Stackable Instructionally-embedded Portable Science (SIPS) Assessments Project

Grade 8 Science
Unit 1 Sample Lesson "Newton's Third Law"
Forces and Energy
January 2023

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Science Grade 8
Unit 1: Forces and Energy
Sample Lesson: Newton's Third Law
Suggested Time to Complete: 120 minutes

Purpose & Use Statement: *This sample lesson was developed for state and local administrators and teacher leaders (e.g. curriculum directors, instructional facilitators, professional learning specialists) to (1) illustrate an example of an instructional lesson developed using a principled design approach, and (2) support accompanying process documentation about how to use the SIPS unit as an instructional framework to intentionally design high-quality lessons in an aligned curriculum, instruction, and assessment system. This sample lesson should be evaluated and refined, as necessary, to align appropriately with a standards-based curriculum, instruction, and assessment system prior to its use. Additionally, teachers should refine this lesson to meet the local, cultural, and individual needs of students.*

Desired Results

Overview of the Learning Goals

In this lesson, students explore hands-on activities, digital resources, and print resources to explore the concepts of Newton's third law. Students watch videos, read, use simulations, and conduct simple small hands-on activities to gather additional information about Newton's third law, building on their ideas and understandings from the experiment.

Connections to Prior Learning

DCIs – (from NGSS Appendix E: DCI Progression within NGSS; see pg. 7)

- **Prior learning from 3-5:**
  - The effect of unbalanced forces on an object results in a change of motion.
  - Patterns of motion can be used to predict future motion.
  - Some forces act through contact; some forces act even when the objects are not in contact.
  - The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.
  - Moving objects contain energy. The faster an object moves, the more energy it has.
  - Kinetic energy can be distinguished from the various forms of potential energy. Energy changes to and from each type can be tracked through physical or chemical interactions.
  - When objects collide, contact forces transfer energy so as to change the objects' motions.

CCC – Systems and System Models

- **Prior learning from 3-5:** Students are expected to understand how a system is composed of components that are interacting with one another and that the system can do things that depend on the different components, which may each have a unique function.
  - In grades 3-5, students understand that a system is a group of related parts that make up a whole. The system can carry out functions its individual parts cannot.
  - They learn to describe a system in terms of its components and their interactions. [Appendix G]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students are expected to develop additional sophistication in identifying the way that components of a system interact with one another and with the environment (surroundings) of the system.
  - Multiple MS PEs use this CCC, so students will likely have some experience with the MS CCC elements prior to starting Grade 8 and Unit 1.
  - An example MS PE that uses the same CCC element (students will have had experience with this CCC if they were previously taught this MS PE) is MS-LS1-3: *Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

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CCC – Stability and Change

- **Prior learning from 1-2 (NOTE: Stability and change are not referenced by any Grade 3-5 PEs):**
  - In grades 1-2, students learn that some things change while others stay the same and that change can occur over short and long time periods.
  - Students learn that some systems appear stable, but over long periods of time, they will eventually change. [Appendix G]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students are expected to be able to characterize how systems change, including using changes over time and considering forces at different scales. Students learn that changes in one part of a system might cause large changes in another part and how some systems are cases of dynamic equilibrium.
  - Multiple MS PEs use this CCC, so students will likely have some experience with the MS CCC elements, prior to starting Grade 8 and Unit 1.
  - An example of an MS PE that uses the same CCC element (students will have had experience with this CCC if they were previously taught this MS PE) is MS-LS2-4: *Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*

SEP –Engaging in Argument from Evidence

- **Prior learning from 3-5:** Students will have the ability to construct scientific explanations or solutions and to critique those proposed by peers by citing relevant evidence about the natural and designed world(s).
  - In grades 3-5, students will develop understanding and skills for how to construct and/or support an argument with evidence, data, and/or a model.
  - They will be able to distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
  - They will use relevant evidence and pose specific questions in the process of respectfully providing and receiving critiques from peers about a proposed procedure, explanation, or model. [Appendix F]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades students will progress to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). This will include presenting an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
  - Multiple MS PEs use this SEP, so students will likely have some experience with the MS SEP elements, prior to starting Grade 8 and Unit 1.
  - An example of an MS PE that uses the same SEP element (students will have had experience with this SEP if they were previously taught this MS PE) is MS-LS1-3: *Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.*

SEP – Constructing Explanations and Designing Solutions

- **Prior learning from 3-5:** Students will use variables that describe and predict phenomena to construct explanations and design multiple solutions to design problems.

