

**Lesson Title:** *Force & Motion*

**Author:** *Donna Shartzter*

**Topic:** *The focus of this lesson is Force & Motion - Guiding question: What forces can affect an object's motion?*

**Targeted Grade Level:** *Eighth Grade*

**Time Needed:** *2 to 3 class periods depending on the population of students.*

**Subject Integration:** *This lesson is an introduction to a unit on Force and Motion which is mainly focused on science concepts, but students will also use engineering and technology to record their thoughts and to sketch out models to help them to record observations from their exploration and to use problem-solving/critical thinking skills to figure out what caused cars in China to appear to float in the air. In addition to science and technology, students will be exposed to social studies ideas related to culture. Students in future lessons will discover how Native Americans used force and motion to help them play their games and/or build their community structures. Math concepts like adding and subtracting negative numbers related to net force will be used in future lessons as well as determining speed, velocity, acceleration, momentum, and kinetic energy.*

**Justification:**

Due to COVID 19, there is a gap in students' understanding of force and motion, so this lesson will reteach concepts from previous grade levels about laws of motion as well as the phenomena of floating cars to help students understand why cars in China suddenly floated at a traffic stop. They will specifically learn about applied forces, gravity, and friction. They will use engineering ideas to design and test their designs that help prove or disprove forces at work that may have created this phenomenon. Students will also revise their designs and hypotheses. Students will use tools like the online MOSA MACK website, research skills, and hands-on exploration to recreate this phenomenon using model cars, rulers, communication skills, etc. to discuss and present their findings to their peers. Through student-generated questions/discussion, students will also explore through research and discussion what city structures like subways, street lights, telephone poles, might have created this floating phenomenon of floating cars. And in later lessons, students will explore how "play" also uses force and motion concepts in their own community but in other cultures like Native Americans.

**Standards:**

06-PS2-1. Apply Newton’s Third Law to design a solution to a problem involving the motion of two colliding objects.

06-PS2-2. Plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object.

**NGSS Performance Expectations**

*In Kentucky, our science standards are grade banded. Our core standards are incorporated into a Curriculum Combined Document along with the NGSS Performance Standards. So today’s lesson will use a sixth-grade standard to apply Newton’s Laws to design a solution to a problem involving the motion of two colliding objects and an investigation where a change in an object’s motion is affected by the sum of the forces and the mass of the object.*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
<p><b><i>Planning and Carrying Out Investigations</i></b></p> <p><i>Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of</i></p>	<p>PS2.A: Forces and Motion For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). (06-PS2-1) The motion of an object is determined by the sum of the forces acting on it; if the total force on the</p>	<p><b><i>Systems and System Models</i></b>  <b><i>Models</i></b> can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (06-PS2-1),(07-PS2-4),</p> <p><b><i>Stability and Change</i></b>  <i>Explanations of stability and change in natural or designed systems can be</i></p>

<p><i>evidence consistent with scientific ideas, principles, and theories. Apply scientific ideas or principles to design an object, tool, process or system. (06-PS2-1)</i></p> <p><i>Scientific Knowledge is Based on Empirical Evidence Science knowledge is based upon logical and conceptual connections between evidence and explanations. (06-PS2-2),(07-PS2-4)</i></p>	<p>object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (06-PS2-2) All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (06-PS2- 2)</p>	<p><i>constructed by examining the changes over time and forces at different scales. (06-PS2-2)</i></p> <p>-----</p> <p><b>Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World</b></p> <p><i>The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (06-PS2-1)</i></p>
--	--	--

**Common Core State Standards:**

*Connections to other DCIs in this grade-band: MS.PS3.A (06-PS2-2); MS.PS3.B (06-PS2-2); MS.PS3.C (06-PS2-1); MS.ESS1.A (07-PS2-4); MS.ESS1.B (06-PS2-2),(07-PS2-4); MS.ESS2.C (06-PS2-2),(07-PS2-4)*

*Articulation across grade-bands: 3.PS2.A (06-PS2-1),(06-PS2-2); 3.PS2.B (07-PS2-3),(07-PS2-5); 5.PS2.B (07-PS2-4);*

