Grade Eight Preferred Integrated Course Model

This section is meant to be a guide for educators on how to approach the teaching of the California Next Generation Science Standards (CA NGSS) in grade eight according to the Integrated Model (see the introduction to this chapter for further details regarding different models for grades six, seven, and eight). It is not meant to be an exhaustive list of what can be taught or how it should be taught.

A primary goal of this section is to provide an example of how to bundle the performance expectations into integrated groups that can effectively guide instruction in four sequential instructional segments (IS). There is no prescription regarding the relative amount of time to be spent on each instructional segment. As shown in figure 5.38, the overarching guiding concept for the entire year is "The processes that change Earth's systems at different spatial scales today also caused changes in the past."

Figure 5.38. Grade Eight Integrated Storyline

Guiding Concept: The processes that change Earth systems at different spatial scales today also caused changes in the past.

Instructional Segment	1 Objects move and collide.	2 Noncontact forces influence phenomena locally and in the solar system.	3 Evolution explains life's unity and diversity.	4 Human activities help sustain biodiversity and ecosystem services in a changing world.
Life Science (LS)	Living systems are affected by physical changes in the environment. Both the physical and biological changes are recorded in the fossil record.	N/A	Mutations in genes affect organisms' structures and functions. Evidence from fossils, anatomy, and embryos support the theory of biological evolution. Natural selection is the main mechanism that leads to evolution of species that are adapted to their environment.	Changes to environments can affect probabilities of survival and reproduction of individual organisms, which can result in significant changes to populations and species.
Earth and Space Sciences (ESS)	The fossil record documents the existence, diversity, extinction, and change of life forms throughout Earth's history.	Models explain lunar phases and eclipses of the Sun and Moon. Gravity plays the major role in determining motions with the solar system and galaxies.	Rock layers record Earth's history like pages in a book.	Annual cycles in the amount of sunlight absorbed cause Earth's seasons. Increases in human population and per-capita consumption impact Earth systems.
Physical Science (PS)	Newton's Laws explain the forces and motions of objects on Earth and in space. Velocity and mass determine the results of collisions between objects.	Gravitational and electromagnetic fields are the basis of noncontact forces. Changing the arrangement of objects in a system affects the potential energy stored in that system.	Chemical reactions make new substances. Mass is conserved in physical changes and chemical reactions.	Waves are reflected, absorbed, or transmitted through various materials. Wave-based digital technologies provide very reliable ways to encode and transmit information.
Engineering, Technology, and Applications to Science (ETS)	Design criteria. Evaluate solutions. Analyze data. Iteratively test and modify.	N/A	N/A	Design criteria. Evaluate solutions.

A primary goal of this section is to provide an example of how to bundle the performance expectations into four sequential instructional segments. There is no prescription regarding the relative amount of time to be spent on each instructional segment.

Integration within each instructional segment and sequentially across the year flows most naturally with the science concepts in Integrated Grade Eight. Integrated Grade Eight is somewhat less amenable to complete integration, but the concept of systems and system models plays a very strong role in connecting within and across grade eight instructional segments.

Each grade eight instructional segment tells a coherent story that generally includes two or more science disciplines that meaningfully connect with each other within that instructional segment (figure 5.38). Earth and space science content provides the conceptual "glue" by separately linking with physical science (solar system, orbital motions, and asteroid collisions) and with life science (human impacts on biodiversity and geologic time scale via fossils in rock strata). Instructional segment 1 and IS4 also feature engineering design intimately connected with the instructional segment science concepts.

Perhaps the most important perspective with respect to Integrated Grade Eight is that it serves as a capstone for the middle grades span. The vignette in IS4 provides one example of integrating across the entire year and connecting back to earlier grade levels. Many of the key concepts that have been flowing, cycling, and building in complexity in the lower grades come together to explain awesome phenomena such as the unity and diversity of Earth's life, how humans impact and can sustain biodiversity, and the beautiful dances within the solar system. These phenomena are happening within a scale of existence that extends from submicroscopic atoms to clusters of galaxies. These phenomena also occur across a scale of time that extends from instants of collisions to billions of years of stability and change. All this grandeur and wonder would be unknown to us without the powerful science and engineering practices (SEPs) and unifying concepts that students experience and apply in CA NGSS middle grades science.

