Mathematics Through the Eyes of Physics

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Overview

I am a Mathematics teacher at Overbrook High School. I currently teach 11th graders, but my roster varies to include 9th and 10th graders. This unit on motion is designed for 11th graders, but could be used for 9th and 10th graders who have a sufficient background. It enriches the School District of Philadelphia's core curriculum. Students will have the opportunity to apply the concepts they learn in the mathematics and appreciate the relevance and importance of mathematics in physics.

The purpose of this unit is to introduce students to the study of kinematics. It helps increase their awareness and familiarizes them with the laws and equations that govern the motion of objects. They will gain a clear insight on linear and quadratic equations that is part of the math curriculum. The unit is designed to enable students develop a strong understanding of basic mathematical concepts such as slope and area under the curve. In addition, they will be able to comprehend the relationships of these concepts to physical quantities such as speed, distance/displacement, time, velocity, and acceleration.

Students will learn to use graphs and equations to express the relationship between physical quantities. Students will learn the importance of reading, interpreting and analyzing graphs using the graphing calculator- TI 83. The use of the graphing calculator in tandem with the motion detector helps reinforce and gain deeper understanding of the subject. Moreover, the use of technology makes learning math more interesting, less abstract and motivates them to delve deeper to make discoveries for themselves. Students will be exposed to a wide range of problems which applies the laws of physics.

Rationale

As a high school teacher of mathematics, I am bombarded with these questions: "Why are we learning math?" "Where will it be used in our lives?", "How does mathematics impact us?" This set me thinking on making math more interesting, more practical - a subject which can be related to other subjects and to events happening around the students lives.

Physics being a mathematical science uses mathematics as its language of communication. The key to understanding and appreciating the underlying concepts and principles of physics is a sound knowledge in basic mathematics which includes Algebra 1, Algebra 2, Geometry and Trigonometry. The District's core curriculum has the above branches of math as its focus in high school math. I have selected specific topics from Physics to integrate with the Math curriculum. In this curriculum unit I have woven the physics and the math together, thereby showing the interdependence of one with the other.

Physics is a part and parcel of our daily life from a simple activity like throwing a ball to navigating a high-speed bullet train or launching a rocket. Physics deals with the fundamental constituents of the universe, the forces they exert on one another, and the results produced by these forces. It is a broad science that encompasses other related sciences – Chemistry, Biology and Geology. Interestingly, it does not stop here as physics finds applications in music, art, motion, dance and the technology around us. In this unit I will focus on the physics of motion.

Linear and Quadratic Equations

To obtain a profound understanding of the principles and concepts in the study of motion students need to have some knowledge of linear and quadratic equations and functions.

A linear equation is an equation in which each term is either a constant or the product of a constant times the first power of a variable. Such an equation is also called a first-degree polynomial. These equations are called "linear" because they are represented by straight lines in Cartesian coordinates. In other words the graph is a straight line as in Figure 1.
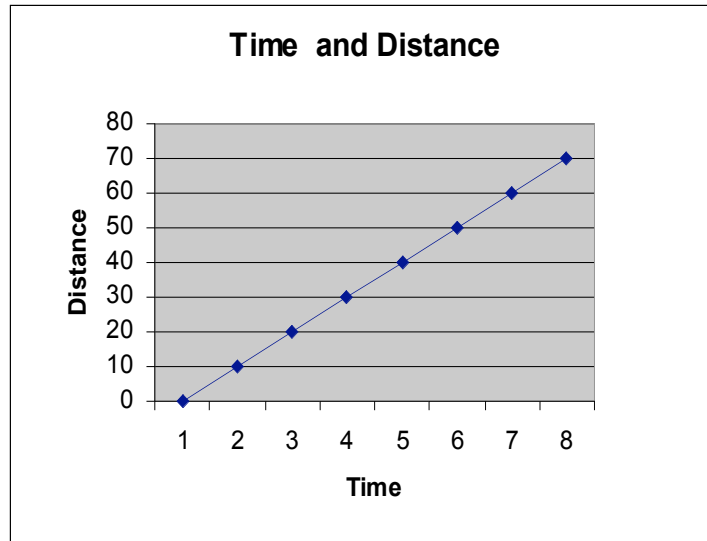
Time and Distance

Fig. 1: Linear graph with time on the x axis and distance on the y axis.

