DeKalb County School District

Fernbank Science Center

Title: PHYSICS OUTREACH LAB (4802) | **Type:** Outreach

Level: All Physics | **Length:** 1 class period

Location: Local School | **Limit:** Single class

Program Description

This program combines instructor demonstrations and stories with student-based activities to examine and explain various physics phenomena. The instructor will bring sufficient apparatus for an entire class. Prior coordination between the Fernbank instructor and the classroom teacher is necessary to allow us to bring something suitable for your class's progress in the physics curriculum. Standard topics are provided in the list below, but the instructor can prepare a program for almost any concept in the physics curriculum. Teachers should refer to the Program Description Addenda to see program-specific information, standards, and vocabulary. This set of programs is suitable for both Accelerated and Advanced Placement Physics classes.

A. 1-D Motion with Constant Acceleration (Air Track lab)
B. Projectile Motion (Air Table lab)
C. Momentum and collisions (Air Table lab)
D. Force and Motion (Rotation Station lab)
E. Work and Energy (Ramp and Pulley lab)
F. Conservation of Energy (Air Table lab)
G. Light and Refraction (Optics Bench lab)
H. Focusing with a Thin Lens (Optics Bench lab)
I. Electrical Current and Resistance (Ohm's Law lab)
J. Magnetic Field Mapping (Permanent and Electromagnet lab)
K. Wave Motion and Sound (Group lab)

The following programs are most suitable for Advanced Placement classes. The topics addressed typically go beyond the treatment in a general-level physics course.

A. 1-D Motion with Constant Acceleration (LabQuest and Motion Detector lab)
B. Centripetal Force (LabQuest and Force Sensor lab)
C. Electrical Circuits (Multimeter lab for Parallel and Series Circuits)
D. Time Response of an RC Circuit (LabQuest and Voltage Sensor lab)
E. Solenoid Magnetic Field Properties (LabQuest and Magnetic Field Sensor lab)
F. Interference and Diffraction (Laser-based lab)

Other labs are available, and there is a great deal of flexibility with regard to duration and the proportion of time spent on demonstrations or explanations versus student lab inquiry. Teachers should feel free to request topics not listed above.

Resources

Holt Physics, Serway and Faugn, Holt, Rinehart, and Winston, 2002
Physics: Principles with Applications, (5th rev. ed.), Giancoli, Prentice-Hall, 2002
Physics for Scientists and Engineers (2nd ed.), Knight, Pearson Addison-Wesley, 2008

Lab A: 1-D Motion with Constant Acceleration (Air Track lab)

Program Description

Students record the motion of a glider on a tilted air track using a spark timer. Typically, each student works as an individual, but teachers may prefer to pair students or group them in threes in the interest of time. Students measure the glider position versus time using the "dot tape" produced and graph the values to observe the relationship. To extend the analysis, students determine instantaneous velocities using pairs of adjacent dots to evaluate whether velocity increases in a linear fashion as predicted by Galileo.

Typical introductory demonstrations: Examples of motion with constant speed, constant velocity, and constant acceleration; Common acceleration of objects in free fall, independent of mass; Observing motion using strobe lights; Measuring speed using microwaves (radar gun).

Standards

SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time.

a. Plan and carry out an investigation of one-dimensional motion to calculate average and instantaneous speed and velocity.
    - Apply one-dimensional kinematic equations to situations with no acceleration, and positive, or negative constant acceleration.
b. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time.

Vocabulary

independent variable	experimental error	linear	kinematics	initial velocity
dependent variable	uncertainty	quadratic	proportional	slope
hypothesis	apparatus	parabola	correlation	acceleration

Pre-Visit Activities

The PhET site contains interactive simulations that you can use to demonstrate key concepts to the full class or have students access individually: https://phet.colorado.edu

Graphing Lines (practice with slope concepts and equations of lines)
Lease-squares Regression (more sophisticated analysis of linear patterns with scatter)
The Moving Man (relation between position, velocity, and acceleration. JAVA required!)

Post-Visit Activities

If not completed during the Fernbank instructor's visit, have students calculate and graph the velocity versus time (linear) pattern and determine the acceleration. Review results from all groups to verify that all found roughly the same value, and discuss the results in the context of experimental errors. Have each group determine their best values for initial position and velocity to produce predictions using the kinematic equations.