IS1 Integrated Grade Eight Instructional Segment 1: Objects Move and Collide

INTEGRATED GRADE EIGHT INSTRUCTIONAL SEGMENT 1: OBJECTS MOVE AND COLLIDE

Guiding Questions

- What are forces and how do they affect the motions of objects?
- Do objects always need a force in order to keep moving?
- What happens when a moving object collides with something?
- How do fossils provide evidence of an ancient collision that wiped out the dinosaurs?

Performance Expectations

Students who demonstrate understanding can do the following:

MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [*Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.*]

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [*Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.*]

MS-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.] [*Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.*]

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

INTEGRATED GRADE EIGHT INSTRUCTIONAL SEGMENT 1: OBJECTS MOVE AND COLLIDE

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or Disciplinary Core Idea.*

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-4] Analyzing and Interpreting Data [SEP-5] Using Mathematics and Computational Thinking [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence	LS4.A: Evidence of Common Ancestry and Diversity PS2.A: Forces and Motion PS3.A: Definitions of Energy ETS1.A: Defining and Delimiting Engineering Problems ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	[CCC-1] Patterns [CCC-2] Cause and effect [CCC-3] Scale, Proportion, and Quantity [CCC-4] System and System Models [CCC-5] Energy and Matter: Flows, Cycles, and Conservation [CCC-7] Stability and Change

Highlighted California Environmental Principles and Concepts:

Principle II The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

Principle V Decisions affecting resources and natural systems are complex and involve many factors.

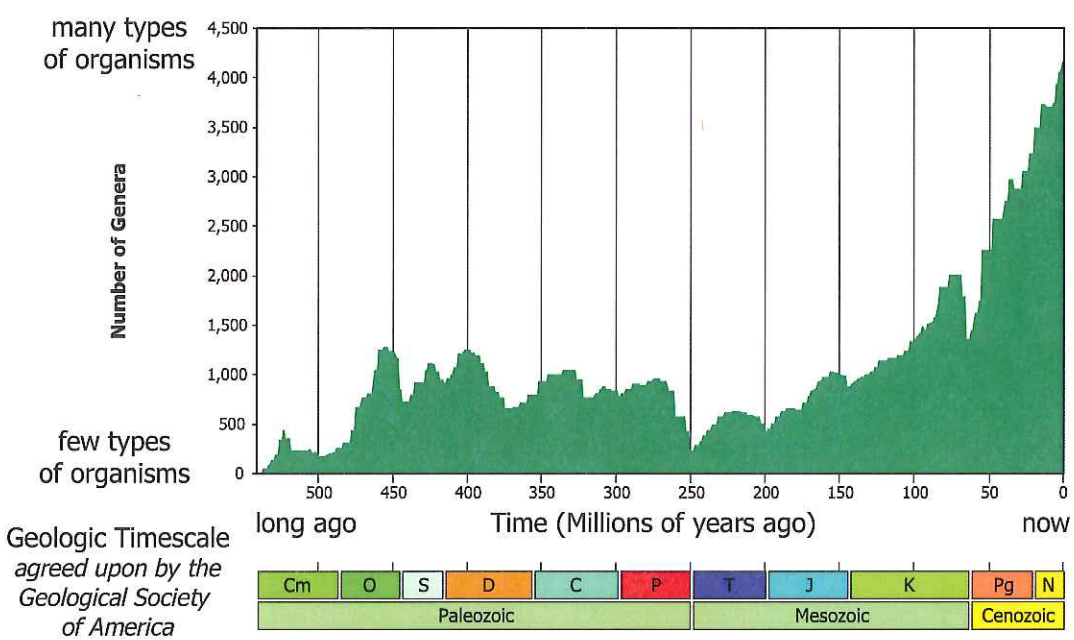
CA CCSS Math Connections: 6.EE.2, 6, 6.NS.5, 6.RP.1, 2, 7.EE.3,4, 7.RP.2, 7.SP.7, 8.EE.1,2, MP.2

CA CCSS for ELA/Literacy Connections: RST.6–8.1, 3, 7, 9, WHST.6–8, 7, 8, 9, SL.8.5

CA ELD Connections: ELD.PI.6.1, 5, 6a–b, 9, 10, 11a

Integrated Grade Eight begins with a year-long mystery on planet Earth about what causes the mass extinctions and species diversification events that happen repeatedly in Earth's history. At first, this phenomenon does not appear to match the title of the instructional segment, but understanding this phenomenon requires that students understand many different aspects of science, including the physics of impacts and collisions. Students know that some types of organisms that lived in the past no longer live on Earth (LS4.A from grade three), but how often does this happen and what causes these changes? Scientists have compiled databases of every type of fossil ever discovered and how long ago those organisms lived. These databases include millions of fossils found in layers of rock deposited at thousands of sites around the world. By summarizing the data, scientists can create a single graph depicting a story of how life has diversified and gone extinct over time (figure 5.39). As students **analyze and interpret [SEP-4]** the graph, they notice a general trend as well as **ask questions [SEP-1]** about what causes the individual ups and downs. Each sudden drop on the graph represents a mass extinction event, so why are there so many of them and what **causes [CCC-2]** them?

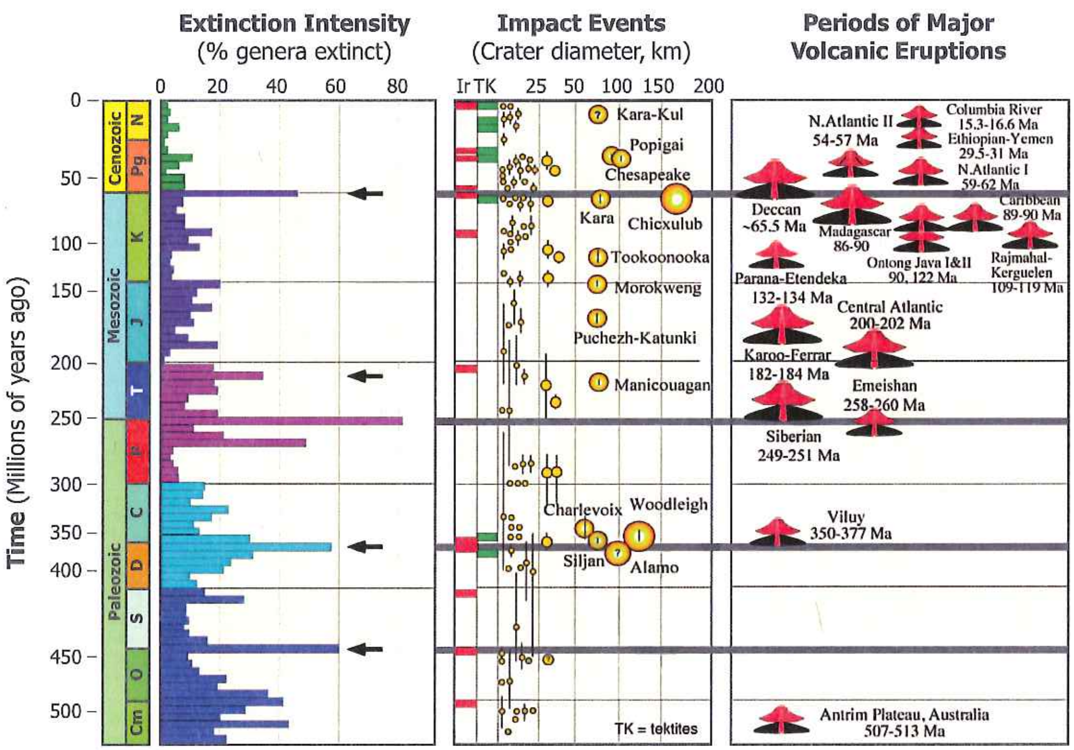
Figure 5.39. Number of Types of Marine Animals from the Last 542 Million Years



The boundaries between geologic periods that scientists have agreed upon (bottom) are often based on major extinction or diversification events when the number of genera changes quickly. *Source:* M. d'Alessio with data from Rohde and Muller 2005.

