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| **Subject:** Science | **Grade:** 8 | **Unit ID:**  |
| **Unit 2:** Motion and Stability: Newton’s Laws / Forces | **Length:** 15 Days |
| ***Stage 1: Desired Results*** |
| **Content Standards:****8.MS-PS2-2.** Provide evidence that the change in an object’s speed depends on the sum of the forces on the object (the net force) and the mass of the object. Clarification Statement: • Emphasis is on balanced (Newton’s first law) and unbalanced forces in a system, qualitative comparisons of forces, mass, and changes in speed (Newton’s second law) in one dimension. State Assessment Boundaries: • State assessment will be limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. • The use of trigonometry is not expected in state assessment. **8.MS-PS2-1.** Develop a model that demonstrates Newton’s third law involving the motion of two colliding objects. State Assessment Boundary: • State assessment will be limited to vertical or horizontal interactions in one dimension. **Practice Standards/Concepts & Skills:**1. Asking questions (for science) and defining problems (for engineering). 2. Developing and using models. 3. Planning and carrying out investigations. 4. Analyzing and interpreting data. 5. Using mathematics and computational thinking. 6. Constructing explanations (for science) and designing solutions (for engineering). 7. Engaging in argument from evidence. 8. Obtaining, evaluating, and communicating information |
| **Overview:**Students will explore motion of objects in this unit. Students will investigate through readings, using models, activities and direct instruction what causes objects to move, or change how they move. Students will review the concept of gravity and what effect gravity has on different objects. By observing motions of different objects, students will reach a conclusion that the motion of an object is determined by the sum of the forces acting on it; and the object’s motion will change if forces acting on it are not balanced (Newton’s first law of motion). Through various activities students will make connection that the acceleration in an object depends on the forces acting on it and the mass of the object (Newton’s second law of motion). 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. Students will be able to explain the motion of a pair of interacting objects and that the force exerted by the first object on the second one is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law). **FOCUS LANGUAGE GOALS:**Students will be able to independently use their learning to DISCUSS what causes motion in an object and what are the factors that determine how much an object will move. Students will be able to EXPLAIN their claim through scientific reasoning with the understanding of balanced and unbalanced forces as well as how mass and amount of force on an object influence the motion of that object. Students will be able to ARGUE/DEBATE how this knowledge of forces and motion can be used to construct engineering product such as roller coasters and ziplines. |
| **Understandings*** The motion of an object is determined by the object’s mass and the sum of the forces acting on it.
* Motion is described as an object’s position over time.
* When two moving objects interact, their motion is affected by equal and opposite forces.
 | **Essential Questions**How can one predict an object’s continued motion, change in motion, or stability?Guiding Questions* How do Newton’s laws explain an object’s continued motion, changes in motion, or stability?
* Why is it important to understand the relationship between forces, energy and matter?
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| **Knowledge:** *Students will know...***Content:*** a force is any push or pull that causes an object to move, stop, or change speed or direction: velocity
* some common examples of forces:
	+ Gravity
	+ Friction
* the difference between balanced and unbalanced forces
* how to describe the motion of an object by its position and/or direction
* that the position and motion of an object can be determined based on a reference point
* that motion can be described as an object’s position over time
* Newton’s 1st, 2nd, and 3rd laws
* How to Interpret a distance vs time graph
	+ Linear slope-constant speed
	+ Horizontal slope-stopped
	+ Variable slopes-changing indicating acceleration

**Language:**Students will become familiar with a variety of different text types in the four skills (reading, writing, listening and speaking) for such purposes as:* Describe inertia and its relationship with mass.
* Describe the relationship between mass, acceleration and force.
* Describe forces between interacting objects
* Describe how motion is determined by forces
* Describe how friction affects our daily lives

**Vocabulary:** [**(see definition of CCSS tiered vocabulary)**](https://drive.google.com/open?id=0B1oO5U3iU008Q1ZGaEpFeFpLVnc)

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| **Tier 1** | **Tier 2** | **Tier 3** |
| Speed, gravity | Force, balanced and unbalanced force, net force, mass, friction, action, weight, reaction, Newton, work, action vs reaction, resist | Motion, reference point, velocity, acceleration, momentum, inertia, linear graph, non-linear graph |

 | **Skills**: *Students can ...***Content:*** model the balanced and unbalanced forces (8.MS-PS2-1)
* design an investigation to demonstrate Newton’s Laws of Motion (8.MS-PS2-1, 8.MS-PS2-2)
* interpret data and graphing to determine if the motion of an object is increasing, decreasing, or remaining the same (8.MS-PS2-2)

