Hitting the Slopes

Overview

Description

Students will examine some simple plots of a person sliding down a snow-covered hill on a sled and relate this to the rider's speed and position along the route. These plots will guide students though different aspects of conservation of energy – addressing initial potential and kinetic energy, conversion of potential to kinetic and vice versa, total energy of a system, and transfer of energy to the surroundings via friction.

Final Product: Students will work in groups to help find their particular weaknesses in the area of conservation of energy and then work individually to write a brief abstract describing conservation of energy, making generalizations that they learned from the different scenarios they investigated in the group work section. Students should not focus on particular examples, but rather address the general ideas – though the use of examples may be helpful to illustrate their generalizations.

Subject

Physics

Task Level

Grade 11

Objectives

Students will:

- Be able to relate height of a hill to potential energy in graphical form.
- Relate the transfer of potential and kinetic energy to total energy of a system.
- Be able to integrate the concept of energy transfer to the surroundings in terms of total energy of the system.

Preparation

- For each student, make a copy of the Student Notes and Handouts pages.

Prior Knowledge

Students should understand the concepts of conservation of energy and transformation of energy from one form to another.

Key Concepts and Terms

- Conservation of energy
- Energy loss and non-conserved system
- Kinetic energy
- Potential energy

Time Frame

This assignment typically requires one or two class periods for a total time of approximately two hours. Additional time may be required if students are not familiar with writing an abstract. To enhance the writing component of the activity, include an additional class period for peer review of first drafts of the abstract. This class period might include some sample abstracts (both related and unrelated to the activity), small group peer review, and some class-wide discussion of a few volunteers' work. This assignment can be modified to meet the needs of different classroom schedules and student ability levels.

Instructional Plan

Getting Started

Learning Objectives

Students will:

- Refresh their understanding of conservation of energy.

Procedure

1. Review the basic concepts of conservation of energy, potential energy, and kinetic energy.
2. Remind students that energy is neither created nor destroyed but rather converted from one form to another.
3. Remind students that any energy "lost" is really energy transferred to an external object not included in our "system."
4. Ask for any comments or questions.

Investigating

Learning Objectives

Students will:

- Self-assess individual weaknesses related to conservation of energy.
- Address difficulties individual students have and common misconceptions in group work related to conservation of energy.
- Further their knowledge of energy by adapting to new situations as well as explaining to fellow classmates their reasoning behind their arguments.

Procedure

1. Have the students work alone (with neither calculators nor computers) to interpret the graphs of a rider sliding down an icy hill in terms of energy and general motion in Activity 1.
2. After they finish with each section, have them work in groups of two or three to compare their answers and convince each other of their answer if there are any discrepancies. Students should write down notes to help them remember what they are discussing.
3. While the students work in groups, walk around the room and provide thought-provoking questions to encourage them to overcome any incorrect thought processes they may be stuck on.

4. When each group has completed their discussion, have them revisit their discussion but with the new situations outlined in Activity 2 (initial velocity due to a running start) and Activity 3 (hill friction).
5. Optional, have the students discuss what would happen if they included both a running start as well as friction (Activity 4).

Drawing Conclusions

Learning Objectives

Students will:

- Effectively and concisely communicate their understanding of conservation of energy.
- Disseminate the key points of the activity.

Procedure

1. Students will type a short (less than 1 page, double-spaced) abstract summarizing the key points of activity and concept of conservation of energy.
2. This should be direct and to the point and cover things as generally as possible, citing specific examples from the activity where appropriate.
3. Inform the students that an abstract is a key component to any scientific paper and should contain all the key information that a scientific paper will address but without the detail of a more formal paper.

Scaffolding/Instructional Support

The goal of scaffolding is to provide support to encourage student success, independence, and self-management. Instructors can use these suggestions, in part or all together, to meet diverse student needs. The more skilled the student, however, the less scaffolding that he or she will need. Some examples of scaffolding that could apply to this assignment include:

- Perhaps highlight for students that the “starting point” on each plot is the left side of the graph (though, of course, students are free to consider what happens when one starts sledding from elsewhere).
- Ask the students what would happen if some part of a particular hill was higher or lower.
- Ask the students what would happen if the rider started with a faster running start.
- Ask the students what would happen if the ground was rougher or smoother.
- Feel free to have the students use any tracks, slopes, carts, etc., to help them if they need them.
- Some students might struggle with the fact that the abstract they are writing merely summarizes their ideas about conservation of energy and does not involve any hypothesis generation or data analysis. Suggest to them that the goal here is not to make an abstract that “looks” like an abstract for a scientific research paper, but rather to practice concisely describing somewhat complicated material (to use as few words as possible to highlight all of the most important ideas that have come out of this activity). To put it a bit differently, the abstract that students are writing in this activity might ultimately be the first part of an actual abstract in which someone is testing something about conservation of energy while sledding.