A common form of a linear equation in the two variables x and y is y = mx + b. *x* is referred to the independent variable, as it could take any value, and *y* is referred to the dependent variable since its value is influenced by *x*. In this form, *m* is a constant that determines the slope or gradient of the line. The slope of a line measures the steepness of a line and is given by rise/run. The rise indicates the change in *y* and the run indicates the change in *x*. The slope *m* can be positive, indicating an increase in *x* leads to an increase in *y*, or negative indicating the reverse. When there is no change in *y* there is no rise. Therefore, the slope is zero and the resulting graph is a horizontal line. On the other hand when there is no change in *x* the run is zero and is considered no slope. The constant *b* determines the point at which the line crosses the *y*-axis and is called the *y* intercept.

Equations involving terms such as x^2, $y^{1/3}$, x^3 and xy are nonlinear. A quadratic equation is a non linear equation. An equation, graph, or data that can be modeled by a degree two polynomial is a quadratic equation. In simpler terms, the variable *x* in the equation is raised to the second power and the graph is a U-shaped graph or n shaped as in the figures below.
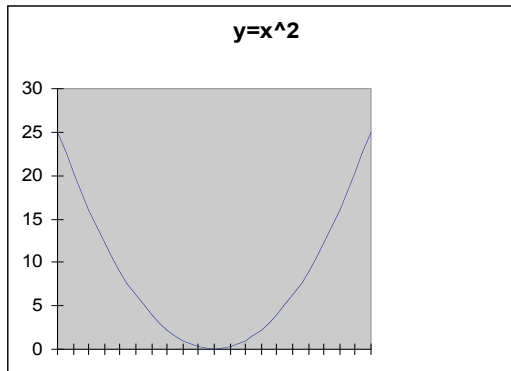
y=x^2

y= - x^2

Fig 2   Fig 3.

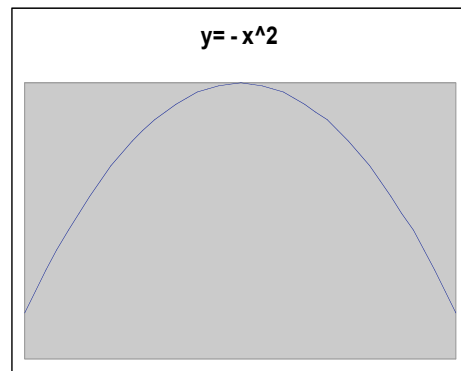Quadratic graph – u shaped   Quadratic graph – n shaped

As part of the standard math curriculum, students learn both how to obtain a linear equation for a given data set and also how to graph linear and quadratic equations. The application and relevance of the above equations will be further explained using illustrations and examples from physics, in particular to the study of motion.

One Dimensional Kinematics

Kinematics is the study of motion without regard to the forces present. It is simply a mathematical way to describe motion. This study like every other study in math and physics includes multiple means by which motion of objects can be represented. The use of words, graphs, equations and numbers are some of these means. When using words, students need to familiarize themselves with some mathematical quantities such as distance, displacement, speed, velocity, and acceleration to describe the motion of objects. These mathematical quantities can be divided into two categories: vector and scalar.

Scalar

Scalars are quantities which are fully described by a magnitude alone. A scalar is said to have magnitude but no direction. Any quantity that can be measured using a single real number is a scalar. Temperature, length, speed, distance and mass are all examples of scalars.

Vectors

A quantity with both direction and magnitude is called a vector. Vectors are quantities that can be drawn as an arrow, with both direction and magnitude. Examples of vectors are force, velocity, acceleration and displacement.

Displacement refers to how far out of place an object is. It is the object's change in position. It is measured in meters.

Velocity refers to the rate at which an object changes its position, and can also be defined as rate of change of displacement or just as the rate of displacement. It gives the distance covered per unit time time and is expressed as $v= d/t$ and measured in meters per second (m/s). Furthermore, an object can have initial velocity which is the velocity when it begins to move and a final velocity which is the velocity after some time has elapsed.

