are take-home assignments that require you to write down solutions to various quantitative physical problems. A portion of the problem set can be also dedicated to some conceptual questions. Each problem set will be worth 16 points. There will be 11 problem sets in total. You will all have approximately 7 days to complete each problem set. The solutions should be uploaded on our Blackboard site in a form of a single pdf file (you can either write the solutions in LaTeX or you can write them by hand, scan the papers and create a pdf). As long as the problem set is open, you will be able to send multiple answers (only the latest submitted answer will matter). The closing time for the problem set is always on the following Thursday at 8 am PT (Pacific Time). Specifically,

- ★ The deadline for the *first* problem set is on Thursday, September 1, 2022, at 8 am PDT
- ★ The deadline for the *second* problem set is on Thursday, September 8, 2022, at 8 am PDT.
- ★ …
- ★ The deadline for the *twelfth* problem set is on Thursday, November 17, 2022, at 8 am PST.

You can find the full schedule in the "Course Schedule: A Weekly Breakdown" section on page 12.

Note, that in those written assignments, the completeness and the clarity of your solution (your calculations or derivations) will matter as much as the final correct answer. Sending just a single final value (even if correct) is not enough. See the table below:

Grade Component	**Meets Expectations (75%-100%) For Problem Sets: 9-12 points**	**Approaches Expectations (50%-75%) For Problem Sets: 6-9 points**	**Needs Improvement (0%-50%) For Problem Sets: 0-6 points**
Completeness (25%)	All questions are answered. All cases are considered.	Most questions are answered. The most obvious cases are considered (for example non-zero forces are examined, but the student didn't consider a special case when F=0).	The main question is not addressed. The answer is irrelevant to the task.

			The analysis of the issues and events is either vague or incomplete.
Clarity (25%)	A non-expert (e.g., a fellow student) can understand the solutions. All concepts and used techniques are defined and explained. Whenever it is applicable, the solution is accompanied by illustrative plots. The plots are explained and interpreted. There are references to sources.	The teacher (or another professional physicist) can understand the solution but a non-expert might have some trouble doing so. The solution has some minor shortcuts or some non-explained assumptions. Not every step of the analysis is explained, but it is still possible to follow the author's logic. Some references are missing.	It is hard to follow the solutions. The solution has some major shortcuts or hidden assumptions. There are no references in the texts. The analysis or evaluations of the issues and events are vague. It is either hard or impossible to understand or verify the correctness of the calculations.
Validity (50%)	All calculations are correct. The final values (or plots) are correct and the final interpretation or conclusions are probable.	Small mistake in the answers and/or calculations (e.g., a wrong sign, a missing constant). The final answer is close to the correct value (e.g., it differs by a small factor - twice too large or twice too small; however, the general trend is correct).	Major mistakes in the calculations and/or in the analysis. The final values and/or conclusions are incorrect.

Student Project

Your task is to:

★ prepare an article (the *absolute* limit of 5000 words; can be shorter; the recommended length is about 3000-3500 words) on one of the topics below.
★ Peer-review two articles prepared by your colleagues.
★ Address the comments that you received from your peers.
★ Record a short summary (3-4 minutes) of your work (either as a video presentation or a narrated slideshow).

The objective of this assignment is to a) explore literature regarding modern topics in the field of classical mechanics, b) synthesize the acquired knowledge in the form of an article, c) write peer-review comments, d) respond to peer-review comments, e) summarize the main points of your work in a form of a short presentation.

Projects Propositions (choose one):

❏ *(For those who like Physics)* Compare three formulations of classical mechanics: 1) Newtonian, 2) Lagrangian, and 3) Hamiltonian formulations. Some possible starting points: Explore what *makes* those formulations similar and what makes them different. Discuss the context in which each formulation is the most likely to be used. Present examples of problems solved in each formalism. Discuss applications of each formalism in other branches of physics (for example Hamiltonian formalism is really popular in describing quantum systems - what makes this formulation more useful in this context?).
❏ *(For those who like programming)* Describe solutions of some classical nonlinear mechanical systems (a good starting point could be a driven damped pendulum; however, you are also encouraged to look at other systems). Possible ways of approaching this topic: Using the programming language of your choice, visualize different solutions for the chosen system. Find the range of parameters that leads to stable and chaotic solutions.