Solutions

The information below is intended to help you assess students' final work products. It may not represent all possible strategies and ideas. The accompanying scoring guide provides specific examples of ways a student might demonstrate content understanding and mastery of cross-disciplinary skills.

Necessary Elements

- Rider starts at the top of the hill and gains speed as he/she proceeds down the hill. At the bottom, he/she has obtained the fastest speed possible as all the potential energy (graph should look very similar to the shape of the hill) is converted to kinetic energy. For all the graphs, the kinetic energy should follow the opposite of the potential energy (if the PE goes down, the KE should go up by the same amount). The total energy for all the graphs should be constant.
- Rider starts at top, reaches highest speed at the lowest point and still makes it up the slightly lower hill with some velocity (not as high as the top speed).
- Same as previous, but the final speed is essentially zero because rider reaches the same height as when started.
- Same as previous, but the rider only reaches up to the same height as when started then will probably reverse and slide backwards back to the starting location.
- Rider starts and picks up speed as he/she goes down the first hill (bottom is max speed). Rider slows down as he/she goes up the second hill. When rider goes down, he/she again gains speed and at the bottom has a speed not as large as the top speed. Rider goes up the last hill and ends with some velocity.
- Rider goes down the hill and gains speed (max speed at bottom). Rider then starts to go up the second hill but doesn't make it up because rider's velocity goes to zero when rider reaches the same height as when rider started the run. If rider gets a running start, rider will go higher up the hill and if rider runs fast enough, rider will make it over the second hill and continue similar to the situations mentioned above.

Key Connections

- Height of the hill relates to the potential energy.
- The speed of the rider is related to the kinetic energy.
- The total energy is constant throughout the rider's run and is equal to the kinetic energy and potential energy.
- The energy of the system can be transferred back and forth between potential and kinetic energy.
- The total energy of the system can be lost due to transferring some of the energy to the surroundings.

Common Misconceptions

The following statements are true, although some students may struggle to understand why they are true.

- With neither friction nor a running start, the height a rider can achieve is equal to the height he/she started at.
- Friction will take away total energy so heights and/or speeds will be lower/slower than the situation without friction.
- Running gives an initial kinetic energy, not an initial potential energy.

TCCRS Cross-Disciplinary Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Key Cognitive Skills			
A.1. Engage in scholarly inquiry and dialogue.	✓	✓	
A.2. Accept constructive criticism and revise personal views when valid evidence warrants.	✓	✓	
B.1. Consider arguments and conclusions of self and others.	✓	✓	✓
B.2. Construct well-reasoned arguments to explain phenomena, validate conjectures, or support positions.	✓	✓	✓
B. 4. Support or modify claims based on the results of an inquiry.		✓	✓
D.1. Self-monitor learning needs and seek assistance when needed.	✓	✓	✓
D.3. Strive for accuracy and precision.	✓	✓	✓
D.4. Persevere to complete and master tasks.	✓	✓	✓
E.1. Work independently.	✓		✓
E.2. Work collaboratively.		✓	
II. Foundational Skills			
B.1. Write clearly and coherently using standard writing conventions.			✓
C.5. Synthesize and organize information effectively.	✓	✓	✓

TCCRS Science Standards Addressed

Performance Expectation	Getting Started	Investigating	Drawing Conclusions
I. Nature of Science: Scientific Ways of Thinking and Learning			
A.2. Use creative and insight to recognize and describe patterns in natural phenomena	✓	✓	✓
C.1. Collaborate on joint projects		✓	