Acceleration is defined as the rate of change of velocity. It is measured meters per second squared (or meters per second per second, m/s²)

Force can most easily be described as a push or a pull. The velocity of an object changes when a force is applied to it. This change in velocity is termed acceleration. Therefore, acceleration is the rate of change of velocity over time and can be a scalar or a vector depending on the path of motion. For motion along a straight line, acceleration is a scalar. For motion on a plane or through space, acceleration is a vector.   In the case of free falling objects the acceleration is due to gravity. Hence, for all objects that fall to the earth the acceleration due to gravity is a constant as long as air resistance can be ignored and is represented by the symbol *g* with a value of 9.8 m/sec^2

Equations and Graphs of Motion

Motion happens all around us. One way to simplify the concept of motion is to consider only the kind of motion that take place in one direction. One-dimensional kinematics is the study of motion along a straight line. The motion of a commuter train on a straight track is an example of this. In this motion the train can move either forward or backward along the tracks. It cannot move left, right, up or down. This straight-line motion can be represented graphically or in an equation.

It is easier to get students interested in a lesson that revolves around topics they can relate to. One such topic that kindles their interest is cars and car racing. An introductory talk on automobiles and car racing can be a springboard for the lesson on motion.

The distance traveled by an object is given as a product of the time of travel and its velocity where time acts as the independent variable, and distance the dependent variable. If the object moves through equal distances during equal time intervals then the velocity, remains the same. The velocity in this case is referred to as constant velocity. Since the relationship between the variables is linear it can be expressed as a linear equation having the form d= *vt* where d represents the distance, t the time and v the velocity. Thus, v can be also represented as change in distance over change in time, mathematically termed as slope.

The above example involving time and distance can be also represented graphically. While plotting the points on a graph, it turns out to be a straight line, as seen in Figure 4. The graph is a straight line because the velocity is constant. In other words the slope of the line gives the velocity which is distance (rise) / time (run)
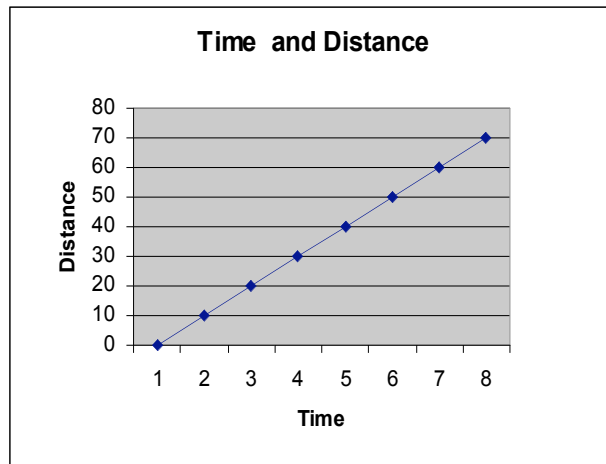
Time and Distance

Fig. 4 – constant velocity

In the case of an object moving with varying speed, the velocity is constantly changing therefore the resulting graph turns out to be a curve as in Figure 5. The slope is not a constant, but changes continuously.
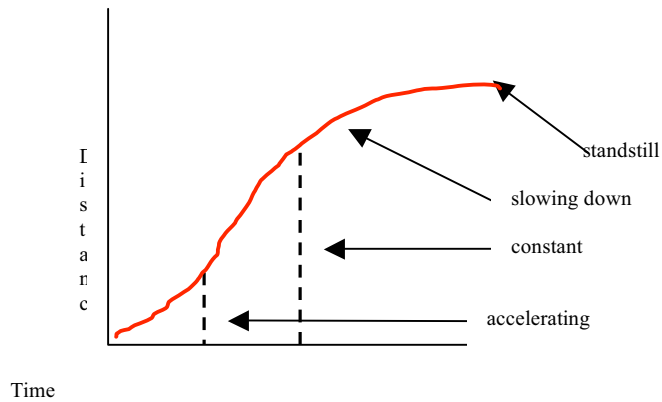
Fig. 5 – changing velocity

Hence, the slope of a position vs. time graph provides detailed information about the object's velocity. For example, a small slope means a small velocity; a negative slope means a negative velocity- downward direction; a positive constant slope means a constant upward velocity as in fig 4.

The various graphs below depict positive/ negative velocity
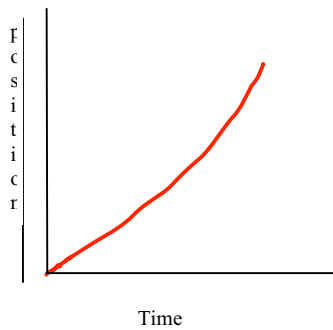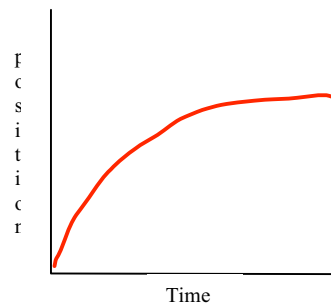

Fig. 6: Positive Increasing Velocity

Fig. 7: Positive velocity, initially increases
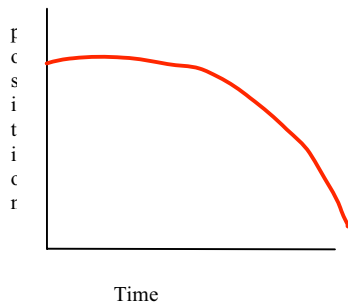
and later slows to standstill

Figure 8: Increasing negative velocity

Therefore, the slope of the line is a useful mathematical tool that allows us to obtain important information about the motion of objects as described by their position vs. time graph.

Having looked at linear motion we now turn to falling objects and objects thrown upwards. In the instance of falling objects it involves motion in the downward direction. As the object falls there are forces that influence its downward motion that accelerates its motion.

It was believed that downward acceleration varied with different objects until Galileo tried to prove that all falling objects accelerate downward at the same rate. Falling objects do accelerate downward at the same rate in a vacuum. However, air resistance cause objects to fall at different rates in air. In the case of free-fall the object falls under the influence of gravitational force alone. Any object that is moving and is being acted upon only by the force of gravity is said to be "in a state of free fall." Therefore, free-falling objects do not encounter air resistance and all free-falling objects (on earth) accelerate downwards at a rate of 9.8 m/s^2.

On the other hand, while an object is being thrown upward, there is an upward force on the ball, but once it leaves the hand it has exactly the same downward force and acceleration as if it were dropped. In both cases the velocity is not constant, but changes. As time increases the velocity becomes more downward, which results in a downward curve in the x vs. t graph. Therefore, it is not a straight line or linear graph, but a curved graph as in the figure below. This curved graph is called a parabola, and the equation to such a graph is a quadratic equation. The relationship is parabolic because the distance varies directly with the square of the time. It can be expressed as $y = kx^2$, where y indicates the distance and x the time. Since it is parabolic the algebra of quadratic equations can be applied to it.
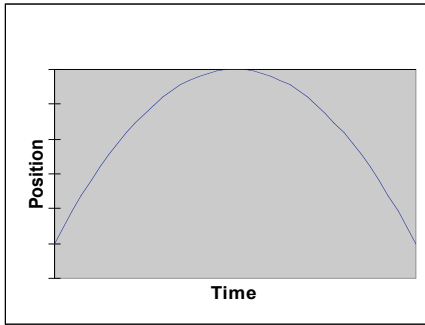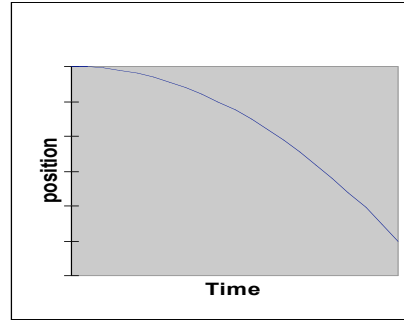
Fig 9. Graph of a ball thrown up
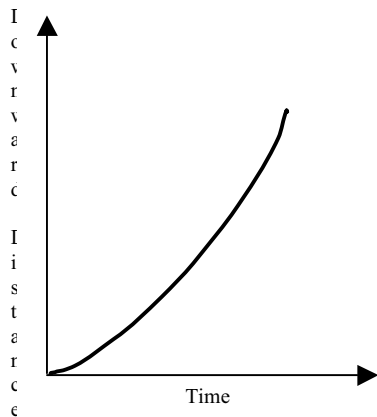

Fig 10. Graph of a free fall

Fig 11. Graph of Free Fall

The graph in fig 11 shows the distance covered when an object is dropped down. From this graph we observe the distance covered is more as it falls down implying acceleration in its downward motion.

