	Zipline Activity	Design: Car Building (Balloon cars)	Investigation: Speed (flat surface)
Objective	Students will construct a zipline to recognize and analyze the motion (and cause of motion) of an object. Students will begin to be able to evaluate the causes of motion and deduce the important factors in measuring motion (time and distance)	Students will design and construct a self-propelled car to examine how forces are used to move objects.	Students will compute the speed of their cars and compare/contrast the speeds of different cars. Students will be able to produce a D vs. T graph from their data.
Student Experience	1) Students brainstorm meaning of motion. 2) Students design a "zipline" from chair to chair that goes thru a straw. 3) Students then attach an object to straw and brainstorm ways of moving it 2) Students investigate what causes motion. (unbalanced forces) 3) Students investigate what causes more/less motion. 4) Students brainstorm how to measure motion/speed. EXTRA: Students investigate if different object's (mass) motion is different.	1) Teacher introduces culminating activity (design a car that completes a track with defined parameters) 2) Teacher allows students access to materials that will be used to build their car 3) Students are introduced to Newton's 3rd Law of motion (rocket examples) as a propulsion method. 4) Students design and construct cars 5) Students diagram their designs showing where and in what directions the forces are located 6) Students give rationale for design EXTRA: Student investigate alternate forms of propulsion (rubberband) Teaching points: Forces can increase and decrease speed	1) Students reminded of class brainstorm about how to measure motion (speed). 2) Students now use knowledge of speed equation to calculate the speed of their car on a flat surface 3) Students improve design to maximize efficiency (end goal in mind = not just fastest) 4) Students graph results of different car designs and analyze the causes for the differences in speed. 5) Students justify their final car design Teaching points: relationship between slope of line and speed
T4T Material	Fishing Line, Balloons, Straws, Tape,	Bottle tops, Dowels, Binder Clips, Tape, Blinds, Balloons	Student Built Balloon Cars, Extra Design Pieces
Big Idea	Motion: distance from a reference point must change. Motion is achieved when a unbalanced forces are applied. The amount of mass and force affect motion of an object. Distances and time are necessary to calculate speed.	Unbalanced forces cause motion. Newton's 3rd Law of Motion: an equal and opposite reaction to propel a car. Alternative ways to propel cars. Friction occurs when two objects are in contact and works against motion. Cars can be more efficient by reducing the friction acting within the car.	Motion energy is kinetic energy. Measuring motion: Speed= distance/time Average speed= total D/total T Graphing speed
Connection to Culminating Activity	Introduction to vocabulary (motion, force, gravity, acceleration, etc.) Unbalanced forces cause motion	Design/build a car that is able to complete track	Speed of car when moving along track. Graphing of speed to present results to class.
CA Standards	8.1.a	8.1.b/8.1.c/8.2.e	8.1.b/8.1.c/8.1.f
Next Gen Sci Standards	PE: MS-PS2-2 S&E Princ: Planning and Carrying out investigations DCI: PS2.A CrossCutting: Cause and Effect/ Stability and Change	PE: MS-PS2-1 S&E PRINC: Constructing Explanations and Designing Solutions DCI: PS2.A CrossCutting: Influence of Science, Engineering, and Technology	PE: MS-PS2-2 S&E Princ: Planning and Carrying out investigations DCI: PS2.A CrossCutting: Cause and Effect/ Stability and Change

	Investigation: Varying mass of car (effect on speed/acceleration)	Investigation: Varying the force acting on car (effect on speed/acceleration)	Predicting: Car collisions
Objective	Students will be able to analyze/evaluate the effect of changing the mass of the car on the car's speed and acceleration.	Students will be able to analyze/evaluate the effect of changing the amount of force (exerted on the car) on the car's speed and acceleration.	Students will be able to predict the outcome of car collisions (taking into account all forces) when cars' mass and force change.
Student Experience	1) Students add varying masses to the car (with force constant) and examine its effect on the motion of the car. 2) Students change mass at least three times and run 3 trials each on flat surface used previously to calculate speed 3) Students data is organized into table and graphed 4) Student data is compared/contrasted between groups 5) Students conclude the effect of adding/subtracting mass on a car's motion 6) F=MA is introduced EXTRA: Teaching points: control variable, experimental error, accuracy, precision	1) Students change the amount of force (adding balloons) exerted on the car and examine its effect on the motion. 2) Students change the amount of force at least 3 times and run 3 trials to calculate speed 3) Students data is organized into table and graphed 4) Student data is compared/contrasted between groups 5) Students conclude the effect of changing the force on a car's motion 6) Students determine how force and mass are proportional to acceleration Teaching points: directly proportional, inversely proportional	1) Students brainstorm how force and mass will affect the outcome of car collisions 2) Students design a test to predict how 2 or 3 different collisions will result when cars of different masses collide. 3) Students make diagrams showing the collisions and predicting the outcome 4) Students perform their test and to evaluate their prediction 5) Students conclude how mass can affect the result of a collision EXTRA: Students investigate multiple car collisions and predict the outcomes Teaching points: net force
T4T Material	Student Built Balloon Cars, Masses	Student Built Balloon Cars, Extra Balloons,	
Big Idea	Newton's 2nd Law of Motion: Changing the mass of car affects the speed and acceleration. The greater the mass of the object the greater the force needed to achieve the same motion.	Newton's 2nd Law of Motion: Changing the force on the car affects the speed and acceleration. The greater the mass of the object the greater the force needed to achieve the same motion.	The motion of objects is determined by the sum of forces acting on the object. Mass and Force affect motion of two interacting objects. When two objects interact each one exerts a force on the other.
Connection to Culminating Activity	Amount of mass the designed car needs for optimal performance.	Amount of force the designed car needs for optimal performance	All forces must be accounted for to predict motion of an object.
CA Standards	8.2.d/8.2.f/	8.2.b/8.2.c/8.1.f	8.2.d/8.2.e
Next Gen Sci Standards	PE: MS-PS2-2 S&E Princ: Planning and Carrying out investigations DCI: PS2.A CC: Cause and Effect/ Stability and Change	PE: MS-PS2-2 S&E Princ: Planning and Carrying out investigations DCI: PS2.A CC: Cause and Effect/ Stability and Change	PE: MS-PS2-1 S&E PRINC: Constructing Explanations and Designing Solutions DCI: PS2.A CC: Influence of Science, Engineering, and Technology

	Investigation: Gravity and Cars (ramps)	Investigation: Uphill climb	Design: Car Course
Objective	Students will be able to show how potential energy changes with the height of an incline and illustrate how the potential energy changes into other forms of energy.	Students will be able to analyze all the forces acting on a car traveling up an incline and will design/construct a car that is able to move up and over an incline	Students will design/construct a car that is able to complete their designed track(or course) and evaluate the effectiveness of their car (including speed, forces acting on car, etc.)
Student Experience	1) Students set up ramps as a way of giving potential energy to cars 2) Students predict the effect of higher/lower incline on motion 3) Students measure distance car will move and time the car moving on different inclines 4) Students collect speed data from different inclines and graph results 5) Students share data for accuracy 6) Students diagram the energy at the car has at different points of the incline (PE→KE) and identify where energy is lost 7) Students conclude how energy in a system is converted from one form to another	1) Students construct uphill ramps for cars to climb 2) Students decide on method of propulsion for car that will allow the car to climb the ramp 3) Students experiment with propulsion method to determine the amount and placement of force needed to climb ramp 4) Students' cars need to complete at least 1 uphill climb in culminating project that propels itself uphill. 5)	1) Students use their previously designed incline as part of a course (track) that their car must complete. 2) One uphill climb must be achieved thru self-propulsion and another uses the potential energy of gravitational pull. 3) Specific criteria for track may vary by class 4) Students improve design of track/car to get most efficient use of energy 5) Students diagram track identifying where energy is lost/gained 6) Students give rationale for design choices
T4T Material	Student Built Balloon Cars ,White Board Ramps, Tape	Student Built Balloon Cars ,White Board Ramps, Tape	Student Built Balloon Cars ,White Board Ramps, Tape
Big Idea	Objects may also contain potential energy depending on relative positions. Potential energy increases as height of ramp increases. When two objects interact energy can be transferred from one object to another.	When two object interact energy can be transferred from one object to another. Amount of force needed to propel car must be greater than forces acting in opposite direction.	Relationship between force, energy, and motion.
Connection to Culminating Activity	Height of hills must give cars enough energy to complete course.	Car's propulsion must allow car to ascend hill In course.	Car and track design and construction.
CA Standards	8.2.b	8.2.b	
Next Gen Sci Standards	PE: MS-PS3-2 S&E PRINC: Developing and using models DCI:PS3.A Definitions of Energy CrossCutting: Scale, Proportion, and Quantity	PE: MS-PS3-2 S&E PRINC: Developing and using models DCI:PS3.A Definitions of Energy CrossCutting: Scale, Proportion, and Quantity	PE: MS-PS2-1 S&E PRINC: Constructing Explanations and Designing Solutions DCI: PS2.A CrossCutting: Influence of Science, Engineering, and Technology

Graphic Organizer to Develop NGSS Aligned Lessons

Selected Performance Expectation:
Students who demonstrate understanding can:

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
[Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]

Describe what you want to see on the final product.

- Students will design/construct a car that is able to complete the designed track(or course)that includes one large hill and a subsequent smaller hill to evaluate the effectiveness of their car (including speed, forces acting on car, etc.)
- After conducting all investigations leading up to the culminating task, students will create a final presentation in the form of a pamphlet, poster, or lab report, that explains the benefits and short comings of their vehicle.

Directions
What should an "A" work look like?

- **Students will have work together in groups of 2 to design their vehicles and run through each of the investigations**
- **Each student will have their own independent data, graphs, tables etc. that are accurate and neatly organized.**
- **The collected data from each investigation is attached to their pamphlet, poster, or lab report.**
- **In their write up students address the following:**
    - Explanation as to why their car performed the way it did
    - Explanation is supported by their data
    - What materials were used to build their car
    - Possible problems/ challenges and solutions
    - Considerations and implications for the future
    - Reflection on the design process

Which **Common Core State Standard**(s) is (are) addressed in student's final work? Explain.
What would the student response look like to show you that the student met this criteria?

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 (MS-PS2-1),(MSPS2-3)

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS2-1),(MS-PS2-2),(MS-PS2-5)

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. (MS-PS2-1),(MS-PS2-2),(MS-PS2-5)

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2),(MS-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. (MS-PS2-1)

6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. (MS-PS2-1),(MS-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. (MS-PS2-1),(MS-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. (MS-PS2-1),(MS-PS2-2)

In going through this unit, students will satisfy many of the common core standards that are addressed for both math and English. Students will be conducting their own research projects, building with partners and sharing data with the entire class. This requires students to utilize many different communication strategies, including reading, writing, and speaking with one another. At the end of the unit, students will be expected to report the statistics of their vehicles, citing their data, and providing evidence for the claims that they have made. While conducting the 8 investigations, students will be required to use mathematical equations and reasoning in order to support their ideas, make conclusions, and make predictions.

Which **Crosscutting Concept** is addressed in student's final work? Explain
What would the student response look like to show you that the student understood the underlying crosscutting concept?

Systems and System Models

Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4),

Students will be designing a Balloon car that will allow them to measure speed, graph it, and analyze data. Students will be drawing conclusions on how the input of force impacts the output in terms of speed, kinetic energy, and potential energy, showing how energy is transformed from one type to another.

Which **Scientific Practice(s)** and **Engineering Practice(s)** are addressed in student's final work? Explain.
What would the student response look like to show you that the student thinks like an engineer and a scientist?

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 evidence consistent with scientific ideas, principles, and theories. Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)

Students will be building cars based on the basic engineering cycle of design, built, test, and revise. Students will be designing solutions to meet the challenges of mass transit engineering and constructing explanations based on data collected from their investigations.

Sequence of lesson to be field tested including estimated instructional time

Lesson 1: Zip-line Activity
Lesson2: Design: Car Building
Lesson 3: Investigation: Speed (Flat Surface)
Lesson 4: Investigation: Varying Mass
Lesson 5: Investigation: Varying Force
Lesson 6: Down Hill (Kinetic Energy and Gravity)
Lesson 7: Uphill Investigation (Potential Energy)
Lesson 8: Car Collisions
Lesson 9: Race Course

Which Performance Expectations fit into and don't fit into our current Forces and Motion Unit?

What are the Performance Expectation?	What is the content to be taught? What content is current? What content will be new?

List any current state standards that are not addressed by the NGSS.

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