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 2-D kinematic equations 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 and

dynamics 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 morion 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

Lesson Performance Task/Assessment: In this lesson, students will measure the distance a ball travels when launched from a launcher. Using this measurement and the height from which the ball was launched, the students will determine the initial velocity of the ball. Using their measured initial velocity and the 2-D kinematic equations of motion, the students will predict the place of impact of the ball when launched at an angle. Students will then be challenged to hit plastic army men with their projectile using their predictions.

Lesson Relevance to Performance Task and Students: Using a simple setup, students will use the 2-D kinematic equations to predict the motion of a real-world object. This exercise will give the students more confidence in the validity of the 2-D kinematic equations of motion 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 make multiple measurements of the distance traveled by a ball launched horizontally from a particular height. They will use these measurements along with the height to calculate the average initial velocity of the ball leaving the launcher. The students must then use their initial velocity to calculate the angle needed to hit an army man placed by the teacher.

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

E: The teacher can divide the students into teams and have a turn based "mock war" where students must place their men and attempt to hit the men of the other team.

Check(s) for Understanding:
What are the relevant kinematic equations needed to 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: