

Course Description - PHY 3110, Analytical Mechanics, 4 3 credit hours

Prerequisite: PHY 2120, MTH 2210 or permission of instructor

This course explores topics from classical physics including linear and nonlinear oscillations, momentum and energy theorems, conservation laws, rigid body dynamics, and central force field motion. The course is intended for physics, engineering physics, pre-engineering, and other science fields.

Companion Class - PHY2895: Special Topics: Mathematical Methods for Physics, 4pm MWF, 1 hour.

(This course used to be the 4th hour of PHY3110)

Instructor: Dr. Hawley

Physical Office: Janet Ayers Academic Center (AYRS), room 4008

Online Office: <https://tinyurl.com/hawleyzoom> (/ TBD, e.g. Microsoft Teams)

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Office Hours: MF 4pm-5pm, WF 11am-noon, and by appointments scheduled via tinyurl.com/hawleycal2

Meeting Times and Location: MWF 12:00–12:50 pm, JMC 304

Course Web Page: <https://hedges.belmont.edu/~shawley/PHY3110/> and Canvas.

Textbook:

Required: [*Analytical Mechanics, seventh edition*](#), by Fowles and Cassiday. Get it *used*.

Optional, also recommended:

- [*Classical Dynamics of Particles and Systems, 5th Edition*](#) by S.T. Thornton and J.B. Marion,
- or other “classical mechanics” texts such as by [John Taylor](#), [Keith Symon](#), or Griffiths (but not Goldstein or Landau).
- [*Schaum's Outline of Mathematical Handbook of Formulas and Tables, Fifth Edition \(Schaum's Outlines\) 5th Edition*](#). While you will be allowed to use online math resources such as [WolframAlpha](#) and [Desmos](#), having a book that groups useful formulas together that you can flip through is “handy” for learning.

Skill Objectives:

1. Students should be able to demonstrate a functional understanding of the analytical methods of classical physics. As such they will be prepared for future studies in science which build upon this knowledge.
2. Students should be able to successfully employ problem solving techniques such as dimensional analysis, approximation methods, and mathematical expansions.
3. Students will be able to work collaboratively in (some) problem solving experiences.

Course Outline

1. Review of Some Fundamental Concepts
 - a. Dimensions in physics
 - b. ~~Math methods~~ Moved to Special Topics: Math Methods course
 - i. ~~Vectors and scalars~~
 - ii. ~~Various coordinate systems~~
 - iii. ~~The transformation matrix~~
 - iv. ~~Mathematical review: Methods of solving ODEs~~
2. Newtonian Mechanics
 - a. Newton's laws; structure and meaning
 - b. Motion in one dimension
 - c. Position dependent forces

- d. Time dependent forces
- e. Velocity dependent forces
- f. Consequences of Newton's laws
- 3. Oscillations
 - a. The simple harmonic oscillator
 - b. Phase space diagrams
 - c. Damped and driven oscillations
 - d. Resonance
 - e. Applications to physical systems
 - f. Nonlinear oscillations
- 4. Non-inertial Frames of Reference
 - a. Accelerated coordinate systems
 - b. Rotating frames of reference
 - c. Dynamics of particles in non-inertial reference systems
 - d. Effects of rotation
- 5. Motion in Central Force Fields
 - a. The inverse square force
 - b. Potential energy in central force fields
 - c. Angular momentum
 - d. Orbits in central force fields
 - e. The gravitational force
 - f. Planetary motion; Kepler's laws
 - g. Rutherford scattering
- 6. Systems of Particles
 - a. Center of mass concept
 - b. Center of mass frame of reference
 - c. Linear and angular momentum
 - d. Motion with variable mass
 - e. Elastic and inelastic collisions
 - f. Cross sections
- 7. Lagrangian & Hamiltonian Dynamics
 - a. Hamilton's variational principle
 - b. Calculus of variations
 - c. Generalized coordinates
 - d. Lagrange's equations
 - e. Constraints & Lagrange multipliers
 - f. Generalized momenta
 - g. Hamilton's equations

Grading Schema

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|-----------------------------------|-----|
| Tests (3) | 60% |
| Final Examination (comprehensive) | 20% |
| Homework / Class Assignments | 20% |

Grading Scale:

| Course Average | Letter Grade |
|----------------|--------------|
| 90 - 100 | A |
| 87 - 89 | B+ |
| 83 - 86 | B |
| 80 - 82 | B- |
| 77 - 79 | C+ |

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| 73 - 76 | C |
| 70 - 72 | C- |
| 67 - 70 | D+ |
| 63 - 66 | D |
| 60 - 62 | D- |
| Below 60 | F |

Examination Schedule. (Take-home tests/exams)

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|------------|---|
| Test 1 | Assigned Fri Sep 20, Due Wed Sep 25 by 5pm |
| Test 2 | Assigned Fri Oct 11, Due Wed Oct 16 by 5pm |
| Test 3 | Assigned Wed Nov 20, Due Mon Nov 25 by 5pm |
| Final Exam | Assigned Dead Day, Due by end of Belmont final exam for this class time |

For exams, you may ONLY refer to the textbook(s), course notes, Instructor, and limited mathematical guides such as WolframAlpha or Desmos. **Collaborating with other students, consulting any (non-approved) external sources (e.g. solutions guides) is STRICTLY PROHIBITED and will result in referral to the Honor Court for cheating.**

Policy on Class Attendance

Your class attendance will not directly affect on your grade in this course, i.e., your grade will not be automatically raised or lowered because of exceptional class attendance or poor class attendance. Your grade, however, will probably be indirectly affected by your class attendance. The University policy on class attendance, stated on pages 51 and 52 of the current **Belmont University Bulletin**, will be followed. You must complete all work that you miss because of not being in class.

University Policies

Honor Code: *I will not give or receive aid during examinations; I will not give or receive false or impermissible aid in course work, in the preparation of reports, or in any other type of work that is to be used by the instructor as a basis for my grade; I will not engage in any form of academic fraud. Furthermore, I will uphold my responsibility to see that others abide by the spirit and the letter of the Honor Pledge.*

Accommodation of Disabilities: *In compliance with Section 504 of the Rehabilitation Act and the Americans with Disabilities Act, Belmont University will provide reasonable accommodations of all medically documented disabilities. If you have a disability and would like the university to provide reasonable accommodations of the disability during this course, please notify Tammy Tanksley, Director of Counseling & Developmental Support, in the Office of Student Affairs (460-6407) as soon as possible.*

Disclaimer:

The policies, topics and course organization described in this syllabus are subject to change. Adequate prior notice will be provided to all students in the event of a change.

Statement on Diversity, Equity, and Inclusion (DEI):

“There is neither Jew nor Gentile, neither slave nor free, nor is there male and female, for you are all one in Christ Jesus.” – Galatians 3:28

As a Christian institution, we aim to provide a welcoming environment for all people. We acknowledge our debt to the Western tradition of evidence-based science, particularly for topics in Analytical Mechanics, yet observe that the practice of science in that tradition was often only available to wealthy males of European descent. In this course we emphasize that anyone can contribute to science, because the natural world transcends human divisions.