NEW JERSEY CENTER
FOR TEACHING & LEARNING

Progressive Science Initiative® (PSI®)
PHYS6663: Learning and Teaching PSI AP Physics C - Mechanics

Primary Student Contact:	Dr. John Ennis	john@njctl.org
Faculty Team:	Dr. Bob Goodman	bob@njctl.org
	Dr. John Ennis	john@njctl.org
	Yuriy Zavorotniy	yuriy@njctl.org
	Katy Goodman	katy@njctl.org

Course Credit: 4.0 NJCTL credits

Dates & Times:
This is a 4-credit, self-paced course, covering 10 modules of content. The exact number of hours that you can expect to spend on each module will vary based upon the module coursework, as well as your study style and preferences. You should plan to spend approximately 15 hours per credit working online, and up to 30 hours per credit working offline.

Graduate Student Handbook: www.njctl.org/graduate-handbook/

COURSE DESCRIPTION:

This course is designed for those who are learning to teach calculus-based AP Physics C for high school or an equivalent course to college students, focusing on conveying physics and mathematical concepts and understandings. The critical topics of this course include vectors, one and two-dimensional kinematics, dynamics, energy, momentum, rotational motion, universal gravitation and simple harmonic motion. The underlying themes of this course include applying general principles of physics and advanced problem solving to all of these topics. The course asks students to identify, understand and communicate the elements, representations and models of scientific phenomena to solve scientific problems, using calculus as a mathematical base. Technology serves as a tool to establish these connections through exploration, problem solving, formative assessment, presentation, and communication.

STUDENT LEARNING OUTCOMES:

Upon completion of the course, the student will be able to:

1. Apply general principles of physics in the areas of vectors, one and two-dimensional kinematics, dynamics, energy, momentum, rotational motion, universal gravitation, and simple harmonic motion.
2. Apply student-centered pedagogy to teach physics to students.
3. Apply basic mathematical tools commonly used in physics including algebra, trigonometry, and graphical analysis.
4. Identify, understand, and communicate the elements, representations, and models of scientific phenomena to solve scientific problems.
5. Analyze concepts, graphs, data, and variable relationships to determine electric force, electric field, and electric potential in relation to their currents and circuits.
6. Examine, investigate, and assess the relationships between various physics models and their variables.

TEXTS, READINGS, INSTRUCTIONAL RESOURCES:

Required Texts:
- PSI AP Physics C: Mechanics uses a free digital textbook accessible at: https://njctl.org/courses/science/ap-physics-c-mechanics/
- Participants will download SMART Notebook presentations, homework files, labs, and teacher resources from the PSI AP Physics C Course

Recommended Texts and Resources:
- Next Generation Science Standards for Physical Science: https://www.nextgenscience.org/sites/default/files/HS%20PS%20topics%20combined%206.12.13.pdf
- AP Central: https://apcentral.collegeboard.org/

COURSE REQUIREMENTS:

Consistent attendance in your online courses is essential for your success. Failure to verify your attendance within the first 7 days of this course may result in your withdrawal. If for some reason you would like to drop a course, please contact your advisor.

Online classes have assignments and participation requirements just like on-campus classes. Budget your time carefully. If you are having technical problems, problems with your assignments, or other problems that are impeding your progress, let your instructor know as soon as possible.

In order to receive a Passing grade, the participant must complete the following course requirements: all short answer assignments, mastery exercises, labs, exams, and the reflection paper outlined in the *Assignments* section of the Class Schedule (below).

GRADE DISTRIBUTION AND SCALE:

Grade Distribution:

Module Exams	70%
Final Exam	10%
Short Answer Assignments	6%
Labs	6%
Mastery Exercises	6%
Reflection Paper	2%

Grade Scale:

A	93 – 100
A-	90 – 92
B+	86 – 89
B	83 – 86
B-	80 – 82
C+	77 – 79
C	73 – 76
C-	70 – 72
D	60.0 – 69.9
F	59.9 or below

ACADEMIC STANDING:
NJCTL has established standards for academic good standing within a student's academic program. Students enrolled in any NJCTL online course must receive an 80 or higher to successfully complete a course and receive credit for that course. An 80 is equivalent to a GPA of 2.7 or B-. Additionally, students in an endorsement program must receive a cumulative GPA of 3.0 for all courses combined in order to successfully complete the program.

ACADEMIC INTEGRITY:
Students must assume responsibility for maintaining honesty in all work submitted for credit and in any other work designated by the instructor of the course. Academic dishonesty includes cheating, fabrication, facilitating academic dishonesty, plagiarism, reusing /repurposing your own work, unauthorized possession of academic materials, and unauthorized collaboration.

CITING SOURCES WITH APA STYLE:
All students are expected to follow proper writing and APA requirements when citing in APA (based on the APA Style Manual, 6th edition) for all assignments.

DISABILITY SERVICES STATEMENT:
We are committed to providing reasonable accommodations for all persons with disabilities. Any student with a documented disability requesting academic accommodations should contact the Dean of Students, Melissa Axelsson, for additional information to coordinate reasonable accommodations for students with documented disabilities (melissa@njctl.org).