  - In grades 3-5, students will be able to identify evidence that supports particular points in an explanation.
  - They will be able to generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. [Appendix F]
- **Prior learning from this grade band (e.g., Grades 6 & 7):** During all MS grades, students will construct explanations and design solutions that are supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
  - Multiple MS PEs use this SEP, so students will likely have some experience with the MS SEP elements, prior to starting Grade 8 and Unit 1.
  - An example of an MS PE that uses the same SEP element (students will have had experience with this SEP if they were previously taught this MS PE) is MS-ESS2-2: *Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.*

Key Vocabulary

Students build conceptual meaning with and use key tier II and tier III vocabulary terms as they make sense of phenomena and phenomena-based design problems. This is not an exhaustive list of terms and should be reviewed and modified by educators, as appropriate.

- Action/Reaction Pair
- Acceleration
- Drag
- Force
- Thrust
- Magnitude

Targeted Stage 1 Learning Goals

Acquisition Goals (AG)

A1. Design a solution to a problem that utilizes the fact that when two objects interact, they exert a force on each other in opposite directions.
A6*. Apply Newton's Third Law to explain a situation involving the motion of two colliding objects. [MS-PS2-1]
A3. Create a model to show the direction of the forces exerted by two interacting objects on each other is opposite.
A8. Engage in argument from evidence that when two objects interact, the force from object one acts on object two and the force from object two acts on object one; therefore, the forces do not cancel each other.

Common Core State Standards (CCSS):

RST.6-8.1
RST.6-8.7

Enduring Understandings (EU)/ Essential Questions (EQ):

EU 1/EQ 1

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
☐ Analyze & Interpret Data	☒ PS2.A: Forces and Motion	☐ Cause & Effect
☐ Ask Questions		☐ Energy & Matter
☒ Construct Explanations		☐ Patterns
☐ Define Problems		☐ Scale, Proportion, & Quantity
☐ Design Solutions		☒ Stability & Change
☐ Develop & Use Models		☐ Structure & Function
☒ Engage in Argument from Evidence		☒ Systems & System Models

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- ☐ Mathematics & Computational Thinking
- ☐ Obtain, Evaluate, & Communicate Information
- ☐ Plan & Carry Out Investigations

Formative Assessment Opportunities

Monitoring	Success Criteria	Possible Instructional Adjustments
• The teacher listens to students while they work in small groups to explore the resources and asks scaffolding and probing questions to students to help provide guidance and clarity of student understanding. • The teacher monitors student progress on the stations and adjusts the time provided accordingly. • When students are refining their explanations and developing their model, the teacher reviews them for incomplete understandings and identifies areas to be revisited in future lessons.	Students can: • Identify action/reaction pairs of force during interactions • Explain why action/reaction forces do not cancel each other out • Relate Newton's third law to the real-life situations of space flight, collisions, and others • Refer to the mass of objects as a basis for deciding how to decrease the amount of force in a collision • Refer to the system model to identify how objects are interacting • Construct a system model to analyze Newton's third law and forces in a collision (force directions) • Determine the effect of speed within a collision • Develop a model for a collision of two colliding objects exerting forces upon one another ○ Model includes relationships among model elements that are sufficient in capturing the strength and direction of the forces each object exerts upon the other in a system	• The teacher provides targeted resources for students who may be overwhelmed by the choice or not have enough time to move through all the resources at their own pace. • Having extra stations, more stations than groups, will allow students to move at their own pace at each station (For example: two sets of each station for 10 total).