he velocity-time graph below (Fig 12) shows a detailed analysis of a train's motion over time. When the train leaves the station, its speed increases over time. The line on the graph plotting this motion slopes up and to the right, as at point A on the graph. When the train moves with constant velocity, the line on the graph continues to the right but it is horizontal, with slope equal to zero. This indicates the train's constant velocity as at point B on the graph. Finally, as the train approaches the station, its velocity decreases over time. The graph representing this motion slopes down to the right, as at point C on the graph. The downward slope indicates that the velocity is decreasing over time.
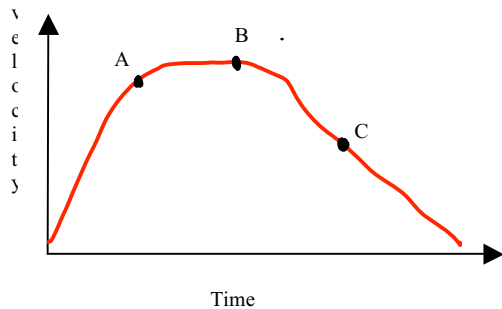
Fig 12. Velocity -Time graph

The equations of motion describe the behavior of an object in motion under the influence of a force. It is expressed as a function of time. The following kinematic equations describe the mathematical relationship between various parameters. The parameters are time, velocity, distance/ displacement and acceleration of an object in motion. They are referred to as DUVAT in short and are used in solving problems on motion. The five variables represent d-displacement, u-initial velocity, v-final velocity, a-acceleration and t-time. Furthermore, students are reminded to apply previously learnt algebraic techniques in solving problems thereby relating math and physics.

The Equations of motion for uniform acceleration

(i) To find the displacement when the acceleration, time and initial velocity are known.

$$d = ut + \tfrac{1}{2}at^2$$

(ii) To find the final velocity when the displacement, acceleration and initial velocity are known

$$v^2 = u^2 + 2ad$$

(iii) To find the final velocity when the acceleration, time and initial velocity are known

$$v = u + at$$

To find the displacement when the time, initial and final velocity are known

(iv) $$d = ((u + v)t) / 2$$

Our focus in this unit will be on constant velocity. Since the velocity is a constant there is no acceleration, and the initial and final velocity are the same. Hence, the above four equations reduce to a single linear equations when the acceleration a is replaced by 0 and is represented as

$$d = vt$$

Equations of Motion for Free Falling Objects

The same set of equations for uniform acceleration could be used for a body in free fall except that the acceleration a is replaced by acceleration due to gravity represented by g. Thus the above four equations become

$$d = u t + \tfrac{1}{2} gt^2$$

where d is the DOWNward distance.

$$v^2 = u^2 + 2g d$$

$$v = u + gt$$

$$d = ((u + v)t) / 2$$

A lesson on equations of motion would not be complete without mentioning the laws that govern an object in motion. The laws of motion also known as Newton's laws of motion as it was put forward by Sir Isaac Newton in the 17th century describes the motion of a body as a whole and valid only for motions relative to a reference frame.

The Three Laws of Motion

The following are brief modern formulations of Newton's three laws of motion:

First law: Objects in motion tend to stay in motion with constant velocity, and objects at rest tend to stay at rest unless an outside force acts upon them. Newton's first law is often referred to as the law of inertia.

Inertia is the property of an object which causes it to to remain at constant velocity unless acted upon by an outside force. The principle of inertia is one of the fundamental laws of classical physics which are used to describe the motion of matter and how it is affected by applied forces.

Consider the following example where the first law can be observed. A car travels with a velocity of 55 miles/hr and continues to travel at this speed as long as no acceleration, no brakes or no other forces are applied to it. Since the velocity is a constant the graph is linear and the equations of motion for uniform acceleration can be applied.

Second law: The acceleration of a body is directly proportional to the net force acting on it, and the direction of the acceleration takes place in the direction of the net force. This law can be written as $F = ma$ where F represents the net force, a the acceleration and m the mass of the body.

Consider the situation of pushing a stalled car in the middle of an intersection. The acceleration is so small when a single person pushes it that the increase in speed is unnoticeable. However, when there are several people to push the car, the net force on the car is much greater, and the car moves so much faster that one has to run to keep up with it. This is because the net force acting on the car is directly proportional to the acceleration of the object.

Third law: To every action (force applied) there is an equal and opposite reaction (equal force applied in the opposite direction).

A swimmer constantly applies this law while swimming. Each time the swimmer pushes the water backwards, the water in turn applies an equal force in the opposite direction moving the swimmer forward in linear motion.

It is important to note that these three laws together with the law of gravitation provide a satisfactory basis for the explanation of motion of everyday macroscopic objects under everyday conditions. However, when applied to extremely high speeds or extremely small objects, Newton's laws break down.

Objectives

The main objective of this unit is for students to integrate math and physics concepts. Specifically, students will apply linear equations in physics applications. Students will draw graphs of time and distance using the motion detector and graphing calculator. They will understand the relationship between time, distance and velocity/ speed. Students will learn the relevance of linear and quadratic equations in solving problems on equations of motion. In addition they will also learn to describe and understand motion of objects beyond just words. They will learn to understand, interpret and analyze various graphs of motion and its relevance in kinematics.

Standards

The lesson in this unit is designed for high school math that incorporates the physical science of motion. Students will get a basic understanding of linear and quadratic equations. They will learn to solve simple equations and then move on to equations of higher degree.

The unit will fulfill the Pennsylvania Academic Standards for Math and Science and Technology listed in the appendix.

Strategies

Math Journal: Every student will be required to keep a journal that records the date and the lesson they learned. This will help students to keep track of lessons they have learnt and to make connections. Moreover, making a note of lessons/topics/concepts not understood helps build a strong foundation.

Cooperative learning: Students will be engaged in group work when an activity is done as they learn other skills besides academics such group dynamics. This approach also encourages peer learning and sharing.

Brainstorming/ Group Discussion: This is something they will use after they have finished an activity and analyze the activity done to draw inferences. This activity promotes critical thinking and increases reasoning skills.

Math Science Glossary: Students gain immensely in keeping track of the words and concepts they learn. It acts also as a quick reference when they are in doubt about a formula, definition or concept. Finally, it helps them see the relationship between the various physics and math terms.

Internet based animation: This is an excellent methodology for abstract concepts. A single picture/animation is worth a thousand words/ expressions/explanations.

Lab Reports: At the end of the activity and brainstorming session they will make observations, write down inferences, and look for connections to math concepts they have learnt.

Problem Solving: An absolute necessity, this helps assess a student's understanding of the concepts. The following strategies will be emphasized while solving a problem -

a. **R**ead the problem b. **I**dentify what needs to be found c. **I**dentify the formula
d. **P**ull out values of known variables e. **S**ubstitute and **S**olve the unknown
 Students can use this mnemonic to help them in problem solving.

Graphing Exercises: Graph exercises such as drawing graphs on graph paper and graphing calculator, reading and interpreting graphs. build their confidence in reading, interpreting and analyzing graphs.

Classroom Activities

Lesson 1

In this unit the students will produce, explore, analyze and interpret the different graphs based on motion using a motion detector along with a graphing calculator TI-83. Students will use the motion detector to produce graphs of their motion. The motion detector uses ultrasound to measure distance. Ultrasonic pulses are emitted by the motion detector, reflected from a target, and then detected by the device. The time it takes for reflected pulses to return is used to calculate position, velocity, and acceleration. This allows us to study the motion of objects such as a person walking, a ball in free fall, or a cart on a ramp.

Using the detector with the graphing calculator students will measure the distance walked in a certain amount of time to get the graph. The almost linear graph obtained from this helps them understand the relationship between distance and time. Having experimented with time and distance students will next work on a velocity - time graph. Using the velocity from the above experiment they will plot a velocity time graph and make observations on the shape of the graph – close to a horizontal line. Students will have a group discussion on what makes the graph horizontal and write their reasons. This brings in the concept of constant velocity and helps them understand that the slope represents the velocity.

The next part of their exercise will be to get another graph but with increasing velocity and compare the two graphs. Once again students will plot the velocity time graph for increasing velocity and note down the shape of the graph. This time it will not be a horizontal line. Another brainstorming session will help them understand concepts such as changing velocity, positive acceleration, negative acceleration, average velocity, instantaneous velocity.

Lesson 1A : Introduction to Linear Equations

Objective: To Identify Linear equations and linear relationships

Duration: 1 Class Period (45 minutes)

Procedure:

I will begin by introducing the term linear, its meaning and scope. I will relate it to hourly wages and total salary of a worker for a week. Students will draw a table and calculate the total pay. I will review graphing and plotting concepts. Next they will graph the table and observe the resulting straight line.

The students will analyze the graph and identify the constant difference and relate it to the slope and predict further wages from reading the graph.

Next they will learn to compose an equation from the data. They will confirm the validity of the equation by graphing it and checking to see if they got the same graph as in the problem.

Lesson 1B: Using the Graphing Calculator (TI-83):

Objective : To Reinforce the graph of a linear equation

Duration: 1 Class Period (45 minutes)

Procedure:

I will take the students through the steps on using the calculator with the help of a projector. Students will then use a worksheet to graph lines on the calculator. This will lead to the lesson on integrating physics and math.

   Students will document the steps and commands on the calculator in their math journal. The students will work in pairs on this exercise. In this exercise the data will be given to the students. In the next lesson the students will learn to collect their own data and get the graph.

Lesson 2: Physics Around Us

Objective: To create an awareness and interest in the physics that surrounds us.
Duration: 1 Class Period (60 minutes)

Procedure:

I will begin with a brainstorming session. Students will work in groups to list the physics they experience in their daily life. The results can be categorized into various branches of physics. For example students might include Sound (cell phones, ipod, musical instruments, sound), Light (computers, sun, rainbow, paintings, cameras, eye), Motion dance, aerobics, sports, cars), Electronics(CD, DVD, video games).

I will next focus their attention on the physics of motion and have them think about everything involved with motion. Students will select one activity (running, biking, driving a car, walking, rowing a boat, riding a train) and list aspects that influence the activity. In conclusion we will identify the commonalities of these various activities. These are the concepts that we will focus on - Speed, Velocity, Time, Distance, Acceleration, Force of Gravity.

I will conclude the lesson by using computer web based animations to show the relationship between time and distance, time and velocity, constant acceleration. Students will observe the motion of two cars and observe the velocity /time graph. Each car is a linear graph with constant velocity. Students will read the time and position when the two cars intersect. In another animation students observe the velocity time graph where the velocity is constant, hence the lines are horizontal and they never intersect. However, at an instant of time they would be at the same position.

Using the animation students will learn to use the formula for time, distance and speed to arrive at the same position algebraically.

Lesson 3: Graphing your Motion Using the Motion Detector

Objective: Students will work on the motion detector and the TI Graphing Calculator to (a) measure distance and velocity, (b) produce their own graphs of motion (distance-time graphs), and (c) analyze and interpret graphs of motion.

Duration: 60 mins.
The procedure for this lesson will be Experiment 35 from the experiments published by Vernier Software in the book titled " Physical science with CBL".
Students will complete the worksheet at the end of the lesson.

Lesson 4A : Introduction to Quadratic Equations

Objective: To Identify Quadratic equations and quadratic relationships

Duration: 1 Class Period (45 minutes)

Procedure:

The term quadratic will be introduced. A class discussion on its meaning and scope will be followed by a quick review of quadratic equations. The standard form of a quadratic equation is $y = ax^2 + bx + c$. Next we will discuss the shape of a quadratic equation using a simple example such as area of a square. Given the length of the side (x), find the area (y). The class activity will be to plot a graph given the x values. X : -2, -1, 0, 1, 2, 3, 4, 8, 16.

The area is obtained by squaring the x which can be written as $y = x^2$. The observation they make on this activity is that when x doubles the area increases 4 times which is a steep increase. In plotting the graph, they will discover it is not a straight line but a u shaped curve.

The next step will be to get the same graph on the graphing calculator using the equation $y = x^2$. Using the graphing calculator they will graph a few quadratic equations and become familiar with the various parabolic graphs. Examples: $y = x^2 + 3x + 1$, $y = -x^2 + 2x + 1$. Having familiarized them with parabolic graphs and quadratic equations they can move on to the next part of the lesson which is a physics application of the above mathematical concept.

Lesson 4B: Falling Objects
Objective: To study the velocities of two different falling objects, observe the shape of the graph and make connections with parabolic functions. The motion detector, CBL System and the TI Graphing Calculator will be used to (a) measure distance and velocity; (b) produce their own distance-time and velocity-time graphs of motion; and (c) analyze and explain the results.