**Language:*** construct an explanation of the forces that cause an object’s motion (8.MS-PS2-1)
* interpret and explain position and time data on a motion graph (8.MS-PS2-2)
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| ***Stage 2: Assessments*** |
| Assessments administered in this unit* Traditional computer based or paper and pencil teacher generated assessment
* Common district assessment questions (pending)
* Pearson Quick Lab: [Around and Around](https://drive.google.com/file/d/1zQRAP-phs1o0Ni-WYvcnDCZReag-TV0p/view?usp=sharing)
* Optional: CER 1: [BPS motion CER](https://bpsscience.weebly.com/uploads/2/2/1/3/2213712/7_force_motion_2016.pdf)
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| ***Stage 3: Learning Plan*** |
| **Summary of Key Learning Events and Instructions:**This unit will be started with a brief review of force which is a push or a pull and that a demonstration that establishes that an object moves when unbalanced forces are applied on the object. Students will recollect the concept of gravity and its effect; topics that students have learned in a prior grade. It is important for students to understand that Newton’s Laws of Motion explain how an object moves and how the motion changes. The following suggestion may be used to ensure logical and smooth flow of concepts and continuity.* Demonstrate how force is a push or a pull and that forces can be balanced or unbalanced.
* Establish that motion is a result of unbalanced forces acting on an object. Define motion as distance traveled from a reference point.
* Discuss why directions are important while discussing certain terms such as force, velocity and displacement.
* Explore the terms speed, velocity and acceleration through graphs and different real life example so that students have a clear understanding in order to understand Newton’s Laws of Motion.
* Investigate Newton’s three laws of motion and inertia through a variety of demonstrations and lab activities.
* Provide opportunities to students to apply the three laws of motion to real life scenarios such as sports, amusement park etc.
* Explore ideas of friction and inertia in real life scenario such cars skidding on icy roads, ice skating etc.
* Explore the connection between momentum and inertia through demonstrations/simulations to understand that momentum and inertia are influenced by mass (ex. semi car versus small car, water slide, seat belts in cars).

Sample lessons are listed below and many of the lessons provide accessibility, modifications, and extensions for all students including English Learners, Students with Disabilities, and SAGE students.[Sample lesson Newton's laws of motion](https://www.lakeshorelearning.com/assets/media/product_guides/DD354.pdf)[Lesson for force and motion](http://www.troup.k12.ga.us/userfiles/929/my%20files/science/ms%20science/8th%20science/force_motion/force_motion_unit_resources_schoolpointe.pdf?id=19847) (Ignore the simple machine related topics)[Lesson resources](https://www.cde.state.co.us/standardsandinstruction/schs-motionandforce-pdf)[CK-12 resource](https://www.ck12.org/ngss/middle-school-physical-sciences/motion-and-stability%3A-forces-and-interactions)[NSTA resources for Force and Motion](http://ngss.nsta.org/classroom-resources-results.aspx?CoreIdea=1) (Some of these resources are for grades 9-12 which could be used for differentiation purpose) |
| **Instructional Notes:****Sociocultural implications*** Students’ prior knowledge must be tested using a pre-assessment.
* Mention contributions of scientists from around the globe towards physics and research.

**Connections to Prior Knowledge*** 6th Grade: Introduction to density and gravity
* 7th Grade: Introduction to Potential / Kinetic energy and energy transformations

**Connections to Future Knowledge*** HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion is a mathematical model describing change in motion (the acceleration) of objects when acted on by a net force.
* HS-PS2-2. Use mathematical representations to show that the total momentum of a system of interacting objects is conserved when there is no net force on the system.
* HS-PS2-3. Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
* HS-PS2-10(MA). Use free-body force diagrams, algebraic expressions, and Newton’s laws of motion to predict changes to velocity and acceleration for an object moving in one dimension in various situations.

**Common Misconceptions*** How the force of gravity acts on falling objects: Heavier objects fall faster.
* Students don’t often account for the impact of friction on the motion of objects
* Mass and weight are the same properties
* Gravity is a push and not a pull
* Speed and velocity mean the same thing
* Force and energy mean the same thing
* Force is inside an object and when an object stops moving
* Acceleration is only speeding up
* Students think that if speed is increasing that acceleration is also increasing
* Students regard objects at rest as being in a natural state in which no forces are acting on the object
* [More misconceptions](https://futurism.com/9-common-misconceptions-physics/)
* [Misconceptions](https://www.neilatkin.com/2015/07/27/teaching-forces-misconceptions-and-how-to-overcome-them/)

**Instructional Strategies*** [Academic vocabulary for ELLs](https://ssec.si.edu/teaching-ell-students%E2%80%93-teaching-academic-vocabulary)
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| **Resources:****Texts:*** Pearson Interactive Science Grade 7 2017 Massachusetts Textbook Reading Chapter 15
* [ck-12 readings](https://www.ck12.org/book/CK-12-Physical-Science-Concepts-For-Middle-School/section/4.0/)
* <https://www.readworks.org/>
* [Science of sports](http://www.explainthatstuff.com/science-of-sport.html)

