# 05_Momentum and Collisions

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| Content Area: | **Science** |
| Course(s): | |
| Time Period: | **Full Year** |
| Length: | **4 weeks** |
| Status: | **Published** |

## General Overview, Course Description or Course Philosophy

This course is about the nature of basic things such as motion, force, energy, matter, sound, light, electricity and the composition of atoms. Laboratory experiments, demonstrations, applications to daily life and current topics in physics provide students with an appreciation of this most basic science.

## OBJECTIVES, ESSENTIAL QUESTIONS, ENDURING UNDERSTANDINGS

Essential question:

- How is a force applied over time related to a change in an object's velocity?

Students will understand:

- All moving objects have momentum
- Laws govern motion on Earth and throughout the universe
- Mathematical representations can be used to understand motion and make predictions about an object’s motion

## CONTENT AREA STANDARDS

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| SCI.HS-PS2-2 | Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. |
| SCI.HS-PS2-3 | Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. |

## RELATED STANDARDS (Technology, 21st Century Life & Careers, ELA Companion Standards are Required)

HSA-CED.A.1: Create equations and inequalities in one variable and use them to solve problems.
HSA-CED.A.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
HSA-CED.A.4: Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

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| MA.K-12.2 | Reason abstractly and quantitatively. |
| MA.K-12.4 | Model with mathematics. |

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| PFL.9.1.K12.P.8 | Use technology to enhance productivity increase collaboration and communicate effectively. |
| MA.N-Q.A.1 | Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. |
| MA.N-Q.A.2 | Define appropriate quantities for the purpose of descriptive modeling. |
| MA.N-Q.A.3 | Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. |
| LA.WHST.11-12.7 | Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. |
| WRK.K-12.P.4 | Demonstrate creativity and innovation. |
| TECH.K-12.P.5 | Utilize critical thinking to make sense of problems and persevere in solving them. |

## STUDENT LEARNING TARGETS

## Declarative Knowledge

Students will know:

- If the net force on a closed system is zero, the total momentum of that sustem is conserved
- The difference between work, potential and kinetic energy, power, momentum, and impulse
- Energy may be transferred from one object to another during collisions

The following preconceptions and/or misconceptions will be addressed during the unit:

- Momentum is the same as velocity
- Systems consist of a single body only
- Expelled gases from rockets pus on air, and that is why the rockets move

## Procedural Knowledge

Students will be able to:

HS-PS2-2

- Students clearly define the system of the two interacting objects that is represented mathematically, including boundaries and initial conditions.
- Students identify and describe the momentum of each object in the system as the product of its mass and its velocity, p = mv (p and v are restricted to one-dimensional vectors), using the mathematical representations.

- Students identify the claim, indicating that the total momentum of a system of two interacting objects is constant if there is no net force on the system.
- Students use the mathematical representations to model and describe the physical interaction of the two objects in terms of the change in the momentum of each object as a result of the interaction.
- Students use the mathematical representations to model and describe the total momentum of the system by calculating the vector sum of momenta of the two objects in the system.
- Students use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it.
- Based on the analysis of the total momentum of the system, students support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant.
- Students identify that the analysis of the momentum of each object in the system indicates that any change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant.

HS-PS2-3

- Students design a device that minimizes the force on a macroscopic object during a collision. In the design, students:

1. Incorporate the concept that for a given change in momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$)
2. Explicitly make use of the principle above so that the device has the desired effect of reducing the net force applied to the object by extending the time the force is applied to the object during the collision. b In the design plan, students describe the scientific rationale for their choice of materials and for the structure of the device.

- Students describe and quantify (when appropriate) the criteria and constraints, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost, mass, the maximum force applied to the object, and requirements set by society for widely used collision-mitigation devices (e.g., seatbelts, football helmets).
- Students systematically evaluate the proposed device design or design solution, including describing the rationales for the design and comparing the design to the list of criteria and constraints.
- Students test and evaluate the device based on its ability to minimize the force on the test object during a collision. Students identify any unanticipated effects or design performance issues that the device exhibits.
- Students use the test results to improve the device performance by extending the impact time, reducing the device mass, and/or considering cost-benefit analysis.

## EVIDENCE OF LEARNING

## Formative Assessments

Strategic questioning

Class/small group discussions

Homework and classwork assignments

Conducting and analyzing labs

## Summative Assessments

- Benchmarks – departmental benchmark given at the end of MP1, MP2, and MP3
- Alternative Assessments
  - Lab inquiries and investigations
  - Lab Practicals
  - Exploratory activities based on phenomenon
  - Gallery walks of student work
  - Creative Extension Projects
  - Build a model of a proposed solution
  - Let students design their own flashcards to test each other
  - Keynote presentations made by students on a topic
  - Portfolio

## RESOURCES (Instructional, Supplemental, Intervention Materials)

The Physics Classroom - http://www.physicsclassroom.com/

PhET simulations - https://phet.colorado.edu/

Pivot - https://www.pivotinteractives.com/

Edpuzzle - https://edpuzzle.com/

Vernier labs - teacher lab manual available in classroom

## INTERDISCIPLINARY CONNECTIONS

Calculations drive connections with mathematics courses

## ACCOMMODATIONS & MODIFICATIONS FOR SUBGROUPS

See link to Accommodations & Modifications document in course folder.