Colorado Teacher-Authored Instructional Unit Sample

Science

High School – Physical Science

Unit Title: Motion and Force

Colorado's District Sample Curriculum Project

INSTRUCTIONAL UNIT AUTHORS

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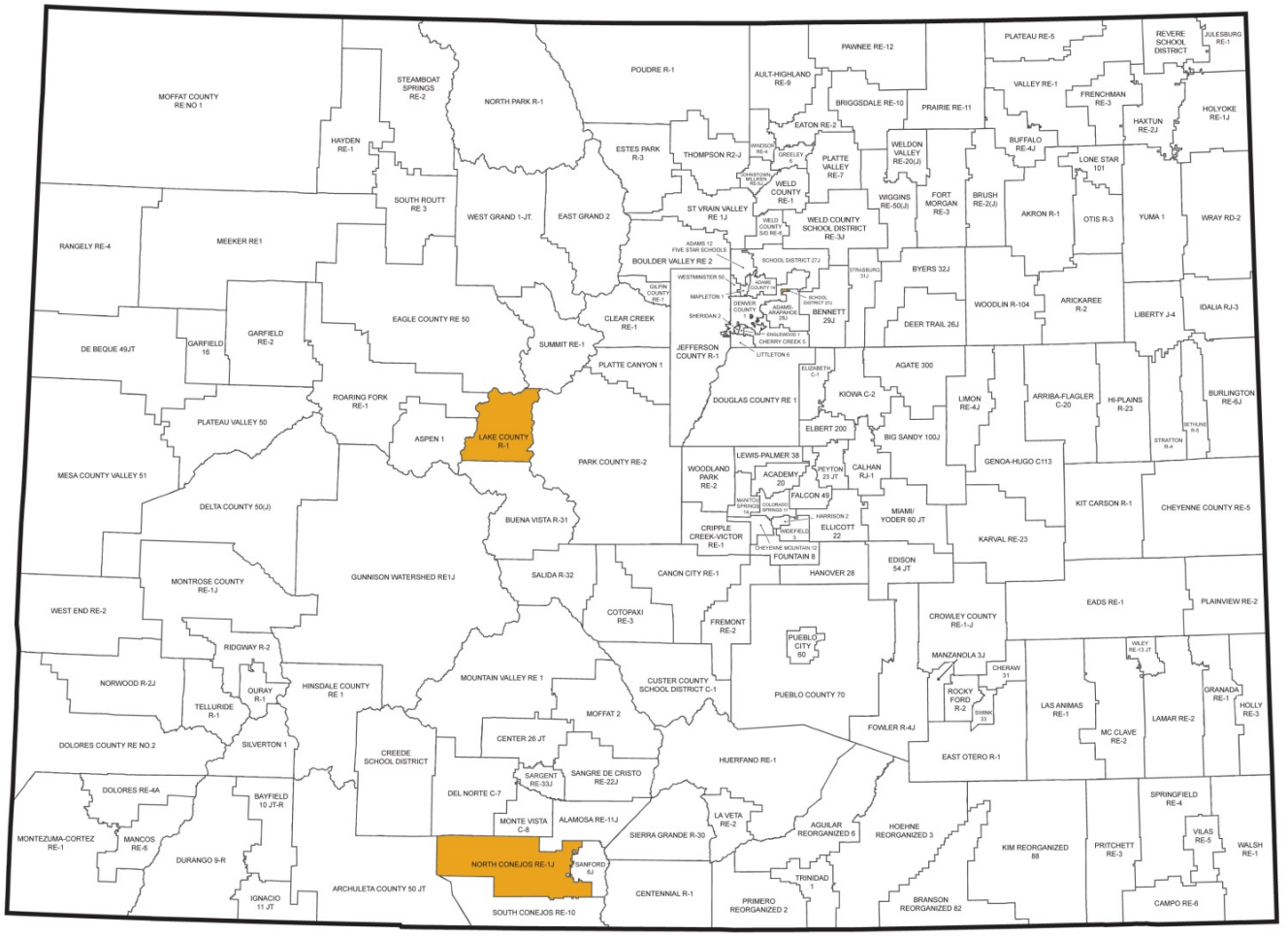

This unit was authored by a team of Colorado educators. The template provided one example of unit design that enabled teacher-authors to organize possible learning experiences, resources, differentiation, and assessments. The unit is intended to support teachers, schools, and districts as they make their own local decisions around the best instructional plans and practices for all students.

