## Grades 9–12

**3.2.9-12.J Physical Science:** Forces and Interactions

**Students who demonstrate understanding can** *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.*

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

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

| Science and Engineering Practices (SEP) | Disciplinary Core Ideas (DCI) | Crosscutting Concepts (CCC) |
|---|---|---|
| **Using Mathematics and Computational Thinking**<br>Mathematical and computational thinking at the 9–12 level 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.<br>• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. | **Forces and Motion**<br>Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.<br>• 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. | **Systems and System Models**<br>• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. |

**Pennsylvania Context:** N/A

**PA Career Ready Skills:** Advocate for oneself in education, employment, and within the community.

### Connections to Other Standards Content and Practices

| Standard Source | Possible Connections to Other Standard(s) or Practice(s) |
|---|---|
| **Agriculture (AFNR)** | CS.01.02.01.a: Research technologies used in AFNR systems. |
| **Science, Environmental Literacy and Sustainability (NAAEE)** | 9-12 Strand 1.F. Working with models and simulations: Learners create, use, test, and evaluate models to analyze environmental questions, problems, issues, or phenomena. |

| Standard Source | Possible Connections to Other Standard(s) or Practice(s) |
|---|---|
| **PA Core Standards: ELA** | N/A |
| **PA Core Standards and Practices: Math** | MP.2: Reason abstractly and quantitatively.<br>MP.4: Model with mathematics.<br>CC.2.1.HS.F.5: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.<br>CC.2.2.HS.D.7: Create and graph equations or inequalities to describe numbers or relationships. |
| **PA Standards: Social Studies** | N/A |
| **Educational Technology (ISTE)** | 1.5. Computational Thinker: Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions. |
| **Technology and Engineering (ITEEA)** | STEL-10: Assess how similarities and differences among scientific, mathematical, engineering, and technological knowledge and skills contributed to the design of a product or system. |