Students brainstorm possible causes of extinction events. Even if students "know" what caused the extinction of the dinosaurs from their prior knowledge, has the same process caused all extinction events? Students are assigned to different possible explanations and receive "clue cards" with evidence that supports their assigned mechanism and students use the **evidence to construct an argument [SEP-7]**. Students must **ask questions [SEP-1]** that probe and test this explanation further and then receive additional clue cards and revise their argument accordingly. While scientists have been weighing this evidence for decades, grade eight students can see that evidence supports many competing ideas (figure 5.40) and leads to multiple viable arguments that explain each extinction event; there is still disagreement even about the best-studied and most recent event that wiped out the dinosaurs (Keller 2011).

Figure 5.40. The Timing of Major Extinction Events and Possible Causes



Note that the time on the vertical axis is not at a uniform scale because of the data set used to make this figure. Each bar in the extinction intensity data set corresponds to rocks deposited during a different sub stage of geologic time. These sub stages were decided before techniques for determining the absolute age of a rock had been developed. At that time, scientists divided geologic time into different time periods based on the systematic changes they observed in the layers of rocks and fossils contained in those layers. Scientists continue to refer to these geologic time periods even though they can now describe geologic time in absolute terms (i.e., millions of years ago). *Source:* Modified from Keller 2011.

One likely mechanism that explains some mass extinctions is the impact of a large asteroid that caused a major disruption to Earth's climate. To motivate students and provide context, students can obtain information about the specific impacts of the Chicxulub Crater that might be responsible for the extinction of the dinosaurs. In addition to introducing one of the year's major topics (the history of life on Earth), this anchoring phenomenon of an asteroid impact also leads into many key concepts related to forces, motion, and gravity. How does science **describe and explain [SEP-6]** the motions of objects such as an asteroid or our planet? How big an asteroid would be needed to cause an extinction? What effects would such an impact have? How can we investigate phenomena related to motions and collisions? These questions mark the transition to a section of the instructional segment that focuses on physical science DCIs.

Motions and collisions provide many engaging ways for learners to **design experiments [SEP-6]**, manipulate variables, and **collect useful data [SEP-8]** over the course of a single or multiple succeeding class periods. Few topics in other science disciplines provide this abundance of laboratory experiences that ignite enthusiasm and quickly provide meaningful data.

Every day we push or pull many things. An object begins to move after we exert a force on it, and then it stops moving shortly after we stop pushing or pulling it. We conclude that forces cause temporary motions in objects. In complete contrast, Newton's First Law of Motion teaches that a force can **cause [CCC-2]** an object to move, and that the object should keep moving at exactly the same speed until another force slows it down, speeds it up, or causes it to change direction. As illustrated in the snapshot below, students need to **investigate [SEP-3]**, **model [SEP-2]**, and **analyze observations [SEP-4]** of many phenomena in order to develop an understanding of the ways in which objects move in scientifically accurate ways, and to correctly use motion concepts to explain the **cause and effect [CCC-2]** relationships that result in observed phenomena.

Integrated Grade Eight Snapshot 5.6: Learning About Motion

After having engaged students in the Earth and space science phenomena of an asteroid impact and asking questions about the speed of the impactor, Ms. Z focused on the physical science DCIs about motion. Ms. Z's students had just finished activities where they described motion in terms of speed. She decided to use the free Forces and Motion education animations (see http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link16) to transition from a focus on constant velocity to acceleration.

Anchoring phenomenon: A toy car doesn't move unless you push on it.

Sometimes, even a mundane observation can lead to great insight. She began by showing students a toy car and asking them to explain in words why the car is not moving. Some students had good ideas, but many struggled to find the right words to express the answer to this seemingly obvious question. She connected to students' investigations from grade three with balanced forces (3-PS2-1). Using an example of a toy car, she wrote up the statement on the board, "When the total force on an object is zero its motion does not change at that instant" (Newton's First Law). She asked students why she emphasized the phrase "at that instant."

Investigative phenomenon: (Students explore various phenomena related to the cases in each computer simulation).

Having established some background, she instructed the students to work individually or with a partner to explore their assigned animation, such that one-third of the class each explored one of the three animations (Motion; Friction; Acceleration). They recorded in their notebooks what they did, any conclusions they reached, and any questions the animation raised.

In the succeeding days, class sessions focused on the animations in the order of Motion, then Friction, and finally Acceleration. As the students presented, they or Ms. Z used the projector to manipulate the animation to support and extend what the students recorded in their notebooks. After reviewing the three animations as a whole class, the students collaboratively agreed on specific questions or concepts to explore further within the animations, such as **analyzing data [SEP-4]** about the **effects [CCC-2]** of mass and velocity on acceleration. These investigations and subsequent **analyses [SEP-4]** resulted in a consensus statement of Newton's Second Law, "When the total force on an object is not zero, its motion changes with an acceleration in the direction of the total force at that instant."

Students were surprised that the scientific meaning of the term *acceleration* includes speeding up, slowing down or changing direction. Some of the students enjoy telling people that vehicles actually have three accelerators: the gas pedal, the brake, and the steering wheel.

Resources:

The physical science narrative in this snapshot and instructional segment uses materials from Daehler, Shinohara, and Folsom 2011b.

The word *motion* in the CA NGSS implies both the object's speed and its direction of travel. The assessment boundaries of performance expectations for grade eight state that students will only be assessed on forces that are aligned, and deal with changes in speed that occur when the net force is aligned to the motion (i.e., only one-dimensional motion).

Speed is a ratio of distance divided by time. Students can **investigate [SEP-3]** speed by conducting experiments in which they measure both distance and time. Manual measurements of time in tabletop experiments using stopwatches are prone to large error, so there are several alternatives: students can pool multiple measurements using collaborative online spreadsheets and take the average, use an app to calculate speed from video clips (such as Tracker at http://www.cde.ca.gov/ci/sc/cf/ch5.asp#link17), use a motion sensor probe, or use computer simulations.

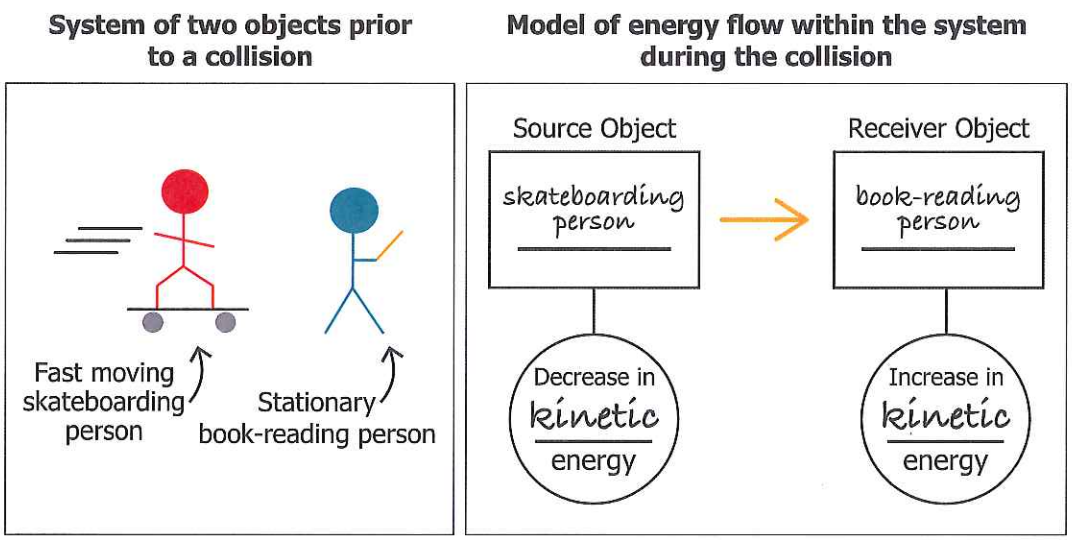
From a mathematical point of view, speed is the ratio of two very disparate quantities (distance such as meters and time such as seconds). Speed itself, the ratio, is also qualitatively different from the distance component and from the time component. This situation is typical in science where ratios are used in specific contexts to analyze phenomena. In order for these science ratios to make sense, students need to specify the units of measure for each component of the ratio and also of the resulting number, such as a speed or a density. This situation is very different from learning about ratios as an abstract relationship of two numbers that do not have units associated with them.

