Unit 2: Designing Systems that Stay Stable During a Collision

Standard(s):
7.1.5 Engage in argument from evidence to support the claim that gravitational interactions within a system are attractive and dependent upon the masses of interacting objects. Examples of evidence for arguments could include mathematical data generated from various simulations. (PS2.B)

7.1.1 Carry out an investigation which provides evidence that a change in an object's motion is dependent on the mass of the object and the sum of the forces acting on it. Various experimental designs should be evaluated to determine how well the investigation measures an object's motion. Emphasize conceptual understanding of Newton's First and Second Laws. Calculations will only focus on one-dimensional movement; the use of vectors will be introduced in high school. (PS2.A, PS2.C, ETS1.A, ETS1.B, ETS1.C)

7.1.2 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects in a system. Examples could include collisions between two moving objects or between a moving object and a stationary object. (PS2.A, ETS1.A, ETS1.B, ETS1.C)

7.2.3 Ask questions to identify constraints of specific geologic hazards and evaluate competing design solutions for maintaining the stability of human engineered structures, such as homes, roads, and bridges. Examples of geologic hazards could include earthquakes, landslides, or floods. (ESS2.A, ESS2.C, ETS1.A, ETS1.B, ETS1.C)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Students plan and conduct scientific investigations in order to test, revise, or develop explanations. **Designing Solutions to Problems** Students design solutions to problems using observations that are consistent with current evidence and scientific principles.	**PS2.A Forces and Motion** **PS2.B Types of Interactions** **PS2.C Stability and Instability in Physical Systems** **ESS2.A Earth Materials and Systems** **ESS2.C The Role of Water in Earth Surface Processes**	**Systems** Students use models to explain the parameters and relationships that describe complex systems. **Stability and Change** Students evaluate how and why a natural or constructed system can change or remain stable over time.

Big Ideas:

- Interactions of an object with another object can be explained and predicted using the concept of forces, which can cause a change in motion of one or both of the interacting objects.
- What happens when a force is applied to an object depends not only on that force but also on all the other forces acting on that object. A static object typically has multiple forces acting on it, but they sum to zero. If the total (vector sum) force on an object is not zero, however, its motion will change.
- 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).
- At the macroscale, the motion of an object subject to forces is governed by Newton's second law of motion. Under everyday circumstances, the mathematical expression of this law in the form $F = ma$ (total force = mass times acceleration) accurately predicts changes in the motion of a single macroscopic object of a given mass due to the total force on it.
- All forces between objects arise from a few types of interactions: gravity, electromagnetism, and strong and weak nuclear interactions.
- Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact. These forces are explained by force fields that contain energy and can transfer energy through space. These fields can be mapped by their effect on a test object (mass, charge, or magnet, respectively).
- Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass. Gravitational forces are always attractive.
- Natural processes can cause sudden or gradual changes to Earth's systems, some of which may adversely affect humans. Through observations and knowledge of historical events, people know where certain of these hazards—such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion—are likely to occur. Understanding these kinds of hazards helps us prepare for and respond to them.
- While humans cannot eliminate natural hazards, they can take steps to reduce their impacts.

Preceding Grade Bands:	**Target Grade Bands:**	**Following Grade Bands:**
● Objects pull or push each other when they collide or are connected. ● Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. ● Each force acts on one particular object and has both a strength and a direction. ● Forces that do not sum to zero can cause changes in the object's speed or direction of motion. ● The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	● 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). ● The motion of an object is determined by the sum of the forces acting on it; if the total force on the 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. ● Gravitational forces are always attractive. There is a gravitational force between any	● Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. ● Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.

● Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that communities can prepare for and respond to these events. ● A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions, severe weather, floods, coastal erosion). Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	two masses, but it is very small except when one or both of the objects have large mass—for example, Earth and the sun. ● Some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions. Others, such as earthquakes, occur suddenly and with no notice, and thus they are not yet predictable. However, mapping the history of natural hazards in a region, combined with an understanding of related geological forces can help forecast the locations and likelihoods of future events.	● Forces at a distance are explained by fields permeating space that can transfer energy through space. ● Natural hazards and other geological events have shaped the course of human history by destroying buildings and cities, eroding land, changing the course of rivers, and reducing the amount of arable land. These events have significantly altered the sizes of human populations and have driven human migrations. ● Natural hazards can be local, regional, or global in origin, and their risks increase as populations grow. ● Human activities can contribute to the frequency and intensity of some natural hazards.

Proficiency Scale:

4 **Advanced**	3 **Proficient**	2 **Approaching Proficiency**	1 **Beginning Proficiency**
I can: **Plan and carry out an investigation** to collect sufficient data to explain how Newton's Laws affect objects in a system. AND **Design a solution** to a problem involving maintaining the stability of human structures during a natural hazard that is consistent with current evidence and scientific reasoning. AND Respectfully critique the investigations and/or designed solutions of others based on current evidence and scientific reasoning.	**I can:** **Plan and carry out an investigation** to collect sufficient data to explain how Newton's Laws affect objects in a system. AND **Design a solution** to a problem involving maintaining the stability of human structures during a natural hazard that is consistent with current evidence and scientific reasoning.	**I can:** **Plan and carry out an investigation** to show how Newton's Laws affect objects in a system. AND **Design a solution** to a problem involving maintaining the stability of human structures during a natural hazard.	**I can:** **Carry out an investigation** showing that forces affect objects. AND **Design a solution** to a problem involving a natural hazard.

Anchoring Phenomenon:

Grass Surfing--The students need to see ~20 seconds of the video between 15:33-15:56. Teachers may want to watch 15:33-18:30.

Essential Question:

How do forces affect the motion of objects?

How can we protect human engineered structures from natural hazards?

Learning Goals:

Students will be able to:

- Construct an explanation based on evidence for what affects the strength of gravitational forces between objects.
- Use data to explain what causes an object's motion to remain stable. (Newton's 1st Law)
- Plan an investigation to collect data that can be used to explain what can cause an object's motion to change. (Newton's 2nd Law)
- Use data to explain how objects exert forces on one another during a collision. (Newton's 3rd Law)
- Design a solution to a problem involving a natural hazard.

	Learning Opportunities	Formative Assessments
Engage	Grass Surfing ● The students need to see ~20 seconds of the video between 15:33-15:56. Teachers may want to watch 15:33-18:30. ● Unit Phenomenon tied to all the learning goals. (Student version), (Teacher version)	**Suggested for this activity** **Options:** ● Student questions ● Student discussions
Learning Goal 2A: Construct an explanation based on evidence for what affects the strength of gravitational forces between objects. (Proficiency Scale)		
Explore	Weight on other planets ● Weight on Other Planets (Student Version), (Teacher Version)	**Suggested for this activity** Optional resources to use: ● Gravity Simulator Create your universe: https://lab.nationalmedals.org/gravity.php ● Gravity Simulator http://www.testtubegames.com/gravity.html **Options:** ● Exit ticket
Explain	● Gravity Force Lab (Phet simulation) ● Universal Law of Gravity - (Student Version), (Teacher Version) ○ Be sure to address the difference between weight and mass. ● Go back to the Unit Phenomena: Grass Surfing, and fill in Part 2 of the assignment.	**Suggested for this activity** **Options:** ● Exit Ticket ● Student answers to questions ● Student Discussion ● Gravity Quiz ○ Gravity Quiz Answer Key ○ *A version of these quiz questions can be found in the Jordan*

		District Item Bank on Mastery Connect.

Learning Goal 2B: Use data to explain what causes an object's motion to remain stable. (Newton's 1st Law) (Proficiency Scale)		
Explore	• Penny Drop (Student Version), (Teacher Version) • Table Cloth magic trick--You can show the video, but it is WAY more fun to just do it.	**Suggested for this activity** **Options:** • Exit Ticket

Explain	All of these activities are different options you could use. You do not have to use them all. Choose one or more of the other activities to do and then make sure you do the recommended activity after that.
	• Spin a coin, washer, or dice.
	  ○ Why does the object slow down and eventually stop?
	  ○ Does the surface an object is on change how long it spins?
	• Edpuzzle
	• Newton's 1st Law in Sports Videos (Student Version), (Teacher Version) The videos below are the videos used in the assignments.
	  ○ Newton's 1st Law of Motion--Science of NFL football
	  ○ Science of Golf: Newton's First and Second Laws
	  ○ Newton's Laws of Motion (1): The Law of Inertia
	• Newton's 1st Law Nearpod
	• *Recommended activity-- Net Force Assignment Teacher Version--This is a Google Form. When you click the teacher link, it will make a copy of the form for you. This is a tutorial that will teach kids how to calculate net force. If they answer the questions incorrectly, they will be sent to a tutorial and then back to the question they answered wrong, hoping that they will be able to answer it correctly this time. If they answer correctly they can move on. So if a student complains that it keeps sending them back to the same question, you will need to help them figure out what they are doing wrong so they can move onto the next question.
		Suggested for this activity
		
		Options:
		• Exit Ticket
		• Student answers to questions
		• Student Discussion
		• Newton's 1st Law Quiz
		  ○ Newton's 1st Law Quiz Answer Key
		  ○ *A version of these quiz questions can be found in the Jordan District Item Bank on Mastery Connect.*

Learning Goal 2C: Plan an investigation to collect data that can be used to explain what can cause an object's motion to change. (Newton's 2nd Law) (Proficiency Scale)		
Explore	• F=MA simulator • F=ma Simulator (Student Version), (Teacher Version)	**Suggested for this activity** **Options:** • Newtonian Bowling (This is the student version. Here are some teacher instructions that might help you.) • Exit Ticket

Explain	All of these activities are different options you could use. You do not have to use them all. Choose one or more of the other activities to do.
	• Newtonian Racing (Student version), (Teacher version)
	• Edpuzzle
	• Newton's 2nd Law Nearpod
	• Sports videos or Olympic videos
	  ○ Science of the Winter Olympics: Ski Jumping
	  ○ NFL Science
	  ○ Newton's 2nd Law in Space
	  ○ You don't need the whole video, but drag racing incorporates this law.
	  ■ How a Top Fuel Dragster works
	  ■ Optional: Sports video Assignment Higher Faster Stronger
		Suggested for this activity
		
		Options:
		• Exit Ticket
		• Student answers to questions
		• Student Discussion
		• Newton's 2nd Law Quiz
		  ○ Newton's 2nd Law Quiz Answer Key
		  ○ *A version of these quiz questions can be found in the Jordan District Item Bank on Mastery Connect.*

Learning Goal 2D: Use data to explain how objects exert forces on one another during a collision. (Newton's 3rd Law) (Proficiency Scale)		
Explore	• Newton's Third Law Phenomenon (Student Copy), (Teacher Copy) ○	**Suggested for this activity** **Options:** • Exit Ticket

Explain	All of these activities are different options you could use. You do not have to use them all. Choose one or more of the other activities to do and then do the recommended activity.
	• Newton's Third Law on Wheels (Student Copy), (Teacher Copy)
	  ○ *Optional Video: Edpuzzle*
	  ■ *This can be used to help with student understanding.*
	• Mars Rover Project (Student Copy), (Teacher Copy)
	• Newton's 3rd Law Nearpod
	
	*Recommended activity: Wrap-up for all 3 of Newton's LawsGo back to the Unit Phenomena: Grass Surfing, and fill in Part 3 of the assignment.
		Suggested for this activity
		
		Options:
		• Exit Ticket
		• Student answers to questions
		• Student Discussion
		• Newton's 3rd Law Quiz
		  ○ Newton's 3rd Law Quiz Answer Key
		  ○ *A version of these quiz questions can be found in the Jordan District Item Bank on Mastery Connect.*

Learning Goal 2E: Design a solution to a problem involving a natural hazard. (Proficiency Scale)		
Explore	• Earthquake Mash (Student Version), (Teacher Version) • Evaluating Prevention Technologies	**Suggested for this activity** **Options:** • Exit Ticket

Explain	• Cause and Effect of Geologic Hazards (Student Version), (Teacher Version)	**Suggested for this activity**
		
		Options:
		• Exit Ticket
		• Student answers to questions
		• Student Discussion
		• Geologic Hazards Quiz
		  ○ Geologic Hazards Quiz Answer Key
		  ○ *A version of these quiz questions can be found in the Jordan District Item Bank on Mastery Connect.*

Elaborate 	Protect your Pringle	
Evaluate	• **Quiz on Newton's 1st and 2nd Laws**	