Lesson Plan Title: “The Physics of Ballistics”

<table>
<thead>
<tr>
<th>Teacher Name: Noel Brooks</th>
<th>School: Roosevelt Middle School (Monticello, Indiana)</th>
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</thead>
<tbody>
<tr>
<td>Subject: Science (Kinetic Energy)</td>
<td>Grade Level: 6</td>
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</tbody>
</table>

**Problem statement, Standards, Data and Technology**

**Asking questions and defining problems**
- Establish driving question for the lesson plan or define problem students will be solving.
- Attach any documents used to establish the driving question or define the problem.

The beginning question is “What is ballistics?” After a good definition is determined by discussion (the study of airborne objects), the driving question for day one is, “Which athletic throwing projectile will have the most kinetic energy during professional play?” Of course this will also spur the question, “How do you figure the amount of kinetic energy a moving object has (KE equals ½ mass times velocity squared)?”

The defining question for day two is, “Which handgun caliber will have the most kinetic energy?”

The driving question for day two is, “Which rifle caliber will have the most kinetic energy?”

Finally the focus for follow-up on day four concerns application of the first three days’ of activities and includes the last defining question, “How is the knowledge of calculating kinetic energy useful in the real world, namely in the fields of nuclear fusion, hydroelectricity, and wind power?”

Students will be doing this “Ballistics” lab activity in their T&D (Truth and Discovery) notebooks. All of the questions, data charts, and record of scientific method will be documented in this special booklet. A picture (diagram) is always required.

**Incorporating Next Generation Science Standards, Common Core, or State Standards**
- State the standards that will be covered during this lesson plan. Include all standards which may apply (NGSS, Common Core, or State Standards).

This activity covers a wealth of sixth grade science and engineering process standards (SEPS). SEPS numbers 1 through 5 are covered. They are:
1. Posing questions and defining problems
2. Developing and using models and tools
3. Constructing and performing investigations
4. Analyzing and interpreting data
5. Using mathematical and computational thinking

LST (Literacy in Science and Technology) standards numbers 1 and 2 are covered as well (reading and comprehending technical texts, and following precise multistep procedures when carrying out experiments and taking measurements).
Also covered are PS (Physical Science) standards 1, 2, and 3:
1. Distinguishing speed and velocity.
2. Describing the relationship between time and position.
3. Describe how potential and kinetic energy can be transferred.

<table>
<thead>
<tr>
<th><strong>Obtaining and evaluating information</strong></th>
<th>Students will be obtaining information in several different ways. They will do research on the average velocity of a golf ball (from the tee), tennis ball (at the serve), and a baseball (from the bat) during professional play. Students will be using internet conversion charts to convert mph to meters per second, feet per second to meters per second, and grams to kilograms. Furthermore, kids will be using “chuckhawks” online recoil table to find average velocities of various calibers (.22, .38, 9mm, .45 for handguns and .22, .22 magnum, .223, .30-30, and .308 for rifles) of ammunition. Note that ammunition is not created equal! There are different grains (masses) of the same caliber. The class as a whole (as instructed by the teacher) will decide which grain to use. A grain to kilogram conversion table will need to be used (online). Children will be obtaining mass by using a double-balance beam as well as an electronic balance.</th>
</tr>
</thead>
</table>
| **Analyzing and interpreting data**  
How will students be analyzing and interpreting the collected data? | Students will find mass of each projectile, convert data to a usable format (metric), calculate total kinetic energy (in joules), and keeping all the units the same, compare the total number of joules for each projectile. |
|---|---|
| **Use of technology and software**  
Indicate the type of technology and software students will be using in order to implement this lesson plan. | Students will need access to the internet for initial ball velocity information. They will use a quality search engine using only trustworthy websites. Kids will use both the old-fashioned double-balance beams and electronic balances to verify their masses of projectiles. Students will need to have access to calculators to figure kinetic energy. |