Students often harbor the preconception that a moving object will naturally stop rather than keep moving. If you kick a soccer ball, it will roll along the ground, slow down, and then stop. From a force point of view, the kick initiated the ball's movement and then friction, a very different force, opposed that movement. It requires a lot of experimentation and discussion before students internalize the understanding that without an opposing force, the ball would actually keep moving forever at the same speed in the same direction. Even after extended investigations and discussions, students may still retain preconceptions, for example, that the initiating force somehow remains associated with the moving object and keeps propelling it. Modeling the forces at different instants of time (before, during and after motion) can help address this kind of preconception. Another very powerful way to deepen understanding of motion is to provide an **energy [CCC-5]** perspective in addition to the force perspective.

The **energy [CCC-5]** perspective can help students understand why objects slow down. The kick transferred kinetic energy from the foot to the soccer ball. If no interactions remove kinetic energy from the soccer ball, it makes sense that the ball will keep moving at the same speed in the same direction. The interaction with the ground transfers some of that kinetic energy to the ground (the grass moves and also becomes a little warmer because of being rubbed by the ball). Since the soccer ball has lost some of its kinetic energy to the grass and the air surrounding, it naturally slows down and eventually stops.

Students can create a diagrammatic **model [SEP-2]** of the **flow of energy [CCC-5]** within **systems [CCC-4]** as shown in figure 5.41. This simple diagram of a collision is a model because it includes components (an energy source and receiver), an understanding of the way these objects will interact based on the laws of physics (energy is conserved, with one object decreasing in energy that is transferred to the other object), and it can be used to predict the behavior of the **system [CCC-4]** (the object that decreases in kinetic energy slows down while the object that increases in kinetic energy should speed up). Students can use these types of diagrammatic models to illustrate transfers of energy.

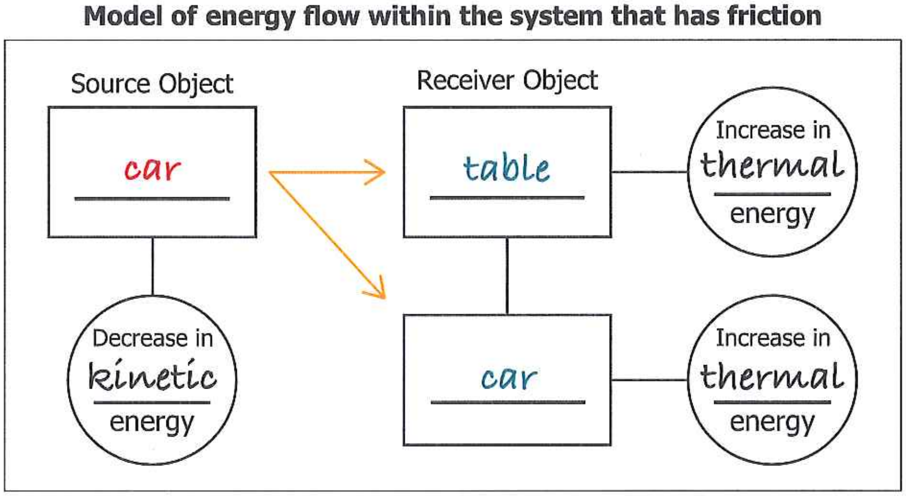
Figure 5.41. Energy Transfer in a Collision



Model of energy flow within a system during a collision. Diagram by M. d'Alessio.