**Websites:*** [Science-Class.net: Force & Motion](http://science-class.net/archive/science-class/Physics/force_motion.htm)
* [PHET Simulation: Motion](https://phet.colorado.edu/en/simulations/category/physics/motion)
* [Phenomena](https://thewonderofscience.com/msps22#phenomena)
* [CDSM Unit](https://docs.google.com/document/d/17566SXUCWYXi2RfrQvQZqCNpcQ_MhLxrkXR0-BEV0rc/edit?usp=sharing)
	+ [Hammer and Feather Drop on the Moon Video Link](https://www.youtube.com/watch?v=03SPBXALJZI)
	+ [What is Gravity? Video Link](https://www.youtube.com/watch?v=mezkHBPLZ4A)
	+ [2nd Floor Gravity Video Link](https://www.youtube.com/watch?v=GrRyIKc1b9w)
	+ Assessment Probes on Newton’s First Law: [Riding in the Parade](https://drive.google.com/open?id=1W2Wybs3hP43z9FjDlwejxbpv-Fa_Sb9DgbYdTZ4VIvz6LE_klmSQm1Jt0MEUMg7gqpBMem4-7ZUyLkzL), [Outer Space Push](https://drive.google.com/open?id=1nQI5KmfgH68ZteOuc8ywho90TtoYSLu6K9iFiT9OzZw7jIqykfkLtontAaMMGaueJirFBVp1pRWHPDTg) (PDF)
	+ Assessment Probes on Forces and Gravity: [Dropping Balls](https://drive.google.com/open?id=1VS_A37gbmLpu9wcK8Q_Gxpj3HVV5qgVy9eH6U0Df5NVPbKH4x936cRvTBYi8Uja1i-mcvm6AycmswwZ6) (PDF)
	+ Assessment Probe on Newton’s Third Law: [Equal & Opposite](https://drive.google.com/open?id=1BlEWzLJ_ZR3RqnHhWO4BrKyQ1X6xs9R65iU4f1h_y_D_5SFxFPrtzt2XfAf0kZvhCWCMRySDJMP8pEBr) (PDF)
	+ [Newton’s Third Law Video Link](https://www.youtube.com/watch?v=8bTdMmNZm2M&list=PLxIdLxS3hx57p8hKbEwrIU18JIGUMtcNY&index=14) (youtube video)
	+ [Newton’s Stations Acitivity](https://drive.google.com/open?id=0B7m8I91o7h0-MElvUnNJSmpSbms) (PDF)
	+ [Motion Stations Link](http://science-class.net/archive/science-class/Lessons/Physics/Force_Motion/motion_stations/motion_stations_answers.pdf) (PDF)
	+ [Newton's Laws Worksheet Link](http://science-class.net/archive/science-class/Lessons/Physics/Force_Motion/Newton%27s_Laws_WS.pdf) (PDF)
* Forces and Motion:<http://www.bozemanscience.com/ngs-ps2a-forces-motions>
* Stability and Change:<http://www.bozemanscience.com/ngs-stability-change>
* NASA: <https://www.grc.nasa.gov/www/k-12/airplane/newton2.html>
* [Motion and force resources](https://www.cde.state.co.us/standardsandinstruction/schs-motionandforce-pdf)

**Arts, Music, Media:*** [Real World Physics](https://www.real-world-physics-problems.com/)
* [NASA activities](https://www.jpl.nasa.gov/edu/teach/tag/search/Motion%20and%20Forces)

**Videos:*** [What is Force](https://www.youtube.com/watch?time_continue=5&v=GmlMV7bA0TM)
* [Crash course Force](https://www.youtube.com/watch?v=kKKM8Y-u7ds)
* [TED-ED Newton's laws](https://www.youtube.com/watch?v=JGO_zDWmkvk)
* [TED-ED Would you weigh less in an elevator](https://www.youtube.com/watch?v=JGO_zDWmkvk)
* [Newton's laws of motion](https://www.youtube.com/watch?v=NYVMlmL0BPQ)
* [Science of football 1st law](https://www.youtube.com/watch?v=08BFCZJDn9w)
* [Science of football 2nd law](https://www.youtube.com/watch?v=qu_P4lbmV_I)
* [science of football 3rd law](https://www.youtube.com/watch?v=e1lzB36aHD4)
* [Gymnastics and Newton's laws of motion](https://www.real-world-physics-problems.com/physics-of-gymnastics.html)

**Teacher resources:*** [Bozeman forces and motion](https://www.youtube.com/watch?v=QD3T7d5SWKk)
* [Bozeman Newton's Laws of Motion](https://www.youtube.com/watch?v=PNTLDNxTMdg)
* [Smithsonian science](https://ssec.si.edu/smithsonian-science)
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