SYLLABUS DEVELOPMENT GUIDE

AP® Physics C: Mechanics

The guide contains the following information:

Curricular Requirements

The curricular requirements are the core elements of the course. A syllabus must provide explicit evidence of each requirement based on the required evidence statement(s). The Unit Guides and the “Instructional Approaches” section of the *AP® Physics C: Mechanics Course and Exam Description* (CED) may be useful in providing evidence for satisfying these curricular requirements.

Required Evidence

These statements describe the type of evidence and level of detail required in the syllabus to demonstrate how the curricular requirement is met in the course.

Note: Curricular requirements may have more than one required evidence statement. Each statement must be addressed to fulfill the requirement.

Samples of Evidence

For each curricular requirement, two to three separate samples of evidence are provided. These samples provide either verbatim evidence or clear descriptions of what acceptable evidence could look like in a syllabus. In some samples, the specific language that addresses the required evidence is highlighted in **bold** text.

Curricular Requirements

CR1	Students and teachers have access to college-level resources, including a college-level textbook and reference materials in print or electronic format.	*See page:* 3
CR2	The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Physics C: Mechanics Course and Exam Description.	*See page:* 4
CR3	The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations.	*See page:* 6
CR4	The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.	*See page:* 7
CR5	The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation.	*See page:* 8
CR6	Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations.	*See page:* 9
CR7	Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics C: Mechanics Course and Exam Description.	*See page:* 10
CR8	The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format).	*See page:* 13

Curricular Requirement 1

Students and teachers have access to college-level resources including a college-level textbook and reference materials in print or electronic format.

Required Evidence

- ☐ The teacher must provide the title, author, and publication date of a calculus-based, college-level textbook on their course audit form.

Samples of Evidence

1. The teacher selects an approved college-level textbook on their course audit form.
2. The teacher provides the title, author, and publication date of a calculus-based, college-level textbook on their course audit form.

Curricular Requirement 2

The course provides opportunities to develop student understanding of the required content outlined in each of the units described in the AP Physics C: Mechanics Course and Exam Description.

Required Evidence

- ☐ The syllabus must include an outline of course content by unit title to demonstrate the inclusion of the required course content listed in the current AP Physics C: Mechanics Course and Exam Description.

  Note: If the syllabus demonstrates a different sequence than the units outlined in the current AP Physics C: Mechanics Course and Exam Description, the teacher must include the following specific statement: All the content in the current AP Physics C: Mechanics Course and Exam Description will be covered in this course.

Samples of Evidence

1. The course will follow the units below listed in the current AP Physics C: Mechanics Course and Exam Description:

   Unit 1: Kinematics

   Unit 2: Force and Translational Dynamics

   Unit 3: Work, Energy, and Power

   Unit 4: Linear Momentum

   Unit 5: Torque and Rotational Dynamics

   Unit 6: Energy and Momentum of Rotating Systems

   Unit 7: Oscillations

2. All the content in the current AP Physics C: Mechanics Course and Exam Description will be covered in this course. We will cover these chapters of our calculus-based, university-level textbook:

   Chapter 2: Vectors

   Chapter 3: Motion Along a Straight Line

   Chapter 4: Motion in Two and Three Dimensions

   Chapter 5: Newton's Laws of Motion

   Chapter 6: Applications of Newton's Laws

   Chapter 7: Work and Kinetic Energy

   Chapter 8: Potential Energy and Conservation of Energy

   Chapter 9: Linear Momentum and Collisions

   Chapter 10: Fixed-Axis Rotation

   Chapter 11: Angular Momentum

   Chapter 12: Static Equilibrium and Elasticity

   Chapter 13: Gravitation

3. All the content in the current AP Physics C: Mechanics Course and Exam Description will be covered in this course. The following topics will be covered throughout the year:
    1. **Forces:** Systems and center of mass, forces and FBDs, Newton's laws of motion, static and kinetic friction, gravitational vs. inertial mass, gravitation, circular motion, spring forces, resistive forces
    2. **Kinematics:** Instantaneous and average motion, vectors vs. scalars, motion graph, 2D motion, relative motion, non-constant acceleration
    3. **Conservation Laws:** Work, power, potential and kinetic energy, conservation of energy, linear momentum, impulse changes momentum, conservation of momentum, elastic vs. inelastic collisions
    4. **Rotation:** Rotational kinematics, connecting linear and rotational, rotational inertia, equilibrium, Newton's first and second laws of rotation, torque and work, rotational kinetic energy, rolling, angular momentum and angular impulse, conservation of angular momentum, orbiting satellites
    5. **Oscillations:** SHM, frequency and period for SHM, analyzing and representing SHM motion, energy in SHM, simple and physical pendulums

Curricular Requirement 3

The course provides opportunities for students to develop the skills related to Science Practice 1: Creating Representations.