- Model includes appropriate model elements that would be necessary to describe when two objects in a system interact, the forces each object exerts upon the other are equal in strength, but opposite in direction
- Model includes an appropriate description that articulates how model elements correspond to a target phenomenon in which the forces each object exerts upon the other are equal in strength, but opposite in direction, while two objects in a system interact

Instructional Plan

Lesson Overview

In this lesson, students work in small groups to explore a variety of learning centers/stations on the topic of Newton's third law. At each station, there will be handouts/instructions that explain the task to students. After students finish all the stations/centers, they revisit the unit anchoring event explanation and make revisions.

Materials & Set-Up

Station 1: Technology with access to video resources:

- STEMonstrations: Newton's Third Law of Motion | NASA [https://www.nasa.gov/stemonstrations-newtons-third-law-rocket-races.html]
- Newton's 3rd Law - YouTube [https://www.youtube.com/watch?v=D4j5bcaV2Ws]
- The Science of Jetpacks and Rockets! - YouTube [https://www.youtube.com/watch?v=Hx9TwM4Pmhc]
  - (Note: In this video, the presenter uses an equation, F = mv, but it is not "m". It is m with a dot and is the mass expelled per second, kg/s. This may be a point of confusion for middle school students and the teacher may need to clarify this if using this video or encourage students to explore the formula and better understand its meaning.)
- Newton's 3rd Law of Motion - YouTube [https://www.youtube.com/watch?v=_sr3hBxu614]
- Best Film on Newton's Third Law. Ever. - YouTube [https://www.youtube.com/watch?v=8bTdMmNZm2M]

Station 2: Reading passages:

- Equal & Opposite Reactions: Newton's Third Law of Motion | Live Science [https://www.livescience.com/46561-newton-third-law.html]
- Newton's Third Law of Motion (physicsclassroom.com) [https://www.physicsclassroom.com/class/newtlaws/Lesson-4/Newton-s-Third-Law]
- Identifying Interaction Force Pairs (physicsclassroom.com) [https://www.physicsclassroom.com/class/newtlaws/Lesson-4/Identifying-Action-and-Reaction-Force-Pairs]
- Newton's Third Law (Read) | Physics | CK-12 Foundation (ck12.org) [https://www.ck12.org/physics/Newtons-Third-Law/lesson/Newtons-Third-Law-MS-PS/]
- 15 Examples of newton's third law of motion - DewWool [https://dewwool.com/newtons-third-law-examples/]

Station 3: Rocket racer materials:

- Styrofoam food trays (like the trays grocery stores use for poultry)
- Small plastic stirrers (round cross-section) – 2 per student
- Flexi-straws – 3 per student
- 4- or 5-inch round balloons
- Balloon pump (recommend having at least 4-5 so students can do testing)
- Masking Tape
- Pencils
- Scissors
- Rulers
- Meter stick or measuring tape
- Sandpaper (optional)
- Additional supplies for modifications to cars (rubber bands, cardboard, CDs, etc.)
- Handouts: STEMonstrations -- Newton's Third Law: Rocket Racers (nasa.gov) [https://www.nasa.gov/sites/default/files/atoms/files/stemonstrations_newtons-third-law.pdf]

Station 4: Newton's car materials:

- Handout and instructions: Rockets Guide - Rocket Activity Newton Car (nasa.gov) [https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-newton-car.pdf]
- Newton's car
  - Cotton string
  - Rubber bands
  - Medicine bottle
  - Straight drinking straws
  - Meter sticks
  - Scale/beam balance

- Materials to provide weight in the bottles
- Eye protection

Station 5: Technology for conducting the simulations

Anchor or Investigative Phenomenon: In this unit, the anchor phenomenon is about collisions. These compelling situations can be used as a starting point for the discussion about collisions in various situations, the effects of those collisions on an object's motion, and the factors that affect the forces and corresponding changes in motion. The chosen collision is up to the teacher. Options are provided in the unit map.

