WILLIAM & MARY
CHARTERED 1693

PHYS 303 – Classical Mechanics of Particles and Waves II

Term: Fall 2024

Credit Hours: 3

Time: Tue/Thu 11:00 am – 12:20 pm

Location: Small Hall, Room 233

Webpage: https://ajackura.github.io/courses/phys303_fall_2024.html

Contact Information

Instructor: Prof. Andrew W. Jackura (he/his/him)

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Phone: 757-221-6369

Office: Small Hall, Room 326B

Office Hours: Tue/Thu 2:00 pm – 3:00 pm, or by arrangement

Grader: Muhammad Nehal Khan

E-mail: mkhan05@wm.edu (*Please contact the instructor with questions about grading*)

Course Information

Prerequisite: PHYS 208 - Classical Mechanics of Particles and Waves I or equivalent. Student should be familiar with Newton's laws of motion, energy and momentum conservation laws, and Lagrangian mechanics, as well as their applications to mechanical systems.

Overview: This is a second course on classical mechanics for undergraduate majors in physics. Topics include, but are not limited to, two-body systems, rigid body rotation, non-inertial frames, continuum mechanics and wave motion, and nonlinear dynamics & chaos.

Outcomes: After successfully completing this course, the student should be able to:

- Analyze and describe the motion of two-body systems interacting via central forces.
- Analyze and describe the motion of mechanical systems in non-inertial reference frames.
- Analyze and describe the translational and rotational motion of rigid bodies.
- Analyze and describe the wave motion of elastic continua.
- Use approximation methods to study the motion of mechanical systems.
- Formulate and solve classical mechanics problems using the Newtonian and Lagrangian formulations.

Text: There is one required text for the course. I recommend having access to some reference on mathematical methods for physics, covering in particular differential equations, advanced techniques in integral calculus, and linear algebra.

Required:

- *Classical Mechanics*,
  by John. R. Taylor, University Science Books, ISBN: 978-1-891389-92-4

Recommended:

- *Mathematical Methods in the Physical Sciences* | 3rd ed.,
  by Mary L. Boas, Wiley, ISBN: 978-0-471198-26-0
- *Classical Dynamics of Particles and Systems* | 5th ed.,
  by Stephen T. Thornton and Jerry B. Marion, Cengage, ISBN: 978-0-534408-96-1
- *Theoretical Mechanics of Particles and Continua*,
  by Alexander L. Fetter and John D. Walecka, Dover Publications, ISBN: 978-0-486432-61-8
- *Classical Mechanics* | 3rd ed.,
  by Herbert Goldstein, Charles Poole, and John Safko, Pearson, ISBN: 978-0-201657-02-9

Readings: The course schedule lists sections of the text that we will try to cover in each lecture. You should reserve about an hour to read over the material before coming to class. *You must read the book carefully and work the example problems to do well in this course.* Much of physics is best learned by reading and doing rather than listening. I am your guide but I cannot cover everything in fine detail during the lecture while also doing examples, computer problems, etc.

Lectures: I plan to focus on advanced topics in classical mechanics of systems of particles, rigid bodies, and continua. A prerequisite for this course is PHYS 208 - Classical Mechanics of Particles and Waves I. This course assumes comfort with applications of Newton's laws of motion and conservation laws, as well as knowledge of Lagrangian mechanics. Having a strong background in mathematical methods for physical applications is useful, including topics such as series expansions, differential equations, linear algebra, and advanced methods in integral calculus, which are typically encountered in your mathematical courses or PHYS 254 - Introduction to Mathematical Physics. As most physical problems are not analytically solvable, we will at times examine numerical solutions to mechanical systems. Having some background knowledge in computational physics is useful, such as PHYS 256 - Practical Computing for Scientists.