The force of friction is an interaction in which **energy [CCC-5]** is transferred. Students must **plan investigations [SEP-3]** to explore the **effects [CCC-2]** of balanced and unbalanced forces on the motion of objects (MS-PS2-2). One such investigation could involve measuring the velocity of model cars with different amounts of friction by attaching sticky notes to the front and sides of the car to vary the amount of friction. Students should notice that when they push the car, they apply a force in one direction (figure 5.42) while friction is a force working in the opposite direction. The overall change in motion (and therefore change in energy) depends on the total sum of these forces. Using an energy source/receiver diagram to model the situation helps draw attention to the fact that all of the energy must be accounted for. The car clearly decreases in energy but that means another component of the system [CCC-4] must increase in energy.

Figure 5.42. Energy Transfer with Friction



Model of energy flow including friction within an experimental system of a tabletop car. Diagram by M. d'Alessio.

Using simple analogies such as friction of hands rubbing together, students can conclude that the energy is likely converted into thermal energy. When rubbing hands together, both hands warm up even if one hand remains stationary during the rubbing. This observation gives rise to two related modifications to the previous simpler energy source/receiver diagram: (1) there can be multiple energy receivers in a system [CCC-4] from a single energy source; and (2) an object (e.g., the car) can be both the source and the receiver of energy if that energy converts from one form (kinetic energy) to another form (thermal energy).

During an interaction when a force acts on an object, that object will gain kinetic energy. How much will the object's motion change during this interaction? Students asked similar questions [SEP-1] in fourth grade (4-PS3-3), and now they will begin to answer them. The answer depends strongly on the target object's mass. This principle becomes easily apparent in collisions. Students can perform investigations [SEP-3] by colliding the same moving object with target objects of different masses that are otherwise identical in shape (for example glass versus steel marbles of different sizes, cars with or without fishing weights attached, etc.). To measure consistent patterns [CCC-1], students will need to plan their investigation [SEP-3] (MS-PS2-2) such that the source object has a consistent speed (by rolling down a ramp of a fixed distance, for example). This procedure will ensure that the initial kinetic energy is constant and will lead to a consistent force initiating the collision interaction, if all other factors remain constant. Students can vary the mass of the target object and see how its speed changes as a result of the impact, plotting the results to look for a consistent pattern. This graphical representation should lead them towards a discovery of Newton's Second Law that relates the change in an object's motion (*acceleration*) to the force applied and the mass of the object. MS-PS2-2 does not require that students have a mathematical understanding of acceleration. Instead this performance expectation focuses on the **proportional [CCC-3]** relationship of motion changes and force.

When the source and target objects have equal masses and collisions transfer all of the **energy [CCC-5]** from source to receiver, the speed of the target object should be similar to the speed of the source object. This phenomenon can be seen clearly in billiards when the cue ball comes to a complete stop after hitting another ball. Observations such as these provide evidence to make the **argument [SEP-7]** that as one object loses kinetic energy during the collision, another object must gain energy, and vice-versa (revisiting MS-PS3-5 from Integrated Grade Six).

In each trial collision so far, the amount of **energy [CCC-5]** transferred to the target object has been held constant. While the amount of energy is constant, changes in the target object's mass can change how the energy transfer affects the object's speed. The motion of smaller target masses changes more (greater acceleration) than the change in motion of larger target masses. This kind of inverse relationship (bigger mass resulting in smaller change) can be confusing for students, so it can help to make that aspect of Newton's Second Law very explicit. Students can explore this idea further by changing the kinetic energy of the source object. In that case, the relationship is direct rather than inverse. Keeping the target object constant, groups of students can predict and demonstrate that increasing the mass or the speed of the source object increases the change in motion of the target object. From the energy perspective, a faster moving or more massive source object can transfer more kinetic energy to the target object. From the force perspective, a faster moving or more massive source exerts a greater force on the target object. Animation investigations can complement these tabletop investigations very nicely, and the dual perspectives of force and energy can help **explain [SEP-6]** the results of changing variables within the animations.

Engineering Connection: Landslide Early-Warning System

MS-PS2-1 provides a capstone goal for IS1. Students **design a solution [SEP-6]** to a problem involving the motion of two colliding objects. The clarification statement for the performance expectation offers examples of collisions between two cars, between a car and a stationary object, or between a meteor and a space vehicle. In order for this challenge to extend deeper into the design process, the suggestion here is to restrict the projects to situations for which students can physically model and obtain data that can be used in iterative testing and refinement of their design solution.

