Teacher Toolkit - Projectile Motion

Objectives:

1. To know the definition of a projectile and to use concepts of force and inertia to explain the manner in which gravity affects a projectile.
2. To be able to describe the horizontal and vertical components of the velocity of a projectile.
3. To be able to describe the horizontal and vertical components of the displacement of a projectile.
4. To be able to numerically describe the various features associated with a projectile's trajectory (e.g., components of displacement, velocity and acceleration).
5. To use kinematic equations to analyze and solve horizontally-launched projectile problems.
6. To use kinematic equations to analyze and solve angle-launched projectile problems.

Readings: The Physics Classroom Tutorial, Motion and Forces in Two Dimensions Chapter, Lesson 2

Interactive Simulations:

1. Projectile Simulator http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Projectile-Simulator
   This HTML5 projectile simulator allows students to alter the launch speed, launch height and launch angle of a projectile and observe the effects upon the trajectory, range, and time of fight.
2. PhET: Projectile Motion http://phet.colorado.edu/en/simulation/projectile-motion
   Students fire various objects out of a cannon, manipulating angle, initial speed, mass, and air resistance, concepts of projectile motion come to light in a fun and game-like environment.
3. Projectile Motion with Angry Birds http://www.compadre.org/OSP/items/detail.cfm?ID=11562
   This resource uses the free Tracker Video Analysis tool to measure and analyze the motion of an angry bird projected from a slingshot to hit a pig.
4. Galileo and Newton Simulation http://www.opensourcephysics.org/items/detail.cfm?ID=12169
   This unique resource models two views of projectile motion - the Galileo version and the Newton version. These two views are mathematically equivalent, but each emphasizes different aspects of the motion.

Video and Animation:

1. Projectile Motion Illustration http://www.compadre.org/Physlets/mechanics/illustration3_4.cfm
   This animation will help students visualize an object's motion in the x and y directions *separately,* which is key to solving projectile motion problems.
2. Uphill and Downhill Projectile Motion http://www.compadre.org/Physlets/mechanics/ex3_5.cfm
   This simulation with accompanying problem set would be ideal for a digital lab on projectile motion. The worksheet was crafted to help learners stay focused on specific questions limited in scope to launch angle and initial speed.
3. The Projectile and the Lamborghini http://www.compadre.org/Physlets/mechanics/prob3_10.cfm
   A projectile is aimed at a moving car. Students change the projectile's launch angle and initial speed with the goal of finding the relationship between v_0 and θ such that the projectile will always hit the car.

Labs and Investigations: http://www.physicsclassroom.com/lab#vp

1. The Physics Classroom, The Laboratory, Basketball Analysis
   Students use video analysis to investigate the horizontal and vertical velocity and acceleration of a basketball.
2. The Physics Classroom, The Laboratory, Projectile Simulation
   Students use an online simulation to investigate the motion parameters of a projectile.
3. The Physics Classroom, The Laboratory, Projectile Problem-Solving
   Students use an online application to master three types of horizontally-launched projectile problems.
4. The Physics Classroom, The Laboratory, Launcher Speed
   Students make measurements in order to determine the launch speed of the projectile launcher.
5. The Physics Classroom, The Laboratory, Maximum Range
   Students use a projectile launcher to experimentally determine which angle projects a launched ball the furthest.
6. The Physics Classroom, The Laboratory, Hit the Target
   Students use a calibrated projectile launcher (from Lab 4: Launcher Speed above) and predict the initial height a target a known distance away must have in order for the launched projectile to strike the target.

Demonstration Ideas:

1. MIT Tech TV: Monkey and a Gun https://www.youtube.com/watch?v=cxvsHNRXLjw
   It's the classic scenario of "Monkey and the Hunter". A stuffed monkey is suspended from a rod. A golf-ball gun is aimed directly at the monkey. The golf ball is shot and the monkey begins falling.
2. Ball Drop https://www.youtube.com/watch?v=qY8bACj1Mac
   This 90-second video demonstrates and explains why a ball launched upward from a platform moving at a constant speed will fall back onto the platform.
3. Upward Launch https://www.youtube.com/watch?v=0W7xhn5KLUI
   This 90-second video demonstrates and explains why a ball released from above a platform moving at a constant speed will land onto the platform.

Minds On Physics Internet Modules http://www.physicsclassroom.com/mop

The Minds On Physics Internet Modules are a collection of interactive questioning modules that target a student's conceptual understanding. Each question is accompanied by detailed help.

Vectors and Projectiles Module

Ass't VP7 - The Nature of a Projectile
Ass't VP8 - The Acceleration and Velocity of a Projectile
Ass't VP9 - Velocity Components for a Projectile
Ass't VP10 - Displacement and Time

Interactive Homework Problems **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Interactive Problem: Projectile http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/02/IE_projectile
2. Interactive Problem: Arrow http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/02/IE_arrow
3. Interactive Problem: Thrown Ball http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/02/IE_thrown_ball

Concept Building Exercises http://www.physicsclassroom.com/curriculum/vectors

1. The Curriculum Corner, Vectors and Projectiles, Projectile Motion

Problem-Solving Exercises http://www.physicsclassroom.com/calcpad/vecproj

1. The Calculator Pad, Vectors and Projectiles, Problems #21 - #34

Science Reasoning Activities http://www.physicsclassroom.com/reasoning/projectiles

1. Science Reasoning Center, Vectors and Projectiles, Up and Down
2. Science Reasoning Center, Vectors and Projectiles, Maximum Range of a Projectile
3. Science Reasoning Center, Vectors and Projectiles, Juggling

Real Life Connections: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Problem-Based Learning: Murder You Solve
   http://pbl.ccdmd.qc.ca/resultat.php?action=clicFiche&he=1050&afficheRecherche=99&IDFiche=140&endroitRetour=99&lesMotsCles=murder%20you%20solve

Common Misconceptions **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Horizontal Launches vs. Vertical Drops from the Same Height
2. Horizontal Velocity Decreases with Time

Elsewhere on the Web: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Could the Black Arrow Actually Kill a Dragon? http://www.wired.com/2014/11/black-arrow-actually-kill-dragon/

Standards:

A. Next Generation Science Standards (NGSS) – Grades 9-12 (See Complete Toolkit for details.)
Disciplinary Core Ideas: HS-PS2.1.i
Performance Expectations: HS-PS2-1
Crosscutting Concepts: Scale, Proportion, and Quantity, Systems and System Models,
Science and Engineering Practices: Practices #1, #2, #6, and #8

B. Common Core Standards for Mathematics (CC) – Grades 9-12
N-VM.1, N-VM.2, A-REI.4.b, A-REI.10, F-IF.4, F-IF.6, and more. **(See Complete Toolkit for details.)**

C. Common Core Standards for English/Language Arts (ELA) – Grades 9-12
Reading Standards for Literacy in Science and Technical Subjects (See Complete Toolkit for details.)