# Physical Science 2 Progression

This progression is about forces and motion. Object interactions can be explained and predicted using the concept of forces, which result in a change of motion of one or all objects.

In elementary grades, students learn that any force acting on an object has both a strength and direction. They also learn that forces cause objects motion to change. They learn to make observations of an object's motion, look for patterns in the motion, and make predictions for future motion (e.g., a swing).

In middle school, students learn that an object's change in motion is called acceleration, which is manifested as an object speeding up, slowing down or changing direction. The way an object accelerates is determined by only two things: the mass of the object, and the sum of the forces acting on the object (net force). If the sum of the forces acting on the object is not zero, its motion will change. Also, the greater the mass of the object, the greater the force needed to achieve the same change in motion. Stated another way, for any given object, a larger force causes a larger change in motion. For any given object, a larger force results in larger change in motion. The relationship between force, mass and acceleration is defined by Newton's 2nd Law: $F = ma$, where $F$ = net force on an object, $m$ = mass of the object, and $a$ = acceleration of the object. The Performance Expectation **(PE)** (03-PS2-2, 06-PS2-2 and HS-PS2-3) is asking students to explore this relationship by planning an investigation. An important point to realize in the clarification statement is that when forces are unbalanced, then the sum of the forces acting on an object is not zero, so an object's motion will change.

In high school, students begin to learn about conservation of momentum, although this PE does not really address that concept. The PE asks students to use engineering principles to design a device to minimize the force on an object.  This PE more directly utilizes middle school concepts discussed in the above paragraph, F = ma.  So, if the goal is to reduce the force on an object when it impacts something, a way to approach it could be to reduce the speed of the object before impact (e.g., parachute), or increase the time over which the force acts on the object (e.g., airbag). Both of these examples reduce acceleration.  Another approach would be to distribute the force over a larger area of the object; the force at any point on the object will be less.  (Consider the force you'd experience if someone stepped on your foot with a spiked heel vs. a flat shoe.  The spiked heel concentrates the force, and the flat heel distributes it over a larger area.)

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Grade 4:

**Alternate KSA Aligned to KCAS for Science**:

**Make observations and/or use measurements of an object's motion to provide evidence that patterns can be used to predict future motion.**

3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a seesaw.]

| SEP (Science and Engineering Practices) | DCI (Disciplinary Core Ideas) | CC (Crosscutting Concepts) |
|---|---|---|
| Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. | The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) | Patterns of change can be used to make predictions. |

**Grade 7:**

**Alternate KSA Aligned to KCAS for Science**:

**With peer or teacher support, plan an investigation and use evidence to determine how change in an object's motion depends on the net force on the object and the mass of the object.**

06-PS2-2: Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.]

| SEP (Science and Engineering Practices) | DCI (Disciplinary Core Ideas) | CC (Crosscutting Concepts) |
|---|---|---|
| Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. | The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. | Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. |

**Grade 11:**

**Alternate KSA Aligned to KCAS for Science**:

**Evaluate the design of a device that minimizes the force on an object during a collision and make suggestions for improvement.**

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. [Clarification Statement: Examples of evaluation and refinement could include determining the success of a 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.]

| SEP (Science and Engineering Practices) | DCI (Disciplinary Core Ideas) | CC (Crosscutting Concepts) |
|---|---|---|
| Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. | 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 can be designed to cause a desired effect. |