Amgen Award for Science Teaching EXCELLENCE

2007
Winning Lesson Plan from Springfield, Kentucky

Motion & Forces

by Millie Blandford
Washington County High School

Subject: Integrated Science
Grade Level: 9–12
Duration: 50-Minute Class Periods

Overview and Purpose

I use this lesson with my Integrated Science classes which consist of freshmen students. It is designed as a performance task to assess my students on motion and forces concepts. The overall unit typically takes up to 3 weeks to complete for my classes that operate on a (84 minute) blocked schedule or may take up to 6 weeks to complete for those class periods that are between 50 & 60 minutes in length. The final product (the motion model) which is the focus of the submitted lesson will take 3-4 days of blocked classes to complete.

To teach motion and forces effectively, it is a must that multiple hands-on activities are implemented. My students do not design their models until they have completed several other activities to learn the concepts relating to motion and forces. Some examples of activities students are actively engaged in throughout this unit include: an investigation of air resistance and terminal velocity by constructing parachutes and dropping raw eggs, calculations of elastic and gravitational potential energy and kinetic energy with homemade bouncing balls, construction of a slow roller to demonstrate, calculate and graph negative and positive acceleration, performing investigations to demonstrate the different types of friction using water bottles with baking soda and vinegar, demonstration of Newton's Laws with various activities such as shooting rubber bands and pulling a tablecloth out from under dishes, and writing a letter to the school principal convincing him of why a field trip to KY Kingdom would be educational.

The assessment model is a means for my students to apply the concepts in a manner that will allow them to take ownership of their learning and help them better understand how motion and forces affect and relate to our everyday lives. This unit addresses the components of the state and national standards from applying concepts with models to constructing graphs and computing mathematical calculations related to motion and forces.

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Standards

National

- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship $F = ma$, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.
- Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.
- All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

Kentucky Program of Studies

- Students will design and conduct investigations involving the motion of objects and report the results in a variety of ways.
- Students will investigate Newton's Laws of Motion and Gravitation. Experimentally test inertia and gravitational acceleration.
- Students will experimentally test conservation of momentum. Use tables, charts, and graphs in making arguments and claims in oral and written presentations.
- Students will create and analyze graphs, ensuring that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly.
- Students will create conceptual and mathematical models of motion and test them against real-life phenomena.
- Students will predict which forces would be predominant in a given system and explain.

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Objectives

Students will achieve an understanding of motion and forces concepts that will enable them to calculate various mathematical problems related to those concepts and describe motion and forces as they relate to real-world phenomena. They will enhance their knowledge of the concepts with the foundation provided from this unit so to achieve success in subsequent physics courses. Extensions beyond the classroom of this unit might include students' awareness and application of concepts as they relate to and affect the sports they play, driving experiences, and trips to amusement parks. One crucial message I want the students to take from this lesson is the importance of wearing seat belts.

Essential Questions:

1) How can motion of real-world phenomena be demonstrated and described conceptually, mathematically, and with models?
2) What forces affect the motion of real-world phenomena?

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Essential Vocabulary:

- Displacement
- Frame of Reference,
- Constant speed
- Average speed
- Velocity
- Acceleration
- Net force
- Balanced forces
- Unbalanced forces
- Friction
- Static friction
- Sliding friction
- Air resistance
- Terminal velocity
- First law of motion
- Inertia
- Second law of motion
- Third law of motion
- Mass
- Gravity
- Weight
- Centripetal force
- Momentum
- Potential Energy
- Kinetic Energy
- Mechanical Energy

Mathematical Calculations:

- Potential Energy(Gravitational and Elastic)
- Kinetic Energy
- Mechanical Energy
- Average speed
- Constant speed
- Velocity
- Terminal Velocity
- Momentum
- Acceleration
- Net Force

Assessment Activity (Motion Model):

The objective of the assessment activity is to provide students with a performance task so they can apply the motion and forces concepts learned throughout the unit.

Materials:

- 1-½ to 2 inch pipe insulation (5 halved sections per group)
- Masking tape
- Duct tape
- Tooth picks
- Peg boards
- Rubber bands
- Straws
- Poster board
- Marbles
- Stop watches
- String
- Paper clips
- Empty 2-liter bottles

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Procedure

- Purchase 3-5 strips of pipe insulation (per group of students) at a hardware store.
- The pipe insulation should be no smaller than ¾ inch in diameter. (One side of the pipe insulation should already be slit with tape on it.)
- Using a razor blade or other sharp cutting tool, slice down the other side of the pipe insulation so you have two pieces. These will be your tracks.
- If your students want tunnels for their model, you can simply cut one strip in half (or how ever long you want) instead of slicing it down the side.
- The pieces of pipe insulation can be connected together with duct tape, broken toothpicks, paper clips, string, etc… To make the first hill, we attach the top of the model to the ceiling or a cabinet with a piece of string or duct tape.
- If you cut the top off of a 2-liter bottle, students can attach it to the model and use it as a funnel for the marble to fall through. As the marble spins around in the bottle, it will demonstrate centripetal force.
- To demonstrate momentum, have the students place a marble on a level spot on the track for the first marble to hit and send on through the rest of the track.
- To demonstrate Newton's 3rd Law, my kids usually place something at the end of the track for the marble to hit and bounce off.

The construction typically takes 2 full class periods of my 84 minute blocked classes. A third class period is used for my students to present their models to younger students, peers, and/or the administration. These presentations provide evidence for me that my students have learned the concepts. I encourage my students to develop a theme for their models and decorate to allow for more ownership in the project. The model must be given a creative name and poster boards should display the graphs and other pertinent information to help explain the concepts. This project is so engaging that I have to literally make my students leave so I can get my next group of students in the room to begin my next class.

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Scoring Guide

THIS IS ONLY A TEST (Motion & Forces)

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THIS SHEET MUST BE ATTACHED TO THE FRONT OF YOUR PACKET YOU TURN IN.

You will design a motion model that demonstrates the motion and forces concepts you have learned with this unit. Your mathematical calculations must relate directly to the performance of your model.

Whole Group Scoring Guide:

- Creativity worth 20 points (e.g. design, name, theme, decorations, etc.)
- Demonstrates motion concepts worth 25 points (1 point each)
- Accuracy of measurements & tests performed worth 20 points (includes: distance traveled per second for calculation of average speed, height of coaster, acceleration at a certain point, mass of marble, distance traveled, marking meters)
- Performance worth 15 points (e.g. motion model does what it's designed to do)
- Presentation worth 20 points (e.g. accuracy of concepts explained, effective explanations for age group, more than one person involved with each presentation, etc.)

Individual Scoring Guide:

You must have a separate sheet for each criteria listed below and stapled together in the order listed below for your packet: First sheet is this handout (Scoring Guide).

- Mathematical Calculations worth 24 points (3 points each—1 pt. for correct unit) These include: average speed, any point of constant speed, momentum, acceleration at 1 point, net force at one point, potential energy, kinetic energy, mechanical energy).
- Line graph of average speed worth 6 points (use graph paper).
- Colored illustration of model with concepts labeled worth 20 points (concepts to label include: potential energy, kinetic energy, centripetal force, momentum, inertia) (use copy paper).
- Description of how each concept is demonstrated worth 25 points. (See concepts in notes).
- Justification of how motion model enhanced your understanding of motion and forces concepts worth 25 points. (Discuss your knowledge of concepts before beginning this unit, throughout the unit, and at the end of the unit when the motion model was designed. Include how this model will benefit you with real-world experiences.)

GROUP GRADE: ____________________ INDIVIDUAL GRADE: ____________________