Lab B: Projectile Motion (Air Table lab)

Program Description

Students record the motion of a metal "puck" on a tilted air table using a spark timer. Typically, each student works as an individual, but teachers may prefer to pair students or group them in threes in the interest of time. For a tilted table, students obtain beautiful parabolic trajectories made up of "dots" recorded by the spark timer. Students identify the true direction of vertical (which may not match the edge of the paper!) based on a simple symmetry technique and then resolve the displacements into Δx and Δy-components. To analyze the result, students make graphs of the horizontal and vertical velocity versus time.

Typical introductory demonstrations: Common acceleration of objects in free fall, independent of mass; Observing motion using strobe lights; Same time of fall for dropped / horizontally launched objects.

Standards

SP1. Obtain, evaluate, and communicate information about the relationship between distance, displacement, speed, velocity, and acceleration as functions of time.

b. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time.
c. Ask questions to compare and contrast scalar and vector quantities.
d. Analyze and interpret data of two-dimensional motion with constant acceleration.
   - Resolve position, velocity, or acceleration vectors into components (x and y, horizontal and vertical).
   - Interpret problems to show that objects moving in two dimensions have independent motions along each coordinate axis.
   - Design an experiment to investigate the projectile motion of an object by collecting and analyzing data using kinematic equations.
e. Analyze and interpret data using created or obtained motion graphs to illustrate the relationships among position, velocity, and acceleration, as functions of time.

Vocabulary

independent variable	experimental error	symmetry	kinematics	initial velocity
dependent variable	uncertainty	quadratic	proportional	acceleration
hypothesis	apparatus	parabola	correlation	projectile

Pre-Visit Activities

The PhET site contains interactive simulations that you can use to demonstrate key concepts to the full class or have students access individually: https://phet.colorado.edu

Equation Grapher (practice with coefficients of quadratic equation. FLASH required!)
Projectile Motion (relation between initial speed / angle and trajectory. FLASH required!)
Motion in 2D (relation between directions of velocity and acceleration. JAVA required!)

Post-Visit Activities

Successfully predict range of an object rolling of table with known (horizontal) velocity.

Lab C: Momentum and collisions (Air Table lab)

Program Description

Students record the collision of two metal "pucks" on a level air table using a spark timer. Typically, students work in groups of three to successfully coordinate all experimental operations. Students identify the true direction of the x-axis (which may not match the edge of the paper!) using the initial direction of motion for one puck and then resolve the Δx displacements for both pucks following their collision. Students assess the claim that linear momentum is conserved.

Typical introductory demonstrations: Common types of collisions on an air track (elastic vs. inelastic, effect of relative mass, etc.); Student propulsion on dynamics cart using momentum; Ninja ball; Newton's cradle with momentum and kinetic energy explanation.

Standards

SP2. Obtain, evaluate, and communicate information about how forces affect the motion of objects.

a. Construct an explanation based on evidence using Newton's Laws of how forces affect the acceleration of a body.
    - Identify the pair of equal and opposite forces between two interacting bodies and relate their magnitudes and directions using Newton's 3rd Law.

SP3. Obtain, evaluate, and communicate information about the importance of conservation laws for mechanical energy and linear momentum in predicting the behavior of physical systems.

d. Construct an argument supported by evidence of the use of the principle of conservation of momentum to:
    - explain how the brief application of a force creates an impulse.
    - describe and perform calculations involving one dimensional momentum.
    - connect the concepts of Newton's 3rd law and impulse.
    - experimentally compare and contrast inelastic and elastic collisions."

Vocabulary

experimental error	scalar	momentum	conservation law
uncertainty	vector	impulse	closed / isolated system
hypothesis	component	kinetic energy	elastic vs. inelastic

Pre-Visit Activities

The Physics Classroom site contains worksheets and simulations for all parts of the physics curriculum: http://www.physicsclassroom.com/Physics-Interactives

The Cart and the Brick (before / after velocity for brick dropped onto moving cart)
Fish Catch (before / after velocity of two fish as one is eaten)
Exploding Carts (momentum analysis for objects starting from rest)

Post-Visit Activities

Have students use the same data from their collision to assess the percentage of kinetic energy retained and describe the elasticity of the collision.