E.1. Use several modes of expression to describe or characterize natural patterns and phenomena. Those modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic	✓	✓	
E.2. Use essential vocabulary of the discipline being studied.	✓	✓	✓
II. Foundational Skills: Scientific Applications of Mathematics			
B.2. Represent natural events, processes, and relationships with algebraic expressions and algorithms.	✓	✓	✓
III. Foundational Skills: Scientific Applications of Communication			
A.1. Using correct application of writing practices in scientific communication			✓
B.3. Recognize scientific and technical vocabulary in the field of study and use this vocabulary to enhance clarity of communication.		✓	✓
C.1. Prepare and present scientific/technical information in appropriate formats for various audiences.			✓
VIII. Physics			
C.1. Understand the fundamental concepts of kinematics.	✓	✓	✓
D.1. Understand potential and kinetic energy	✓	✓	✓
D.2. Understand conservation of energy	✓	✓	✓
D.3. Understand the relationship of work and mechanical energy	✓	✓	✓

TEKS Standards Addressed

Hitting the Slopes - *Texas Essential Knowledge and Skills (TEKS): Physics*
112.39.c.1. Scientific processes. The student conducts investigations, for at least 40% of instructional time, using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to: 112.39.c.1.A. demonstrate safe practices during laboratory and field investigations.
112.39.c.2. Scientific processes. The student uses a systematic approach to answer scientific laboratory and field investigative questions. The student is expected to: 112.39.c.2.F. demonstrate the use of course apparatus, equipment, techniques, and procedures, including multimeters (current, voltage, resistance), triple beam balances, batteries, clamps, dynamics demonstration equipment, collision apparatus, data acquisition probes, discharge tubes with power supply (H, He, Ne, Ar), hand-held visual spectroscopes, hot plates, slotted and hooked lab masses, bar magnets, horseshoe magnets, plane mirrors, convex lenses, pendulum support, power supply, ring clamps, ring stands, stopwatches, trajectory apparatus, tuning forks, carbon paper, graph paper, magnetic compasses, polarized film, prisms, protractors, resistors, friction blocks, mini lamps (bulbs) and sockets, electrostatics kits, 90-degree rod clamps, metric rulers, spring scales, knife blade switches, Celsius thermometers, meter sticks, scientific calculators, graphing technology, computers, cathode ray tubes with horseshoe magnets, ballistic carts or equivalent, resonance tubes, spools of nylon thread or string, containers of iron filings, rolls of white craft paper, copper wire, Periodic Table, electromagnetic spectrum charts, slinky springs, wave motion ropes, and laser pointers; 112.39.c.2.G. use a wide variety of additional course apparatus, equipment, techniques, materials, and procedures as appropriate such as ripple tank with wave generator, wave motion rope, micrometer, caliper, radiation monitor, computer, ballistic pendulum, electroscope, inclined plane, optics bench, optics kit, pulley with table clamp, resonance tube, ring stand screen, four inch ring, stroboscope, graduated cylinders, and ticker timer; 112.39.c.2.K. communicate valid conclusions supported by the data through various methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports; and 112.39.c.2.L. express and manipulate relationships among physical variables quantitatively, including the use of graphs, charts, and equations.
112.39.c.3. Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: 112.39.c.3.A. in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.

Hitting the Slopes - *Texas Essential Knowledge and Skills (TEKS): Physics*
112.39.c.4. Science concepts. The student knows and applies the laws governing motion in a variety of situations. The student is expected to: 112.39.c.4.A. generate and interpret graphs and charts describing different types of motion, including the use of real-time technology such as motion detectors or photogates.
112.39.c.6. Science concepts. The student knows that changes occur within a physical system and applies the laws of conservation of energy and momentum. The student is expected to: 112.39.c.6.A. investigate and calculate quantities using the work-energy theorem in various situations; 112.39.c.6.B. investigate examples of kinetic and potential energy and their transformations; and 112.39.c.6.D. demonstrate and apply the laws of conservation of energy and conservation of momentum in one dimension.

Hitting the Slopes

Introduction

In this activity, you will be asked to consider a scenario of a person sliding down a snowy hill in the winter on a sled. The graphs you will be presented represent the profile of the hill. You will be asked to come up with what is happening to the rider as she travels down the hill. Pay attention to the rider's speed and direction.

Directions

Getting Started

1. Pay attention as your teacher reviews the concept of conservation of energy.
2. On your own, look at the graphs presented in Activity 1 and try to figure out what is happening to the rider as he/she proceeds down the hill. Make careful notes on what your thoughts are and what reasoning you are using. Be prepared to scientifically argue your point to your fellow classmates.

