PHYS 310: Classical Mechanics

Term: Fall 2026
Credits: 4.0
Lecture Times & Location: Monday, Tuesday, Wednesday, Friday 11:00–11:50 a.m., Meridian Science Center 140
Modality: In-Person

Instructor Information

- **Instructor:** Dr. Chidi Okoro (Associate Professor of Physics)
- **Email:** cokoro@university.alkimi.ai
- **Office:** Meridian Science Center 412
- **Office Hours:**
  - Monday & Thursday: 1:00–2:30 p.m. (In person, Meridian Science Center 412)
  - Wednesday: 2:00–3:00 p.m. (Virtual via Zoom; link posted in Canvas)
  - Also available by appointment.

Course Description

Newtonian mechanics of particles and systems, oscillators, central-force motion, noninertial frames, rigid-body rotation, and the Lagrangian and Hamiltonian formulations. PHYS 310 provides an advanced, mathematically rigorous treatment of classical mechanics for upper-division physics and engineering students. Building upon multivariable calculus, linear algebra, and differential equations, we reformulate Newtonian particle dynamics into the analytical frameworks of Lagrange and Hamilton. Core topics include damped and driven harmonic oscillators, central-force orbital motion, noninertial reference frames and Coriolis effects, rigid-body tensor dynamics, coupled oscillations, and canonical Hamiltonian mechanics.

Prerequisites

PHYS 121, MATH 240, and MATH 340.

Measurable Student Learning Outcomes

Upon successful completion of PHYS 310, students will be able to:

1. **Analyze Advanced Newtonian Dynamics:** Formulate and solve differential equations of motion for complex single-particle and multi-particle systems subject to velocity- and position-dependent forces.
2. **Evaluate Harmonic Oscillations and Phase Space:** Analyze damped, driven, and resonant oscillators using Fourier techniques and construct phase-space trajectories.
3. **Apply Central Force Motion and Gravitation:** Derive the orbital equation for central force potentials, analyze Keplerian orbits, and calculate orbital transfers and scattering cross-sections.
4. **Transform Equations in Noninertial Frames:** Derive equations of motion in rotating coordinate systems, calculating centrifugal, Coriolis, and transverse Euler forces.

5. **Construct Lagrangian Mechanics Formulations:** Determine generalized coordinates, formulate Lagrangians, derive Euler-Lagrange equations, and identify conserved quantities using Noether's theorem.
6. **Formulate Hamiltonian Dynamics and Coupled Systems:** Perform Legendre transformations to construct Hamiltonians, solve canonical equations of motion, and evaluate normal modes for coupled oscillators.

Required Course Materials & Approximate Costs

1. **Taylor, John R. *Classical Mechanics*. University Science Books, 2005.** Approx. $65 for digital or paperback; approx. $95 for hardcover purchase.
2. **Computational software environment (Python 3 with NumPy, SciPy, and Matplotlib).** Free open-source software.
3. **Total estimated cost:** $65 to $95.

Generative AI Policy (AI Level 2: AI Permitted with Disclosure for Specified Tasks)

In accordance with Alkimi University Academic Policies (Student Handbook §5.8), PHYS 310 operates under **AI Level 2**.

- **What is permitted:** You may use AI tools to check intermediate differential equations, plot phase-space trajectories, clarify the Euler-Lagrange equations, or explore numerical integrations using Python or Mathematica.
- **What is prohibited:** You may not submit AI-generated analytical solutions or derivations for homework assignments, copy AI-written proofs, or access any generative AI or connected devices during examinations.
- **Disclosure:** Include a brief disclosure note at the end of each problem set stating which AI tools were consulted and the specific prompts utilized, or confirm that no AI assistance was employed.

Grading Components and Weights

- **Midterm Exam 1:** 20% (In class, Friday, September 25)
- **Midterm Exam 2:** 20% (In class, Friday, October 30)
- **Weekly Analytical Problem Sets:** 25% (Due Fridays at 11:59 p.m. in Canvas (weeks 2–13; lowest dropped))
- **Computational Mechanics Projects:** 10% (Computational Python/Jupyter modeling assignments due Wednesdays at 11:59 p.m. in Canvas)
- **Final Comprehensive Examination:** 25% (Tuesday, December 15, 2026, 10:30 a.m.–12:30 p.m.)

Grading Scale (Alkimi University Standard)

- **A:** 93–100% | **A-:** 90–92%
- **B+:** 87–89% | **B:** 83–86% | **B-:** 80–82%
- **C+:** 77–79% | **C:** 73–76% | **C-:** 70–72%
- **D+:** 67–69% | **D:** 60–66% | **F:** Below 60%
- **Extra credit:** No extra credit assignments are offered in PHYS 310.

Course Schedule (Fall 2026)

Week	Dates	Topics & Readings	Assignments & Deadlines
Week 1	Aug 26, 28	**Newton's Laws and Particle Dynamics:** Newtonian mechanics in inertial frames, differential equations in Cartesian, polar, and spherical coordinates, and conservation of linear momentum. *Reading: Taylor Ch. 1*	*First day of classes: Wed Aug 26.*

Week	Dates	Topics & Readings	Assignments & Deadlines
Week 2	Aug 31–Sep 4	**Projectiles and Drag Forces:** Linear and quadratic drag force models, horizontal and vertical trajectory equations with resistance, terminal speed, and range corrections. *Reading: Taylor Ch. 2*	*Wed Sep 2: Add/section change deadline.*
Week 3	Sep 8–11	**Conservation Laws and Multi-Particle Systems:** Center of mass dynamics, angular momentum for single and multi-particle systems, torque, and internal versus external forces. *Reading: Taylor Ch. 3*	*Mon Sep 7: Labor Day (no classes). Wed Sep 9: Census date (last day to drop without a W).*
Week 4	Sep 14–18	**Energy and Conservative Potentials:** Line integrals, curl of conservative forces, 1D and 3D potential energy functions, gradient fields, and equilibrium stability criteria. *Reading: Taylor Ch. 4*	—
Week 5	Sep 21–25	**Oscillations, Driven Systems, and Resonance & Midterm Exam 1:** Simple harmonic motion, underdamped, critically damped, and overdamped oscillators, sinusoidally driven systems, and Q-factor; Midterm Exam 1 in class. *Reading: Taylor Ch. 5*	**Midterm Exam 1 (in class).**
Week 6	Sep 28–Oct 2	**Calculus of Variations:** Euler-Lagrange equation derivation, shortest path problems, brachistochrone problem, and variational principles with constraints. *Reading: Taylor Ch. 6*	—
Week 7	Oct 5–9	**Lagrange's Equations in Generalized Coordinates:** Generalized coordinates, degrees of freedom, holonomic constraints, kinetic and potential energy in generalized coordinates, and Lagrange's equations. *Reading: Taylor Ch. 7.1–7.4*	—
Week 8	Oct 14, 16	**Conserved Quantities and Noether's Theorem:** Ignorable/cyclic coordinates, generalized momentum, energy function, spacetime symmetries and conservation laws via Noether's theorem. *Reading: Taylor Ch. 7.5–7.10*	*Oct 12–Oct 13: Fall break (no classes).*
Week 9	Oct 19–23	**Central-Force Motion and Effective Potentials:** Reduction to one-body equivalent problem, conservation of angular momentum, effective potential energy curves, and classification of orbits. *Reading: Taylor Ch. 8.1–8.4*	—
Week 10	Oct 26–30	**Kepler's Problem and Orbital Mechanics & Midterm Exam 2:** Derivation of Kepler's first, second, and third laws, orbital eccentricity, orbital transfers (Hohmann), and Rutherford scattering; Midterm Exam 2 in class. *Reading: Taylor Ch. 8.5–8.8 & 14*	**Midterm Exam 2 (in class).**
Week 11	Nov 2–6	**Mechanics in Noninertial Frames:** Accelerating reference frames, rotating coordinate transformations, centrifugal force, Coriolis force, Foucault pendulum, and weather cyclones. *Reading: Taylor Ch. 9*	*Fri Nov 6: Last day to withdraw (W) or elect Pass/No Pass.*
Week 12	Nov 9–13	**Rigid Body Dynamics: The Inertia Tensor:** Center of mass rotation, angular velocity vector, inertia tensor components, principal axes of inertia, and parallel-axis theorem for tensors. *Reading: Taylor Ch. 10.1–10.4*	—
Week 13	Nov 16–20	**Euler's Equations and Tops:** Euler angles, Euler's dynamical equations for rigid body rotation, torque-free motion of symmetric tops, and forced precession. *Reading: Taylor Ch. 10.5–10.9*	—
Week 14	Nov 23, 24	**Coupled Oscillations and Normal Modes:** Two and three-body coupled mass-spring systems, matrix eigenvalue formulations, secular equation, normal coordinates, and normal modes. *Reading: Taylor Ch. 11*	*Nov 25–Nov 27: Thanksgiving break (no classes).*
Week 15	Nov 30–Dec 4	**Hamiltonian Mechanics:** Generalized momentum, Legendre transform, Hamiltonian function, Hamilton's canonical equations of motion, and phase space trajectories. *Reading: Taylor Ch. 13*	—

Week	Dates	Topics & Readings	Assignments & Deadlines
Week 16	Dec 7–9	**Nonlinear Mechanics, Chaos Prelude, and Review:** Driven nonlinear pendulum, bifurcation diagrams, Poincaré sections, Liapunov exponents, and semester synthesis. *Reading: Taylor Ch. 12 & Review*	*Wed Dec 9: Last day of classes. Thu Dec 10: Reading Day.*
Finals	Dec 15	**Final Comprehensive Examination:** Tuesday, December 15, 2026, 10:30 a.m.–12:30 p.m., Meridian Science Center 140.	Comprehensive examination covering Newtonian, Lagrangian, and Hamiltonian mechanics, oscillations, and rigid bodies.

Course Policies

Attendance Policy

Mastering theoretical classical mechanics requires regular attendance and active engagement during classroom derivations. If an unavoidable illness or approved university event causes an absence, inform Dr. Okoro via email as soon as possible. Repeated unexcused absences will directly impair your understanding and final grade. Students who miss the first two class meetings without notifying the instructor may be dropped. Students may miss class for religious observance without penalty if they notify the instructor in writing within the first two weeks of the semester (by Wednesday, September 9, 2026). Absences for university-sponsored activities (athletics, performances, conferences) are excused with a letter from the sponsoring office at least one week in advance.

Late Work Policy

Homework submissions after the Friday deadline receive a 20% penalty per 24 hours. Because full solutions are distributed shortly after submission, no assignments will be accepted more than 24 hours late. The single lowest analytical problem set score is automatically dropped.

Final Exam Policy

The final examination (Tuesday, December 15, 2026, 10:30 a.m.–12:30 p.m.) is scheduled by the University Registrar and can't be moved without the Dean's written approval (Faculty Handbook §5.5). A student with three or more final exams on the same calendar day may reschedule one of them. Requests go to the instructor of the middle exam by the last day of classes. For this term, send the request by Wednesday, December 9, 2026 (Student Handbook §6.4).

Academic Integrity

Alkimi University is an academic community devoted to rigorous scholarship, open intellectual inquiry, and uncompromising ethical conduct. All students are subject to the regulations of the Alkimi University Academic Integrity Policy. Academic dishonesty—including plagiarism, cheating on examinations, unauthorized collaboration, fabrication of empirical data, and unauthorized submission of academic work generated by artificial intelligence—undermines the integrity of the university and carries severe disciplinary sanctions. Sanctions range from a failing grade on an assignment or exam to an administrative course failure recorded as an 'XF' on the official transcript, academic suspension, or expulsion. Suspected violations are formally investigated and resolved through the Office of Academic Integrity in accordance with Faculty Handbook §6. For detailed information, consult the Office of Academic Integrity, Lovell Hall 315, (555) 555-0163, integrity@university.alkimi.ai.

Accessibility Services

Alkimi University is committed to providing equitable educational access and reasonable accommodations for all students with documented disabilities, including physical, sensory, psychological, learning, and chronic health conditions. Students requesting academic accommodations must formally register with the

Office of Accessibility Services, Harlan Hall 204, (555) 555-0155, access@university.alkimi.ai. Once approved, students will receive an official Faculty Accommodation Letter detailing approved accommodations. Students should present this letter to the instructor as early in the semester as possible, and at least one week prior to any exam or assignment requiring accommodation. Accommodations cannot be applied retroactively.

Student Wellness and Mental Health

Your physical health, psychological well-being, and mental health are essential to your academic success. If you experience heightened stress, anxiety, depressive symptoms, personal trauma, or academic burnout, free, confidential counseling and medical care are available through the Hollis Health & Counseling Center, located in the Hollis Center. Routine appointments are available Monday–Friday 8:00 a.m.–6:00 p.m. and Saturday 10:00 a.m.–2:00 p.m. during the semester by calling (555) 555-0190 or emailing health@university.alkimi.ai. Urgent, 24/7 crisis psychological counseling is accessible immediately at (555) 555-0199.

Campus Student Support Services

- **Academic Advising Center:** Lovell Hall 101 | (555) 555-0158 | advising@university.alkimi.ai
- **Writing Center:** Whitcombe Library 3rd Floor | Free consultations on papers, reports, and research projects at any stage.
- **Whitcombe Library:** Whitcombe Library, Main Floor | (555) 555-0170 | askalibrarian@university.alkimi.ai
- **Hollis Health & Counseling Center:** Hollis Center | (555) 555-0190 | 24/7 Counseling Line: (555) 555-0199 | health@university.alkimi.ai
- **Physics Tutoring Center:** Drop-in peer tutoring and conceptual assistance are available Monday through Thursday from 2:00 to 6:00 p.m.