Required Evidence

- ☐ The syllabus must include a section labeled “Science Practice 1” describing one assignment, activity, or lab where students create representations that depict physical phenomena.

Clarifying Terms

The following task verbs are commonly associated with Science Practice 1: sketch, draw, or plot.

Samples of Evidence

1. **Science Practice 1**

   A problem-solving activity in which students are asked to use a multiple-representation scheme as follows (e.g., a 2D projectile throw).

   a) **Draw** a pictorial representation to explain the context of the problem.

   b) **Draw** motion diagram and the relevant free-body diagram for both horizontal and vertical directions.

2. **SP1**

   While studying forces on connected systems, students will **draw** free-body diagrams for the individual objects. They will also **draw** a free-body diagram for the system.

3. **Science Practice 1**

   Given distance and time for a falling object, students will find gravity by **plotting** an appropriate graph.

Curricular Requirement 4

The course provides opportunities for students to develop the skills related to Science Practice 2: Mathematical Routines.

Required Evidence

- ☐ The syllabus must include a section labeled "Science Practice 2" describing one assignment, activity, or lab where students use mathematical routines.

Clarifying Terms

The following task verbs are commonly associated with Science Practice 2: calculate, compare, derive, determine, estimate, or show.

Samples of Evidence

1. **Science Practice 2**

   A mini project/activity in which students are asked to model the oscillatory behavior of a spring.

   1. **Derive** an expression from the first principle by solving the second order DE.
   2. **Calculate** energy by employing the principle of conservation of energy

2. **SP2**

   Students will use calculus to **derive** theoretical relationships among physical quantities. For example, they will derive an expression for the rotational inertia of a thin rod about a perpendicular axis through the center of gravity.

3. **Science Practice 2**

   Atwood Machine: Students will **determine** the relationship between acceleration and total mass as well as acceleration and mass difference. Student will measure the time for the masses to fall and will use a kinematics equation to **calculate** the acceleration then graph the acceleration and total mass, as well as acceleration and mass difference, to determine the relationships.

Curricular Requirement 5

The course provides opportunities for students to develop the skills related to Science Practice 3: Scientific Questioning & Argumentation.

Required Evidence

- ☐ The syllabus must include a section labeled “Science Practice 3” describing one assignment, activity, or lab where students design experimental procedures, and make and justify claims.

Clarifying Terms

The following terms are commonly associated with Science Practice 3: claim, describe, design, explain, indicate, justify, predict, or state.

Samples of Evidence

1. **Science Practice 3**
    1. **Design** an experiment to find the relationship between acceleration and mass for a variety of objects of varying mass by exerting the same force.
    2. **Make** a claim about relevant sources of error.
    3. **Explain** how resistive forces would change the outcome.

2. **SP3**

    In the lab, students will **design** an experiment to determine physical quantities using data analysis—for example, acceleration due to gravity using velocity vs. time data for a freely falling object.

3. **Science Practice 3**

    Toy Wind-up Car Challenge: Students will **design a lab** to **predict/make a claim** where a toy wind-up car will land when launched horizontally from a table, and **justify** the discrepancy between their prediction and the measurements.

Curricular Requirement 6

Students spend a minimum of 25% of instructional time engaged in hands-on laboratory investigations.

Required Evidence

- ☐ The syllabus must include an explicit statement that at least 25% of instructional time is spent engaged in hands-on laboratory investigations, with an emphasis on inquiry-based labs.

Samples of Evidence

1. 25% of this course is spent doing hands-on laboratory investigations.
2. Students will spend a minimum of 25% of the course engaged in hands-on laboratory investigations.
3. 25% of course time is spent engaged in hands-on labs.

Curricular Requirement 7

Students engage in hands-on laboratory investigations representative of the topics outlined in the AP Physics C: Mechanics Course and Exam Description.

Required Evidence

- ☐ The syllabus must include a title and brief description for each laboratory investigation. The labs listed should be representative of the topics outlined in the AP Physics C: Mechanics Course and Exam Description.