NETIQUETTE:
Respect the diversity of opinions among the instructor and classmates and engage with them in a courteous, respectful, and professional manner. All posts and classroom communication must be conducted in accordance with the student code of conduct. Think before you push the Send button. Did you say just what you meant? How will the person on the other end read the words?

Maintain an environment free of harassment, stalking, threats, abuse, insults or humiliation toward the instructor and classmates. This includes, but is not limited to, demeaning written or oral comments of an ethnic, religious, age, disability, sexist (or sexual orientation), or racist nature; and the unwanted sexual advances or intimidations by email, or on discussion boards and other postings within or connected to the online classroom.

If you have concerns about something that has been said, please let your instructor know.

CLASS SCHEDULE:

Module	Module Learning Outcomes	Assignments
0 – Optional Calculus Review	• Calculus review (optional)	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam
1 - Vectors	• Differentiate between vector and scalar quantities. • Perform mathematical operations using vector addition/subtraction, vector cross product and the scalar dot product. • Relate basic vector operations to vector graphical analysis.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam
2 – Kinematics in 1D	• Understand the special case of motion with constant acceleration. • Understand the relationship among words, equations and graphs for motion in one dimension. • Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. • Use calculus to solve 1D Kinematics problems.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam

3 – Kinematics in 2D	● Express the motion of an object using narrative, mathematical, and graphical representations in two dimensions. ● Design an experimental investigation of the motion of an object. ● Analyze experimental data describing the motion of an object and express the results of the analysis using narrative, mathematical, and graphical representations. ● Use vector diagrams, calculus and trigonometry to solve two-dimensional, uniform circular motion and projectile motion problems. ● Understand the concept of reference frames and apply them to find the solution of two-dimensional kinematics problems.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam
4 - Dynamics	● Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. ● Analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. ● Predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in two dimensions. ● Create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. ● Design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. ● Use calculus, trigonometry and geometry to solve force/motion problems.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

5 – Work & Energy	• Apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system. • Define open and closed systems for mechanical energy problems and apply conservation concepts for energy to those situations. • Calculate the work done on objects when the force is not parallel to the displacement. Explain the effect on the object's kinetic energy. • Understand and solve problems relating potential energy to its related force, using calculus and graphical analysis. • Distinguish between conservative and non-conservative forces and how they relate to the determination of a potential energy. • Compare and contrast the solutions of dynamics problems using Conservation of Energy vs. the application of Newton's Laws. Use these two methods in parallel for complex problems.	• Short Answer Assignment • Lab • Mastery Exercises • Module Exam

6 - Momentum	● Apply the principles of conservation of momentum and conservation of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. ● Classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. ● Plan data collection strategies to test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically. ● Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. ● Classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values. ● Calculate the center of mass of a system of particles or an extended mass and relate it to collisions. ● Use calculus to derive the equation for rocket flight.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

7 – Rotational Motion	● Use representations of the relationship between force and torque and compare the torques on an object caused by various forces. Estimate the torque on an object caused by various forces in comparison to other situations. ● Understand the analogy between translational and rotational kinematics so they can write and apply relations among the angular acceleration, angular velocity, and angular displacement of an object that rotates about a fixed axis with constant angular acceleration. Be able to solve these problems. ● Make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis. ● Predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum. ● State the relation between net external torque and angular momentum, and identify situations in which angular momentum is conserved. ● Use calculus to calculate moments of inertia of symmetric objects. ● Solve Conservation of Energy problems using rotational and translational kinetic energy in conjunction with kinematics and dynamics processes.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

8 – Universal Gravitation	● Make claims about the force on an object due to the presence of other objects with the same property, leading to the application of Newton’s Law of Universal Gravitation. Apply F=mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. ● Apply g=GM/r2 to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M. Understand that this is only applicable when the objects are very close to each other. ● Calculate, using calculus and vector algebra, the gravitational potential energy of objects at a significant distance from each other, from the gravitational force performing work on one of the objects. ● Understand, and derive Kepler’s Three Laws, and predict the orbital motion of planetary/stellar objects by applying the laws to physical phenomena. ● Using Conservation of Energy to calculate the total energy and orbital velocity of objects in orbit and the escape velocity for planetary masses. Explain how objects stay in orbit due to the interplay of Newton’s Law of Universal Gravitation and their tangential velocity.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam
9 – Simple Harmonic Motion	● Understand how restoring forces can result in oscillatory motion, and be able to plot and interpret graphs showing this motion. ● Understand how a spring exerting a linear restoring force increases with mass and decreases with spring stiffness, and solve spring problems using Hooke’s Law. ● Demonstrate simple pendulum and simple mass spring experiments. ● Use trigonometry and calculus to solve more complex pendulum, spring, conical pendulum and physical pendulum problems. ● Write equations to describe the position, velocity and acceleration as functions of time for simple harmonic motion. Use calculus to relate the three quantities to each other.	● Short Answer Assignment ● Lab ● Mastery Exercises ● Module Exam

10 – Reflection & Final Exam	• Review Course Topics as needed • Discussion board posts and Zoom meeting with instructor, as needed	• Reflection Paper • Final Exam