Characterize (and visualize) the chaotic solutions. Describe the role of non-linearity for the existence of chaotic behavior.

- ❏ *(For those who like math)* Explore solutions of the discrete logistic equation. Possible course of actions: Plot the sequence of points generated by logistic equations for a range of parameters. For some values of the parameters, the solutions lead to chaotic behavior. Characterize that chaotic behavior and experimentally find (some) bifurcation points. Contrast your findings with the literature.
- ❏ *(For those who like astronomy)* Discuss the problem of three (or more) moving bodies in a vacuum. The bodies have a non-zero mass and interact with each other via gravitational force. Discuss the possibility of making long-term predictions regarding the position of those bodies. Possible course of actions: Characterize if the orbits of those objects can be stable. Describe the chaotic behavior of the system. Contrast your findings with the literature describing state-of-the-art simulations of our Solar System. Is our Solar System chaotic? With more than three bodies (for example with 5) even more interesting solutions are possible. Yet one another possible direction (I don't want to limit you, only give some possible starting points) might be related to the concept of "space invaders" (particles that enter our system from infinity). The ramifications of the "space invaders" existence are far reached - also on the philosophical level, as they challenge the belief that Newtonian systems can be deterministic. This particular direction is related to with the next topic...
- ❏ *(For those who like reading)* Compare different takes on the question of whether the Newtonian systems are deterministic. Possible starting points: Describe the "space invaders" concept and the "Norton's Dome" construction. Confront those examples with the statement made by Mark Wilson in *"Determinism and the Mystery of the Missing Physics"*, The British Journal for the Philosophy of Science **60**, 173–193 (2009). This article can be your starting point - but you should not stop there. You are expected to find other relevant sources. At the end of your article, you might express your own opinion. After all your research, are Newtonian systems deterministic or not? What about our world? Is our world deterministic or non-deterministic?
- ❏ *(For those who don't like the above projects)* Modify the above propositions or propose your own project. Discuss your choice with the instructor.

Structure and Formatting:

We encourage you to use the LaTeX template https://www.overleaf.com/read/xhhfdbkzycdt that I prepared for you in Overleaf. If you use a WYSIWYG editor, please remember to submit your article in PDF format (not as a docx, rtf, or odt). If any numerical methods were used to visualize or calculate anything, a link to a GitHub repository with relevant code, scripts, or notebooks (for those who used Mathematica or Jupyter) should be provided. If you are using numerical methods, you are free to use any language of your choice - as long as the code is clear and well commented (to give me a chance to understand what you did). Regarding the format of your article, you are expected to follow either the APS Physical Review or the Nature style guidelines, see:

- https://journals.aps.org/prb/authors (APS Physical Review)
- https://cdn.journals.aps.org/files/styleguide-pr.pdf (APS Physical Review)
- https://www.nature.com/articles/nphys724 (Nature Physics)

Steps:

1. Prepare and post a work plan by **Tuesday, September 6, by 8 am PDT**. At this point, you don't have to have any particular topic in your mind. However, you should have a plan for how long your "exploration" phase should last. You should plan: when you should have your topic, when you should start writing your article, etc. Make sure that your plan is consistent with all the deadlines described in this syllabus.
2. Choose your topic.
3. Find relevant literature. Read about your topic. Prepare a literature review **by Tuesday, September 20, by 8 am PDT**.
4. Make a plan for your article. Decide which aspects you are going to describe and which aspects you will leave out. After all, you have limited space (only a couple of pages, including figures and bibliography, see the template that I prepared for you) and you can not fit everything. Submit your paper outline **by Tuesday, October 4, by 8 am**.
5. Complete the necessary calculations (depending on your topic, there will be some numerical or analytical calculations). Prepare plots and figures.
6. Write the first version of your article. You should have an early draft by October 18. You do not have to upload it yet - it is your internal deadline.
7. Proofread your article. Make sure that all key terms are defined. Make sure that the article has the right structure (introduction, the main content, summary, bibliography). Remember, that the list of references at the end of your paper is not enough - your sources must be cited in the article (see the template that I prepared for you).
8. Prepare a pdf of your article. Make sure that the number of words is below the maximum limit. Make sure that your name, affiliation, abstract and paper title are visible on the first page. Submit the pdf using Blackboard **by Tuesday, November 1, not later than 8 am PDT**.
9. Choose two articles prepared by your peers (we will coordinate this process, to make sure that each article gets an equal number of reviewers). Read the articles. Using the Blackboard forum, give each author suggestions on how they can improve their papers. You should complete this action **by Tuesday, November 15, by 8 am PST**.
10. Read the suggestions you received from your peers. Address them (either incorporate the suggested changes or challenge them, describing in a separate post why you think those changes would not improve the quality of your article).
11. Submit your final article **by Tuesday, November 29, by 8 am PST**.
12. Record a short summary of your work (3-4 minutes), either as a brief video presentation or a narrated slideshow. Submit your video **by Thursday, December 1, no later than 8 am PST**.
13. Write an academic reflection, summarizing your experience. Submit it **by Thursday, December 1, by 8 am PST**.

Additional Notes:

You are free to use any sources. However, you must cite all sources that you used (if not, you will violate the academic integrity standards). It might happen that you will cite non-peer-reviewed sources, like technical documentation of certain libraries or technical blog posts. This is acceptable as long as the non-peer-reviewed sources do not constitute the majority of your bibliography. If you decided to use quotes, remember to use them correctly. Plagiarism (or using sources without proper citations) is a major violation of the university academic integrity standards and will be reported to the Office of Student Judicial Affairs and Community Standards at USC, see details at https://sjacs.usc.edu/students/academic-integrity/ - to review the possible sanctions and penalties, check the Appendix A: Academic Dishonesty Sanction Guidelines.

When you write your article, think about your audience. Your main audience is not the instructor, but rather your peers. Write in a way that your colleagues can understand. You can assume certain fluency in math and technology in your readers, but do not assume that your audience has any specific prior familiarity with the topic of your paper.

Grading Criteria:

Grade Component	Meets Expectations (90%-100%)	Approaches Expectations (75%-90%)	Needs Improvement (50%-75%)	Inadequate (0%-50%)
Content	The content matches the topic. The overall quality of the work is high. The topic is challenging. The analysis and the discussion are comprehensive.	The content matches the topic. The overall quality of the work is high - however, there are some minor problems. For example, the discussion part doesn't cover all the important aspects.	The content matches the topic. However, there are some major issues. For example, the analysis and the discussion are far from being comprehensive.	The content does not match the topic; There are major factual mistakes. We detected that *any* part of the text was not written independently (plagiarism).
Support	All claims are supported by relevant citations. Citations are high quality (mostly peer-reviewed sources).	All claims are supported by relevant citations. Citations are low quality (mostly non-peer-reviewed sources).	Not all claims are supported. Citations are low quality (mostly non-peer-reviewed sources).	No citations (note, a simple list of references at the end is not enough)
Clarity	The reader can understand everything without any problem.	There might be a few places in the paper, where the reader might have trouble understanding all the details.	There might be several parts of the paper that might be unclear to the reader.	The reader might have trouble understanding what the paper is about.
Organization	The organization of the article makes sense given the topic. All key sections are present (in correct order).	Minor problems with the organization of the article.	Problems with the organization of the article might affect the ability of the reader to understand the work (e.g., the reader might feel like sections are not connected, that the flow of the article is abrupt or chaotic).	Not all key sections are present, e.g., there are no abstract or no conclusions.
Format and Style	The format and the style match the journal's guidelines. In other words: the end product looks like an academic article.	Minor problems with the style and the format.	Major problems with the style and the format.	The format and style of the article violate the journal's guidelines.

Final Exam

You will be asked to solve similar problems as those that are included in the weekly problem sets. The official date for our exam is Tuesday, December 13 from 4.30 to 6.30 pm, see https://classes.usc.edu/term-20223/finals/.

Technological Proficiency and Hardware/Software Required

None required.