Lecture Notes: Lecture notes will be posted on the course website, which will sometimes contain a bit more information than we cover during lecture time. *Please let me know of any errors you spot in the notes.*

Important Dates: See the University registrar for the complete academic calendar (link). Please note the following dates:

Add/Drop Deadline	Mon, Sep 9
Midterm Exam 1	Thu, Oct 03
Fall Break	Thu, Oct 10 (**no class**)
Withdrawal Deadline	Mon, Oct 28
Election Day	Tue, Nov 05 (**no class**)
Midterm Exam 2	Thu, Nov 07
Thanksgiving Break	Tue, Nov 26 & Thu, Nov 28 (**no class**)
Last Day of Class	Fri, Dec 05
Final Exam	Wed, Dec 11

Tentative Schedule: Here is a tentative outline of the subjects that we will cover throughout the course, including relevant readings from the textbook *Classical Mechanics*, by Taylor.

Week	Date	Topic	Readings	PSets
1	Thu, Aug 29	Introduction & Review	Ch. 1 - 7	
2	Tue, Sep 03	Two-Body Systems I	Ch. 8.1 - 8.3	
	Thu, Sep 05	Two-Body Systems II	Ch. 8.4 - 8.5	PS1 due
3	Tue, Sep 10	Two-Body Systems III	Ch. 8.6 - 8.8	
	Thu, Sep 12	Collision Theory I	Ch. 14.1 - 14.4	PS2 due
4	Tue, Sep 17	Collision Theory II	Ch. 14.5 - 14.8	
	Thu, Sep 19	Non-Inertial Frames I	Ch. 9.1 - 9.3	PS3 due
5	Tue, Sep 24	Non-Inertial Frames II	Ch. 9.4 - 9.7	
	Thu, Sep 26	Non-Inertial Frames III	Ch. 9.8 - 9.10	PS4 due
6	Tue, Oct 01	Rigid Body Motion I	Ch. 10.1 - 10.2	
	Thu, Oct 03	**Midterm Exam 1**		
7	Tue, Oct 08	Rigid Body Motion II	Ch. 10.3 - 10.4	
	Thu, Oct 10	**Fall Break (no class)**		
8	Tue, Oct 15	Rigid Body Motion III	Ch. 10.5 - 10.7	
	Thu, Oct 17	Rigid Body Motion IV	Ch. 10.8 - 10.10	PS5 due
9	Tue, Oct 22	Coupled Oscillations I	Ch. 11.1 - 11.3	
	Thu, Oct 24	Coupled Oscillations II	Ch. 11.4 - 11.7	PS6 due
10	Tue, Oct 29	Continuum Mechanics I	Ch. 16.1 - 16.3	
	Thu, Oct 31	Continuum Mechanics II	Ch. 16.4 - 16.5	PS7 due
11	Tue, Nov 05	**Election Day (no class)**		
	Thu, Nov 07	**Midterm Exam 2**		
12	Tue, Nov 12	Continuum Mechanics III	Ch. 16.6 - 16.8	
	Thu, Nov 14	Continuum Mechanics IV	Ch. 16.9 - 16.13	
13	Tue, Nov 19	Nonlinear Mechanics & Chaos I	Ch. 12.1 - 12.4	
	Thu, Nov 21	Nonlinear Mechanics & Chaos II	Ch. 12.5 - 12.9	PS8 due
14	Tue, Nov 26	**Thanksgiving Break (no class)**		
	Thu, Nov 28	**Thanksgiving Break (no class)**		
15	Tue, Dec 03	Hamiltonian Mechanics I	Ch. 13.1 - 13.3	
	Thu, Dec 05	Hamiltonian Mechanics II	Ch. 13.4 - 13.7	PS9 due
16	Wed, Dec 11	**Final Exam: 2:00 p.m. - 5:00 p.m**		

Assessment

Problem Sets: There will be weekly exercises assigned on Thursdays, and due the following week. All problem sets are to be turned into the grader's mailbox by the due date. In case of holidays, breaks, or conferences, the deadline may be adjusted accordingly. All problem sets are individual assignments, where you will turn in your own solution to the prescribed problems. I strongly encourage you to discuss the problems with your fellow students. However, mindless copying of solutions will not be tolerated. Assignments can be submitted either typeset or handwritten, however please ensure your submissions are well-structured and legible. *Show your work & clearly indicate your final answer. Late assignments will not be accepted unless prearranged under extreme circumstances.*

On occasion, there will be assigned problems which require numerical solutions. Most real-world problems require numerical methods to approximate solutions. It is recommended to use `python`, a free programming language, or `Mathematica`, free to William & Mary students, to solve these problems.

Exams: There will be two midterm exams, as well as a comprehensive final exam. The midterm exams will be held on **Thursday October 03** and **Thursday November 07** during the usual lecture time. The final exam takes place on **Wednesday December 11, 2:00 pm - 5:00 pm**. All exams are cumulative. In contrast to the exercises, you are expected to work on the exams individually. All exams will be graded by the instructor. Exams must be taken at the designated time unless prior approval is obtained. Exceptions are granted at the instructors discretion and may require a letter from the Dean of Students. Per college policy, the final exam must be taken at the designated time.

Evaluations: A record of the grades for problem sets and tests will be kept on the course Blackboard webpage. Final grades will be calculated from the weekly problem sets, and the take-home final exam. Their contributions to the total grade is:

Problem Sets	25%
Midterm Exam 1	20%
Midterm Exam 2	20%
Final Exam	35%

Final letter grades will be determined from the numerical grades using:

Grade	Percentage	Grade	Percentage	Grade	Percentage
		A	94 – 100	A-	90 – 94
B+	87 – 90	B	84 – 87	B-	80 – 84
C+	77 – 70	C	74 – 77	C-	70 – 74
D+	67 – 60	D	64 – 67	D-	60 – 64
F	< 60				

Policies

Attendance: Attendance does not form part of the grade for this class and thus is not mandatory. However, you are responsible for your own understanding of the course material. Attending class will significantly improve your enjoyment of the course and will likely improve your satisfaction with both your own understanding and your grade.

Auditing: Students are welcome to audit this course (i.e., participate not for credit). Since one only learns by doing, students who audit this course are expected to hand in exercises as well as the final take-home exam. Although you will not be graded on them, you are expected to make a good faith effort as you would for other courses.

Electronic Devices: You are welcome to bring laptops and mobile devices to class and are responsible for their appropriate use. Please be considerate of others in the class and avoid disrupting the lecture.

Code of Conduct: You will be expected to follow the William & Mary Honor Code as well as the Code of Student Conduct. "As a member of the William & Mary community, I pledge on my honor not to lie, cheat, or steal, either in my academic or personal life. I understand that such acts violate the Honor Code and undermine the community of trust, of which we are all stewards." To read the Honor Code, please see `https://www.wm.edu/honor`.

Accommodations: William & Mary accommodates students with disabilities in accordance with federal laws and university policy. Any student who feels they may need an accommodation based on the impact of a learning, psychiatric, physical, or chronic health diagnosis should contact Student Accessibility Services staff at 757-221-2512 or at sas@wm.edu to determine if accommodations are warranted and to obtain an official letter of accommodation. For more information, please see `https://www.wm.edu/sas`.

Mental and Physical Well-Being: William & Mary recognizes that students juggle different responsibilities and can face challenges that make learning difficult. There are many resources available at W&M to help students navigate emotional/psychological, physical/medical, material/accessibility concerns, including:

- The W&M Counseling Center at 757-221-3620. Services are free and confidential.
- The W&M Health Center at 757-221-4386.
- To seek assistance for interpersonal, academic, and wellness challenges, please contact Care Support Services at `wm.edu/care` (care@wm.edu).
- For a list of other resources available to students, see `https://www.wm.edu/offices/wellness/resources/`