"Marbles on an Inclined Plane"

Tehani Finch, Howard University GK12 Program

October 18, 2007

I. DCPS Standards:

8.1.2 Test hypotheses that pertain to the content under study.

8.5.2 Describe kinetic energy as the energy of motion and potential energy as the energy of position or configuration.

8.5.3 Investigate and explain how kinetic energy can be transformed into potential energy, and vice versa.

II. Goals:

Students will understand how motion down an inclined plane produces acceleration.

Students will appreciate that motion down an inclined plane demonstrates the conversion of potential energy to kinetic energy.

III. Objectives:

Students will describe (gravitational) potential energy, kinetic energy, and how one is converted into the other.

IV. Prerequisite Knowledge: **Acceleration** is a change in velocity, either in its magnitude (i.e. the speed) or direction. Here we will be concerned with the former. Motion down an inclined plane produces constant acceleration. Accelerated motion must be caused by a force; in this case the forces acting on the marble are gravity and the normal force from the inclined plane. Since these forces do not cancel each other, accelerated motion results. This exercise shows that the time to travel a fixed distance lessens for increasing acceleration.

Kinetic Energy is the energy an object has by virtue of its motion.

[Gravitational] **Potential Energy** is the energy an object has by virtue of its position; in this case the relevant position parameter is the height above the earth's surface.

V. Essential Questions:

As the board's (or ramp's) incline becomes more steep, does the marble's potential energy (at the top of the ramp) increase or decrease? Will a marble released from the top of the ramp have more or less kinetic energy than one released from the middle of the ramp? Will a heavier object have more or less kinetic energy than a lighter one of the same velocity? Will a heavier object have more or less potential energy than a lighter one at the same height? Can an object have potential and kinetic energy at the same time?

VI. Materials: Meter Stick/Ruler, Stopwatch, Marbles, wooden board(s) possibly with a "starting line" drawn.

VII. Differentiating Instruction: This activity involves a combination of visual, verbal, and experiential modalities for facilitating student comprehension.

VIII. Rationale: This activity is designed for students to gain a rudimentary understanding of how the concepts of potential and kinetic energy pertain to everyday phenomena.

IX. Activity Procedure Students work in pairs. The activity can be done as one demonstration for the entire class or on a pairwise basis if there are enough boards and marbles. Students first formulate hypotheses about whether it will take more or less

time for the marble to reach the bottom of the board (or ramp) as the incline of the board increases. The length L from the starting mark to the end is measured. The board is tilted slightly above the horizontal position by leaning against a stack of paper/magazines, a textbook, or a wall, and the marble is released from a marked portion of the board. (One of the participants may have to hold the board in place if it tends to slide.) The vertical height of the starting mark above the lower end of the board is measured. (If there's no starting mark, the end of the board is suitable.) At the timer's command, the marble is released from the starting mark; the timekeeper measures how long it takes the marble to roll down the board. The measurements are recorded in a table in the data book. The process is repeated at a steeper incline (requiring more magazines, more paper, more of an angle to the wall, etc.) The amount of inclination is increased for five or so trials.

X. Evaluation and Assessment: Ask what trends are noticed? Were their respective hypotheses correct? Will the time for the marble to roll down the slope decrease forever as the incline increases [No, it asymptotically approaches $\sqrt{(2L/g)}$]? Does the marble accelerate down the board [yes unless the board is horizontal]? What happens when the board is completely horizontal? What can they say about the potential and kinetic energy of the marble based on this experiment?