Note, that some students' projects might require a basic knowledge of a programming language (it could be one of many: R, Python, Julia, Java, or C++) or basic proficiency in some mathematical software (e.g., Mathematica, MATLAB). However, this is optional. You can always choose a project that requires no programming skills whatsoever (where all solutions can be solved analytically or using standard approximation techniques). So if you do not like programming, you have options to avoid tasks that require numerical calculations.

Required Readings and Supplementary Materials

We will mainly follow John R. Taylor, *Classical Mechanics* (2005) and (partially) L. D. Landau and E. M. Lifshitz, *Mechanics* (1976).

Note, that the digital version of L. D. Landau and E. M. Lifshitz, *Mechanics* (1976) is available for *free* via the USC library (go to https://libraries.usc.edu/, search for *Landau Mechanics*, enter the Elsevier ScienceDirect Books Complete and download chapters of the book).

Grading Breakdown

Course Element	Points
Weekly Problem Sets (12)	176 (=16x11)
Work Plan	4
Literature Review	10
Project Outline	10
Project Draft	20
Peer Reviews	20
Student Project	80
Final Presentation	10
Academic Reflection	10
Final Exam	60
TOTAL	**400**

Grading Scale

Course final grades will be determined using the following scale.

Final Grade	% of Total Points	Number of Total Points (rounded down)
A	[92% - 100%]	368-400
A-	[89% - 92%)	356-367.9
B+	[86% - 89%)	344-355.9
B	[81% - 86%)	324-343.9
B-	[78% - 81%)	312-323.9
C+	[75% - 78%)	300-311.9
C	[70% - 75%)	280-299.9
C-	[67% - 70%)	268-279.9
D+	[64% - 67%)	256-267.9
D	[59% - 64%)	236-255.9
D-	[55% - 59%)	220-235.9
F	[0% - 55%)	0-219.9

Assignment Submission Policy

Late solutions to quizzes or problem set solutions will not be accepted. The reason is, that after the deadline, during the following lecture I will discuss the correct solutions - thus, after that, if you sent me late work, I won't be able to determine whether your solution is original or not.

Note, that the grading brackets in the table above are lower than in other courses. It means that you can be late (or omit) two problem sets (2x16 points) and still be able to collect up to 368 points and receive A.

Grading Timeline

I will make every effort to grade and return homework within 10 days after it is received. Homework solutions will be either described during the lectures or posted on Blackboard.

Academic Integrity

You will get an individual grade at the end of this course, thus you shall write answers to any assignments individually as well. As long as the submission period for the problem set is open, you shall not share your solutions. Specifically, on Piazza, before the deadline is due, you are forbidden to explicitly discuss the solutions to the problems. However, if you see that somebody is stuck, you can help your colleague by giving a hint, explaining the concept your colleague struggle with, or suggesting a helpful resource. If you are uncertain whether a particular hint or help is allowed, ask and we will be happy to assess the situation for you.

If you happened to find a solution to a problem in a textbook, on the internet, or in some other resources, you are obligated to acknowledge this by providing a proper citation. You should also clearly indicate which portion of your solution was inspired by some sources (or people) and what is your individual contribution. I acknowledge that it is hard to unseen things that you have seen, so if you happened to find a similar problem with a solution, you should not pretend that it didn't happen, just acknowledge the source. I will never punish honest behavior. However, if we find that you copied a part of your solution without providing an appropriate acknowledgment or citation, we will see this as a violation of academic integrity. Note, that using sources without proper citations is a form of plagiarism and as such, it is a major violation of the university academic integrity standards and will be reported to the Office of Student Judicial Affairs and Community Standards at USC. See the detailed description of what a violation of academic integrity is at https://sjacs.usc.edu/students/academic-integrity/ and to have an overview of the sanctions and penalties, check the Appendix A: Academic Dishonesty Sanction Guidelines.

Additional Policies

Names, Gender:

If you have a name and/or pronouns that differ from those in your official USC records, please let me know.

If I am mispronouncing your name, please correct me. I am highly empathetic on this point because my given name (Marcin) is pronounced [ˈmart͡ɕin] using the International Phonetic Alphabet and is often mispronounced in the US.

Mental Health:

If you feel that experiences outside of class are impacting your course performance, please come and talk to me. If you would rather consult someone outside the classroom, you might contact the USC Counseling and Mental Health (https://studenthealth.usc.edu/counseling/) or the Academic Counseling (https://undergrad.usc.edu/services/counseling/) services.

Faculty Liaisons:

All classes in the Department of Physics & Astronomy have an assigned Faculty Liaison (previously called "Course Ombudsman") to serve students as a confidential, neutral, informal, and independent resource when they wish to discuss issues concerning their course without directly confronting their instructor. The Faculty Liaison for this class is Dr. Jack Feinberg, e-mail: feinberg@usc.edu, phone 213-740-1134. You can also find him in the SSC 327 (room 327 in the Seaver Science Center).

Equity and Diversity and Title IX:

The Office of Equity and Diversity (OED) and the USC Title IX Office works with faculty, staff, visitors, applicants, and students around issues of protected class: https://eeotix.usc.edu/. Incidents of bias, hate crimes, and microaggressions can be confidentially reported to: https://studentaffairs.usc.edu/bias-assessment-response-support/.

Accommodations:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me as early in the semester as possible. If you have registered accommodations with the Disability Services and Programs Office (https://dsp.usc.edu/), please communicate those to me at your earliest convenience so we can discuss your needs in this course. For those on or near campus, DSP is located in STU 301 and is open from 8.30 am to 5.00 pm, Monday through Friday. They can be contacted online or by phone at (213) 740-0776 (Phone), (213) 740-6948 (TDD only), or via email, ability@usc.edu.

Statement for observance of religious holidays

USC's policy grants students excused absences from class to observe religious holidays: http://orl.usc.edu/life/calendar/absences/. In this case, please contact your instructor in advance (at least a week in advance) to agree on alternative course requirements.

Hybrid Classroom Policies

Sadly, the pandemic is not over. We should be mindful of the various risks and the challenges present this year. By all means, we should protect our health and the health of other people. While the official recommendation of the university is that we should have classes in person, I will do everything possible to offer you a choice. I designed this class so it can be delivered in a hybrid format. You can attend our in-person classes. However, whenever you feel like your physical presence could put you or others at risk (e.g., you feel like you had a potential exposure - for example, you attended a party where many unmasked individuals were present; you feel unwell or you had felt unwell sometime in the last 10 days; you have any conditions that puts you at higher risk; any other reason), you can also choose to participate remotely. I will steam live our lectures, so you will be able to attend them remotely, in a synchronous way. The setup of the classroom will allow you to not only watch the lecture live but also ask questions, receive answers and interact with other students (at least, via voice). I will do my best to make sure that your learning experience is the same regardless of whether you are in the same room as me, or your participation is remote. All assignments are compatible with the asynchronous learning principles. It means, that even if your physical location is in a different time zone, you will have a chance to complete all assignments. Students for whom our course time falls outside the reasonable learning hours[1] in their time zone, don't have to attend our live sessions (Your sleep is important). Instead, you will be able to watch the recorded sessions. You will be able to find them on the Blackboard page of our class.

Special Accommodations

If you need any special accommodations, tell me.

If you are in a situation that prevents you from attending the lectures (either in person or remotely), e.g., the time of the lectures collides with your work or with other obligations (e.g., you are a primary caregiver for a child, elderly parents, or other dependants), please let me know.

Camera Policy (For Those Attending Remotely)

The official Camera Policy can be found at
https://www.provost.usc.edu/policy-and-guidelines-for-asynchronous-learning/.

Seeing your faces can help me to gauge if the tempo of the lectures is adequate. Therefore, it would be a great help if you keep your cameras turned on. However, I acknowledge that there might be many reasons why you might wish to keep your privacy. You might also face bandwidth

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[1] See https://www.provost.usc.edu/policy-and-guidelines-for-asynchronous-learning/, espeficially the section on the Class Participation and Attendance in Synchronous Sessions.

limitations that prevent you from using the camera. I encourage the use of virtual backgrounds and earphones/headsets whenever it is possible to mitigate privacy concerns.

