Richmond Public Schools

Department of Curriculum and Instruction
Curriculum Pacing and Resource Guide – Unit Plan

Course Title/ Course #: Physics / 2900

Unit Title/ Marking Period # (MP): Circular and Projectile Motion / MP2

Start day: 51

Meetings (Length of Unit): 2 weeks

Desired Results ~ What will students be learning?

Standards of Learning/ Standards

PH. 1 a-g

PH.5 The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes. Key concepts include

b) uniform circular motion;
c) projectile motion;

Essential Understandings/ Big Ideas

In order to meet this standard, it is expected that students will

- solve problems involving displacement, velocity, acceleration, and time in one and two dimensions (only constant acceleration).
- draw vector diagrams of a projectile's motion. Find range, trajectory, height of the projectile, and time of flight (uniform gravitational field, no air resistance).
- distinguish between centripetal and centrifugal force.
- solve problems related to free-falling objects, including 2-D motion.
- describe the forces involved in circular motion.

Key Essential Skills and Knowledge

The concepts developed in this standard include the following:

- In a uniform vertical gravitational field with negligible air resistance, horizontal and vertical components of the motion of a projectile are independent of one another with constant horizontal velocity and constant vertical acceleration.
- An object moving along a circular path with a constant speed experiences an acceleration directed toward the center of the circle.
- The force that causes an object to move in a circular path is directed centripetally, toward the center of the circle. The object's inertia is sometimes falsely characterized as a centrifugal or outward-directed force.

Vocabulary

Projectile	Gravity	Horizontal component	Vertical component	Apex
Parabola	Trajectory	Range	Centripetal	Centrifugal
Inertia	Period	Tangent	Tangential velocity	Uniform circular motion

Assessment Evidence ~ What is evidence of mastery? What did the students master & what are they missing?

Assessment/ Evidence

Use http://www.problem-attic.com/ to create a multiple choice or free response quiz or test.

Students may explain, verbally or in writing, the role of centripetal force and acceleration in circular motion, including an explanation of the invalidity of "centrifugal" forces.

Students may explain, verbally or in writing, the independence of horizontal and vertical components of motion in a projectile's trajectory.

After students have an understanding of Newton's Laws of Motion, students may explain how these laws, especially the 1^{st} and 2^{nd}, apply to circular and/or projectile motion.

Students may complete poster-size diagram of circular motion, including labels for centripetal force, centripetal acceleration, and tangential velocity vectors, radius, the trajectory an object would take if the centripetal force disappeared, and key equations.

Students may complete a poster-size diagram of projectile motion, including labels for the apex, range, initial velocity vector components, gravity, and velocity vectors during flight. Key questions may also be included.

Solve problems involving displacement, velocity, acceleration, and time in one and two dimensions (only constant acceleration).

Draw vector diagrams of a projectile's motion. Find range, trajectory, height of the projectile, and time of flight (uniform gravitational field, no air resistance).

Distinguish between centripetal and centrifugal force.

Solve problems related to free-falling objects, including 2-D motion.

Describe the forces involved in circular motion.

Learning Plan ~ What are the strategies and activities you plan to use

Learning Experiences/ Best Practice

Students may experiment and explore projectile trajectories with home-made or store-bought projectile launchers, focusing on the relationships between initial velocity, angle, maximum height, and range.

Students complete internet scavenger hunts or guided notes to explore relevant topics in physicslab.org or www.physicsclassroom.com.

Using SMART Board or white board, the teacher can demonstrate for students the various "parts" of a projectile trajectory and how it can be explained using concepts such as Newton's 1st and 2nd Laws of Motion.

- Many online simulations, such as the Projectile Motion simulation, are powerful visualization tools for students, who can explore these themselves or observe a teacher manipulate them on a SMART Board or projected computer.

Complete "I do, we do, you do" cycles to demonstrate and practice the following concepts:

- Finding horizontal and vertical components of a projectile's initial velocity, given a magnitude and angle
- Finding the maximum height, time of flight, range, and final velocity of a projectile, given initial conditions

Students may explore and experiment with objects on a string in circular motion, noticing what forces are required to keep an object in a circular path and how the motion of the object appears when that force disappears.

Using SMART Board or white board, the teacher can demonstrate for students the various "parts" of a uniform circular motion path and how it can be explained using concepts such as Newton's 1st and 2nd Laws of Motion.

- Many online simulations, such as the Ladybug Revolution simulation, are powerful visualization tools for students, who can explore these themselves or observe a teacher manipulate them on a SMART Board or projected computer.

Complete "I do, we do, you do" cycles to demonstrate and practice the following concepts:

- Finding the velocity of an object in uniform circular motion, given its radius and period
- Finding the centripetal acceleration, given its velocity, radius, and/or period

Technology Integrations

- Students may use electronic probeware, such as Vernier equipment, to make digital measurements of position and time.
- Students may use Logger Lite (free) or Logger Pro ($$) software to analyze data electronically.
- Students may use Microsoft Excel to organize and analyze data, Microsoft Word to write lab reports, and Microsoft PowerPoint to plant and present experimental plans, results, and conclusions.
- Online simulations, including Gizmos, PhET, and Concord Consortium
- Students may use scientific or graphing calculators to aid them in complex mathematical calculations during problem solving.

Resources

A wide variety of home-made projectile launchers can be constructed using easy-to-obtain objects, from very simple to the extremely complex. Simple launchers, including toys such as the Stomp Rocket, may also be used. For more precise scientific explorations of projectile motion, launchers may be purchased such as those from Vernier or non-digital options.

To demonstrate uniform circular motion, wrist bungee balls or yo-yos may be purchased at dollar stores or party supply stores.

Gizmos

- Uniform Circular Motion
- Shoot the Monkey
- Golf Range

PhET Simulations

- Gravity and Orbits
- Ladybug Revolution
- Projectile Motion

- Ladybug Motion 2D
- Motion in 2D

Physics Lab Online: Projectiles

Physics Lab Online: Uniform Circular Motion

The Physics Classroom:
- Tutorial: Circular Motion and Satellite Motion
- Tutorial: Vectors – Motion and Forces in Two Dimensions
- Interactives: Vectors and Projectiles
- Interactives: Circular and Satellite Motion
- Problem Set: Vectors and Projectiles
- Problem Set: Circular Motion and Gravitation

Khan Academy: Two-Dimensional Motion

Khan Academy: Optimal Angle for a Projectile

Khan Academy: Centripetal Acceleration

Cross Curricular Connection

- Projectile motion lends itself to sports and recreation applications, aeronautical applications, and engineering applications
- Circular motion lends itself to space travel and exploration applications and serves as a good introduction to planetary motion.
- Circular motion also lends itself to driving applications involving turns, road engineering, and safety concerns involving moving objects while turning.
- Mathematical operations and problem-solving skills are needed to solve problems involving displacement, velocity, acceleration, and time.
- Technical and persuasive writing techniques are necessary for writing well-supported scientific conclusions.