Samples of Evidence

1.
    - Constant Velocity/Constant Acceleration: Students design labs to show constant velocity and constant acceleration.
    - Projectile Challenge: Students determine the landing spot for a projectile launched at an angle and lands below its launch point.
    - Friction Lab: Students design experiments to determine the coefficients of friction for various surfaces.
    - Flying Cow: Students design an experiment to determine the tension in the flying cows' "leashes."
    - Atwood's Machine: Students design an experiment to determine the relationship between acceleration and total mass as well as acceleration and mass difference.
    - The Unknown Mass: Students design a circular motion experiment to predict the value for an unknown mass.
    - Mechanical Energy: Students design an experiment to determine total mechanical energy of a tossed ball and an oscillating spring.
    - 1D & 2D Collisions: Students design experiments to determine in which types of 1D and 2D collisions momentum and/or kinetic energy are conserved.
    - Rotational Inertia Lab: Given different shapes, students predict and verify the I value for each shape.
    - Newton's Second Law of Rotation: Students verify Newton's second law of rotation.
    - Toilet Paper Lab: Students predict where to drop an unrolling roll of toilet paper so it hits the ground at the same time a roll of toilet paper is dropped from 2 meters.
    - Spring Lab: Given different springs, students must predict and verify the period of the spring.

2.

1. Constant Velocity Lab – Students design a lab to show an object moves with constant velocity
2. Constant Acceleration Lab – Students design a lab to show an object moves with constant acceleration
3. Predict the Projectile – Students have to predict the landing site of a ball when launched from the top of a lab table at a given angle
4. Friction Lab – Students design a lab to determine the coefficient of friction between a book and the lab table using only a ruler and stopwatch
5. Atwood's Machine Lab – Students determine the relationship between total mass and acceleration and the mass difference and acceleration
6. Flying Cow Lab – Students design a lab to determine the velocity of the flying cow using only a ruler and stopwatch
7. Friction 2 Lab – Students determine the coefficient friction between block and a table with only a ruler
8. Impulse Lab – Using video analysis, students determine the impulse of two people who are pushing off each other on carts
9. 1D Collisions Lab – Students design a lab using carts and a track to determine if momentum is conserved, and to identify if a collision is elastic or inelastic
10. 2D Collisions Lab – Students design a lab to determine if momentum is conserved in 2D using hover disks
11. Rotational PVC Lab – Students design a lab to determine the moment of inertia (I) of a PVC structure, then compare it to a calculated value
12. Toilet Paper Lab – Students predict where to place an unrolling roll of toilet paper so that it hits the ground at the same time a roll of toilet paper is dropped from 2 meters; students must use forces and torques
13. Conservation of Angular Momentum – Students design a lab to determine if angular momentum is conserved when various objects are dropped onto a spinning disk
14. Pendulum Lab – Students design a lab to determine which variables affect the period of a pendulum
15. Beats Lab – Students design a lab to construct a mass on a spring and a pendulum that have a period made to match the beat of a song

3.

Unit 1: Kinematics
How is motion recorded? Students will make predictions and reproduce the different kinematics graphs with a motion detector.

Unit 2: Force and Translational Dynamics
Atwood machine: Students will determine the relationship between acceleration and total mass as well as acceleration and mass difference. Students will measure the time for the masses to fall and will use a kinematics equation to calculate the acceleration then graph the acceleration and total mass, as well as acceleration and mass difference, to determine the relationships.

Unit 3: Work, Energy, and Power
Power lab: Students will collect data to determine the amount of power generated in walking stairs and doing pushups.

Unit 4: Linear Momentum
Ballistic pendulum lab: Students will develop a method for determining the launch velocity of a sphere.

Unit 5: Torque and Rotational Dynamics
Toilet paper challenge: Students must predict where to drop an unrolling roll of toilet paper so it hits the ground at the same time as a roll of toilet paper dropped from 2 m.

Unit 6: Energy and Momentum of Rotating Systems
Angular momentum lab: Students determine if angular momentum is conserved when dropping objects onto rotating plates.

Unit 7: Oscillations
Physical pendulum lab: Students determine the rotational inertia of a weighted meter stick.

Curricular Requirement 8

The course provides opportunities for students to record evidence of their scientific investigations in a portfolio of lab reports or a lab notebook (print or digital format).

Required Evidence

- ☐ The syllabus must include an explicit statement that students are required to maintain a lab notebook or portfolio (hard copy or electronic) that includes all their lab reports.

Samples of Evidence

1. After performing the lab, students are expected to submit a lab report electronically or maintain the lab notebook for each experimental activity.
2. Students are expected to keep a lab notebook where they will maintain a record of their laboratory work.
3. All investigations are reported in a laboratory journal.