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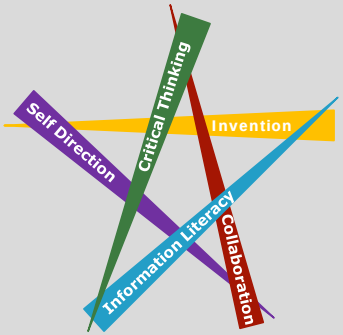
Colorado Teacher-Authored Sample Instructional Unit

Content Area	Science	**Grade Level**	High School
Course Name/Course Code	Physical Science		

Standard	**Grade Level Expectations (GLE)**	**GLE Code**
1. Physical Science	1. Newton's laws of motion and gravitation describe the relationships among forces acting on and between objects, their masses, and changes in their motion – but have limitations	SC09-GR.HS-S.1-GLE.1
	2. Matter has definite structure that determines characteristic physical and chemical properties	SC09-GR.HS-S.1-GLE.2
	3. Matter can change form through chemical or nuclear reactions abiding by the laws of conservation of mass and energy	SC09-GR.HS-S.1-GLE.3
	4. Atoms bond in different ways to form molecules and compounds that have definite properties	SC09-GR.HS-S.1-GLE.4
	5. Energy exists in many forms such as mechanical, chemical, electrical, radiant, thermal, and nuclear, that can be quantified and experimentally determined	SC09-GR.HS-S.1-GLE.5
	6. When energy changes form, it is neither created not destroyed; however, because some is necessarily lost as heat, the amount of energy available to do work decreases	SC09-GR.HS-S.1-GLE.6
2. Life Science	1. Matter tends to be cycled within an ecosystem, while energy is transformed and eventually exits an ecosystem	SC09-GR.HS-S.2-GLE.1
	2. The size and persistence of populations depend on their interactions with each other and on the abiotic factors in an ecosystem	SC09-GR.HS-S.2-GLE.2
	3. Cellular metabolic activities are carried out by biomolecules produced by organisms	SC09-GR.HS-S.2-GLE.3
	4. The energy for life primarily derives from the interrelated processes of photosynthesis and cellular respiration. Photosynthesis transforms the sun's light energy into the chemical energy of molecular bonds. Cellular respiration allows cells to utilize chemical energy when these bonds are broken.	SC09-GR.HS-S.2-GLE.4
	5. Cells use the passive and active transport of substances across membranes to maintain relatively stable intracellular environments	SC09-GR.HS-S.2-GLE.5
	6. Cells, tissues, organs, and organ systems maintain relatively stable internal environments, even in the face of changing external environments	SC09-GR.HS-S.2-GLE.6
	7. Physical and behavioral characteristics of an organism are influenced to varying degrees by heritable genes, many of which encode instructions for the production of proteins	SC09-GR.HS-S.2-GLE.7
	8. Multicellularity makes possible a division of labor at the cellular level through the expression of select genes, but not the entire genome	SC09-GR.HS-S.2-GLE.8
	9. Evolution occurs as the heritable characteristics of populations change across generations and can lead populations to become better adapted to their environment	SC09-GR.HS-S.2-GLE.9

3. Earth Systems Science	1. The history of the universe, solar system and Earth can be inferred from evidence left from past events	SC09-GR.HS-S.3-GLE.1
	2. As part of the solar system, Earth interacts with various extraterrestrial forces and energies such as gravity, solar phenomena, electromagnetic radiation, and impact events that influence the planet's geosphere, atmosphere, and biosphere in a variety of ways	SC09-GR.HS-S.3-GLE.2
	3. The theory of plate tectonics helps to explain geological, physical, and geographical features of Earth	SC09-GR.HS-S.3-GLE.3
	4. Climate is the result of energy transfer among interactions of the atmosphere, hydrosphere, geosphere, and biosphere	SC09-GR.HS-S.3-GLE.4
	5. There are costs, benefits, and consequences of exploration, development, and consumption of renewable and nonrenewable resources	SC09-GR.HS-S.3-GLE.5
	6. The interaction of Earth's surface with water, air, gravity, and biological activity causes physical and chemical changes	SC09-GR.HS-S.3-GLE.6
	7. Natural hazards have local, national and global impacts such as volcanoes, earthquakes, tsunamis, hurricanes, and thunderstorms	SC09-GR.HS-S.3-GLE.7

Colorado 21st Century Skills



Critical Thinking and Reasoning: *Thinking Deeply, Thinking Differently*

Information Literacy: *Untangling the Web*

Collaboration: *Working Together, Learning Together*

Self-Direction: *Own Your Learning*

Invention: *Creating Solutions*

Reading & Writing Standards for Literacy in Science and Technical Subjects 6 - 12

Reading Standards

- Key Ideas & Details
- Craft And Structure
- Integration of Knowledge and Ideas
- Range of Reading and Levels of Text Complexity

Writing Standards

- Text Types & Purposes
- Production and Distribution of Writing
- Research to Construct and Present Knowledge
- Range of Writing

Unit Titles	Length of Unit/Contact Hours	Unit Number/Sequence
Motion and Force	7-9 weeks	1

