Forces and Motion

9th/Physical Science
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Idaho State Science Performance Standards:

- **PSP1-HS-1.** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- **PSP1-HS-2.** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
- **PSP1-HS-3.** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Science & Engineering Practices:

- Analyze and Interpret Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions

Crosscutting Concepts:

- Cause and Effect
- Systems and System Models

Idaho Math & ELA Standards:

ELA/Literacy

- CCRA.W.7 Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
- CCRA.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Mathematics

- HS.A.SSE.1 Interpret parts of an expression, such as terms, factors, and coefficients
- HS.A.REI.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
- HS.A.REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Learning Objectives:

What will students be able to do, know, understand, etc?

1. I will utilize scientific principles to design and construct a car that is aerodynamically favorable and will travel a certain distance. (Motion)
2. I will design and conduct an experiment that will determine the effects of friction on the motion of a car. (Motion)
3. I will utilize scientific principles to design and construct a devise to minimize the impact of a collision. (Force)
4. I will construct a paper airplane that will fly a certain distance with an upward pitch. (Fluid Force)
5. I will create a force diagram to visualize the forces effecting a paper airplane in flight. (Fluid Force)
6. I will design and construct a boat that will hold a certain amount of weight and travel a distance. (Fluid Forces)

Essential Question:

How do forces and motion improve our ability to travel?

Guiding Questions:

What questions will constantly focus the students on the Big ideas/Critical Question within the unit in student language?

1. How can an understanding of physics improve your personal interests?
2. What aspects of a car will give it good fuel economy and safety?
3. How does the type of road affect a car's ability to travel?
4. How can you reduce the impact of a collision (like a car crash, football helmets colliding, or dropping a phone)?
    a. How can Newton's Law be used to reduce the impact of a collision?
5. What causes a plane to fly?
    a. How might a plane taking off from an aircraft carrier differ from one taking off from a standard runway?
6. What causes boats to float and travel through water?
    a. Why will a load-bearing boat differ from a speed boat in structure?
    b. How can an understanding of fluid forces improve your profession?

Misconceptions/Evolving Conceptions:

What might students commonly misunderstand about the subject? How will I directly address these?

Scaffold of Activities:

What is your lesson sequence you will use to get students to the culminating project?

1. **Frontloading/Introduction**
    a. Students will do a quick write on the following: *How can an understanding of the way things **move** improve your favorite hobby or future career?*

b. Students will watch a short martial arts clip and ask to identify where the instances of motion occur and how the character's understanding of motion improved their martial arts. Students will complete a notice/wonder note catcher during the clips.
c. Students will build a car with the provided materials. There should also be challenges presented, such as "the car must survive an impact" or "the car must travel 10m from the bottom of a 1m high ramp. Students should calculate the car's average speed during this activity (s=d/t). Students will complete a reflection on building a car and how to calculate the speed of a car travelling a distance.

2. **Friction Lab**
    a. Students will design a lab to test the effects of different surfaces on the speed of Hot Wheels.
    b. Students will create a data collection sheet and collect data as they run their experiment. Using this data, students will calculate the average speed (s= d/t), average velocity (speed & direction), and acceleration (Vf-Vi/T) of each surface and determine which has the least amount of friction.
    c. Students will watch a video on the effects of friction.
    d. Students will reflect on the friction lab
3. **Football Helmets**
    a. Students will watch excerpts of *Concussion* (2015). Students will read articles on the effects of head collisions on concussions and health of football players.
4. **Egg Drop Challenge**
    a. Students will construct a better "football" helmet, using an egg as a model for the human head. Students should build their capsule with the provided materials. Challenge restrictions can be provided, such as the capsule must be "4X4 inches," or "dropped at any angle," or "dropped from 40 feet."
    b. Students will calculate speed (s= d/t), velocity (speed & direction), and acceleration (Vf-Vi/T), mass (W=mg), force (F=ma), and momentum (M= mv)
    c. Students will reflect on the egg drop challenge.
5. **Newton's Laws of Motion Jigsaw**
    a. In groups, students will explore one of Newton's Laws and enter their information into a Google sheet. Groups will then present out to the class.
6. **Airplanes Fluid Friction Inquiry**
    a. Students will create paper airplanes that meet the challenge requirement of "travelling 10 feet and having an upward pitch." Students can remake and test their paper airplanes as many times as they want in the given time.
    b. Students will practice drawing force arrows to show the reason that the plane pitches upwards.
7. **Fluid Forces Mini-Presentations**
    a. Students will choose how one of the fluid forces (Archimedes', Bernoulli's, or Pascal's) can be used in a career of their choice. They will present these in small groups of their peers.
8. **Buoyancy Lab**
    a. Students will make a cork float, sink, and suspend within a plastic cup by adding/removing pins or thumb tacks.
9. **Boat Building Activity**