*HS.PS2.A (06-PS2-1),(06-PS2-2); HS.PS2.B (07-PS2- 3),(07-PS2-4),(07-PS2-5); HS.PS3.A (07-PS2-5); HS.PS3.B (06-PS2-2),(07-PS2-5); HS.PS3.C (07-PS2-5); HS.ESS1.B (07-PS2-4)*

*Math: MP.2 Reason abstractly and quantitatively. (06-PS2-1),(06-PS2-2),(07-PS2-3) 6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (06-PS2-1) 6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. (06-PS2-1),(06-PS2-2) 7.EE.B.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (06-PS2-1), (06-PS2-2) 7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. (06-PS2-1),(06-PS2-2)*

*ELA: Kentucky Academic Standards Connections: ELA/Literacy – RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (06-PS2-1),(07-PS2-3) RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (06-PS2-1),(06-PS2-2),(07-PS2-5) WHST.6-8.1 Write arguments focused on discipline-specific content. (07-PS2-4) WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (06-PS2-1),(06-PS2-2),(07-PS2-5)*

### **ITEEA Standards**

**Standard 9** *Students will develop an understanding of engineering design.*

**Standard 10** *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem-solving.*

### **Measurable Student Learning Objectives:**

*Students will conduct an investigation to explain how vehicles in China appeared to float. At the end of the lesson, students will use the following terms: applied force, gravity, and friction to write an explanation of what caused cars to levitate and to label a video screenshot of the levitating cars.*

### **Nature of STEM:**

In this lesson, students will use introductory concepts related to force and motion, specifically gravity, applied forces, and friction, which cause vehicles to float in the air. STEM activities students will specifically use are science, technology, and reverse engineering. Students will use matchbox cars and various items like magnets, string, tape, wire, etc. to reverse engineer a traffic scene in China to deduce a possible cause to the question, "Can cars just float in the air?". By recreating the scene, students will be able to explain if it is possible for cars to suddenly float into the air. Students begin by viewing the video and making observations and asking questions. After viewing the video several times, students will design a possible scenario that may have produced the levitating cars and then test out their design, alter their designs, retest, and finally share their findings with the class.

### **Engaging Context/Phenomena:**

*The hook for this lesson is to show students a video posted on the MOSA Mack website, <https://mosamack.com/home/force-motion/lessons/live> where a street camera in China observed vehicles suddenly floating up into the air. Students will watch the video all the way through once and then rewatch the video several times, recording observations and any questions that were generated as they watch the video. Students will then research what forces might cause objects to lift off the ground by going to NASA's websites such as STEMonstrations: <https://www.nasa.gov/stemonstrations-newtons-first-law-of-motion.html> to observe NASA astronauts investigate what forces affect objects in space. Through discussion with peers and whole-class discussions, students will generate possible questions to design an investigation that tests out their hypotheses.*

### **Data Integration:**

*Students will collect data to test out their hypotheses of a design developed by them of what caused the levitating cars to lift off the ground. Students will then analyze their data to determine if they have any evidence to prove or disprove that the cars in China were levitating. They will use claims, evidence, and reasoning statements to share their findings with the class.*

**Differentiation of Instruction:**

In my classes, I have a combination of students that range from high academic level to students working at an elementary level as well as students labeled EBD and autistic (I have 2 classes with several students in each of these classes that are autistic). For my lower academic level students, my lesson is more teacher-directed and guided. For students working on the higher academic level, they are more student-led and I do more facilitation. My lower-level students are still asking questions that they will answer in their investigation, but when it comes to recording data and answering questions, I do a lot of modeling and we move at a slower pace. Instructions are broken down into chunks. For my autistic students and EBD students, I do a lot of prompting and redirecting. My autistic students can do the work, but at times do get fixated on an idea and forget what the original task is, so they need redirection and cueing to get them back on track.

**Real-life Connection:**

Real-life connections are a way I help students connect to the science content. As we learn about a particular idea like friction or applied force through discussion and surveying, I ask students if they have ever fallen out of their chairs or run into a door, ride a roller coaster, ride a merry-go-round, etc. We also connect to sports activities or activities students have participated in their everyday life. Part of this surveying/questioning helps us to also discuss how things have changed over time, such as where did basketball come from, what games Native Americans play, etc.

**Possible Misconceptions:**

Students often believe an object at rest has no forces acting on it, and students also tend to believe that objects in motion are not balanced.

**Lesson Procedure:**

5E Model	5E Objectives
<u>Engage</u> Introduce students to	<b>Procedure:</b> <ul style="list-style-type: none"><li>• Show the <a href="#">video</a> of levitating cars in China. Ask students to view the video all the way</li></ul>

force and motion using the [video](#) to generate inquiry.

through without any discussion. Explain to students this video was recorded by a street camera and they are going to try to figure out how the cars levitated.

- Explain to students that they are going to view the video several more times, but this time they are going to use the online site [MOSA Mack](#), step 2, to record their observations and any questions that come to mind. Remind them not to hit the submit button until directed to do so. Walk around the room several times to be sure students are on the right site and record their observations and questions. Prompt students with questions like what cars were affected? Why weren't all the cars affected? to guide them into making detailed observations.
- After viewing the video, ask students to “Think, Pair, Share” what they observed with their elbow partner. Ask students to take turns sharing and to add any new observations to their list of observations in [MOSA Mack](#).
- Discuss/Brainstorm with the whole class, possible inferences that may have caused the cars to levitate, and what questions come to mind when they observe this. Survey the class for what possible forces may be at work causing the cars to lift, where might they have seen something similar to this situation? Also, discuss, How might we figure out a way to test our ideas?

**Modifications** For lower academic students, move at a slower instructional pace and break instructions up into chunks. Model for students, what observations might look like by giving them sentence starters that students can complete. Walk around the room frequently to be sure students are on task and understand instructions. Students without technology access or cultural restrictions (I have Amish students.) have paper copies printed and show video on the main screen.

**Standards Addressed:** Science and Engineering practices are being specifically taught by asking students to question and hypothesize a design to test their questions. Students are also using technology ITEEA standards 9 and 10

**Formative/Summative Assessments:** Through whole-class discussion, formatively assess if students are understanding what the problem is (cars are levitating in a city street)

**Resources:** *MOSA Mack. Force and Motion Lesson 1 Phenomenon.*  
<https://mosamack.com/home/force-motion/lessons/live>

## Explore

### **Procedure:**

- After viewing and discussing the video, ask students to sketch a design where they can test out their possible hypotheses of what led to the cars in China to levitate. Model for students an example of possible questions they might ask in their investigation and show how to use technology to complete the sketch online. Remind students to be sure to use arrows and labels in their designs.
- Instruct students in their small groups (groups of 2) to generate their scenarios of forces that may have caused the cars to levitate.
- Have students collect supplies necessary to test out their hypothesis from the following list: matchbox cars, string, wire, magnets, tape, pennies or objects to add weight, and/or paper clips that are needed to test out their hypothesis. Explain that they may or may not need all the supplies mentioned.
- Once students have the supplies needed, instruct them to set up the cars and other items necessary to test out their hypothesis based on their design sketch. Encourage them to try to duplicate the same situation viewed in the video. Instruct them to record the results of their tests and what changes they made to their design.
- After investigating, ask students to share the results of their investigations and other possible theories that may have led to the cars levitating.

### **Modifications**

Guide students who struggle by modeling examples for students and give sample sentence starters to students who struggle with putting their thoughts in writing.

### **Standards Addressed**

*Students are using scientific thinking and engineering practices to design and test out their hypotheses.*

### **Formative/Summative Assessments**

*Circulate between the students, look to see if students can use problem-solving skills and critical thinking skills to formulate a way they can recreate a similar incident, levitating cars, using the*

	<p><i>supplies given to them.</i></p> <p><b>Resources</b></p> <ul style="list-style-type: none"><li>● <i>matchbox cars</i></li><li>● <i>string</i></li><li>● <i>wire</i></li><li>● <i>magnets</i></li><li>● <i>computers and access to Mosa Mack site</i></li></ul>
<p><b><u>Explain</u></b></p>	<p><b>Procedure:</b></p> <ul style="list-style-type: none"><li>● <i>When students have tested their designs and concluded whether or not their cars could float in the air, call on students to present their discoveries to the class and discuss.</i></li><li>● Ask students to summarize their findings in writing either on paper or on the <a href="#">MOSA Mack</a> website step 3.</li><li>● Next explain to students the following terms, motion, friction, applied force, gravity. Ask students to reflect on the video shown at the beginning of class where the cars levitated. Show them the video again if necessary. Challenge them to use the 4 terms to explain in writing using paper or <a href="#">MOSA Mack</a>, step four, where they saw motion, friction, applied force, and gravity occurred in the video.</li><li>● Once they write their explanation, have them use those same four terms as well as arrows to show the direction of motion to write on a picture where forces occurred. For example, where a car is up in the air and has the potential to fall, ask students to think about what forces are at work that might make the car fall back on the ground, gravity.</li><li>● Ask students to complete the 5 question <a href="#">quiz</a> to assess their understanding of the terms and their understanding of applying the terms to different situations. You can use the google form link or use the <a href="#">MOSA Mack</a> website, step five.</li></ul> <p><b>Modifications</b></p> <p>Guide students who struggle by modeling examples for students and give sample sentence</p>

	<p>starters to students who struggle with putting their thoughts in writing.</p> <p><b>Standards Addressed</b></p> <p><i>Students are applying terminology to understand what forces are causing an object's motion to change (06-PS2-2 Kentucky State Core Standard)</i></p> <p><b>Formative/Summative Assessments</b></p> <p>Use the following <a href="#">quiz</a> to assess their understanding of the terms and their understanding of applying the terms to different situations. You can use the google form link or use the <a href="#">MOSA Mack</a> website, step five.</p> <p><b>Resources</b></p> <p>Paper, pencil, chromebooks, <a href="#">MOSA Mack</a> website</p>
<p><b><u>Elaborate</u></b></p>	<p><b>Procedure:</b></p> <ul style="list-style-type: none"><li>● To end the lesson, show the full video of the levitating cars and what happened to cause the cars to float.</li><li>● Discuss with class. How did a cable get on the road? Where did the cable come from that it became entangled in the street sweeper's brush? What forces were the cause of the floating cars? How does the size of the object determine how the object moves?</li></ul> <p><b>Modifications</b></p> <p>No modifications are needed except if a student is visually impaired ask someone to describe the</p>

	<p>scene.</p> <p><b>Standards Addressed</b></p> <p><i>Students are applying terminology to understand what forces are causing an object's motion to change (06-PS2-2 Kentucky State Core Standard)</i></p> <p><b>Resources</b></p> <p><a href="#">MOSA Mack</a> website</p>
<p><b><u>Evaluate</u></b></p>	<p><b>Procedure:</b></p> <ul style="list-style-type: none"><li>• Evaluate students understanding of the problem and how forces affected the motion of the vehicles in the video, ask students to complete and exit slip on a post-it note by writing an answer to the question, "Explain what caused the cars to levitate at a street light in China?"</li></ul>

**Teacher Background:**

*The teacher needs to have an understanding of forces and motion that cause objects to move as well as how to get students to use inquiry to design and carry out an investigation.*

**References**

Ap, Tiffany for CNN. November 30, 2015. The Mystery of China's Levitating Cars Solved.  
<https://www.cnn.com/2015/11/30/asia/china-levitating-car-accident/index.html>

Kentucky Department of Education. Kentucky Academic Standards - Science - Middle Level. June 2015. (page 40).  
[https://education.ky.gov/curriculum/standards/kyacadstand/Documents/Kentucky\\_Academic\\_Standards\\_Science.pdf](https://education.ky.gov/curriculum/standards/kyacadstand/Documents/Kentucky_Academic_Standards_Science.pdf)

MOSA Mack. Force and Motion Lesson 1 Phenomenon. <https://mosamack.com/home/force-motion/lessons/live>

*National Aeronautics Space Administration. NASA STEMonstrations: Newton's First Law of Motion. April 15, 2021.*  
<https://www.nasa.gov/stemonstrations-newtons-first-law-of-motion.html>

*National Aeronautics Space Administration. NASA STEMonstrations: Newton's 2nd Law of Motion. February 26, 2018.*  
<https://www.youtube.com/watch?v=sPZ2bjW53c8>

*National Aeronautics Space Administration. NASA STEMonstrations: Newton's Third Law of Motion. March 15, 2018.*  
<https://www.youtube.com/watch?v=dCF--YOjjOw>

Standards for Technology Literacy: Content for the Study of Technology. Third Edition (2007). Nature of Design Standards 9 and 10. (pages 109-122) <https://www.iteea.org/File.aspx?id=67767&v=b26b7852>