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| **TEAM Lesson Plan Template** |
| Teacher: Ray Whitmer |
| Subject/Grade: 6th grade Science |
| Lesson Title: Bang! At the end of the ramp (and more data) |
| **STANDARDS** | **Identify what you intend to teach.** State, Common Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| 6.PS3.3 Analyze and interpret data to show the relationship between kinetic energy and the mass of an object in motion and its speed. This lesson emphasizes:Engineering practice: Asking questionsCCC: Energy and matterLearning Performances: The students will ask questions about the relationship between kinetic energy and mass of and object and its motion and speed emphasizing the CCC of energy and matter.  |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledgeStudent-Friendly (I Can Statement) |
| I can measure how fast a ball bearing rolls. I can explain the difference between kinetic and potential energy.I can graph and interpret data to show the relationship between kinetic energy and the mass of an object. |
| **MATERIALS AND RESOURCES**  | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook.  |
| **Activities & Materials**Masking tape, marker **Per Group/Pair:** 10’ section of PVC half-pipe, a large ball bearing and a smaller ball bearing, tape measure, worksheet, pencil, writing surface (like a book cover), straightedge or ruler, stopwatch. **Per Class:** Room for several groups to work at stairs with hallway stretching out from base of stairs (or a table in a hallway: what is actually needed is a height from which to release the ball bearing and a long smooth surface on which it can roll until it stops.) If possible, measure distances in advance and mark with masking tape on the floor to save measuring time: students will not have to measure from the base of the ramp, but only from the nearest piece of masking tape. **Routine for distributing materials:** Students in groups will pick up materials as they move to the hallway. Two students per group should carry the pipe, another individual carries the worksheet, and another carries the remaining items. [ one student can carry the pipe, but having one student at each end makes them less likely to bump into and break things ]  |
| **ACCOMMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners** **Differentiation****Flexible Grouping:** Handling the ramp and ball, measurement, and graphing are each different and may be performed by different group members.**Accommodations****\_\_\_ Preferential Seating \_\_\_ Extended Time \_\_\_ Small Group \_\_\_ Peer Tutoring** **\_\_\_ Modified Assignments \_\_\_ Other** **Early Finishers:** Encourage early finishers to repeat the experiment. Are their results consistent from iteration to iteration?  |

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| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant  |
| Discussion collisions. Billiard balls, molecules of gas, football helmets, cars . . . Roller coaster safety inspection video mentions preventing collisions between trains (2:23, car collision prevention part is between 1:30 and 2:23) <https://www.youtube.com/watch?v=3sS4nT5odP4>  |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| ***Introductio*n** Sometimes things bang into each other (collisions). There are several types of collision. A type where neither thing deforms and they don’t stick together. A type where the things deform during the collision and don’t stick together. Finally, a type where the things stick together. We will look at the type where the things don’t stick and don’t deform. Where would you see this type of collision?  *Arrange students in groups of 4. Pass out worksheets and have students record their names to learn their roles.*  We are going to move to the hallway. As we exit, Readers bring the worksheet, a pencil, a book or something as a writing surface and a straightedge; Rollers and Ramp holders each take one end of a piece of half-pipe; Measurers get one large and one small ball bearing and a tape measure. **Middle** *Let students follow the worksheet instructions. Remember that a point of the lesson is for students to design and conduct the investigation. Let them struggle.*  *Do point out that three graphs can fit on one sheet of graph paper. If any group is falling too far behind, prompt them with questions about the instructions to ensure that they understand what they are being asked to do.* **End/Closure** *Collect materials, clean up, and return to class. Regain the whole group’s attention. Lead students in a discussion of what they observed*. How did you measure how far the ball rolled? When you released the ball from a greater height, did it roll farther? Which ball rolled farther for a given height? How did you measure the ball’s velocity as it left the ramp? When did the ball have the greatest potential energy? When did the ball have the greatest kinetic energy? What did we learn about potential and kinetic energy? **Motivating Students** \_x\_ Relate to Real World: This experiment is linked to roller coasters, with which most students are familiar. \_x\_ Verbal reinforcement: encourage students as they make their measurements **Presenting Instructional Content** \_x\_ Discovery Learning: The students will plan and conduct an experiment on kinetic and potential energy.***Instructional strategies:******Input -* Hook (Set):** Discuss roller coasters**Modeling and Guided Practice *-*** The teacher will monitor students’ work and ask questions to prompt them if they are stuck. Ensure that students are recording results.  **Check for Understanding (CFU) –** ***What am I doing for students that progress at different rates?*** Encourage students to help each other within their groups. If one group is significantly ahead of another, ask one group to help the other. ***What do I do if they get it?*** Ask the students to think about what different aspects people must think about when designing or building a real roller coaster.***What do I do if they don’t get it?*** A potential source of confusion is average velocity vs. instantaneous velocity. The worksheet asks for speed “as it leaves the ramp,” meaning instantaneous velocity. Students might measure average velocity along the entire ramp or average velocity from the ramp to stopping. Ask questions like “Is the ball moving at the same speed at the top of the ramp as it is at the bottom?”  |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning:** These questions will occur throughout the activity as prompts based on groups’ or individual students’ progress.**Knowledge:** What is the ball bearing made of?What are some units of measure that we can use? [ steps, floor tiles, feet, inches] **Comprehension:** How do we calculate speed?Which has more potential energy, a book on a shelf or a book on the floor? Does the mass of the ball affect its velocity as the ball leaves the ramp? Does velocity as the ball leaves the ramp depend on the height from which the ball is released? **Application:**Is the ball traveling at the same speed for the entire length of the ramp? How is this experiment an example of a roller coaster? In what other aspects of life have you seen kinetic and potential energy? During which part of the ride does the ball bearing have the most potential energy? During which part of the ride does the ball bearing have the most kinetic energy?Should you just take one measurement, or should you take several? **Analysis:** Would we get the same type of results if we used two rubber balls instead of two steel balls? What about two balls of play-dough? Explain the difference in the speeds of the larger and smaller ball bearings.How are velocity and speed alike?How are velocity and speed different? Do you agree that the larger the ball is, the faster it goes? Explain your answer**Synthesis:**Predict the distance the large ball would travel after collision if you released the large ball from twice as high as you actually did before it collides with the small ball. In the game of baseball, there are collisions between bat and a ball or a ball and glove. Which of these is more like our steel ball roller coaster collisions? What, if anything, do our steel ball roller coaster collisions tell us about the baseball collisions? **Evaluation:****Thinking**  \_x\_ **Practical**: Holding the pipe in one position, releasing the ball consistently, and measuring the distance travelled by the ball are practical skills. \_x\_ **Creative:** Students have to plan their investigation. They can take repeated measurements or not. They have to figure out how to time the ball, that is, from where to where. \_x\_ **Analytical**: Students have to present their data graphically. \_x\_ **Research-based**: Students use different ball bearings with different masses to see the relation between velocity and mass.**\*What am I going to do to give students an opportunity to?** **1. Generate variety of ideas:** At the beginning of the experiment, the students will be able to brainstorm with their group.**2. Analyze problems from multiple viewpoints:** Students must consider the input of each member of their group. **Problem Solving** **\_x\_ Creating and designing:** The worksheet does not specify how students are to conduct measurements**\_x\_\_ Improving Solutions:** The students will have the opportunity to try different measurement techniques and use the more effective ones. **\_\_x\_ Observing and Experimenting:** The experiment allows the students to see how kinetic and potential energy work as the ball moves through the PVC pipe so that they will have a better understanding of these energies. |

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| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Heterogeneous groups of four
* Roles. Reader/task focuser/recorder: Reads instructions to the group, keeps the worksheet, records data, operates stopwatch; Ramp holder: holds the pipe; Roller: releases the ball bearing from the top of the ramp: Measurer: measures how far the ball rolled and returns the ball to the Roller.
* Group members assign roles and acknowledge their understanding of their role during the lesson introduction.
* Transition to groups. Students will walk with their group to the hallway or stairwell the class will be using for the experiment once they have the materials needed. The teacher will signal for the whole group’s attention or return students to group work.
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| **ASSESSMENT** | **Formative and/or summative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction.  |
| ***Assessments:*** **Teacher Made Test:** **Exit Ticket:** *\****Students should achieve \_\_\_\_\_% mastery of this objective: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |
| **CLOSURE** | **Reflection/Wrap Up.** Summarizing, reminding, reflecting, restarting, connecting. |
| * ***Review/Summary: wrap up what has been learned and accomplished in the lesson (even if they are in the middle of an exercise, it is still important to summarize to the point where they are now). Ideally involve students in this synthesis.***
* ***Preview for next lesson: link what they did to day with where they are going next.***
* ***Upcoming assignments: remind them of any upcoming assignments.***

***Today we…. Turn to your partner and…. Let’s review our I Can statements……*** ***Here is your exit ticket for today…..*****Follow-up Activities/Extension *These may be designed to create a longer or more intense lesson. For example, if the class is able to cover the material in a lesson much faster than expected, extensions may prove helpful. Extensions may also be useful in various parts of a lesson where the teacher (and class) decides they should spend more time on a skill or topic.******Reflection: You must reflect on every lesson you teach.*** |

**NOTES:**

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Potential and Kinetic Energy

Roller Coaster with a Bang! Worksheet

Reader (Read instructions, record results, operate stopwatch): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ramp holder (Hold the ramp): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Roller (Release the ball): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Measurer (Measure distance ball travels, return ball to Roller): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. After recording your names, arrange your pipe as a roller coaster on the stairs. A section at the bottom should be level.
2. How fast does the big ball bearing normally go at the bottom of the ramp when there is no collision? (Use data from an earlier experiment or measure this speed. ) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. How fast does the small ball bearing normally go at the bottom of the ramp when there is no collision? (Use data from an earlier experiment or measure this speed.) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. Use the big ball bearing as the coaster and the smaller bearing as the thing at the bottom of the hill (on the level section of the ramp). Release the large ball and let it collide with the small ball. Measure the speed of each ball AFTER the collision. Do this several times, from at least four different heights. Each time, answer the following questions.
5. After the collision, how fast does the big ball bearing go?

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1. After the collision, how fast does the small ball bearing go?

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1. After the collision, does the large ball bearing keep going in the same direction or change direction?

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1. On one set of axes, produce two graphs. One should show the big ball bearing’s speed as a function of initial height of the big ball bearing. The second should show the small ball bearing’s speed as a function of initial height of the big ball bearing.
2. Use the small ball bearing as the coaster and the larger bearing as the thing at the bottom of the hill. Release the small ball and let it collide with the large ball. Measure the speed of each ball AFTER the collision.
3. After the collision, how fast does the big ball bearing go?

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1. After the collision, how fast does the small ball bearing go?

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1. After the collision, does the large ball bearing keep going in the same direction or change direction?

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On one set of axes, produce two graphs. One should show the big ball bearing’s speed as a function of initial height of the big ball bearing. The second should show the small ball bearing’s speed as a function of initial height of the big ball bearing.

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