



PHYS 5310

Fall 2024

Classical Mechanics

Mario C. Díaz

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Class meeting dates and times: Mondays and Wednesdays 9:30 AM to 10:45 AM

Course Modality: Traditional Face-to-Face Courses (TR) but see comments regarding attendance below.

Course webpage: <http://www.mariodiaz.org/classical-mechanics.html>

Course Description: This is an introduction to Classical Mechanics at a graduate level. It does require a knowledge of Calculus of Multiple Variables, some knowledge of differential equations and a knowledge of classical mechanics at the undergraduate level.

required to connect their video feed as well.

1 Teaching philosophy

I personally don't like talking about "Teaching philosophy". I don't know much about the pedagogy of teaching and much less about the philosophy of teaching. I prefer to talk about teaching style. I do not consider myself a good teacher, but I argue that I am a considerate teacher. This means that provided a student makes the necessary effort to read, study and try to understand the material it is my responsibility to guide the student and help them learn the material. I do not repeat (at least not verbatim) a book content in class. I like to look at the students' faces in class, I like interaction, to receive questions and discuss possible answers. The socratic method it's probably the best way to learn a material. This is difficult to do it in Physics. But we (you the students and I the teacher) should try it. Although I would use a zoom link for every class (and record it) I encourage you to participate physically in the class as much as possible. I will teach in person physically as much as possible (there are times when I will be traveling for business and I'll be forced to teach through zoom). When we use zoom all students are

2 Learning Objectives

This is probably the most fundamental course in the education of a professional physicist. Developed fundamentally in the XVIII century, systematizing the fundamental work of Kepler, Galileo and Newton, it laid down the theoretical foundation of physics in general. Fundamental concepts like physical system, energy, momentum, angular momentum, physical interactions and mathematical constructions like Lagrangian and Hamiltonian of a system in electromagnetism, statistical mechanics, quantum mechanics and modern physics (including nuclear physics and relativity) in general, stand on the foundations developed by the mechanics rationalists of the XVIII century.

A solid command of these concepts and the ability to formulate physical problems in general using this framework of rational mechanics is the major expected outcome of successful completing this course.

WARNING: the topics in the layout below are tentative. There is no guarantee that we will be able to cover all of them. I will prioritize in depth understanding by the majority of the students over amount of topics covered.

3 Course layout

I. THE PRINCIPLE OF LEAST ACTION AND THE EQUATIONS OF MOTION

1. Generalized Coordinates.
2. The principle of least action.
3. Galileo's relativity's principle.
4. The Lagrangian for a free particle.
5. The Lagrangian for a system of particles.

II. CONSERVATION LAWS

6. Energy.
7. Momentum.
8. Centre of Mass.
9. Angular momentum.
10. Mechanical similarity and the Virial Theorem.
11. Noether's theorem.

III. INTEGRATION OF THE EQUATIONS OF MOTION

12. Motion in 1-dimension.
13. Potential energy and period of oscillation.
14. Reduced mass.
15. Motion in a central field.
16. Kepler's problem.

IV. COLLISIONS BETWEEN PARTICLES

17. Disintegration of particles.
18. Elastic collisions.
19. Scattering.
20. Rutherford's formula.
21. Small angle scattering.

V. SMALL OSCILLATIONS

22. Free oscillations in 1-D.
23. Forced oscillations.
24. Oscillations with several degrees of freedom.
25. Vibrations.
26. Damped oscillations.
27. Parametric resonance.
28. Anharmonic oscillations.
29. Motion in a rapidly oscillating field.

VI. MOTION OF A RIGID BODY

30. Angular velocity.
31. The inertia tensor.
32. Angular momentum of a rigid body.
33. The equations of motion of a rigid body.
34. Eulerian angles.
35. Euler's equations.
36. The asymmetrical top.
37. Rigid bodies in contact.
38. Motion in a non-inertial frame of references.

VII. THE CANONICAL EQUATIONS

39. Hamilton's equations.
40. The Routhian.

41. Poisson brackets.
42. The action as a function of the coordinates.
43. Maupertuis' principle.
44. Canonical transformations.
45. Liouville's theorem.
46. The Hamilton-Jacobi equation.
47. Separation of variables.
48. Adiabatic invariants
49. Canonical variables.

VIII. RELATIVISTIC MECHANICS

50. Velocity of propagation of interaction.
51. Intervals.
52. Proper time.
53. The Lorentz transformation.
54. Transformation of velocities.
55. Four-vectors.
56. Four-dimensional velocity.
57. The principle of least action.
58. Energy and momentum.
59. Transformation of distribution functions.
60. Decay of particles.
61. Invariant cross-section.
62. Elastic collisions of particles.
63. Angular momentum.

4 Evaluation

Evaluation will be based on:

1) submission of the solutions for the homework problems assigned at the end of each chapter which are due exactly 1 week after assignment (20%) and, 2) four exams (20% each). The dates for the exams are Monday September 23, Monday October 21, Monday November 18, and Wednesday December 11 (Finals Day).

The exams will be based on the HW assigned.

5 Bibliography

No text book is required. Most of the material will follow **Mechanics** by L. Landau and E. M. Lifshitz (Pergamon Press), but I will be using many other sources in particular for the Relativistic Mechanics part.

I will be providing notes which will be following Landau's book format but also elaborating more on certain topics and presenting others that not every student could have necessarily been exposed to (and Landau's book does not cover Relativistic Mechanics). Notes will be provided in LaTeX, if time permits, or in handwritten pdfs otherwise. Students are encouraged to participate in the editions of these notes.

It is not necessary to buy a book, but if you want to buy one I definitely recommend Landau's.

A good book as a resource is Goldstein, Herbert (1980). *Classical Mechanics* (2 ed.). Addison-Wesley.

ISBN 0201029189.

Other quite famous books are Arnol'd, Vladimir (1978). *Mathematical Methods of Classical Mechanics*. Springer-Verlag. ISBN 0387968903.

Abraham, Ralph; Marsden, Jerrold (1978). *Foundations of Mechanics*. Addison-Wesley.

Lanczos, Cornelius (1986). *The Variational Principles of Mechanics* (4th ed.). Dover Publications. ISBN 0486650677.

Whittaker, E. T. (1999). *A treatise on the analytical dynamics of particles and rigid bodies : with an introduction to the problem of three bodies* (4th ed.). Cambridge University Press. ISBN 0-521-35883-3.

Sommerfeld, Arnold (1952). *Mechanics: lectures on theoretical physics*. New York: Academic Press Inc. ISBN 978-0-12-654670-5. OCLC 803152309.

Fetter, Alexander L; Walecka, John Dirk (1980). *Theoretical mechanics of particles and continua*. New York: McGraw-Hill. ISBN 978-0-07-020658-8. OCLC 6110997.

The following information is provided to you as required by UTRGV policy:
Course Policies and Procedures

We value a positive and supportive learning environment, and for us to thrive together, we must recognize that our responsibilities, actions, and contributions can impact and transform our learning. The course policies listed below are created to ensure your success by fulfilling course expectations while remaining flexible to account for unexpected events.

ATTENDANCE

Students are expected to attend all scheduled classes. UTRGV's attendance policy excuses students from attending class if they are participating in officially sponsored university activities, such as athletics, accommodation by Student Accessibility Services (SAS), observance of religious holy days, or military service.

RECORDING OF CLASSES:

All classes will be recorded and made available to the students. The use of classroom recordings is governed by the Federal Educational Rights and Privacy Act (FERPA), UTRGV's acceptable-use policy, and UTRGV HOP Policy STU 02-100 Student Conduct and Discipline. A recording of class sessions will be kept and stored by UTRGV, in accordance with FERPA and UTRGV policies. Your instructor will not share the recordings of your class activities outside of course participants, which include your fellow students, teaching assistants, or graduate assistants, and any guest faculty or community-based learning partners with whom we may engage during a class session. You may not share recordings outside of this course. As referenced in UTRGV HOP Policy STU 02-100 Student Conduct and Discipline, doing so may result in disciplinary action.

COURSE DROPS

Instructor-initiated drops can have significant financial consequences for students. According to UTRGV policy, students may drop any class without penalty earning a grade of DR (drop) until the official drop date. Following that date, students must be assigned a letter grade and can no longer drop the class. Students considering dropping the class should be aware of the "3-peat rule" and the "6-drop" rule so they can recognize how dropped classes may affect their academic success. The 6-drop rule refers to Texas law that dictates undergraduate students may not drop more than six courses during their undergraduate career. Courses dropped at other Texas public higher education institutions will count toward the six-course drop limit. The 3-peat rule refers to additional fees charged to students who take the same class for the third time.

ACADEMIC INTEGRITY

Members of the UTRGV community uphold the Vaquero Honor Code's shared values of honesty, integrity and mutual respect in our interactions and relationships. In this regard, academic integrity is fundamental in our actions, as any act of dishonesty conflicts as much with academic achievement as with the values of honesty and integrity. The Writing Center is an excellent resource to assist in learning about and avoiding plagiarism in writing. Violations of academic integrity include, but are not limited to: cheating, plagiarism (including self-plagiarism), and collusion; submission for credit of any work or materials that are attributable in whole or in part to another person; taking an examination for another person; any act designed to give unfair advantage to a student; or the attempt to commit such acts (Board of Regents Rules and Regulations, STU 02-100, and UTRGV Academic Integrity Guidelines). All violations of Academic Integrity will be reported to Student Rights and Responsibilities through Vaqueros Report It.