Driving Question: What forces are applied to objects when two objects interact?

	Teacher Does	Students Do
Engage ☑ Introduce object, event, phenomenon, problem, or question ☑ Build background knowledge ☑ Facilitate connections		
Explore ☑ Explore object, event, phenomenon, problem, or question ☑ Guided exploration with hands-on activities	Ahead of time, the teacher should set up a variety of learning centers/stations around the classroom in a way that makes sense for students. The teacher groups students into small groups. While students work at each station, the teacher monitors the time and facilitates students moving through all of the stations. While students are working at the stations, the teacher walks around the room and uses informal assessments to evaluate students' progress as they explore. The teacher asks probing questions to challenge student thinking and gain insight into student understanding.	Students cycle around different learning stations. **Station one video media:** Students explore the resources below to learn more about Newton's third law. As they watch the videos, they record notes in their science notebook in a concept map. Students draw connections between bubbles and make notes on the connecting lines on how the different factors relate/connect. Videos: • NASA Demonstration from the International Space Station: ○ https://www.nasa.gov/stemonstrations-newtons-third-law-rocket-races.html • Demonstration of Newton's Third Law:

- https://www.youtube.com/watch?v=D4j5bcaV2Ws
- Veritasium: The Science of Jetpacks and Rockets:
  - https://www.youtube.com/watch?v=Hx9TwM4Pmhc
- HR MacMillion Space Center, Ask an Astronomer:
  - https://www.youtube.com/watch?v=_sr3hBxu614
- Veritasium: Best Film on Newton's 3rd Law. Ever.
  - https://youtu.be/8bTdMmNZm2M

Station two reading passages: For this center, students read articles as a group using the reading strategy of Reciprocal Teaching. Articles can be from a core text, online resources, or others. A list of potential articles is provided in the resources section. For this activity, each student reads with a different role, summarizer, clarifier, questioner, and predictor. In their group of four, they select a reading passage to read together. As they do, they use the reciprocal reading template and guiding questions as they read the text based on their designated role.

After reading one of the passages:

- The summarizer highlights the key ideas.
- The questioner then poses questions about the selection:

- Unclear parts
- Puzzling information
- Connections to other concepts already learned

- The clarifier addresses confusing parts and attempts to answer the questions that were just posed.
- The predictor can offer predictions about what the author tells the group next or, if it's a literary selection, the predictor might suggest what the next events in the story will be.
- The roles in the group then switch one person to the right, and the next selection is read. Students repeat the process using their new roles.

Station three rocket racers: Students follow the instructions on pages 4 to 6 of the NASA rocket races activity: https://www.nasa.gov/sites/default/files/atoms/files/stemonstrations_newtons-third-law.pdf

Station four Newton's car: Students use Newton's car to experiment with and observe Newton's third law in action. See the link below for more information on how to build your own car and for the general set up of this station. https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-newton-car.pdf

Station five digital simulations: At this station, students

explore a series of simulations that review the lab activity and Newton's third law. As they explore each simulation, they record the answers to the questions in their science notebook.

Simulation one: https://www.ck12.org/c/physics/newtons-third-law/simulation/Third-Law-Simulation/

Questions for students:

- Level One:
  - Draw in your journal a sketch of Joey and the cart. Then draw and label all the forces acting on Joey and the cart.
  - Adjust the pulling force of Joey. What do you notice about the forces and how they change?
- Level Two:
  - What did you need to do to make it possible for Joey to reach a constant speed?
- Level Three:
  - What did you set the force at for Joey's pulling force? What is the size of the force from the cart on Joey?

After going through all the questions in the simulation, write down any questions you are unsure about.

Simulation two: https://interactives.ck12.org/simulations/physics/pirate-ship/app/index.html?lang=en&referrer=ck12Launcher&backUr

		l=https://interactives.ck12.org/simulations/physics.html&&requestor=/ Students explore the simulation, then answer the questions on the handout for the simulation, page 4: • Which is stronger, the thrust force acting on the cannon or on the cannonball? • What is the third law pair to the downward gravitational force acting on the pirate? • In which direction does the tension force on the pirate point when a gust of wind rises up? Simulation three: https://www.olabs.edu.in/?sub=1&brch=1&sim=105&cnt=4 In this simulation, students conduct an experiment similar to the hands-on experiment. They use the simulator to collect data from several data points, record the data in their science notebook, and write a paragraph explaining what happened and why using evidence from the simulation.
Explain ☑ Explain understanding of concepts and processes ☑ Introduce new concepts and skills to seek conceptual clarity	The teacher listens to students and provides support while they work on revising their explanations, taking note to remind students to use evidence to support their claims and reasoning within their model.	After students have moved through all the stations, they return to their explanations and revise their anchoring event explanation. Students share their explanations with a peer to get feedback and make additional revisions if needed.

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Elaborate

☑ Build on or extend understanding and skill

☑ Apply concepts in new or related contexts

Evaluate

☑ Self-assess knowledge, skills, and abilities

☑ Evaluate student development and lesson effectiveness

Closing

Think about your day so far. Choose a moment from the last 24 hours when you had an interaction with an object, any object. Draw a diagram of the interaction and then label all the forces acting on you and the other object. Then identify all the action/reaction pairs in your diagram.

Differentiation Strategies and Resources

"Universal Design for Learning (UDL) is a framework to improve and optimize teaching and learning for all people based on scientific insights into how humans learn" (CAST, 2022). Taking time to reflect on prior instruction when planning for accessible, differentiated, and culturally responsive instruction for diverse learners and culturally diverse classrooms serves to identify ways to improve future instructional practices. The UDL Guidelines provide a framework for this reflection. The guidelines include three principles as ways to focus on variety and flexibility in instructional practices:

 Multiple Means of Engagement

 Multiple Means of Representation

 Multiple Means of Action & Expression

By examining instruction and instructional materials through the lens of each of these principles, the teacher can identify and thus reduce or remove barriers to diverse learners.

Learning Opportunities	UDL Principle	Example Differentiation Strategies & Resources
Explore		
In groups, students cycle around different learning stations.		Provide different level of support and scaffolds • Stations utilize a variety of media types, with multiple options within each type. Some students may be able to complete a multiple-step task with no support, while other students may need verbal or visual cues to complete each step Provide choices

		• There are two hands on activities for students, one features designing and one manipulating a set up
		Present clear and important goals and objectives • Have students write goals into simple I can statements (e.g., I can use a model of applied forces to predict how a motion of an object will change using different forces.) • Explain scientific terms along with the goals so that students understand what they are working towards Encourage collaboration with partners and in groups • Be intentional on how groups are formed so that they include a variety of students (e.g., race, national origin, socioeconomic status, disability, etc.)
		Provide information in a variety of ways • The different media types at the different stations all focus on the same topic providing alternative ways of covering the same content
		Provide options for accessing instructional activities and materials. Provide information in a variety of ways • Allow enough time for all students to move from one activity to the next, or to perform a task • Ensure access is available for students who have a hearing impairment or visual impairment, who are blind, deaf, or deaf/blind (e.g., include audio description for video content, closed captions for video content, alternative text for graphics, preferential seating, an American Sign Language (ASL) interpreter, screen reader, enlarged text, etc.) • Use technology or assistive technology (AT) to broaden access to instructional materials Use technology or assistive technology (AT) to broaden access to instructional materials • Use computer simulations of force and motion
Explain		
Students return to their explanations after circling all the stations and presenting to peers to revise		Allow ownership of parts of instructional tasks • Provide several options for students to practice the science vocabulary terms (e.g., use terms in a story, create a song about each, pair with illustrations that describe the term) and how to present what they did (e.g., perform live, record and share, with photos, written format, orally share)

their anchoring event explanation.		Use a flexible way to present information • Have different options for students to choose on how they want to present their findings e.g chart. Powerpoint slides, etc
		Vary the ways for students to respond to questions or a task. • Students decide how best to represent their new learning when they add information to their explanation using diagrams, text, or both Provide support for decoding of written text and symbols • Through peer presentations, students add additional revisions to their explanatory model

Resources

Video resources

- STEMonstrations: Newton's Third Law of Motion | NASA [https://www.nasa.gov/stemonstrations-newtons-third-law-rocket-races.html]
- Newton's Third Law of Motion | Forces and Motion | Physics | Don't Memorise - YouTube [https://www.youtube.com/watch?v=TVAxASr0iUY]
- (2) The Science of Jetpacks and Rockets! - YouTube [https://www.youtube.com/watch?v=Hx9TwM4Pmhc]
- (2) Newton's 3rd Law of Motion - YouTube
- [https://www.youtube.com/watch?v=_sr3hBxu614]
- (2) Best Film on Newton's Third Law. Ever. - YouTube [https://www.youtube.com/watch?v=8bTdMmNZm2M]

Balloon rocket/car

- STEMonstrations -- Newston's Third Law: Rocket Racers (nasa.gov) [https://www.nasa.gov/sites/default/files/atoms/files/stemonstrations_newtons-third-law.pdf]

Newton's car

- Newton Car | NASA [https://www.nasa.gov/stem-ed-resources/newton-car.html]
- Rockets Guide - Rocket Activity Newton Car (nasa.gov) [https://www.nasa.gov/sites/default/files/atoms/files/rockets-guide-20-newton-car.pdf]

Simulation/interactives:

- Third Law Simulation (Simulations) | Physics | CK-12 Foundation (ck12.org) [https://www.ck12.org/c/physics/newtons-third-law/simulation/Third-Law-Simulation/]
- Pirate Ship (Newton's Third Law, Free Body Diagrams, Types of Forces) | Physics | CK-12 Exploration Series (ck12.org) [https://interactives.ck12.org/simulations/physics/pirate-ship/app/index.html?lang=en&referrer=ck12Launcher&backUrl=https://interactives.ck12.org/simulations/physics.html&&requestor=/]

- Newton's Third law of Motion (Simulator) : Class 9 : Physics : Online Labs for schools - Developed by Amrita Vishwa Vidyapeetham and CDAC Online Lab (olabs.edu.in)
  [https://www.olabs.edu.in/?sub=1&brch=1&sim=105&cnt=4]

Handouts

- conceptmap1.pdf (readingrockets.org)
  [https://www.readingrockets.org/content/pdfs/conceptmap1.pdf]
- inference-graphic-organizer.pdf (readingrockets.org)
  [https://www.readingrockets.org/pdfs/inference-graphic-organizer.pdf]
- Reciprocal Teaching WS.indd (readingrockets.org)
  [https://www.readingrockets.org/content/pdfs/reciprocalteaching_worksheet.pdf]
- Predict: (readingrockets.org)
  [https://www.readingrockets.org/content/pdfs/reciprocalteaching_handout.pdf]

Core Text Connections

Reading

- Equal & Opposite Reactions: Newton's Third Law of Motion | Live Science
  [https://www.livescience.com/46561-newton-third-law.html]
  Newton's Third Law of Motion (physicsclassroom.com)
  [https://www.physicsclassroom.com/class/newtlaws/Lesson-4/Newton-s-Third-Law]
- Identifying Interaction Force Pairs (physicsclassroom.com)
  [https://www.physicsclassroom.com/class/newtlaws/Lesson-4/Identifying-Action-and-Reaction-Force-Pairs]
- Newton's Third Law (Read) | Physics | CK-12 Foundation (ck12.org)
  [https://www.ck12.org/physics/Newtons-Third-Law/lesson/Newtons-Third-Law-MS-PS/]
- 15 Examples of newton's third law of motion - DewWool
  [https://dewwool.com/newtons-third-law-examples/]