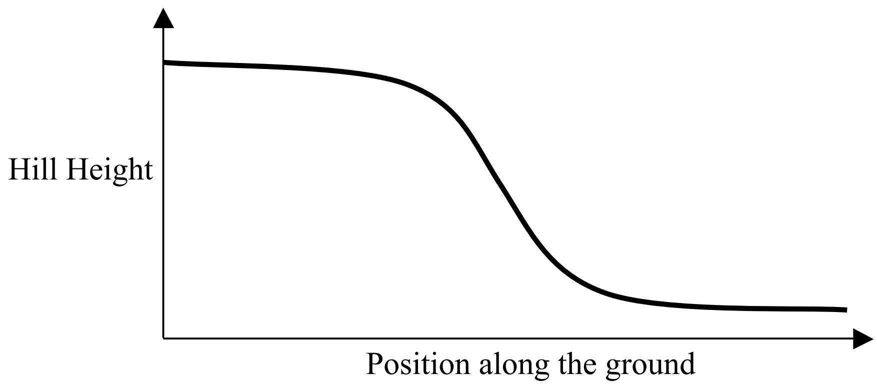
Investigating

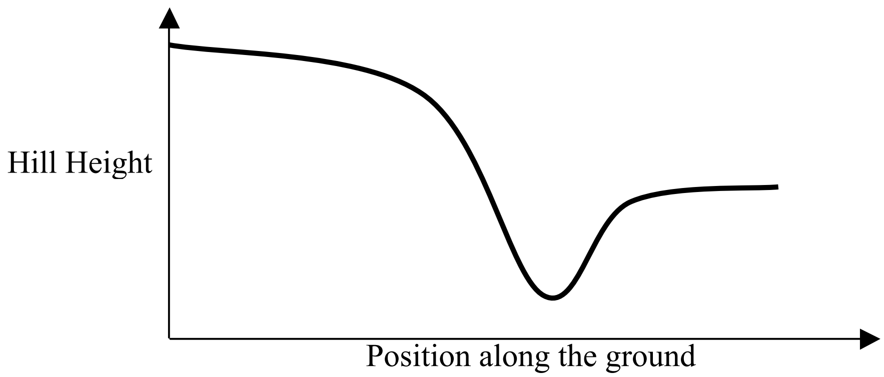
1. Work together in groups of 2 or 3 and try to convince your classmates what you think is happening in reference to the rider and the sledding hills presented in Activity 1. If you and any members of your group do not agree on your interpretation of the rider's motion, discuss this with each other and try to logically come to a consensus.
2. Once you and your group reach a consensus on the rider's motion, you should modify your notes on each scenario to make sure you have the right explanations.
3. Move on to Activity 2, and in your group, figure out how to modify and append your responses to Activity 1 to incorporate the new information. Make sure you take careful notes.
4. Do the same for Activity 3.

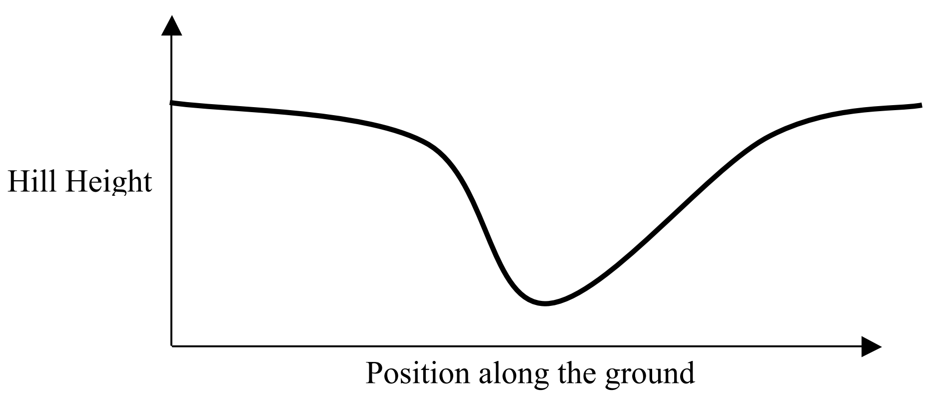
Drawing Conclusions

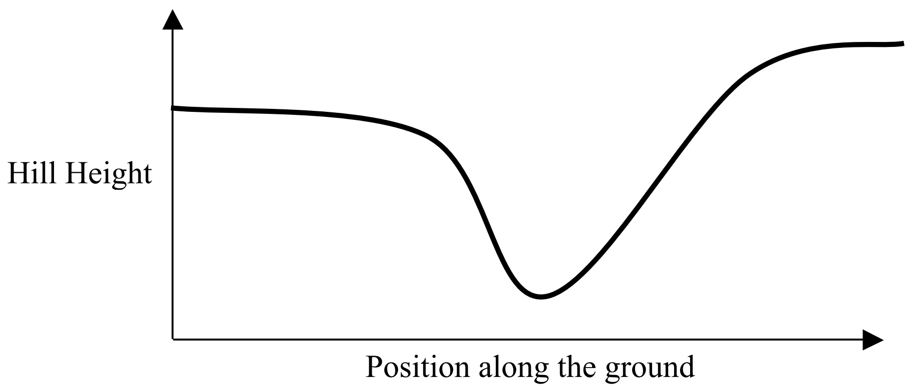
1. Using your notes, individually write a brief and concise abstract (less than one page, double-spaced) discussing the concept of conservation of energy. You should strive to make as many general statements as you can, though referencing the examples is ok. The point of the abstract is to give the reader a quick but thorough description of what you are writing about.

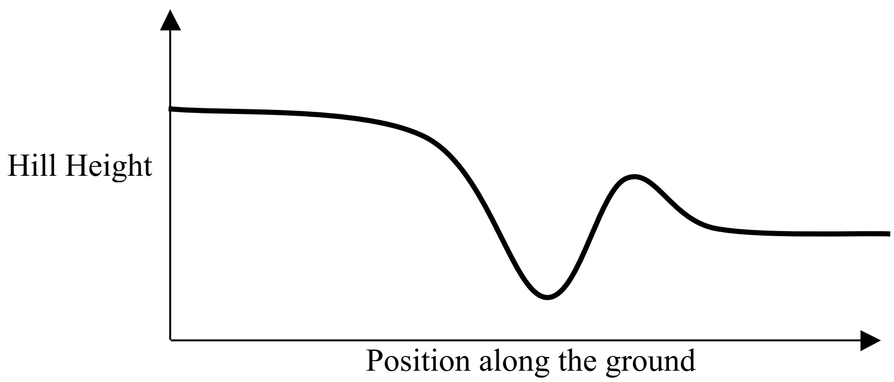
Activity 1 – Conservation of Energy:

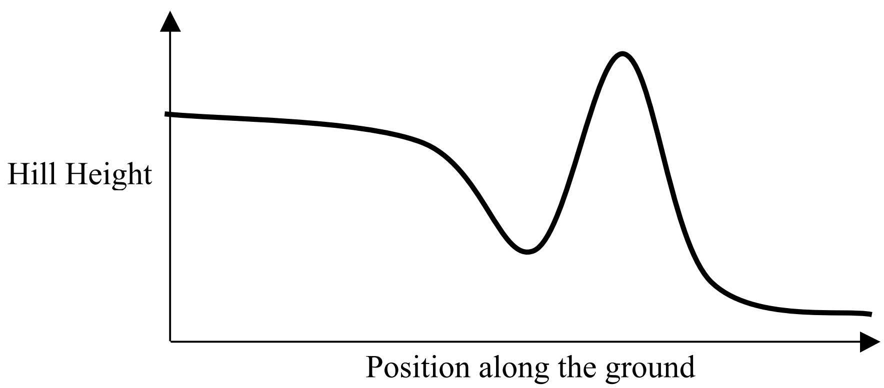







Hill Height
Position along the ground


Hill Height
Position along the ground


Hill Height
Position along the ground

Activity 2 – Initial Kinetic Energy:

Revisit the graphs in Activity 1 and consider what would happen if the rider took a running start before sliding down the hill. What can you say about the new motion that the rider would experience?

Activity 3 – Loss of Energy:

Consider what would happen if the rider went down a hill that was covered with dirty and sandy snow.

Optional Extension:

Activity 4 – Initial Kinetic Energy and Loss of Energy:

Consider the scenarios in Activity 1 with the additions of both initial kinetic energy (Activity 2) as well as loss of energy (Activity 3).