**Collaboration, critical thinking and communication**

| **Collaboration**  
Indicate how students will be collaborating during the implementation of the lesson plan. | Students will be grouped into “threes” for this activity. Students will initially collaborate to get an agreed on baseline of the velocities of projectiles. If this isn’t done, there’ll be discrepancies in the final outcome for kinetic energy. This will be done by averaging each group’s findings for velocity, which means each group will work collectively as a whole group on a couple of occasions (as directed by the teacher). When finished finding data and completing data tables, each group will share findings with the group as a whole to “test” whether the experiment was performed scientifically. |
|---|---|
| **Critical Thinking**  
How will the students evaluate the question or defined problem to reach an objective conclusion?  
How will the students being using the learned content and collected data to be able to critically think about the established question and/or problem on this lesson plan? | Evaluation of the defined problem is straightforward. They must use the formula for kinetic energy to plug in the numbers. While this seems simple, the curve-ball is converting to science’s preferred metric units. Again, online conversion charts will be used. Mass will be converted from grams to kilograms, and velocity will be plugged into the formula in meters per second. Using a calculator, students will take half of the mass of the projectile and multiply it by the square of the velocity. Students will see how incredibly important velocity is to increasing kinetic energy. They will understand (eventually) that a faster moving projectile that is small can have significantly more kinetic energy than a much larger projectile moving at slower velocities. This might be counter-intuitive to students, as most believe that bigger, more massive objects must have more kinetic energy. Comparison of the final “answers” will determine if indeed their prediction (hypothesis) was correct, and set the record straight! |
**Communication**
How will the students communicate their findings and conclusion regarding the established question and/or problem?

Once again, the “T&D” (Truth and Discovery) notebook will be used (as previously stated) to document their four major questions, research, predictions, data charts and calculations, conclusions, diagrams, etc.

**References**

**Teacher’s References**
Include all references used to develop and implement this lesson plan.

Developing this lesson plan, I used the following internet sources:

- [http://www.convertunits.com/from/grams/to/kilograms](http://www.convertunits.com/from/grams/to/kilograms)
- [http://www.metric-conversions.org/speed/miles-per-hour-to-meters-per-second.htm](http://www.metric-conversions.org/speed/miles-per-hour-to-meters-per-second.htm)
- [http://www.metric-conversions.org/speed/feet-per-second-to-meters-per-second.htm](http://www.metric-conversions.org/speed/feet-per-second-to-meters-per-second.htm)
- [http://www.chuckhawks.com/handgun_recoil_table.htm](http://www.chuckhawks.com/handgun_recoil_table.htm)
- [http://www.chuckhawks.com/recoil_table.htm](http://www.chuckhawks.com/recoil_table.htm)

Since I am the sole creator of this lesson, there are no other references to cite!

**Student’s References**
Include all references students will need to complete this lesson plan.

Students will need to access the same references (or similar) as I did to create this lesson. I didn’t include research websites to determine ball velocity. This will vary.

- [http://www.convertunits.com/from/grams/to/kilograms](http://www.convertunits.com/from/grams/to/kilograms)
- [http://www.metric-conversions.org/speed/miles-per-hour-to-meters-per-second.htm](http://www.metric-conversions.org/speed/miles-per-hour-to-meters-per-second.htm)
- [http://www.metric-conversions.org/speed/feet-per-second-to-meters-per-second.htm](http://www.metric-conversions.org/speed/feet-per-second-to-meters-per-second.htm)
- [http://www.chuckhawks.com/handgun_recoil_table.htm](http://www.chuckhawks.com/handgun_recoil_table.htm)
- [http://www.chuckhawks.com/recoil_table.htm](http://www.chuckhawks.com/recoil_table.htm)
**Assessment Plan**

<table>
<thead>
<tr>
<th>Assessment Plan</th>
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<tbody>
<tr>
<td>How will the students be assessed during and/or at the end of the lesson plan?</td>
</tr>
<tr>
<td>Include resources that will be used to assess the students for the lesson plan.</td>
</tr>
<tr>
<td>I use a rubric to grade the responses in the “T&amp;D” notebook. I am looking for <strong>completeness</strong>, <strong>neatness</strong>, <strong>accuracy</strong>, <strong>work shown</strong>, and a <strong>diagram</strong> included. Students should be able to give their documented activity to a complete stranger, and it would be interpreted with no problems. Students should be able to look at their entry five years from now and understand their thoughts and data charts. <strong>Each</strong> of the five segments is rated with either a check + for exemplary work, a checkmark for acceptable work, an asterisk (for slight improvement needed), or a minus (for much work needed).</td>
</tr>
</tbody>
</table>
## Resources and Costs

