Lesson Title	Projectile Motion: Hit the Army Men
Length of Lesson	1 day
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Subject	Physics
Grade Level	11-12
State Standards	Physics: 2 a, b;
DOK Level	DOK 3
DOK Application	Explain Phenomena in terms of concepts
National Standards	9-12: B (physical);
Graduate Research Element	Example of particles with a velocity distribution

Student Learning Goal: Develop students' confidence in their ability to use the data analysis to predict the results of an experiment.

Physics: 2. Develop an understanding of concepts related to forces and motion:
(a) Use inquiry to investigate and develop an understanding of the kinematics anddynamics of physical bodies; (c) Analyze real-world applications to draw conclusions about Newton's three laws of motion.; (d) Apply the effects of the universal gravitation law to graph and interpret the force between two masses, acceleration due to gravity, and planetary motion.
National Science Education Standards of Content 9-12
B (Physical): Motions and Forces: Objects change their motion only when a 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 be 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.

Materials Needed (supplies, hand-outs, resources): Projectile Launcher (available from several vendors, e.g. Pasco), Carbon Paper, Plastic Army men, PC with MS Excel

Lesson Performance Task/Assessment: Students will be challenged to correctly predict the proper angle for the launcher to be at, in order to hit a given target. Students will also complete a lab write-up detailing their methods, data, and results from their curve fit and challenge launch.

Lesson Relevance to Performance Task and Students: Using a simple setup, students will use data analysis techniques to predict the motion of a real-world object. This exercise will give the students more confidence in the validity of the data collection/analysis and their ability to use them to make predictions.

Anticipatory Set/Capture Interest: The teacher will knock down an army man placed at random by the students. The students will then be challenged to repeat this accurate prediction.

Guided Practice: The teacher will demonstrate the correct use of the launcher and the proper method for recording data using the carbon paper.

Independent Practice: Students will measure and record the distance a ball travels when launched from a launcher at different angles. At each selected angle the ball will be launched multiple times and the data recorded. Using Excel students will input their data points, find the average distance for each angle, and plot distance as a function of the launcher angle. Students will then fit a curve to their data and use this curve to predict the place of ball impact when launched at an angle. Students will then be challenged to hit plastic army men with their projectile using their predictions.

Remediation and/or Enrichment:
R: individual IEP; partner help throughout lesson

E: The teacher can discuss 2D kinematic equations and how they compare directly to the students' experimental data

Check(s) for Understanding:
Why is the data in the shape of a curve?
Which kinematic equations could also predict the impact of a projectile?
What complications would you have to consider in a real war?

Closure: Challenge students to hit an army man.

Possible Alternate Subject Integrations:
*Math – Students must resolve the vector components of the initial velocity of the ball.

Teacher Notes: