Unit Title: Motion and Design	**Content Area:** Physical Science/Force and Motion	**Grade Level:** 5

Unit Summary: The Motion and Design unit combines the physics of forces and motion with technological design. Students use plastic construction materials, weights, rubber bands, and propellers to design and build vehicles, then test how those vehicles respond to different forces of motion, like pushes, pulls, or rubber band energy. They explore, through experiments and multiple trials, how forces like friction, gravity, and air resistance work against motion to slow their vehicles down. Students must apply the concepts they learn to a design challenge, designing a vehicle that can perform to certain specifications, but also meets certain "cost" requirements. The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; energy and matter; Structure and Function; and systems and systems models are called out as organizing concepts for this unit. Students are expected to demonstrate proficiency in the science practices of developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information; and to use these practices to demonstrate understanding of the core ideas.

Unit Essential Questions:

- What happens to the energy in a system? -----Where does this energy come from, how is it changed within a system, and where does it ultimately go?
- How does the flow of energy affect the material in the system?
- How do we know that things have energy?
  How can energy be transferred from one material to another?
  What happens to a material when energy is transferred to it?

Unit Enduring Understandings:

- Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy, and types of energy associated with the position of mass and with energy fields (potential energy).
- Changes take place because of the transfer of energy.
- Energy is transferred to matter through the action of forces.
- Different forces are responsible for the transfer of the different forms of energy.
- Moving objects have energy

Possible Student Misconceptions:

- Distinguishing between active objects and objects that support or block or otherwise act passively, such as a table. Students tend to recognize the active actions as forces but often do not consider passive actions to be forces.
- The belief that if a body is not moving, there is no force acting on it.
- Understanding that all interactions involve equal forces acting in opposite directions on the separate, interacting bodies.
- The belief that animate objects (like a person's hands) can exert forces whereas inanimate objects (like tables) cannot.
- Understanding gravity as a force, and its relationship to weight.
- Students do not always identify a force to account for falling objects. They think objects "just fall naturally" or that the person letting go of the object has caused it to fall.

NJCCCS: 5.1.4.A-C, 5.2.6.E.1, 5.2.6.E.3

NGSS Performance Expectations: *Students who demonstrate understanding can…*

- 3-5-ETS1-1:Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost
- 3-5-ETS1-2Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem
- 3-5-ETS1-3-Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Primary CCSS ELA/Literacy Connections: RI.5.1, RI.5.4, RI.5.9, W.5.2, W.5.8, W.5.9, SL.5.1, SL.5.4	**Primary CCSS Mathematics Connections:** 5.OA.2, 5.NBT.1, 5.NF.3

Lesson Pace & Sequence

Lesson 1: Designing Vehicles		**Learning Objective(s):** Build vehicle to meet design requirements			**Lesson Duration:** 100 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	KWL Chart--Students begin by writing independently in their science notebooks. First, they write what they know about how vehicles move. Then, they write what they know about how to design vehicles.		Asking Questions and Defining Problems		
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Whole group discussion "What we know about the Motion and Design of Vehicles (TG, section 4, pg9, figure 1-3)--Create a list.				
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student groups build vehicles to meet the following design requirements: In 20 minutes or less, design and build a vehicle (cart) that will move at least 100 cm (39 in.)	• STC Motion and Design Kit/ student manual(TG, Section 4, pg. 11)	Developing and Using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	PS2.A: Force and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the objects speed or direction of motion. (3-PS2-1)	Systems and System Models: A system can be described in terms of its components and their interactions.
Explain: How will you help students connect their exploration to the concept/topic under investigation?	STC Literacy Series™ Motion and Design: Part 1, "Adapted for Survival" pgs. 14–17	• STC Literacy Series™ Motion and Design: Part 1			
	Based on data/evidence students will individually record answers to the following questions in their science notebooks: 1. How did you get your vehicle to move? 2. What was one problem your group encountered while building the vehicle? How did you solve the problem? W.5.2, W.5.8		Constructing Explanations and Designing Solutions: Identify the evidence that supports particular points in an explanation.	PS2.A: Force and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the objects speed or direction of motion. (3-PS2-1)	Systems and System Models: A system can be described in terms of its components and their interactions.

Extend: How will students deepen their conceptual understanding through use in new context?	Use extended engineering lesson to build on existing learning objectives.	• Transportation and the Environment Lesson Plan: http://www.teachengineering.org/view_lesson.php?url=collection/cub_/lessons/cub_intro/cub_intro_lesson02.xml			Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (3-5-ETS1-2)
Lesson Pace & Sequence					
Lesson 2: Using Drawings to Record and Build	**Learning Objectives:** Students draw the vehicles they designed in Lesson 1 and learn about technical drawing.				**Lesson Duration:** 100 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Refer students to the brainstorming list from Lesson 1, "What We Know about the Motion and Design of Vehicles." Ask students to identify statements that relate to drawing or to design plans. Let students know that engineers use science and math to plan, design, and construct products. They often sketch their ideas and plans before they build. They also make detailed records of their products after building them, either by drawing them or using computer graphics, so the products can be studied and improved. Let students know they will do similar activities in this lesson.				

