Unit 5: Momentum and Impulse

Content Area: **Science**
Course(s):
Time Period: **Marking Period 3**
Length: **4 Weeks**
Status: **Published**

Summary

Momentum, its conservation, Impulse, and collisions are all constructed, developed and applied in this unit. Students will analyze real-world collisions using momentum bar charts, setting the foundation for energy bar charts in the next unit. Car safety or rocket propulsion will be used as examples for this unit.

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CS.9-12.8.1.12.DA.5	Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
CS.9-12.8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
CS.9-12.8.2.12.ED.1	Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
CS.9-12.8.2.12.ED.2	Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.
LA.RST.9-10	Reading Science and Technical Subjects
LA.WHST.9-10	Writing History, Science and Technical Subjects
MA.K-12.1	Make sense of problems and persevere in solving them.
MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.3	Construct viable arguments and critique the reasoning of others.
MA.K-12.4	Model with mathematics.
MA.K-12.5	Use appropriate tools strategically.
MA.K-12.6	Attend to precision.
MA.K-12.7	Look for and make use of structure.
MA.K-12.8	Look for and express regularity in repeated reasoning.
SCI.HS.PS2.A	Forces and Motion
SCI.HS.PS2.A	Forces and Motion
SCI.HS.ETS1.A	Defining and Delimiting Engineering Problems
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.
TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CT.2	Explain the potential benefits of collaborating to enhance critical thinking and problem solving (e.g., 1.3E.12profCR3.a).
	Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for

statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Using Mathematics and Computational Thinking

Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.

Cause and Effect

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.

Use mathematical representations of phenomena to describe explanations.

Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

Systems and System Models

Newton’s second law accurately predicts changes in the motion of macroscopic objects.

Assessment is limited to systems of two macroscopic bodies moving in one dimension.

Assessment is limited to qualitative evaluations and/or algebraic manipulations.

Essential Questions/ Enduring Understandings

Essential Questions

How has our knowledge of impulse and momentum influenced the design of cars and rockets?

Why do we say that conservation of momentum is a fundamental conservation law in physics?

How does the choice of system influence problem solving strategies in physics?

Enduring Understandings

The total momentum of a system can only change if an external object interacts with the system.

Objectives

Students will know the concept of a “system” and systems thinking in physics.

Students will know the difference between the terms “constant” and “conserved”.

Students will know that momentum is a conserved quantity, but not necessarily constant in a particular system.
Students will be skilled at choosing a system and initial and final states when analyzing a process involving impulse and momentum.
Students will be skilled at representing processes involving impulse and momentum using bar charts.
Students will know how to identify the system, initial and final states, and decide whether momentum is constant or not in the process. If momentum is not constant, they need to be able to account for the change through impulse.
Students will be skilled at comparing and contrasting force and impulse, impulse and momentum, force and momentum.
Students will know how to apply momentum and impulse to solve problems in one and two dimensions.
Students will know the relationship between the generalized impulse-momentum principle and Newton’s laws.
Students will know how momentum and impulse ideas explain how practical applications such as airbags work to save lives.

Learning Plan

Students will begin with qualitative observations of collisions to determine a pattern in the change in velocity vectors when two objects interact.

Consistency with Newton's 3rd Law will be highlighted and discussed.

Working in groups, students will work with real data from collisions to find a constant quantity for each situation. This constant quantity will be defined as momentum. Students will practice using this new quantity for basic problem solving.

Students will be introduced to bar charts for conserved quantities, relating to mass and money as quantities that cannot disappear or reappear out of nowhere, just like momentum.

The difference between the terms constant and conserved will be emphasized and discussed.

Once students have bar charts and momentum as tools, they can start analyzing collisions of different types, including elastic, inelastic, and explosion/separation. How these apply to car collisions and rockets will be discussed in groups and as a whole class.

Students will complete the Happy/Sad Ball activity in small groups to determine what kind of collision results in the largest impulse.

Students will be introduced to situations where momentum is not constant, thus leading to the concept of impulse. Students will analyze new situations where the system is not isolated using bar charts, equations, diagrams, and words.

At the conclusion of the unit, students will construct a device that protects a falling egg from damage as an analogy to a car and its role in protecting humans.

Students will write an engineering design document to chart their progress and design decisions throughout the project.

Assessment

Formative:

Students will engage in small group problem solving and show their work on whiteboards using bar charts, equations, words, and diagrams. Teacher will provide feedback, as will students in other groups through critique. Students will complete frequent homework assignments that will be reviewed in class so that students can self-assess.

Summative:

Egg Drop Project: Students will work in small groups or individually to design, build, and test a device that will protect a raw egg during drops of various heights. End of chapter test, at least one quiz during the unit, Happy/Sad Ball activity, at least one lab either using equipment in class or using the PhET simulation Collision Lab.

Benchmark: This unit will be included in the final exam.

Materials

Computer with PowerPoint/Google Slides and internet access

Textbook Physics: Principles and Problems, Glencoe

Calculators, rulers, meter sticks, colored pencils, graph paper, Chromebooks for students, whiteboards for collaborative work, dry erase markers and erasers for student groups, Pasco cars and tracks, Happy and Sad balls with track and block or video equivalent, Physics of Car Crashes video (YouTube or EdPuzzle), eggs, Sharpie.

Integrated Accommodations and Modifications

Integrated Accommodation and Modifications, Special Education students, English Language Learners, At-Risk students, Gifted and Talented students, Career Education, and those with 504s

https://docs.google.com/spreadsheets/d/18XhAi7Rm-E8LJwO4uMQS7ZEh0dh3NxYbTFH2IoHLH7Y/edit?usp=sharing