a. Students will build a tinfoil load-bearing boat that can travel down a small stream. Students should calculate the overall pressure of the weights pushing down on the boat.

Ongoing Formative Assessments:

Summative Assessment/Culminating Project:

Students will choose one of their unit projects (Car building, Friction Lab, Egg Drop Challenge, Airplanes, Boat Building) and revise it. Students will present a plan to the teacher about how they will revise their project. Once approved, they will begin altering their original projects to achieve an additional challenge set by the teacher (for example, for the egg drop, 4x4 might be turned into 3X3).

- Students will be assessed on their ability to improve upon their original plan. They will also be assessed on their reflection that includes how they used Newton's Law or their original calculations to improve the project.
- Students will present/demonstrate their revisions to their peers and receive feedback.

Additional Helpful Resources:

Sources for lessons, website, etc.

Forces & Motion: Car Building Challenge

9th/Physical Science

Standards:

- PS2-MS-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- HS.A.REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Objectives:

- We will design and build a car that can travel a certain distance and survive a collision.

Materials:

- Cardboard
- Bottle caps
- Used CDs
- Wood blocks
- Screws/nails
- Weights
- Duct tape
- Wire

Time Requirement:

4 regular classes (55 minutes)

Vocabulary:

- speed
- direction
- time
- velocity
- gravity
- s=d/t

Lesson Sequence

1. Day 1
    a. **Blueprint:** Students will sketch and label a blueprint of their car. During this time, students should also define vocabulary words and manipulate formulas.
    b. **Peer Sharing:** Students will explain their model to other students, seeking procedural feedback.
2. Day 2 & 3

    a. **Car Building:** Students will work on building their cars with their materials.
3. Day 4
    a. **Car Test:** Students will test their cars and calculate the speed(s=d/t), and velocity. They will try different ramp heights/lengths to determine which will make their car have the greatest speed and velocity.
    b. **Reflection:** Students will write a reflection, indicating a learning experience, the personal, academic, and civil connections, and what they learned.

Differentiation

- **Remediation:** Students can work in groups. Students can be shown examples. or be allowed to look up possible ideas. Students can do fewer math equations (possibly just speed and mass). Students can write less on the reflection.
- **Extension:** Students can also add another challenge, such as shrinking the size of their car or creating it out of cheap materials. Students can be peer instructors for others. Students can add compare/contrast elements, creative writing from the egg's perspective, etc. on their reflection.

Assessment

- **Formative:** over-the-shoulder feedback during blueprint work. Blueprint sketches will be the preassessment of applying and using Newton's Laws. The teacher will assess critical thinking as students construct the car.
- **Summative:** Teacher will assess student use of Newton's Laws and solving for various variables from student note catcher. Teacher will assess students' ability to reflect and demonstrate understanding.

Forces & Motion: Egg Drop Challenge

9th/Physical Science

Standards:

- PS2-MS-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- HS.A.SSE.1 Interpret parts of an expression, such as terms, factors, and coefficients
- HS.A.REI.1 Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.
- HS.A.REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Objectives:

- We will read and discuss the importance of having good protection in contact sports.
- We will design an egg drop capsule, keeping in mind the cost of the materials.