The classic egg drop could be used but many of the solutions to that problem involve slowing the falling egg before the collision. The emphasis for the performance expectation is on applying Newton's Third Law that objects experience equal and opposite forces during a collision. For example, a variation where students attach eggs to model cars and design bumpers will follow naturally from their prior tabletop experiments. At the conclusion of their testing and refinement, students should be able to use their models of **energy transfer [CCC-5]** and kinetic energy to make an **argument [SEP-7]** about how their design solution works. Bumpers tend to reduce the effects of collisions by two processes: (1) they absorb some of the source kinetic energy so that less of it gets transferred to kinetic energy in the target object and more of it gets converted to thermal energy; and (2) they make the collision last longer so that the transfer of energy occurs over a longer time interval.

No matter what type of collisions students **investigate [SEP-3]**, they will need to identify the constraints that affect their design as well as the criteria for identifying success (MS-ETS1-1). As student teams evaluate competing design solutions (MS ETS1 2) and identify common features of successful models (MS ETS1 3), they can identify and model the physical processes that are involved, using the dual perspectives of forces and energy transfers. Students should be able to discuss their bumper solution in terms of energy source/receiver diagrams such as figure 5.41. Towards the end of their design challenge, students need to **explain [SEP-6]** why certain choices they made actually work, and then use their more detailed **models [SEP-2]** of their system to further refine their design.

Now students return to the anchoring phenomenon of an asteroid impact and can use models of energy transfer to explain various observations of rock layers that formed at the time the dinosaurs went extinct. First, Earth's motion appeared largely unaffected by the asteroid impact. What does this say about the size of the asteroid relative to Earth? Small chunks, however, were thrown into the air at high speed. Could they fly up faster than the original asteroid? Lastly, impact sites like Chicxulub Crater show evidence of rock that melted at the impact site, and many of the distant deposits include solidified droplets of formerly molten rock. Where did the energy come from to melt this rock?

The CCC of **energy and matter: flows, cycles and conservation [CCC-5]** is applied in many different contexts throughout the middle grades. One of the middle grade bullets used to describe this CCC states that "the transfer of energy drives the motion and/or cycling of matter." In Integrated Grade Six and Integrated Grade Seven, the emphasis is on the role of energy transfer in driving the cycling of matter (water cycle, rock cycle, and cycling of matter in food webs). In Integrated Grade Eight IS1, the emphasis is on the role of energy transfer in driving the motion of matter.

Using this CCC throughout the middle grades serves at least three complementary purposes. As students gain experience in applying the CCC, it helps them connect with different DCIs and understand these DCIs and the related phenomena in greater depth. As students apply the CCC in different contexts, they get to understand the CCC itself in greater depth (e.g., transfers of energy can drive cycles of matter and motion of objects). Thirdly, students experience science as a unified endeavor rather than separate and isolated topics. Ultimately all of science works together as a unified whole system.

Now that students understand more about the physical science effects of a giant impact, they can return to the anchoring phenomenon to consider how such an impact would affect the biosphere. They will need to draw on their understanding of Earth's interacting systems from earlier grades (ESS2.A). Students also know that dinosaurs went extinct, while other species survived and then thrived following the impact. Why? Can we use this information about how living systems were affected to determine more details about the physical changes to Earth's climate following the impact? A goal of the Integrated Model is that students see how understanding one domain can enhance understanding in others.

To transition to the next instructional segment, students might wonder more about these asteroids and how they move in space. This turns their attention to the sky.

IS2 Integrated Grade Eight Instructional Segment 2: Noncontact Forces Influence Phenomena

Many phenomena are controlled by forces that do not touch the affected object. In IS2, students explore gravity and electromagnetism in the context of observable features of the Sun, Moon, stars, and galaxies. After years of noticing patterns in the movement of these objects in earlier grades, they finally develop a model that explains these celestial motions. This model does appear until grade eight because it requires students to visualize complex motions from multiple frames of reference (both as observers on Earth and out in space). What makes this unit "integrated" is that the motions are considered in tandem with the gravitational forces that cause them.