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Using the STC interactive white board lesson; "Engineering and Design" Identify the order an engineer would use to design and create a product that meets a human need.	• STC™ Motion and Design Interactive Whiteboard Activity (pg. 2)			
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students draw the vehicles they designed in Lesson 1 and learn about technical drawing. The concept that the position and motion of an object may be changed by a force, such as pushing or pulling is emphasized.	• STC Motion and Design (TG, Section 4, pgs. 18–21)	Developing and using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	PS2.A: Force and Motion: Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the objects speed or direction of motion. (3-PS2-1)	Cause and Effect: Cause and effect relationships are routinely identified, tested, and used to explain change
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Student pairs will read "Taking to the Skies" pgs. 7–9,	• STC Literacy Series™, Motion and Design, Part 1			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student will individually evaluate the following questions: Based on the text, can designers learn from failures as well as from successes? Use supportive evidence from the text to explain your answer. Compare some of your own experiences in design failure and success from Lesson 1 to that of the story. Use details from the text to support answers. RI.5.1 Explain, using textual evidence, the relationship between our understanding of how birds fly and the Wright's airplane wing design. RI.5.3,	• STC Motion and Design Kit/ student manual: Taking to the Sky pages 7-10 and The Race to Fly pages 37-40			
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Making accurate technical drawings of their vehicles - Appropriate use of design vocabulary -				

Extend: How will students deepen their conceptual understanding through use in new context?	1. Place an object in a place where everyone can see it. Now ask volunteers to walk around the object and describe, in writing, how it looks from different directions. Ask which view or views provide the most useful information. - Challenge students to find out what a scale drawing is. Ask them to look at their vehicles and their vehicle drawings. Is the vehicle drawn to scale (all parts in proportion)? For example, are the wheels the correct size when compared with the body of the vehicle? Students can also find a scale on maps. Have them use the scale to calculate actual distances between cities.		Asking Questions and Defining Problems		Scale, Proportion, and Quantity

Lesson Pace & Sequence

Lesson 3: Pulling a Vehicle: Looking at Force		**Learning objective(s):**		**Lesson Duration: 75 min.**	
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	Invite a student to move from one end of the room to another. Have the class describe the student's motion. Ask the student to move again, this time showing a change in motion (for example, walk and then run). Ask the class to describe the student's change in motion. Let the class know they will describe motion and changes in motion in this lesson and throughout the unit.				
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	As students follow along, go over the Student Instructions for Setting Up a Falling-Weight System (pgs. 14–15 in the Student Investigations book). Ask a student volunteer to demonstrate the investigation using the falling-weight system you set up at the front of the room. Ask students to speculate about the purpose of the bookend. Provide mini-lesson on kinds of motion.	• STC Motion and Design, student investigation book			
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will set up a system to test the effect of a falling weight on the movement of the standard vehicle they built in lesson 2	• STC Motion and Design Kit	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	PS2.B: Motion and Stability: Forces and Interactions: Types of Interactions: Objects in contact exert forces on each other. (3-PS2-1) - Energy: PS3C: Relationship Between Energy and Forces: When objects collide, the contact forces transfer energy from one object to another as to change the objects' motion. (4-PS3-3)	Energy and Matter: Energy can be transferred in various ways and between objects-------Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Read in STC Literacy Series™, Motion and Design, Part 1, "Gliding through Air or Water" pgs., 10-11	• STC Literacy Series™, Motion and Design			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student groups will record Data: Let students know that for each set of weights they test (four sets in all), they are to record the motion and changes in motion of their vehicles. Encourage Discussion based on data/evidence (students should answer these questions individually in their notebooks): When did you observe your vehicle begin to move? ■ What caused your vehicle to move? ■ Did the vehicle move differently when you changed the weight? Why do you think this happened? ■ What made the vehicle stop moving each time? ■ Why did you use the bookend? Did you need it each time? Why or why not? ■ For each different weight you used, how would you describe the motion of the vehicle?	• (TG)Sheet 3-A: Recording How Our Vehicle Moves.	Constructing Explanations and Designing Solutions: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	PS2: Motion and Stability: PS2.A; Forces and Motion	
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Building a system to pull vehicles - Completion of Record Sheet 3-A "Recording How our Vehicle Moves" - Evaluation of discussion questions in groups/notebooks.				

Extend: How will students deepen their conceptual understanding through use in new context?	Have the class play tug-of-war with adult supervision. Conduct the following investigation and discussion. Begin with just one student on each side. Add one student at a time to either side. Do the pulls (forces) remain balanced? Does the center marker move? Why or why not? When each side has an equal number of students, begin randomly adding or removing students. Observe the direction in which the center marker moves. What determines the direction in which the rope moves? Have students explain why the rope might not move at all, even though students on both sides are pulling.	• Additional Science Resources and Activities: Brain Pop Jr.: Pushes and Pulls http://www.brainpopjr.com/science/forces/pushesandpulls/preview.weml • Our Place in Space Gravity: http://www.projectshum.org/Gravity/	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	ETS1.B: Developing Possible Solutions Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Lesson Pace & Sequence

Lesson 4	**Learning Objective:** Students test how adding weights (load) to their vehicle affects their motion.				**Lesson Duration:** 100 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Introduce the lesson by asking students to think about how adding blocks to their vehicles might change the way the vehicles move. Have students spend a few minutes writing predictions in their notebooks. Discuss their predictions.				

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Hold up one vehicle and two blocks of wood. Ask students how they could adapt their vehicles to hold two blocks of wood while moving. Discuss as a whole group.		Asking Questions and Defining Problems	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will add blocks to their vehicles and evaluate the effects of a load on its motions. Students will also measure, record, and graph the time it takes for a loaded vehicle to move a given distance.	• STC Motion and Design Kit - Record Sheet 4-A: Graphing Data: How Loads Affect the Time a vehicle travels (TG, Section 4, pg. 50)	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3) ----------Analyzing and Interpreting Data Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) -
Explain: How will you help students connect their exploration to the concept/topic under investigation?	STC Literacy Series™, Motion and Design, Part 1, "Learning from Butterflies" pgs. 12–13 Writing stories about the transport of a shipment, (TG, Section 4, pg. 45) Researching load-bearing vehicles, (TG, Section 4, pg. 45)	• STC Literacy Series™, Motion and Design			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student groups will evaluate discussion questions based on data/evidence (record in notebooks): What did you observe when testing various loads (blocks)? ■ How did the vehicle move when it was loaded with two blocks? ■ How did the motion of the vehicle change when you removed one block? How did it change when you removed both blocks?■ What do you think would happen if you added a third or fourth block to the vehicle?■ When the vehicle carried no blocks, what was left to influence its motion? (the weight of the vehicle)■ What can you conclude about the effects of load (such as blocks) on a vehicle's motion? (Help students understand that the heavier the vehicle, the longer the vehicle takes to respond to a force.)■ What situations at home or in school may be similar to what you tested in this lesson? Each student will use collected data from recording sheet and discussion questions in lab report.		Engaging in Argument from Evidence Support an argument with evidence, data, or a model. (5-PS2-1)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1)	
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Written predictions of effect of load on speed. - Measurement of time and distance - Graphical representation of data on Record Sheet 4-A 'Graphing Data" - Lab report data interpretation and conclusion.				

Extend: How will students deepen their conceptual understanding through use in new context?	Ask students to investigate how the position of the vehicle's load might affect their results. They might try blocks stacked horizontally instead of vertically, or a front-loading vehicle instead of a back-loading one. - Ask students to imagine they are transporting an important shipment across the continent. What will the shipment be? What is the destination? Why must the shipment be delivered? How will they transport it? After they have delivered their load, how will the return trip be different?		Asking Questions and Defining Problems Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Lesson Pace & Sequence

Lesson 5: Design Vehicles to Meet Requirements	**Lesson Objective(s):** Students build vehicles to meet design specifications.	**Lesson Duration:** 75 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Ask students to write a few sentences in their notebooks about what caused their vehicles to move slowly and what caused them to move fast when they used the falling-weight system in Lessons 3 and 4. Have students share their responses with the class. Using colored markers, record their ideas on the newsprint list in the appropriate columns.		Asking Questions and Defining Problems		

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	In groups, students will brainstorm situations in which a vehicle would be required to move slowly or quickly. (record and report out to the class)		Asking Questions and Defining Problems	ETS1.B: Developing Possible Solutions (3-5-ETS1-2)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student groups will be challenged to apply data/evidence collected in lessons 3 and 4 to design a vehicle that will move across a workspace in 4-6 seconds. (TG, section 4, pg. 51)	• STC Motion and Design Kit - Design Challenge Card: Lesson 5 (blackline master)	Constructing Explanations and Designing Solutions: Use evidence (e.g. measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	Structure and Function - Energy and Matter - Energy can be transferred in various ways and between objects
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Student pairs will read 'Lunar Rover: Making Tracks on the Moon" (pgs. 26-27 in the Student Investigations book). As students read ask them to think about why engineers designed this specialized vehicle to move slowly (discuss in groups and report out to class).				
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	An evaluation of students written and illustrated description of the process they used to build and test their vehicle - Successful planning and testing of vehicle design.				
Extend: How will students deepen their conceptual understanding through use in new context?	Students can design and make their own paper airplanes. After a test flight, have students change the features of their paper airplanes to make them fly farther - Ask students to take repeated measurements of the time it takes their vehicles to move 60 cm (23½ in). Have students graph their data using a line plot (as in Lesson 4) or a line graph.	• Additional Science Resources and Activities: Designing a Roller Coaster: http://www.learner.org/interactives/parkphysics/coaster/	Asking Questions and Defining Problems	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) - ETS1.C: Optimizing the Design Solution Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3) -	Structure and Function
Lesson Pace & Sequence					

Lesson 6: Evaluating Vehicle Design: Looking at Rubber Band Energy		**Lesson Objective(s):** Students examine different energy sources to drive their vehicles.			**Lesson Duration:** 50 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Student groups will brainstorm and record, "What is energy?" (report out in whole group discussion) Discussion should include: types of energy, and transferring energy.				
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Providing free exploration given the question: Is there a way to make the standard vehicle move using rubber bands?		Asking Questions and Defining Problems	Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will continue their investigation on rubber band energy while completing Record Sheet 6-A: Evaluating Our Vehicle Design for Rubber Band Energy.	• STC Motion and Design kit/ TG, section 4, pgs. 66-67	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	STC Literacy Series™, Motion and Design, Part 2, "Bicycles Roll In" pgs. 32–36	• STC Literacy Series™, Motion and Design,			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Based on the data/evidence collected, student groups will refer to their record sheets as they share what they discovered about rubber band energy. Include in the discussion such issues as the following: ■ What did you feel in your hand as you wound the rubber band? Did this feeling change as you wound the rubber band tighter? If so, how? ■ Did the direction in which you wound the rubber band affect the direction in which your vehicle traveled? If so, how? 2. Discuss students' initial observations of how the rubber band affected the distance their vehicles traveled. What did they do to make their vehicles move a longer distance? What did they do to make their vehicles move a shorter distance? Do they know why this happened? Let students know they will conduct a formal investigation of this phenomenon in Lesson 7.3. Ask students to return their standard vehicles and other materials to the distribution center. Make certain each vehicle is in its standard configuration. Students can refer to the technical drawing in Lesson 2 (pg.5),		Constructing Explanations: Using evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Completion of record sheet 6-A: Evaluating Our Vehicle Design for Rubber Band Energy - Participation in class discussion on energy.				

Extend: How will students deepen their conceptual understanding through use in new context?	Have students conduct research to find out how the design of the automobile has changed over time. Ask students to create a time line to show these changes. Students might also research changes in other inventions, such as the telephone or computer. - Ask students to bring in advertisements for automobiles and trucks. Have them prepare their own advertisement promoting the special features of one of these vehicles. Their advertisement could take the form of a skit or a poster board display.		Analyzing and Interpreting Data Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)		

Lesson Pace & Sequence

Lesson 7: Testing the Effects of Rubber Band Energy	**Lesson Objective(s):** Students investigate how variable amounts of energy affects the motion of their vehicle.				**Lesson Duration:** 50 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Teacher will provide mini-lesson on forms of energy. Students will use interactive games (Brain Pop) to reinforce skills.	• www.brainpop.com/science/energy/formsofenergy/			

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Ask students to think about rubber bands in terms of stored energy and transfer energy using guiding questions for group discussion and recording: (TG, Section 4, pgs. 72-73) ■ Where does the energy to wind the rubber band come from? (your muscles, fueled by sugar in your blood)■ Where does the energy to move the vehicle come from? (rubber band) ■ How do you store energy in the rubber band? (wind rubber band around axle)■ How do you release the energy stored in the rubber band? (let go of vehicle)■ What happens when the stored energy in the rubber band is released? (vehicle gains energy of motion, axle turns)■ How does the number of turns on the rubber band affect the distance the vehicle travels? (more energy stored means farther distance)■ Why was it important to keep the number of turns the same for all groups in the class? (to make fair comparisons)■ What would happen if the number of turns was only 1? What if the number of turns was 10? 373		Asking Questions and Defining Problems Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)	Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students will make predictions and collect data to investigate how the number of turns of a rubber band affects the distance the vehicle travels. - Students will collect data on paper strips and compare predicted stop points with the actual distance traveled	• STC Motion and Design kit	Planning and Carrying Out Investigations	ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1.1) - Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	Patterns: (5-ESS1-2) - Cause and Effect: (5-PS2-1)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Student pairs will read, STC Literacy Series™, Motion and Design, Part 2, "The Race to Fly" pgs. 37-40	• STC Literacy Series™, Motion and Design, Part 2			
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Invite groups to display their paper strips, horizontally, one above the other, on the chalkboard, a wall, or the floor. Student groups will use evidence to discuss what differences and patterns they observe among the vehicles at each number of turns of the rubber band around the axle. Have groups point out the predicted stopping point for their axle-driven vehicles and compare each prediction to the actual distance. How did their results compare with their predictions?		Engaging in Argument from Evidence Support an argument with evidence, data, or a model. (5-PS2-1)--------Analyzing and Interpreting Data Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	ETS1.B: Developing Possible Solutions: At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) - Energy: PS3.B: Conservation of Energy and Energy Transfer, PS3.C: Relationship Between Energy and Forces	Patterns Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2) Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Participation in class discussion about stored energy in the rubber band - Ability to design controlled experiments on the relationship between number of turns and distance travelled				

Extend: How will students deepen their conceptual understanding through use in new context?	Challenge students to investigate what happens if they add a load (wooden blocks) to their axle-driven vehicles. Also ask them to find out how the position of the load affects the way their vehicles move. - After teacher guided lesson, student can play game based on Newton's 1st and 2nd law (Brain Pop)	• Newton's Laws of Motion Lesson Plan – Impulse Game: http://www.brainpop.com/educators/community/lesson-plan/impulse-game/?bp-topic=forms-of-energy	Asking Questions and Defining Problems: Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)		Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Lesson Pace & Sequence

Lesson 8: Evaluating Vehicle Design: Looking at Friction	**Lesson Objective(s):** Students examine how their design variables reduce or increase the force of friction on their vehicles.	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Have the class discuss what they observe about their vehicles wheel structure. Focus the discussion by asking students what they think causes the wheels to slow down and eventually stop moving.		Asking Questions and Defining Problems	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of Interactions (3-PS2-1)	Cause and Effect (5-PS2-1)
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Brainstorm as a class what students already know about friction and what questions they would like answered. Record their responses on the brainstorming list - View Brain Pop video on Pushes and Pulls.	• Brain Pop Jr.: Pushes and Pulls: http://www.brainpopjr.com/topics/pushesandpulls		Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student groups will examine specific design features and focus on how these features create friction and slow the vehicle. Students will use Record Sheet 8-A: Evaluating Vehicle Design for Friction, to guide their investigation.	• STC Motion and Design Kit/ TG, section 4, pgs. 82-84	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	Structure and Function: Substructures have shapes and parts that serve functions - Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Explain: How will you help students connect their exploration to the concept/topic under investigation?	Read in STC Literacy Series™, Motion and Design, Part 2, "The Real McCoy" pgs. 23–28. -"The Real McCoy" How does the author explain the meaning of the expression "Is this the real McCoy?" What evidence does the text use to support his claim (the meaning of the expression)? Research the origin of the expression. What evidence can you find that explains the origin of the expression? Which one do you believe most? Explain why. (Suggested text: Wood, Richard (2007, February 01), Staging the Real McCoy. Beaver, (1), 8) RI.5.1, RI.5.4, W.5.8, W.5.9 In what ways did McCoy demonstrate a "trained engineer's mind?" RI.5.4 Did doing the activities on page 26-27 help you to explain friction? How did the directions help or impede your ability to complete the task and answer the two questions. "Which kinds of surfaces would provide more friction?" and "Which surfaces would provide less?" RI.5.1, RI.5.4, W.5.2 Students share results from their experiments of how their design variables reduce or increase the force of friction on their vehicles. SL.5.1 Students write and illustrate a description of the process they used to reduce or	• Read in STC Literacy Series™, Motion and Design, Part 2 -			

	increase the force of friction on their vehicles. W.5.2				

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Discuss vehicle design features that can either increase or decrease friction using questions such as the following: ■ Is there anything on your vehicle that rubs together? (tires against the frame, wheels against the axle)■ What can this rubbing do to the motion of your vehicle? (slows it down, takes away energy available to vehicle, creates wasteful friction)■ What vehicle design features help reduce the amount of rubbing between the wheels and the vehicle's axle and frame? (tan hub connectors, crossbars)■ What vehicle design features increase the friction between the floor or work surface and the wheels? (tires)■ How does this rubbing influence your vehicle's motion? (creates useful friction, helps it move)				
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Accuracy of Record Sheet 8–A: "Evaluating Vehicle Design for Friction. - Responses to reading materials -Participation in class discussion of friction and vehicle design.				

Extend: How will students deepen their conceptual understanding through use in new context?	1. Students can perform tests of friction by dragging weights behind their moving vehicles. How does this influence the vehicles' motion? Why? - 2. Students can design investigations that demonstrate useful and wasteful friction. One test of useful friction might be the following. Have students place plastic bags over their shoes and then walk across a carpeted surface. Have them remove the bags and walk again. They can compare the two trials. Which way made walking easier? Why? Have students describe the friction between their shoes and the carpet. Then have them make a list of other situations in their lives that involve useful and wasteful friction.		Asking Questions and Defining Problems Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1) - Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	- Structure and Function: Substructures have shapes and parts that serve functions. - Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Lesson Pace & Sequence

Lesson 9: Designing and Building Vehicles with a Sail		**Lesson Objective(s):** Students adapt their vehicles to hold a sail and discuss how it might affect their motion.			**Lesson Duration:** 50 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***

Elicit: How will you access students' prior knowledge?	Direct students' attention to the brainstorming list from Lesson 5. Encourage them to suggest any new ideas they have about what might cause their vehicles to move slowly or fast. Use a marker of a different color to add their new ideas to the list.				
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Have students hypothesize what influences a sail might have if it were fastened to their vehicles. Use another colored marker to add these ideas to the brainstorming list. (If students do not mention it, encourage them to discuss how the sail might affect the vehicle's motion when moving with the wind and against it. Also ask students if the sail would have any effect on the motion of the vehicle if there were no wind.)		Asking Questions and Defining Problems: Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	- Structure and Function: Substructures have shapes and parts that serve functions. - Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student groups will adapt their vehicle through trial and error to hold a cardboard sail. -Student will individually record their observations with words and drawings.	• STC Motion and Design Kit	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1 - ETS1.C: Optimizing the Design Solution: Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	- Structure and Function: Substructures have shapes and parts that serve functions Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student groups will discuss how they completed the design challenge. What successes did they have? What problems did they encounter? How did they solve them? 2. Students will hypothesize, or make an educated guess about, how the sail might affect the vehicle's motion when the sail is pushing against the air. Students will test their hypotheses in Lesson 10.				
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Completion of "Student Self-Assessment A" - Participation in brainstorming how a sail might affect the motion of an axle-driven vehicle - Discussion and completion of design challenge				
Extend: How will students deepen their conceptual understanding through use in new context?	1. Students can use an electric fan or a mounted blow dryer to simulate moving a sail-driven vehicle with wind energy. Have them mark the distances their vehicles travel at various wind speeds (different speeds on the fan or blow dryer) and then measure the distances and graph the results. 2. Encourage students to research the history of the sailboat. How has its design changed over the years? How has the use of sails changed? When is a sail a hindrance to the boat's forward motion?		Asking Questions and Defining Problems	-Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) - ETS1.B: Developing Possible Solutions: Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)	- Structure and Function: Substructures have shapes and parts that serve functions. - Structure and Function:

Lesson Pace & Sequence

Lesson 10: Testing the Effects of Air Resistance on a Vehicle's Motion	**Lesson Objective(s):**	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Ask student groups to hypothesize how the upright sail might affect their vehicles' motion and record in their notebooks.				
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student groups conduct an investigation to test the effects of air resistance on the motion of their axle-driven vehicles. • Students specifically investigate the sail and its positioning; turns of the rubber band and weight of the vehicle remain constant. • Students are introduced to the importance of controlling variables.		Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	Cause and Effect: Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will read "Shirley Muldowney's -----Drag Racer" (Student Investigation book pg. 51) ----Student pairs will discuss how the shape of Shirley's vehicle affected its motion.	• STC Motion and Design: Student Investigation books			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students look for patterns in the data collected; paper strips with colored dots marking distances are posted and analyzed: student groups will discuss and record what they observed when their vehicles moved with the sail influencing the motion (red dots) and with the sail having less influence on the vehicles' motion (blue dots). What patterns they noticed? What differences? Why do they think this happened? 2. Student groups will discuss the ways in which they adapted the sail to have less influence on their vehicles' motion. 3. Students will individually write a lab report using evidence from data and observations from this investigation.		Analyzing and Interpreting Data: Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	ETS1.B: Developing Possible Solutions: At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)	Patterns Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Journals (observations of vehicle's movement) -Participation in investigation and class discussion -Design challenge completion -Lab Report -Formal Assessments can be found in TG, Section 5				

Extend: How will students deepen their conceptual understanding through use in new context?	Challenge students to use materials other than cardboard to make sails. How does the material affect the vehicle's design? Ask students to hypothesize how each material will affect their vehicles' motion. Then have them test their hypotheses.	• Additional Science Resources and Activities: An interactive Smartboard activity: http://www.bbc.co.uk/schools/scienceclips/ages/10_11/forces_action.shtml 1. How could you make a sheet of paper fall as quickly as possible? 2. When an object falls, air resistance… 3. Weight is a force and is measured in… 4. If gravity pulls you towards the center of the Earth, why don't you fall through the pavement? 5. When an object is at rest/stationary…	Asking Questions and Defining Problems Asking questions and defining problems in 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1---- ETS1.C: Optimizing the Design Solution: Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	Structure and Function: Different materials have different substructures, which can sometimes be observed.

Lesson Pace & Sequence

Lesson 11: Building a Propeller-Driven Vehicle	**Lesson Objective(s):** Students design and build propeller-driven vehicles and compare them with their axle-driven vehicles.	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Involve whole class in a brainstorming session in which they describe what they know about propeller-driven vehicles (record in notebooks)				

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Ask students to think about vehicle design features that might be necessary to move their vehicles with a propeller. Encourage them to share their ideas List their design ideas on the sheet of newsprint titled "Design Ideas for Propeller-Driven Vehicles."----------2.Direct students' attention to the technical drawing of the propeller-driven vehicle (Figure 11-4 on pg. 109 in TG and pg. 55 in the Student Investigations book). Ask students to describe how this drawing is different from the one used in Lesson 2		Asking Questions and Defining Problems	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	Structure and Function: Substructures have shapes and parts that serve functions.
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students design and build propeller-driven vehicles from a technical drawing and compare them with their axle-driven vehicles.	• STC Motion and Design Kit	Planning and Carrying Out Investigations	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1------- ETS1.B: Developing Possible Solutions: Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)	Structure and Function
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Read in STC Literacy Series™, Motion and Design, Part 2, "Blast Off!" pgs. 44–46.	• STC Literacy Series™, Motion and Design, Part 2			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student groups will present their completed vehicles to the class. Have them discuss any difficulties or successes they had while building from the three-view technical drawing. In what ways was it easier to build from the drawing in this lesson than it was in Lesson 2? In what ways was it more difficult?		Engaging in Argument from Evidence Support an argument with evidence, data, or a model. (5-PS2-1)	ETS1.B: Developing Possible Solutions: At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)	
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Journals/notebooking (brainstorming about propelled vehicles and their design features) -Participation in Investigation (assembly of vehicle from technical drawing)				
Extend: How will students deepen their conceptual understanding through use in new context?	Students can use self-stick dots and a 4-m (13-ft) strip of adding machine tape to test how far their vehicles will move with various turns on the propeller (for example 30, 50, and 75 turns). Have students use a 100-cm (39-in) tape to measure the three distances. Students can measure the distances from the starting line to each dot and record the distance (in cm) on a data table similar to the one in Figure 11-5 below. They can then select and record the average distance traveled.		Asking Questions and Defining Problems Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)---------- Analyzing and Interpreting Data Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)	ETS1.A: Defining and Delimiting Engineering Problems (3-5-ETS1.1) - Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) Energy: PS3.A1	Scale, Proportion, and Quantity

Lesson Pace & Sequence

Lesson 12: Analyzing the Motion and Design of a Propeller-Driven Vehicle	**Lesson Objective(s):** Students evaluate the design of their propeller-driven vehicles.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Using the record Sheet 12-A: What Happens If . . .Students groups will remove pieces and modify their vehicle to answer a series of "What if" questions to further investigate the movement and design of their vehicle.• Student groups will investigate design features including frame size and rigidity, and how the features affect propeller movement.	• STC Motion and Design Teachers Guide	Asking Questions and Defining Problems Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1) ---------- Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) ETS1.C: Optimizing the Design Solution: Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) Structure and Function: Substructures have shapes and parts that serve functions
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Literacy: STC Literacy Series™, Motion and Design, Part 2, ------ What does the text state about Leonardo? What can you infer about Leonardo? Use evidence from the text to support your answers. RI.5.1	• STC Literacy Series™, Motion and Design, Part 2-------"The Great Leonardo" pgs. 20-22			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Show students the axle-driven vehicle. Ask students to revisit the discussion from Lesson 11 in which they compared the design and motion of the propeller-driven vehicles with vehicles built in previous lessons. Use questions such as the following: ■ What caused the propeller-driven vehicle to move? ■ What happened to the rubber band as you wound the propeller? ■ Think back to previous lessons. What caused the axle-driven vehicle to move? ■ In what ways is the rubber band used differently in this lesson? In what ways is it used in the same way? ■ How is air involved in moving the propeller-driven vehicle?		Constructing Explanations and Designing Solutions: Use evidence (e.g. measurements, observations, patterns) to construct or support an explanation or design a solution to a problem	Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Participation in Investigation (Successful modification of vehicles to meet design requirements) -Record Sheet 12-A What Happens if… -Appropriate use of terms -Formal Assessments can be found in TG, Section 5	• STC Motion and Design Teachers Guide			
Extend: How will students deepen their conceptual understanding through use in new context?	Ask students to research and report on the flying machines designed by Leonardo da Vinci. Students can create models of these flying machines with paper.				

Lesson Pace & Sequence

Lesson 13: Looking at Cost	**Lesson Objective(s):** Students determine the cost of their vehicles and modify the design to reduce cost.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Challenge student groups to think like engineers about the requirements of cost when designing and building products. Record in notebooks				
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Student groups will present the cost of their vehicles to the class. Discuss why the cost for all groups is similar or the same. Have students use this number as the vehicle's average cost. Invite students to determine, on the basis of the average cost, what they would consider to be an "inexpensive" vehicle. What would they consider to be an "expensive" vehicle?	• Record Sheet 13-A Evaluating the Cost of Our Design	Obtaining, Evaluating, and Communicating Information		
Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Student groups will discuss the effects of reducing vehicle cost. Answer and record the following questions: ■ How did you reduce the cost of your vehicle? ■ How much money did you save? ■ At any point, did reducing the vehicle's cost affect your vehicle's appearance? Describe what you did in this situation.■ At any point, did reducing the vehicle's cost affect its performance? Describe what you did in this situation.2. Ask students to describe the trade-offs, or compromises, they made		Constructing Explanations and Designing Solutions: Use evidence (e.g. measurements, observations, patterns) to construct or support an explanation or design a solution to a problem		

	when modifying their vehicles on the basis of cost.				
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Participation in Investigation (brainstorming session on reducing costs and contribution to class chart "How to Reduce Vehicle Costs") -Completion and accuracy of Record Sheet 13-A Evaluating the Cost of Our Design				
Extend: How will students deepen their conceptual understanding through use in new context?	-Have students think about the standard vehicle they built using the top- and side-view drawings in Lesson 2. Invite them to evaluate the cost of that vehicle and suggest ways to reduce cost. For each suggestion made, have students explain what effect the change would have. -Ask students to suggest how the design of a product currently on the market could be changed to reduce cost. How might the changes affect customers' feelings about buying the product? What features could be added to the product to increase its appeal without significantly increasing cost?		Asking Questions and Defining Problems: Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1.1)	ETS1.C: Optimizing the Design Solution Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)	

Lesson 14: Planning Our Final Design Challenge		**Lesson: Objective(s):** Student teams brainstorm how they will solve a design challenge.			**Lesson Duration:** 100 minutes
Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Refer students to the class brainstorming list from Lesson 1. Ask them to discuss which comments on the list they now know to be true. Is there anything on the list they would correct or update? Which investigations in the unit support their ideas?				
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Read "Making the Switch from Kids' Stuff to Engineering" (pg., 67-68 in student Investigation book). - Student pairs will list in their notebooks activities they do at home or in school that relate to engineering and technological design (designing products systems, or environments that solve problems and extend human capabilities)	• STC Motion and Design Student Investigation book			

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Each team receives one design challenge card. Teams use their brainstormed ideas, as well as previously collected data, to plan a solution to the challenge. Teams will plan how they will solve the challenge, design a vehicle, and test its motion.	• STC Motion and Design Teachers Guide/Kit.	Developing and Using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. ---------Constructing Explanations and Designing Solutions: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2)	-Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) ---------- ETS1.A: Defining and Delimiting Engineering Problems: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1.1) -	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) ----------Structure and Function: Substructures have shapes and parts that serve functions
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Ask teams to display their lists of ideas.- Discuss each team's planned solution to its design challenge.-Have students share any difficulties they had in developing a team solution to the challenge. - Ask teams to display the sketches of their proposed vehicles. - Discuss special features of each proposed vehicle and how each feature will help the vehicle meet the challenge. - Encourage other teams to offer feedback regarding each team's solution and proposed vehicle - Teams will record their plan on Record Sheet 14-A: Planning Our Final Design Challenge.		Developing and Using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. -------Constructing Explanations and Designing Solutions: Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	ETS1.A: Defining and Delimiting Engineering Problems Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1.1)---------Motion and Stability: Forces and Interactions: PS2.A: Force and Motion, PS2.B: Types of interactions (3-PS2-1) -	Structure and Function: Substructures have shapes and parts that serve functions. ---------- Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Allow teams to modify their plans and sketches as needed, on the basis of the class feedback. Ask students to record in their notebooks responses to the following questions: ■ What is your team's final solution to the challenge? ■ Why did your team decide on this solution?		Developing and Using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	ETS1.A: Defining and Delimiting Engineering Problems Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1.1)	
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Set up an invention area where students can bring in devices developed either by themselves or by others. Have them present the items to the class.4. Encourage students to develop design requirements for a product they would like to make with the building pieces. Have them build the product and present it to the class.5. Invite students to research an invention and its inventor. Have them identify some qualities of inventors.	• STC Motion and Design Teachers Guide: Record Sheet 14-Planning Our Final Design Challenge"			

Extend: How will students deepen their conceptual understanding through use in new context?	Set up an invention area where students can bring in devices developed either by themselves or by others. Have them present the items to the class. - Encourage students to develop design requirements for a product they would like to make with the building pieces. - Have them build the product and present it to the class. - Invite students to research an invention and its inventor. - Have them identify some qualities of inventors.				

Lesson Pace & Sequence

Lesson 15: Refining Our Design	**Learning Objective(s):** The teams build and test their vehicles and refine their design plans.	**Lesson Duration:** 50 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Elicit: How will you access students' prior knowledge?	Ask students to refer to their "Solutions" list from Lesson 14 and to the completed Record Sheet 14-A: Planning Our Final Design Challenge. Teams will discuss what materials do they need to build and test their vehicles?	• STC Motion and Design Teachers Guide: Record Sheet 14-A: Planning Our Final Design Challenge			

Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Ask students to set up their design plans from Lesson 14 as shown in (Figure 15-2 in TG). Students can add to their "Solutions" sheet a list of ways they have refined, or changed, their vehicles to meet their design requirements - Ask each team to determine the cost of its vehicle by completing Record Sheet 13-A: Evaluating the Cost of Our Design. Encourage students to use the second copy of the record sheet if they modify their vehicles to reduce cost. (Remind students that they determined the value for an expensive and inexpensive vehicle in Lesson 13.) Ask teams to retest their vehicles' performance to make certain the modified vehicles still meet the design requirements.	• STC Motion and Design Teacher Guide: Record Sheet 13-A: Evaluating the Cost of Our Design	Asking Questions and Defining Problems	ETS1.A: Defining and Delimiting Engineering Problems Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1.1)	Structure and Function
Explore: What hands-on/minds-on common experience(s) will you provide for students?	Students implement their plans from Lesson 14 by building, testing, and evaluating their vehicles and the systems for moving them. Students determine the cost of their designs.	• STC Motion and Design Kit/Teachers Guide	Planning and Carrying Out Investigations Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)---------- Developing and Using Models: Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.		Structure and Function---------- Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Students will create a written report describing their design plan. Prepare for class presentation in Lesson 16				

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Ask students to suggest how teams could present their solutions in Lesson 16. Possibilities include the following: ■ Invite guests.■ Use props or backdrops to emphasize the “engineering design team” approach to solving the challenge.■ Create a story or context for the presentations. For example, students could be part of an engineering team that is making a presentation to a large company.				
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	-Participation is group discussion and building and testing of their vehicle. - Accuracy and completion of record sheet 13-A: "Evaluating the Cost of Our Design" and Record Sheet 14-A: Planning Our Final Design Challenge.				

Extend: How will students deepen their conceptual understanding through use in new context?	Present the following questions/activities: What questions can you ask to help you efficiently find information about inventions? - What key words in your questions help you locate information quickly and effectively? http://science.howstuffworks.com / RI.5.7 - How can you gather information to find out more about an invention? Write a story about an inventor of a strange new invention using details from your research. RI.5.9, W.5.8, W.5.9 - Compare your work and experiences of designing your vehicle to that of an inventor and his/her invention. RI.5.9, W.5.8, W.5.9 - Developing and performing a skit on changes to the telephone. (TG, Section 4, pg. 147) W.5.2				

Lesson Pace & Sequence

Lesson 16: Presenting Our Final Design Challenge	**Learning Objective(s):** The teams present their solutions to their classmates.	**Lesson Duration:** 100 minutes

Learning Cycle ***What lesson elements will support students' progress towards mastery of the learning objectives(s)?*** ****Elements do not have to be in conducted in sequence.***	***Learning Activities*** ***What specific learning experiences will support ALL students' progress towards mastery of the learning objective(s)?***	***Resources/Materials*** ***What curricular resources/materials are available to facilitate the implementation of the learning activities?***	***Science and Engineering Practices*** ***What specific practices do students need to use in order to progress towards mastery of the learning objective(s)?***	***Disciplinary Core Ideas*** ***What core ideas do students need to understand in order to progress towards mastery of the learning objective(s)?***	***Crosscutting Concepts*** ***What crosscutting concepts will enrich students' application of practices and their understanding of core ideas?***
Engage: How will you capture students' interest and get students' minds focused on the concept/topic?	Student teams will meet briefly to prepare for their presentation				

Explore: What hands-on/minds-on common experience(s) will you provide for students?	Student teams will present their design challenge and solution by demonstrating the motion of their vehicle.				
Explain: How will you help students connect their exploration to the concept/topic under investigation?	Literacy: STC Literacy Series™, Motion and Design, Part 3, "Thanks, CAD!" pgs. 58-61 Sample CCSS Tasks: "Thanks, CAD!" Use the author's words to explain why CAD is powerful? RI.5.1 Describe why the Boeing 777 was originally considered a virtual plane? What makes it unique? RI.5.1, RI.5.4 Explain what the author means when he says that the teams were "pooling their talent." RI.5.1, RI.5.4 How has technology, such as CAD, made working on big design projects easier and more efficient? RI.5.1	• STC Literacy Series™, Motion and Design, Part 3			

Elaborate: How will students apply their learning and develop a more sophisticated understanding of the concept/topic?	Students will respond in their notebooks to one or more of the following topics: ■ Describe the steps you used in solving design challenges throughout this unit.■ Describe how your vehicle moved and what method you used to move it. ■ Describe something you do at home or in school in which you use problem-solving skills like those in this unit. ■ Describe how you might use the steps of technological design in making a paper airplane or building a sand castle.■ Describe one product that has changed greatly over the years. Why were these changes made? Do you feel the changes were good ones?■ Describe the similarities and differences between what happened in the classroom in the last three lessons and what engineering teams or scientists do to solve a problem.		Asking Questions and Defining Problems: Use prior knowledge to describe problems that can be solved.		
Evaluate: How will students demonstrate their mastery of the learning objective(s)?	Presentations that includes: vehicle design, cost sheet and design record, report on how the challenge was met and a demonstration of the vehicle. - Review of individual self-assessment (Self-Assessment A (TG, section 4, pg. 155). - Formal assessments can be found in TG, Section 5.				

Extend: How will students deepen their conceptual understanding through use in new context?	-Have students identify a need that could be met by an invention. Invite them to plan the invention, build it, and present it to the class. - Ask students to identify activities they do outside of school in which they use the steps of technological design. Examples include designing a game to play with a friend or fixing a broken bicycle chain.		Planning and Carrying Out Investigations: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3)	ETS1.B: Developing Possible Solutions Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)	Cause and Effect Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1) Scale, Proportion, and Quantity Natural objects exist from the very small to the immensely large. Influence of Science, Engineering, and Technology on Society and the Natural World People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS-1