Materials:

- Cardboard
- Sponges
- Bubble wrap
- Cotton Balls
- Foam Padding
- Straws
- String
- Duct tape
- Small trash bags

Time Requirement:

4 regular classes (55 minutes)

Vocabulary:

- collision
- impact
- force
- momentum
- speed
- distance
- time
- acceleration

- gravity
- velocity
- mass

Lesson Sequence

1. Day 1
    a. **Hook** Students will watch a brief video clip of collisions and an excerpt from *Concussion.* Students will also read articles on football concussions and the physics related to them.
    b. **Vocabulary and Formulas Practice:** Students will define vocabulary words, write formulas, and sketch a design for their capsule.
2. Day 2
    a. **Capsule Building:** Students will build the capsules using the materials they selected
3. Day 3
    a. **Egg Drop:** With teacher assistance, students will drop their egg from the top of a ladder. They will calculate speed (s= d/t), velocity (speed & direction), and acceleration (Vf-Vi/T), mass (W=mg), force (F=ma), and momentum (M= mv). They will use the data they collected to solve each of these equations.
    b. **Reflection:** Students will write a reflection, indicating a learning experience, the personal, academic, and civil connections, and what they learned.

Differentiation

- **Remediation:** Turn on subtitles for *Concussion.* The minimum observations during the clip can be reduced. Students can work in groups. Students can be shown examples. or be allowed to look up possible ideas. Students can do fewer math equations (possibly just speed and mass). Students can write less on the reflection.
- **Extension:** Students can also add another challenge, such as shrinking the size of the capsule or creating it out of cheap materials. Students can be peer instructors for others. Students can add compare/contrast elements, creative writing from the egg's perspective, etc.

Assessment

- **Formative:** During discussions and review of note catchers, the teacher will evaluate critical thinking, questions formation, and observations skills. Sketches will be the preassessment of applying and using Newton's Laws. Teacher will assess their critical thinking as they construct the capsule.
- **Summative:** Teacher will assess student use of Newton's Laws and solving for various variables from their note catcher. Teacher will assess students' ability to reflect and demonstrate understanding.

Forces & Motion: Fluid Friction

9th/Physical Science

Standards:

- PSP1-HS-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- PSP1-HS-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system
- CCRA.W.7 Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
- CCRA.SL.4 Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Objectives:

- I will construct a paper airplane that will fly a certain distance with an upward pitch. (Fluid Force)
- I will create a force diagram to visualize the forces effecting a paper airplane in flight. (Fluid Force)

Materials:

- Paper
- Technology for Presentations

Time Requirement:

4 regular classes (55 minutes)

Vocabulary:

- force
- force arrows
- pitch
- fluid forces
- lift

Lesson Sequence

1. Day 1

    a. **Activity:** Students will construct their airplanes. As they develop a model, they will test it. The teacher should mark off the distance and allow students to line up and test their planes. After each test, they should make revisions.
    b. **Instruction:** Reveal how air moves around a plane causing flight. Allow students to compare and contrast their own drawings to the actual and make adjustments if necessary.
2. Day 2
    a. **Research:** Students will choose a career or a hobby and make a list where fluid friction may show up.
    b. **Presentation:** Students will make 8 ½" x 11" posters that show all the instances of fluid friction will informally present to one another during "speed dating" and give each other feedback.

Differentiation

- **Remediation:** For students who are stuck and struggling to meet the requirements of the challenge, the teacher can give them hints. Students can work in groups. Students can be shown examples. or be allowed to look up possible ideas. The one-on-one presentations reduce anxiety about public speaking.
- **Extension:** Add an additional challenge to the airplane building.

Assessment

- **Formative:** Students can be evaluated for their problem solving/revision strategies. Students can also be evaluated on their air movement drawing for an understanding of fluid friction. Students will be evaluated on their communication and speaking skills.
- **Summative:** The presentations will demonstrate student understanding of identifying and utilizing fluid friction.