Unit Title	Motion and Force			**Length of Unit**	7-9 weeks
Focusing Lens(es)	Cause and Effect	**Standards and Grade Level Expectations Addressed in this Unit**	SC09-GR.HS-S.1-GLE.1		
Inquiry Questions (Engaging-Debatable):	• What are the pros and cons related to building cars out of less dense materials? • How does an understanding of the laws of motion create a safer and/or more dangerous world?				
Unit Strands	Physical Science				
Concepts	Mass, Velocity, Motion, Acceleration, Force, Friction, Law, Theory, Gravitation, Matter, Inertia, Momentum				

Generalizations **My students will Understand that…**	**Guiding Questions** **Factual**	**Conceptual**
Laws of motion and gravitation capture (in formula) how forces affect the motion of matter (SC09-GR.HS-S.1-GLE.1-EO.b,c; IQ.1; N.1)	What are the different ways that motion can be affected by force? (Speed up, slow down, change direction, have no effect). What determines which kind of motion results from a force? (SC09-GR.HS-S.1-GLE.1;IQ.1) and (SC09-GR.HS-S.1-GLE.1;IQ.2)	What are some causes of forces? How do forces affect velocity and acceleration? (SC09-GR.HS-S.1-GLE.1-E.O.b)
Unbalanced forces cause motion to change (SC09-GR.HS-S.1-GLE.1-E.O.a,b; N.1)	How is force related to mass and acceleration (F=ma)? What determines how much force is needed to move an object? (SC09-GR.HS-S.1-GLE.1-EO.a,b;N.1)	How can you build a 150 story building without it falling over? How do structural engineers determine if a building or bridge will collapse or keep a sound structure?
An object can increase or decrease in acceleration without impacting velocity. (SC09-GR.HS-S.1-GLE.1-EO.a,b)	How can acceleration change but not velocity? How can you decrease velocity and still increase acceleration?	What designs in consumer products are influenced by the relationship between velocity and acceleration?
The relationship between force and friction leads engineers to employ more efficient technological designs (ex. automobiles). (SC09-GR.HS-S.1-GLE.1-EO.a,b,c)	What type of surface would be needed for an object to slide freely? (SC09-GR.HS-S.1-GLE.1-EO.c) Why do skiers put wax on their skis? What is the difference between a scientific Theory and a common theory or hypothesis? (SC09-GR.HS-S.1-GLE.1;N.3) What is the difference between a scientific Law and a social law? (SC09-GR.HS-S.1-GLE.1;N.3)	What would happen if there was no air resistance? How would you determine that an observation has become a Law? (SC09-GR.HS-S.1-GLE.1;N.3)

Objects traveling at the same velocity exemplify the direct relationship between inertia and momentum. (SC09-GR.HS-S.1-GLE.1-EO.a,c)	A semi-truck and a small car are traveling at the same speed, which has a greater momentum? Which has a greater inertia?	Why is it important for cars to have seatbelts? (SC09-GR.HS-S.1-GLE.1;IQ.2)

Critical Content: **My students will Know…**	**Key Skills:** **My students will be able to (Do)…**
• Newton's laws of motion. (SC09-GR.HS-S.1-GLE.1-EO.a,b,c,d) • The law of universal gravitation. (SC09-GR.HS-S.1-GLE.1-EO.a,b,c,d) • The position, velocity, and acceleration of moving objects. (SC09-GR.HS-S.1-GLE.1-EO.a) • How and why acceleration is produced by a net force. (SC09-GR.HS-S.1-GLE.1-EO.b) • The effects of action-reaction force pairs on the motion of two interacting objects. (SC09-GR.HS-S.1-GLE.1-EO.c;RA.1,2,3) • The limitations of Newton's laws of motion. (SC09-GR.HS-S.1-GLE.1-EO.d) • The difference between law and theory. (SC09-GR.HS-S.1-GLE.1;N.3) • The relationship between mass, acceleration and force. (SC09-GR.HS-S.1-GLE.1-EO.a,b;NS.1) • The forces present in the Earth that lead to plate tectonics. (SC09-GR.HS-S.1;RA.3) and (SC09-GR.HS-S.3-GLE.3-EO.c) • The significant differences between scientific and social laws. (SC09-GR.HS-S.1-GLE.1;N.3) • The significant differences between scientific Theories and "common theories" (SC09-GR.HS-S.1-GLE.1;N.3)	• Gather, analyze, and interpret data and create graphs of objects in motion(SC09-GR.HS-S.1-GLE.1-EO.a;N.2,4) • Develop, communicate, justify, and predict the outcome of Newton's Second Law. (SC09-GR.HS-S.1-GLE.1-EO.b;RA.1,2,3;N.1,2,4) • Develop, communicate, justify, and predict the outcome of Newton's Third Law. (SC09-GR.HS-S.1-GLE.1-EO.c;RA.2,3;N.1,2,4) • Examine the effect of Newton's law of universal gravitation to a system of two bodies. (SC09-GR.HS-S.1-GLE.1-EO.d;N.1,2,3,4)