<table>
<thead>
<tr>
<th>Resources Needed</th>
<th>Calculators and laptop computer per student</th>
</tr>
</thead>
<tbody>
<tr>
<td>List all the resources needed (equipment, facilities, materials or any other resources).</td>
<td>12 double balance beams and/or 12 electronic balances.</td>
</tr>
<tr>
<td>Golf ball, tennis ball, baseball, extracted projectiles of designated calibers, and rubber gloves (to handle lead projectiles).</td>
<td>No casings, powder, or primers! Projectiles must be harmless inert rounds of lead or copper, easily removed at home with pliers (or better yet purchased or DONATED from a reloading supply center). At no time should real ammunition be brought to a school!</td>
</tr>
</tbody>
</table>

### Costs

List the estimated cost of implementing this lesson plan. Include all costs related to equipment, materials and any resource critical to the implementation of the lesson plan.

- Most schools have all the resources necessary. Electronic balances are very expensive, and can be used at a “mass station,” so all groups wouldn’t need a balance. One round each is all that’s needed for each caliber…and can be “rotated” among groups. Most balls can be found within the school or at home. Using existing supplies, there should be minimal cost. Donated rounds can be used from fellow teachers (live rounds shouldn’t be brought to school however!). Note that inert rounds should be saved for following years! The only item needed to purchase would be latex gloves, one pair per “weigher.” Estimated cost is ten dollars.

## Implementation Plan

### Implementation Plan Timeline

Establish the timeline to implement the lesson plan. Provide an estimate of time and days in order to complete the lesson plan.

- It would make the most sense for this activity to follow the study of MATTER, since measurement of matter (mass) would have already been covered. This lesson on kinetic energy would obviously fit in the ENERGY unit. Three whole 50 minute class periods should keep the kids hopping, and a fourth day of an estimated 20 minutes should be devoted to finishing journal entries and attacking the final set of questions relating what they’ve learned to alternative forms of energy. Since alternative forms of energy would have been covered (in my case), this would be a great “spiraling” activity, hitting on previous knowledge.
“The Physics of Ballistics” Day #1

Name_______________________________

Question 1: Which ball will have the most kinetic energy?

A. Hypothesis/Prediction (with explanation):

B. Data Table:

<table>
<thead>
<tr>
<th>Projectile</th>
<th>Mass (grams)</th>
<th>Mass (kg)</th>
<th>Velocity (mph)</th>
<th>Velocity (m per sec)</th>
<th>K.E. (joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golf Ball</td>
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<td></td>
<td></td>
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<tr>
<td>Tennis Ball</td>
<td></td>
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<td></td>
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<tr>
<td>Baseball</td>
<td></td>
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C. Calculations (show each mathematical step you did to calculate kinetic energy for each ball):

D. Conclusion:

E. Diagram/Picture:
“The Physics of Ballistics” Day #2

Name_________________________________________

Question #2: Which handgun caliber will have the most kinetic energy?

A. Hypothesis/Prediction (with explanation):

B. Data Table:

<table>
<thead>
<tr>
<th>Caliber</th>
<th>Mass (g)</th>
<th>Mass (kg)</th>
<th>Velocity (ft per sec)</th>
<th>Velocity (m per sec)</th>
<th>K.E. (joules)</th>
</tr>
</thead>
<tbody>
<tr>
<td>.22</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>.38</td>
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<td>9 mm</td>
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C. Calculations (Show each mathematical step you did to calculate kinetic energy for each caliber):

D. Conclusion:

E. Diagram/Picture:
“The Physics of Ballistics” Day #3

Name_____________________________________________

Question #3: Which rifle caliber will have the most kinetic energy?

A. Hypothesis/Prediction (with explanation):

B. Data Table:

<table>
<thead>
<tr>
<th>Caliber</th>
<th>Mass (g)</th>
<th>Mass (kg)</th>
<th>Velocity (ft per sec)</th>
<th>Velocity (m per sec)</th>
<th>K.E. (joules)</th>
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<td>.22 mag</td>
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<td>.223</td>
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<td>.30-30</td>
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<td>.308</td>
<td></td>
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</tbody>
</table>

C. Calculations (Show each mathematical step you did to calculate kinetic energy for each caliber):

D. Conclusion:

E. Diagram/Picture: