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| **Lesson Title** | Collision and Impulse (Force and Energy) Part 2 |
| **Length of Lesson** | 1 Day |
| **Created By** | Henry Stauffenberg IV, Matthew Lee |
| **Subject** | Physics |
| **Grade Level** | 9-12 (Physics) |
| **State Standards** | Physics: 1 a, b, c, d, e, f; 2 a, b, c ; 3 a, c |
| **DOK Level** | Physics: 3 |
| **DOK Application** | Hypothesize, organize, collect, interpret, investigate, connect, explain, prove, draw conclusions, graph, predict, integrate |
| **National Standards** | 9 – 12 A: Inquiry; B: Physical Science; E: Science and Technology |
| **Graduate Research Element** | Working with data studio, excel, and inquiry based from hypothesis |

**Student Learning Goal:**

The purpose of this lesson is to define and investigate Inelastic and Elastic collisions; In addition, to investigate impulse with respect to the conservation of momentum/kinetic energy and Newton's second law. In the first part students will understand what happens to the energy in both elastic (conserves both kinetic energy and momentum) and inelastic (conserves momentum but not kinetic energy). They will be able to explain where the energy is lost and conserved between the projectile and kart.

In the 2nd part (the next lab day) they will connect impulse (force per unit of time) to elastic and inelastic collisions investigated in part one. They will gain an understanding into the scientific process (creating a hypothesis followed by testing) through investigation of how different materials effect impulse energy for both types of collisions. They will be able to explain that even though different materials create different looking force graphs the area under the curve (Impulse) will be the same for each graph; that impulse is not changed by the material it moves through and that the change of momentum in an object (calculated in part 1) equals the impulse delivered by applied forces for both collisions.

Finally, to finish part 2 using their knowledge of the basics (What they have learned in this lab and past semester) to answer a more complex problem. The problem is pure inquiry and response (college level) and after completion of the problem students will be able to explain inelastic collisions on a micro scale and Newton's second law.

<u>Mississippi State Standards</u>

Physics: 1: (a) Use current technologies such as CD-ROM, DVD, Internet, and on-line data search to explore current research related to a specific topic; (b) Clarify research questions and design laboratory investigations; (c) Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations; (d) Organize data to construct graphs to draw conclusions and make inferences; (e) Evaluate procedures, data, and conclusions to critique the scientific validity of research; (f)

Formulate and revise scientific explanations and models using logic and evidence; 2: (a) Use inquiry to investigate and develop an understanding of the kinematics and dynamics of physical bodies; (b) Analyze, describe, and solve problems by creating and utilizing graphs of one-dimensional motion; (c) Analyze real-world applications to draw conclusions about Newton's three laws of motion; 3: (a) Explain and apply the conservation of energy and momentum, Concept of kinetic energy, using the elementary work-energy theorem, Concept of conservation of energy with simple examples, Principles of impulse in inelastic and elastic collisions; (c) Apply the principles of impulse and compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions.

National Science Education Standards of Content 9 – 12

A: Inquiry: identify questions and concepts that guide scientific investigations

- Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding the hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and a conceptual understanding of scientific investigations.

B: Physical Science: motion, forces, and the conservation of energy

- Objects change their motion only when net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can calculated using the relationship F=ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the square of the distance between them.
- The total energy in the universe is constant. Energy can be transferred in collisions, light waves, and many other ways. Energy can never be destroyed. As these transfers occur, the matter involved steadily becomes less ordered.
- All energy can be considered kinetic, the energy of motion; potential, energy that depends on relative position, or energy contained in a field such as electromagnetic waves.

E: Science and Technology: understanding about science and technology

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering. New disciplines of science, such as geophysics and biochemistry often emerge at the interface of two older disciplines.

**Materials Needed (supplies, hand-outs, resources):**
Instructions for Impulse part 2 (support material to this lesson plan), Computer, data studio program, excel, copper wire, string, fishing line, coat hanger, rubber band, kart, kart basket with foam catcher, track elevated by 4 textbooks, pasco spring gun, 10g steel ball, pasco motion sensor, and pasco force gauge (that can measure pull force), Track barriers

**Lesson Performance Task/Assessment:**

- Ability to use pasco equipment and experimental design to gather data
- Successful completion of instructions (see materials) and answer critical questions within instructions
- Successful confirm or rejection of hypothesis and explain why
- Ability to inquire and completely answer the complex problem at the end of part 2 without significant help from instructor
- Ability to explain, prove, and define elastic vs. inelastic collision using own words with respect to conservation of kinetic energy and momentum and connecting it to impulse
- Ability to combine and analyze data from previous labs
- Generating graphs and other statistical data in excel to present in lab report

**Lesson Relevance to Performance Task and Students:**

- To develop student skills with new and useful technology, especially when it comes to data manipulation using excel
- To introduce experimentation design, following direction, and data analysis that graduate research utilizes
- To promote inquiry and discussion about collision energy and impulse
- To connect and integrate collision part 1 lab and what they have learned in previous labs/semester to interpret data and explain results
- To promote understanding with physical results and proof of data

**Anticipatory Set/Capture Interest:**
A cannon will shoot a steel ball into a kart with a basket...what more do I need to say? It is a complete hands on activity that involves collisions and the opportunity to investigate and perform an experiment just like a real physicist. Especially for part 2, the inquiry is their own and they will be in control of the lab.

**Guided Practice:**
Briefly show what the track and entire setup for the experiment should look like, a model for them to look at. Demonstrate a single run (launching of the cannon projectile into kart basket) and stress the importance of cannon safety for aiming and loading. The kart should be tied to a force sensor and emphasize they will only be changing the material that links kart to sensor (impulse must travel through taught medium), no need to use motion sensor described in collision lab part 1 instructions. Give the handout of

instructions and let them follow the directions. The teacher at this point is to walk around room and help out when needed. The instructions are step by step, simple, and the students will take control of experiment and completion of instructions/questions.

**Independent Practice:**
Analysis of graphical data and writing of a report.

**Remediation and/or Enrichment:**
Remediation: individual IEP, partner with helpful student, make lesson more walk through intensive.

Enrichment: Make it so the students have to record their data in triplicate and average results for greater accuracy. Have students export all data to excel and curve fit/integrate data. Show students more advanced excel skills for data interpretation.

**Check(s) for Understanding:**

- Ability to use pasco equipment and gather complete data
- Completion of handout and questions
- Successful collection, processing, and interpretation of results suited to lab goals
- Ability to explain in own words conservation of energy with respect to impulse and collisions
- Complete answer of complex problem with more inquiry that follows (evidence of further thought beyond problem set)
- Asking of questions that go beyond ones stated in handout

**Closure:**
Sum up what they have learned with a brief discussion. Answer any questions the students may have.

**Possible Alternate Subject Integrations:**

Calculus: Regression and integration and curve fitting.

**Teacher notes:**
1) Make sure students read directions
2) Part 2, coat hanger and copper data noisy; however, with other data you will find out what coat and copper impulse should be.
3) Make sure label each run
4) Save data often
5) If time is an issue expand part one with more shots to record for greater accuracy, also export data to excel and curve fit and integrate to increase difficulty for calculus proficient students.