The procedure for this lesson will be Experiment 40 from the experiments published by Vernier Software in the book titled "Physical science with CBL". Students will complete the worksheet at the end of the lesson

Problem Solving

The goal of the problem solving portion of the lesson is to integrate the Math and the Physics in a wide range of problems. Listed below are few problems on the equations of motion. Students learn to apply the strategies for problem solving. After reading the problem the first step they need to do is identify the formula to be used. Formula identification is one way to assess understanding of concepts. Step two will be to apply algebraic skills in solving them.

1. A plane starting at rest at one end of the runway undergoes a uniform acceleration of 5.2 m/s^2 for 17 s before takeoff. What is the speed at takeoff? How long must the runway be for the plane to be able to take off?

2. A racing car reaches a speed of 40 m/s. It then begins a uniform negative acceleration, using its parachute and braking system and comes to rest 4.5 s later. Find how far the car moves while stopping.

3. A person pushing a stroller starts from rest, uniformly accelerating at a rate of 0.6 m/s^2. What is the velocity of the stroller after it has traveled 5.5 m?

4. Jerry hits a volley ball so that it moves with an initial velocity of 5.8 m/s straight upwards. If the volleyball starts from 2.3 m above the floor, how long will it be in the air before it strikes the floor assuming no player touches the ball before it hits the floor.

5. A flower pot falls from the windowsill 25 m above the sidewalk. How fast is the flowerpot moving when it strikes the ground? How much time does a passerby on the sidewalk below have to move out of the way before the flower pot hits the ground?

Glossary
In mathematics, the **Cartesian coordinate system** is used to determine each point uniquely in a plane through two numbers, usually called the *x-coordinate* and the *y-coordinate* of the point
Frame of reference: A co-ordinate system for specifying the precise location of objects in space.
Polynomial: In mathematics, a **polynomial** is an expression that comprises one or more variables and constants, using only the operations of addition, subtraction, multiplication, and constant positive whole number exponents. Example x^3 + 2x -5 is a polynomial

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http://www.answers.com/topic/newton-s-laws-of-motion
www.dir.yahoo.com/science/physics
www.britanica.com
http://www.antonine-education.co.uk/Physics_AS/Module_2/Topic_1/Graph_2.gif
 www.physicsclassroom.com/mmedia/kinema/plv.html - Lesson 2

Annotated Bibliography

Teacher/Student Resources
http://id.mind.net/~zona/mstm/physics/mechanics/kinematics/constVelProblems/kin10.htm This site has animations on position- time and velocity-time graphs.

 http://www.physicsclassroom.com/mmedia/kinema/plv.html An excellent site for concepts on kinematics.

http://www.racemath.info/motionandenergy/distance_time_graph.htm This site has examples on velocity- time graph and problems on speed

http://library.thinkquest.org/C0110840/Acceleration.htm A good site. for acceleration problems, with samples.

http://www.regentsprep.org/Regents/math/conics/PracPar.htm: To practice graphs of parabolas

http://www.gravitywarpdrive.com/General_Relativity.htm good site to see a animation of a falling ball

http://www.mathwords.com/s/scalar.htm : For math definitions.

http://id.mind.net/~zona/mstm/physics/mechanics/mechanics.html
This site has problems on displacement, time, average and constant velocity.

http://www.sciencebyjones.com/acceleration_problems.htm For problems on acceleration

Appendix / Standards

 Pennsylvania Academic Standards for Mathematics

Students will have the opportunities to develop and use computation concepts, operations and procedures with real numbers in problem-solving situations. Students will use estimation to solve problems for which an exact answer is not needed. In addition they will construct and apply mathematical models, including lines and curves of best fit, to estimate values of related quantities.
    Students will use a variety of technological and information resources to gather and synthesize information, and to create and communicate knowledge. They will demonstrate skills for using graphing calculators, use operations.

2.2 Computation and Estimation

Basic functions (+, -, ×, ⬜), Reasonableness of answers, Calculators
2.3   Measurement and Estimation
Types of measurement (e.g., length, time)
Units and tools of measurement,
2.4   Mathematical Reasoning and Connections
Using inductive and deductive reasoning
2.5 Mathematical Problem Solving and Communication
Problem solving strategies
Representing problems in various ways
Interpreting results
2.6 Statistics and Data Analysis
Collecting and reporting Data (e.g., charts, graphs)
Analyzing data
2.8   Algebra and Functions
Equations
Patterns and functions
2.10 Trigonometry
Using graphing calculators