Critical Language: includes the Academic and Technical vocabulary, semantics, and discourse which are particular to and necessary for accessing a given discipline.
EXAMPLE: A student in Language Arts can demonstrate the ability to apply and comprehend critical language through the following statement: *"Mark Twain exposes the hypocrisy of slavery through the use of satire."*

A student in _____ can demonstrate the ability to apply and comprehend critical language through the following statement(s):	The type of motion, acceleration, and velocity of an object are dependent on the net force acting on that object.
Academic Vocabulary:	Analyze, interpret, synthesize, justify, limitations, minimize, differentiate, disciplines of science
Technical Vocabulary:	Forces, motion, acceleration, velocity, net force, gravitation, interplanetary, momentum, inertia, mass, speed, law, theory

Unit Description:	This unit focuses on students exploring the Laws of Motion. The unit describes Newton's Laws of Motion, gravity, friction, momentum, and force. Beginning with a review of the Laws of Motion and then progressing through the concepts that unbalanced forces cause motion to change, an object can increase or decrease in acceleration impacting velocity, the relationship between force and friction, and objects traveling at the same velocity exemplify the direct relationship between inertia and momentum. The unit culminates in a performance assessment that asks students to identify and graph (motion) four skateboard stunts, including at least one law of motion with each stunt, and using all three laws within the four stunts.
Considerations:	**Consideration**: Teachers need to consider that the timing of the unit may not coincide with the original intention of the unit creators due to district high school scheduling differences. **Possible misconceptions**: Weight is the same as mass Velocity is the same as speed
Unit Generalizations	
Key Generalization:	Laws of motion and gravitation capture (in formula) how forces affect the motion of matter.
Supporting Generalizations:	Unbalanced forces cause motion to change.
	An object can increase or decrease in acceleration impacting velocity.
	The relationship between force and friction leads engineers to employ more efficient technological designs (ex. automobiles).
	Objects traveling at the same velocity exemplify the direct relationship between inertia and momentum.

Performance Assessment: *The capstone/summative assessment for this unit.*	
Claims: (Key generalization(s) to be mastered and demonstrated through the capstone assessment.)	Laws of motion and gravitation capture (in formula) how forces affect the motion of matter
Stimulus Material: (Engaging scenario that includes role, audience, goal/outcome and explicitly connects the key generalization)	ESPN is creating a video series around the physics of sport. You are a skateboarder in the X-Games and you have been asked to explain to ESPN viewers your gravity defying performances. You will have to include four stunts identifying at least one of Newton's Laws of motion for each stunt and you need to use all three laws at least once. You will use models/simulations to gather, analyze, and interpret data and create graphs of objects in motion (acceleration, velocity, and position) to include in a written report.
Product/Evidence: (Expected product from students)	Students will take on the role of a skateboarder and have to explain to their peers their gravity defying performances. They must identify which law of motion applies to each of four stunts and need to use at least each law once. They will use models/simulations to gather, analyze, and interpret data and create graphs of objects in motion (acceleration, velocity, and position) to include in a written report. http://phet.colorado.edu/en/simulation/energy-skate-park (Simulation of skate park) http://www.nbclearn.com/nhl/cuecard/56615 (The physics of sport)

	http://xgames.espn.go.com/video/9522955/big-air (Example of the physics behind a skateboarder)
Differentiation: (Multiple modes for student expression)	Teachers may provide a timing sheet (goal for work). Teachers may provide some examples (pictures or videos) of stunts in advance. Teachers may provide an incomplete data table and graph with word lists. Extension: Students may find or create a more complex trick that includes all three laws of motion. Students may calculate the coefficient of friction for a ramp and skateboard wheels. Students may calculate momentum of one stunt.

Texts for independent reading or for class read aloud to support the content

Informational/Non-Fiction	Fiction
http://www.123helpme.com/physics-of-dog-mushing-view.asp?id=153251 (Physics of dogsledding) http://www.exploratorium.edu/skateboarding/trick02.html (Forces of skateboarding)	http://www.earthsonglodge.com/dogsleddingstories.html (Dog sled stories) http://www.teenink.com/nonfiction/sports/article/15240/Skateboarding/ (Skateboarding poem)

Ongoing Discipline-Specific Learning Experiences

1.	Description:	Working like a scientist: Creating and interpreting graphs and data tables.	Teacher Resources:	http://www.temple.edu/carversciencefair/ActivityModel.pdf (Model for scientific inquiry) http://www.enchantedlearning.com/graphicorganizers/scientificmethod/1.shtml (Scientific graphic organizer)
			Student Resources:	http://www.bing.com/images/search?q=scientific+method&qpvt=scientific+method&FORM=IGRE#view=detail&id=CF6F847AA09A972C6E6CA69C34EC09D11A05E4B8&selectedIndex=6 (Color diagram of scientific method) https://www.youtube.com/watch?v=eA86dYxrg4Q (Scientific method video/rap)
	Skills:	Identify independent and dependent variable in experiment. Identify what data needs to be collected. Set up appropriate data table. Recognizing sources of error in data collection. Analyze data table.	Assessment:	Students conduct an experiment and graph the independent and dependent variables, making certain to label the graph and axis, and use an appropriate measurement (units) scale. An example of this experiment could be having four different stations: 1) measure mass of three different objects 2) measure length 3) measure temperature 4) measure volume. The students can create a hypothesis before they start the experiment, and then write a conclusion after the experiment.

		Analyze graphical information. Recognize trends in data. Compare two or more sets of data to relate and draw conclusions. Synthesize given information in graphic organizer. Summarizing main concepts in paragraph.		
2.	Description:	Working like a scientist: Using technology to model applications of laws.	Teacher Resources:	http://phet.colorado.edu/en/simulation/forces-and-motion-basics http://phet.colorado.edu/en/simulation/energy-skate-park-basics
			Student Resources:	http://phet.colorado.edu/en/simulation/forces-and-motion-basics http://phet.colorado.edu/en/simulation/energy-skate-park-basics
	Skills:	Gather, analyze, and interpret data and create graphs of objects in motion	Assessment:	Students can complete online simulations such as PHET labs, and graph their results.
3.	Description:	Thinking like a scientist: Predicting motion of objects.	Teacher Resources:	http://www.columbusisd.org/cms/lib/TX01001718/Centricity/Domain/165/Physics%20Powerpoints/Chapter%201%20-%20Thinking%20like%20a%20Scientist.pptx https://sites.google.com/a/d118.org/ms-secler/Units-of-Study/unit-1
			Student Resources:	http://www.mos.org/taxonomy/term/2115 http://www.theglobeandmail.com/news/national/education/every-student-can-think-like-a-scientist-heres-how/article19315732/
	Skills:	Gather, analyze, and interpret data and create graphs of objects in motion Develop, communicate, justify, and predict the outcome of Newton's Second Law. Develop, communicate, justify, and predict the outcome of Newton's Third Law. Examine the effect of Newton's law of universal gravitation to a system of two bodies.	Assessment:	Students explain ways to change the effects of friction on the motion of objects; therefore, the primary focus of assessment should be to construct a cause-and-effect model of the ways to change the effects of friction on motion including those listed in the indicator. However, appropriate assessments should also require students to recognize factors that affect friction; illustrate a diagram of objects moving to determine which factors are increasing friction to slow down or stop the motion; summarize major points about the factors that affect friction with their increasing or decreasing the effects; infer which factors are increasing or decreasing friction to slow down or speed up the motion of objects.

Prior Knowledge and Experiences
Students need to have a basic understanding of: Newton's laws of motion, force, the difference between speed and velocity, gravity, the difference between a law and a theory, friction, mass, and math skills manipulating variables. Vertical alignment: Students have last seen concepts related to this unit in 8th and 2nd grades and Kindergarten.

Learning Experience # 1		
The teacher may demonstrate different types of forces (push, pull, gravitational, etc.) so that the students can understand the results of different applied forces.		
Generalization Connection(s):		
Teacher Resources:	http://www.physicsclassroom.com/class/newtlaws/Lesson-2/Types-of-Forces, https://www.flickr.com/photos/physicsclassroom/galleries/72157625278916478/,	
Student Resources:	http://www.physicsclassroom.com/morehelp/recforce/recforce.cfm, http://phet.colorado.edu/en/simulation/forces-and-motionhttp://phet.colorado.edu/en/simulation/ramp-forces-and-motion ,	
Assessment:	The students will identify the net forces and movement of objects based on applied forces.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide opportunities and resources to allow the student access to PHET. The teacher may provide a modified set of examples for the students to make predictions on.	The student may use a PHET simulation to practice how applied forces generate a net force. The student may use a modified set of examples.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide guidance so that students may create free body diagrams.	The student may create their own free body diagrams of applied and net forces.
Critical Content:	Force Net force Applied force Contact force At-a-distance force Newtons	

Key Skills:	Predict
Critical Language:	Force, net force, applied force, contact force, at-a-distance force, predict

Learning Experience # 2		
The teacher may demonstrate balanced and unbalanced forces so that the student can predict resultant motion.		
Generalization Connection(s):		
Teacher Resources:	http://www.physicsclassroom.com/class/newtlaws/Lesson-1/Balanced-and-Unbalanced-Forces https://www.khanacademy.org/science/physics/forces-newtons-laws/balanced-unbalanced-forces/v/balanced-and-unbalanced-forces http://www.slideshare.net/rickaturner/balanced-and-unbalanced-forces-5408256	
Student Resources:	http://www.physicsclassroom.com/class/newtlaws/Lesson-1/Balanced-and-Unbalanced-Forces http://utahscience.oremjr.alpine.k12.ut.us/sciber99/8th/forces/sciber/forces.htm http://eschooltoday.com/science/forces/balanced-forces.html	
Assessment:	The students can create free body diagrams of applied and net forces.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may show students how to model balanced and unbalanced forces.	The student may physically demonstrate balanced and unbalanced forces.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may ask students to create a model that demonstrates balanced and unbalanced forces.	The student may construct a physical model that demonstrates balanced and unbalanced forces.
Critical Content:	• Force • Balanced force • Unbalanced force • Free body diagram • Mass • Acceleration	
Key Skills:	• Predict • Calculate	
Critical Language:	Force, balanced force, unbalanced force, free body diagram, mass, acceleration, predict, calculate	