Student Support Resources

We are committed to your personal, academic, and professional success; please know you can reach out to me for questions and/or I can help you identify the resources you need. UTRGV offers student support resources designed to contribute to your well-being and academic excellence. Students seeking academic help in their studies can use university resources in addition to an instructor's office hours. University Resources include the Advising Center, Career Center, Counseling Center, Learning Center, and Writing Center. These centers provide services such as tutoring, writing help, counseling services, critical thinking, study skills, degree planning, and connections student employment (through Handshake and HR Student Employment). In addition, services, such as the Food Pantry are also provided. Locations are listed below. Advising Center, AcademicAdvising@utrgv.edu, BMAIN 1.400 (ph 665-7120), EITTB 1.000 (ph 665-7120) Career Center, CareerCenter@utrgv.edu, BINAB 1.105 (ph 882-5627), ESTAC 2.101 (ph 665-2243). Counseling Center, Counseling@utrgv.edu Mental Health Counseling and Related Services List, BSTUN 2.10 (ph 882-3897), EUCTR 109 (ph 665-2574) Food Pantry, FoodPantry@utrgv.edu, BCAVL 101 & 102 (ph 882-7126), EUCTR 114 (ph 665-3663) Learning Center, LearningCenter@utrgv.edu, BMSLC 2.118 (ph 882-8208), ELCTR 100 (ph 665-2585) University Library, circulation@utrgv.edu, www.utrgv.edu/library, BLIBR ph 882-8221, ELIBR, ph 665-2005 Writing Center, WC@utrgv.edu, BLIBR 3.206 (ph 882-7065), ESTAC 3.119, ph 665-2538.

University Policy Statements

We care about creating a safe and supportive learning environment for all students. The University policy statements below are intended to create transparency for your rights and responsibilities as students. We each contribute to ensuring a safe and positive environment through our actions and conduct, and students are encouraged to advocate for their needs.

STUDENT ACCESSIBILITY SERVICES

Student Accessibility Services staff can be contacted at either campus to learn about and explore accessibility services.

Campus: Brownsville

Location: Music and Learning Center (BMSLC, 1.107)

Phone: phone (956) 882-7374

Campus: Edinburg

University Center (EUCTR, 108)

phone (956) 665-7005

e-mail: ability@utrgv.edu

STUDENTS WITH DISABILITIES

Students with a documented disability (physical, psychological, learning, or other disability which affects academic performance) who would like to receive reasonable academic accommodations should contact Student Accessibility Services (SAS) for additional information. In order for accommodation requests to be considered for approval, the student must apply using the mySAS portal and is responsible for providing sufficient documentation of the disability to SAS. Students are required to participate in an interactive discussion, or an intake appointment, with SAS staff. Accommodations may be requested at any time but are not retroactive, meaning they are valid once approved by SAS. Please contact SAS early in the semester/module for guidance. Students who experience a broken bone, severe injury, or undergo surgery may also be eligible for temporary accommodations.

PREGNANCY, PREGNANCY-RELATED, AND PARENTING ACCOMMODATIONS

Title IX of the Education Amendments of 1972 prohibits sex discrimination, which includes discrimination based on pregnancy, marital status, or parental status. Students seeking accommodations related to pregnancy, pregnancy-related condition, or parenting should submit the request using the form found at Pregnancy and Parenting | UTRGV.

SEXUAL MISCONDUCT AND MANDATORY REPORTING

In accordance with UT System regulations, your instructor is a “Responsible Employee” for reporting purposes under Title IX regulations and so must report to the Office of Institutional Equity & Diversity (OIED@utrgv.edu) any instance, occurring during a student’s time in college, of sexual misconduct, which includes sexual assault, stalking, dating violence, domestic violence, and sexual harassment, about which she/he becomes aware during this course through writing, discussion, or personal disclosure. More information can be found through the Office of Institutional Equity and Diversity, including confidential resources available on campus. The faculty and staff of UTRGV actively strive to provide a learning, working, and living environment that promotes personal integrity, civility, and mutual respect that is free from sexual misconduct, discrimination, and all forms of violence. If students, faculty, or staff would like confidential assistance, or have questions, they can contact OVAVP (Office for Victim Advocacy & Violence Prevention) at (956) 665-8287, (956) 882-8282, or OVAVP@utrgv.edu.

DEAN OF STUDENTS

The Dean of Students office assists students when they experience a challenge with an administrative process, unexpected situation, such as an illness, accident, or family situation, and aids in resolving complaints. Additionally, the office facilitates student academic related requests for religious accommodations, support students formerly in foster care, helps to advocate on behalf of students and inform them about their rights and responsibilities, and serves as a resource and support for faculty and campus departments. Vaqueros Report It allows students, staff, and faculty a way to report concern about the well-being of a student, seek assistance in resolving a complaint, or report allegations of behaviors contrary to community standards or campus policies. The Dean of Students can be reached by email (dos@utrgv.edu), phone (956-665-2260), (956-882-5141), or by visiting one of the following office locations: Cavalry (BCAVL) 204 or University Center (EUCTR 323).

MANDATORY COURSE EVALUATION PERIOD

Students have the opportunity to complete an ONLINE evaluation of this course, accessed through your UTRGV account (<http://my.utrgv.edu>). Course evaluations are used by the instructor to better understand the student experience in the course, which can inform revisions of the course to ensure student success. Additionally, course evaluations are also used by the instructor for annual performance review and promotion applications, teaching award applications, among others. For these reasons, your feedback, reflections, and insights on your experience in the course are invaluable to ensure student success and a quality education for all. You will be contacted through email with further instructions. Students who complete their evaluations will have priority access to their grades.

Online evaluations will be available on or about:

Fall Regular Term 2024 November 13 – December 4, 2024