Course Schedule: A Weekly Breakdown

	Topics	Readings	Deliverables
Week 1 August 23 August 25	Introduction, Newton's Law of Motion, Projectiles, Air Resistance, Linear Drag, Quadratic Drag.	Taylor Chapters 1 and 2.	--- ---
Week 2 August 30 September 1	Linear and Quadratic Drag (continuation). Motion in Uniform Magnetic and Electric Field. Momentum, Angular Momentum.	Taylor Chapters 2 and 3.	Problem Set 1 (September 1)
Week 3 September 6 September 8	Kinetic Energy, Work, Path Integrals, Potential Energy, Conservation Laws, Conservative Forces, Central Forces.	Taylor Chapter 4.	Work Plan (September 6) Problem Set 2 (September 8)
Week 4 September 13 September 15	Oscillations, Driven and Damped Oscillators, Resonance, Fourier Series.	Taylor Chapters 5.	Problem Set 3 (September 15)
Week 5 September 20 September 22	Calculus of Variation, the Euler-Lagrange Equations.	Taylor Chapters 6 and 7. Landau Chapter 1 and 2.	Literature Review (September 20) Problem Set 4 (September 22)
Week 6 September 27 September 29	Lagrange's Equations with Constraints. Again About Conservation Laws. Motion in Central Field.	Taylor Chapter 7. Landau Chapter 3.	Problem Set 5 (September 29)
Week 7 October 4 October 6	Two-Body Central-Force Problem, Reduced Mass, Equation of the Orbit. *(Midterm Grading Period begins)*	Taylor Chapter 8.	Project Outline (October 4) Problem Set 6 (October 6)
Week 8 October 11 ---	Mechanics in Noninertial Frames, Coriolis Force.	Taylor Chapter 9.	
Week 9 October 18 October 20	Collision Theory, Scattering.	Taylor Chapter 14.	Problem Set 7 (October 20)
Week 10 October 25 October 27	The Motion of a Rigid Body, Principal Axes of Inertia, Euler's Equations, and Euler Angles.	Taylor Chapter 10.	Problem Set 8 (October 27)
Week 11 November 1 November 3	Coupled Oscillators and Normal Modes. Small Oscillations. *(Midterm Grading Period ends)*	Taylor Chapter 11. Landau Chapter 5.	Article Draft (November 1) Problem Set 9 (November 3)
Week 12 November 8 November 10	Hamiltonian Mechanics. Ignorable Coordinates. Conservation Laws Again.	Taylor Chapter 13.	Problem Set 10 (November 10)
Week 13 November 15 November 17	A Buffer Week (in case we had a delay) or some special topics, e.g., Continuum Mechanics, the Wave Equation, Stress Tensor, Hooke's Law.	TBA or Taylor Chapter 16.	Peer Reviews (November 15) Problem Set 11 (November 17)
Week 14 November 22 ---	Nonlinear Systems and Chaos Theory. Bifurcation Diagram. The Logistic Map.	Taylor Chapter 12.	
Week 15 November 29 December 1	Special Relativity. Time dilatation. Length Contraction. The Lorentz Transformation.	Taylor Chapter 15.	Final Article (Nov 29) Final Presentation (Dec 1) Academic Reflection (Dec 1)

Final Exam December 13	Official Examination Day is Tuesday, December 13 from 4.30 to 6.30 p.m. *(Final Grading Period ends on December 20)*		

Student Hours (also known as Office Hours)

I will host an additional 60-minute meeting, on Wednesday from 6 pm to 7 pm. You can access it via Zoom: https://usc.zoom.us/j/8934576028 (the meeting passcode you will find on our course page on Blackboard). Those Student Hours (also known as Office Hours) are a dedicated time when you can come to ask questions and resolve confusion about course material, as well as discuss career and educational goals as they relate to this course.

No special appointment is needed, however, if you sent me an email a day earlier, announcing a type of question you have, I might be able to prepare a better answer for you in advance.

If you have any sensitive questions, you can also contact me via mail, mjabram@usc.edu and we can schedule a 1-on-1 meeting via Zoom outside the student hours period. If you attend in-person meetings, you can also chat with me after the class.

Support Systems

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct,

intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
uscsa.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.