Learning Experience # 3		
The teacher may model how to differentiate vector and scalar quantities (distance v. displacement, speed v. velocity), so that the students can understand how vector and scalar quantities are used in the real world (e.g., car accident, football, riding a bike).		
Generalization Connection(s):		
Teacher Resources:	http://www.physicsclassroom.com/class/1DKin/Lesson-1/Scalars-and-Vectors http://webphysics.iupui.edu/JITTworkshop/152Basics/vectors/vectors.html	
Student Resources:	http://www.physicsclassroom.com/class/1DKin/Lesson-1/Scalars-and-Vectors http://www.grc.nasa.gov/WWW/k-12/airplane/vectors.html https://www.khanacademy.org/science/physics/one-dimensional-motion/displacement-velocity-time/v/introduction-to-vectors-and-scalars	
Assessment:	The students will apply their learning to real-world examples differentiating between vector and scalar quantities.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide scaffolded notes of key vocabulary and play videos from Khan Academy.	The student may copy down notes from teachers visual scaffolded notes, and watch videos with visuals from Khan Academy.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may teach students how to investigate a car accident.	The students may diagram and report the vector and scalar quantities of a specific, given, car accident.
Critical Content:	• Vector • Scalar • Speed • Velocity • Displacement • Distance	
Key Skills:	• Vector addition • Graphing • Interpreting	

Critical Language:	Vector, scalar, speed, velocity, displacement, distance, vector addition, graphing, interpreting

Learning Experience # 4		
The teacher may provide opportunities to explore (discussion, models, lab, etc.) acceleration and velocity so that the students can understand what acceleration and velocity mean in order to facilitate the understanding of laws of motion and how they are applied to various fields.		
Generalization Connection(s):		
Teacher Resources:	http://www.physicsclassroom.com/class/1DKin/Lesson-6/Sample-Problems-and-Solutions http://www.sheffield.k12.oh.us/Downloads/Speed,velocity,%20and%20acceleration%20problems.pdf http://www.ducksters.com/questions/physicsvelocity.php	
Student Resources:	http://www2.franciscan.edu/academic/MathSci/MathScienceIntegation/MathScienceIntegation-836.htm https://docs.viedu.org/teacherresources/physcispeedaccelkey.htm	
Assessment:	The student will complete word problems using motion formulas or complete a lab report.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide a three variable math triangle. http://www.tildee.com/HSAxRc	The student may use a three variable math triangle while solving the problems.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide a lab for students to explore their own acceleration and velocity	The student may complete a running lab, in which they run a certain distance (50m) and then sprint the next 50 meters, for a total of 100m. They could then calculate their acceleration and velocity.
Critical Content:	• Velocity • Speed • Time • Distance • Displacement • acceleration	
Key Skills:	• Calculating • manipulating formulas	

Critical Language:	Velocity, speed, time, distance, displacement, acceleration, calculating, manipulating formulas

Learning Experience # 5		
The teacher may lead lab investigations around Newton's three laws of motion, so that they students can investigate the concepts of motion (inertia, F=ma, action and reaction pairs).		
Generalization Connection(s):		
Teacher Resources:	http://www.youtube.com/watch?v=NYVMlmL0BPQ, http://www.physicsclassroom.com/SpecialPages/Search.aspx?searchtext=newton%27s%20three%20laws&searchmode=anyword	
Student Resources:	http://phet.colorado.edu/en/contributions/view/3248, http://staweb.sta.cathedral.org/departments/science/physics/inertiagames/swing_Race.html, http://www.physicsclassroom.com/Class/newtlaws/u2l2d.cfm#Practice	
Assessment:	The students will complete motion graphs and diagrams of the lab outcomes.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide a variety of laboratory experiences surrounding Newton's three laws. The teacher may provide a skeletal data table and graph.	The student may select a modified lab to complete. The student may use a template to complete data tables and graphs.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide a variety of laboratory experiences surrounding Newton's three laws.	The student may graph potential and kinetic energy at each point in time for an interaction and interpret the results with respect to mechanical energy
Critical Content:	• Inertia • Mass • Force • Acceleration • Velocity • Net force • Motion graphs • Action and reaction pairs • Newtons • Kilograms	

Key Skills:	• Measuring • Graphing • interpreting graphs and diagrams • manipulating formulas and variables • making predictions
Critical Language:	Inertia, mass, force, acceleration, velocity, net force, motion graphs, action and reaction pairs, measuring, graphing, interpreting graphs and diagrams, manipulating formulas and variables, making predictions

Learning Experience # 6		
The teacher may provide opportunities for students to investigate examples of Newton's laws of motion so that students can apply their understanding to real-world scenarios.		
Generalization Connection(s):		
Teacher Resources:	https://www.flickr.com/photos/physicsclassroom/galleries/72157625278916478/, http://www.youtube.com/watch?v=zxvBSQx3SYg,	
Student Resources:	http://phet.colorado.edu/en/simulation/gravity-force-lab, http://phet.colorado.edu/en/simulation/energy-skate-park-basics	
Assessment:	The student may report out their findings of real world examples (case studies) of the laws of motion.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide choice in case studies and examples.	The student may choose a case study at their Lexile level.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide choice in case studies and examples. The teacher may provide options for students to share out their findings to a larger audience (YouTube, younger students, etc.)	The student may choose a case study at their Lexile level. The student may share out their case study to a different audience besides the class.
Critical Content:	• Inertia • Mass • Force • Acceleration • Velocity • net force • motion graphs • action and reaction pairs • Newtons	

	• Kilograms
Key Skills:	• Analyzing • Researching
Critical Language:	Inertia, mass, force, acceleration, velocity, net force, motion graphs, action and reaction pairs, Newtons, Kilograms analyzing, researching

Learning Experience # 7		
The teacher may facilitate a lab on work and power so that the students can understand how mass (their own or other masses) can be applied over distances to do work. (Important note: it will be important to discern mass and weight).		
Generalization Connection(s):		
Teacher Resources:	http://www.physicsclassroom.com/class/energy/Lesson-1/Calculating-the-Amount-of-Work-Done-by-Forces http://www.sparknotes.com/physics/workenergypower/workpower/problems.html	
Student Resources:	http://www.physicsclassroom.com/class/energy/Lesson-1/Calculating-the-Amount-of-Work-Done-by-Forces https://www.flickr.com/photos/physicsclassroom/galleries/72157625199307955/ http://hyperphysics.phy-astr.gsu.edu/hbase/wcon.html	
Assessment:	The students can compile class data and graph the results of the lab, distinguishing the difference between mass and weight.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide a lab for students to calculate their power and work on a school staircase.	The student can calculate their own weight and mass so that they can solve for their own personal power and work in the staircase lab.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide more complex labs for students to calculate their power and work (ex: running, stationary bike, jumping, etc.)	The student can calculate their own weight and mass so that they can solve for their personal power and work in more complex situations (stationary bike, running, jumping on boxes).
Critical Content:	• Work • Power • Distance • Force • Time • Motion	

	• Joules • Newtons
Key Skills:	• Graphing • calculating
Critical Language:	Work, power, distance, force, time, motion, joules, Newtons, graphing, calculating

Learning Experience # 8		
The teacher may explore ideas of friction and inertia utilizing various examples (e.g., curling, air hockey) so that students can conceptualize inertia and come to understand the impact of friction.		
Generalization Connection(s):		
Teacher Resources:	http://www.nbclearn.com/olympics/cuecard/47272, http://www.spokaneschools.org/cms/lib/WA01000970/Centricity/Domain/1138/620.Hockey%20Physics%20Demonstration.pptx	
Student Resources:	http://www.real-world-physics-problems.com/physics-of-curling.html, http://phet.colorado.edu/en/simulation/friction, https://www.cs.kent.ac.uk/pubs/ug/2007/co600-projects/pbanim/report.pdf, http://www.youtube.com/watch?v=371k7zHAXy0	
Assessment:	The student will create a working hovercraft and explain the relation of the design to friction and inertia.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	Teachers may arrange a field trip so that students can explore the concept of a frictionless surface on an air hockey table.	Students can go to a local arcade and experience first-hand the concept of friction or the lack of friction.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	Teacher may set up opportunities for students to have a hovercraft competition, with the winner being the hovercraft that travels the furthest.	Students can create a functioning hovercraft, and can communicate how friction and inertia are demonstrated in the hovercraft.
Critical Content:	• Friction • Inertia • relationship between force and friction	
Key Skills:	• Determine cause and effect • Analyze the relationship between friction and inertia	
Critical Language:	Force, friction, inertia, analyze	

Learning Experience # 9		
The teacher may lead a Socratic seminar around friction and efficiency so students can explore different real-world scenarios that apply to both concepts.		
Generalization Connection(s):		
Teacher Resources:	https://www.khanacademy.org/search?page_search_query=friction+&kind=Video https://www.khanacademy.org/search?page_search_query=friction+ http://www.shell.com/global/products-services/on-the-road/oils-lubricants/cars/how-oil-works.html (car motor oil/efficiency)	
Student Resources:	http://www.s-cool.co.uk/gcse/physics/energy-calculations/revise-it/power-and-efficiency (calculating efficiency) http://www.evo.com/how-to-wax-skis-and-snowboards.aspx (waxing skies and snowboards)	
Assessment:	The student will complete a note catcher during the seminar and debrief as a whole group.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may teach a lesson on Socratic seminars before the actual friction and efficiency seminar.	The students can follow the Socratic seminar structure, and use the Socratic seminar structure to share ideas with other classmates about real-world efficiency and friction scenarios.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may introduce controversial friction and efficiency scenarios to the students.	The students can participate in debates with each other on the pros and cons of the controversial friction and efficiency scenarios.
Critical Content:	• Friction, efficiency, relationship between force and friction, structure and interactions of matter, difference between scientific law and social law	
Key Skills:	• Determine cause and effect • Calculate efficiency • Analyze the relationship between friction and efficiency	
Critical Language:	Friction, force, efficiency, matter, interactions, laws, analyze, determine	

Learning Experience # 10	
The teacher may provide opportunities to explore the connection between momentum and inertia through demonstrations/simulations so that students can understand that momentum and inertia are influenced by mass (e.g., semi car versus small car, water slide, seat belts in cars).	
Generalization Connection(s):	

Teacher Resources:	http://www.loc.gov/rr/scitech/mysteries/rollercoaster.html (Basics of how roller coasters work (article)) http://science.howstuffworks.com/engineering/structural/roller-coaster3.htm (more basics (article)) http://www.sciencechannel.com/video-topics/engineering-construction/machines-rollercoaster.htm (roller coaster video)	
Student Resources:	http://science.howstuffworks.com/engineering/structural/roller-coaster.htm (How rollercoasters work (article)) http://science.howstuffworks.com/4661-how-roller-coasters-work-video.htm (video)	
Assessment:	The students will create a lab report with the results of their investigations (including calculations and explanations). The lab report will be on the momentum and inertia utilized in a roller coaster.	
Differentiation: (Multiple means for students to access content and multiple modes for student to express understanding.)	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may allow students to create a roller coaster out of popsicle sticks and hot glue.	The students will explore momentum and inertia in their roller coaster models.
Extensions for depth and complexity:	**Access** (Resources and/or Process)	**Expression** (Products and/or Performance)
	The teacher may provide opportunities and examples of a full roller coaster (scale model).	The students will explore momentum, inertia, and friction within their roller coaster model.
Critical Content:	• Momentum • Inertia • conservation of momentum	
Key Skills:	• Calculate momentum • Graph the relationship between mass and momentum • Determine the relationship between mass and inertia	
Critical Language:	Momentum, inertia, conservation, calculate	

Learning Experience # 11	
The teacher may provide students with opportunities to research the local park (skate park, amusement park, playground) so that students can understand the how and why of design of the park in relation to the laws of motion.	
Generalization Connection(s):	
Teacher Resources:	http://www.huffingtonpost.com/carolyn-beans/skate-park-physics_b_4403742.html (Skateboarding basic physics (article) https://www.youtube.com/watch?v=75iI3-dV4Rc https://www.youtube.com/watch?v=I3ub1yFTeRQ & (physics of skate park videos)
Student Resources:	http://phet.colorado.edu/en/simulation/energy-skate-park (Skate park physics (simulation)) http://blogs.pennmanor.net/lorihuel/files/2012/01/Skateboard-Science-Student-Guide.pdf (reading and activities/lab)
Assessment:	The students will turn in a written report on the different features of the park, including an explanation for the specific design.

<table>
<tr><td rowspan="2">Differentiation:
(Multiple means for students to access content and multiple modes for student to express understanding.)</td><td>Access (Resources and/or Process)</td><td>Expression (Products and/or Performance)</td></tr>
<tr><td>The teacher may have the students fill out a guided worksheet, helping them to understand what measurements and equations they should perform.</td><td>The students can fill out the worksheet, and create drawings for all park features that they are measuring and completing calculations.</td></tr>
<tr><td rowspan="2">Extensions for depth and complexity:</td><td>Access (Resources and/or Process)</td><td>Expression (Products and/or Performance)</td></tr>
<tr><td>The teacher may allow the students to build their own skate park features, and have them calculate the different motion and force equations.</td><td>The students can recall which formulas should be used to calculate different motion and force values with their model skate park features.</td></tr>
<tr><td>Critical Content:</td><td colspan="2">• Momentum
• Inertia
• conservation of momentum</td></tr>
<tr><td>Key Skills:</td><td colspan="2">• Calculate momentum
• Graph the relationship between mass and momentum
• Determine the relationship between mass and inertia</td></tr>
<tr><td>Critical Language:</td><td colspan="2">Momentum, inertia, conservation, calculate</td></tr>
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