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> "For generations, teaching physics has been more about manipulating math problems than learning the basic principles that guide the discipline. That's precisely why, according to a growing body of research, even students who aced physics courses often don't understand the field."
>
> —**David Hoff,** *Education Week*, March 2003

The practice of teaching physics through difficult math problems has not only handicapped most students who would otherwise understand physics, but it has even handicapped those who do understand the math. SKATEBOARD SCIENCE proves that much of basic mechanics—the physics of motion—can be understood with minimal math and through hands-on experiences.

Working in teams, students build and experiment with three-dimensional models of skate park equipment to explore the physics of skateboarding. Then using what they have learned about potential and kinetic energy, friction, and inertia, they design and build a cardboard working skate park! As part of the final activity, students send marble "skaters" through their park, and explain how the skater and each piece of equipment demonstrate the physics of motion.

Knowledge

- Understand working definitions of matter and energy
- Recognize examples of transformations of energy
- Understand the difference between potential and kinetic energy
- Understand a working definition of force and recognize that gravity is a force
- Understand that matter is composed of atoms and molecules that are "wiggling and jiggling" and that heat is the average speed of these moving atoms
- Understand that when a moving object contacts another object, some of the moving object's energy is transferred to the atom movement in the second object. Friction is an example of this kind of transfer.
- Realize that the sun is the source of almost all energy on earth

Skills

- Follow detailed directions for construction and scientific investigations
- Collect data through measurements
- Record observations, make speculations, and draw conclusions from data
- Work cooperatively to complete a team project safely and on time

Attitudes

- Gain confidence that they can learn even "difficult" subjects such as physics by conducting investigations, making observations, and drawing conclusions
- Appreciate that physics is part of our everyday life, and not just a subject in school
- Appreciate the advantages of teamwork and shared responsibilities

PURPOSE

Phase One — Learning about *Mechanics — the physics of motion*
Working in teams of four, the students build skate park obstacles and test them with marble-skaters. As they perform different inquiry activities, they learn how to keep the marble-skater safely on the track, how to reduce loss of energy through friction, and how to ensure the marble-skater has enough energy to flow from one obstacle on to the next. Daily background essays explain concepts such as potential vs. kinetic energy, conservation of energy, and friction. Teams earn Construction Cash for good cooperative work, sound scientific procedures, and clear explanations of the physics behind each of the obstacles. Their goal in this Phase is to discover how the laws of mechanics control the behavior of a marble-skater.

Phase Two — Designing and Building a Skate Park
Each student team designs and builds a working model of a skate park. They may use some or all of the obstacles built in Phase One as part of their final model. They use the Construction Cash earned in Phase One to buy and build additional obstacles to enhance their park design. Their goal in this phase is to produce a skateboard park with the best "flow." Good flow is rewarded in Phase Three because teams earn more points when their marble-skater flows continuously from one obstacle to another.

Phase Three — *Skate Park Expo*
At the *Skate Park Expo*, student teams demonstrate their skate park models to an audience of "investors." Teams try to convince investors that their design will attract many customers and result in a better investment return. Teams able to explain the physics principles that underlie their park design will impress investors. Parks with good "flow" earn more investment points. Injuries and the resulting insurance liability may cause investors to shy away, even if the design is exciting. The team's goal in this phase is to design and demonstrate the most exciting, yet safest possible skate park.

Differentiated Instruction
Like all Interact units, SKATEBOARD SCIENCE provides differentiated instruction through its various learning opportunities. Students learn and experience the knowledge, skills, and attitudes through multiple intelligences as described by Howard Gardner. Adjust the level of difficulty as best fits your students. Assist special needs students in selecting activities that utilize their strengths and allow them to succeed. Work together with the Resource Specialist teacher, Gifted and Talented teacher, or other specialist to coordinate instruction.

ABOUT SKATEBOARD SCIENCE AND PHYSICS

Mechanics, the branch of Physics that deals with motion, has the reputation for being challenging to students and overwhelming to teachers not specifically trained to teach it. Why is that?

Physics demands three ordeals from its students.

1. Several key concepts are difficult to describe and define. For example, the relationships among *work*, *force*, and *energy* must be understood together right at the beginning, yet even university professors are very careful about describing the nature of energy.

2. Introductory Physics courses use algebra to describe relationships. It's not advanced algebra, just entry-level equations. But many students who can easily manipulate equations do not have the conceptual understanding of the operations needed to select the algebraic operation for a particular Mechanics situation.

3. Mechanics, more than any other science, begins with a handicap. We routinely use the words *work*, *energy*, *inertia*, and *momentum*. They serve us well conveying shared meaning in our everyday conversations. Unfortunately, the commonly held meanings of these words are worse than wrong—they are terribly misleading in the context of mechanics. Before progress can be made, the student must "un-learn" these incorrect definitions. The student readings explain the correct meanings in the context of the simulation.

SKATEBOARD SCIENCE does not require that students use algebra.

SKATEBOARD SCIENCE is not intended as a whole course in Mechanics. However, it is an excellent readiness activity for Physics. SKATEBOARD SCIENCE introduces several key concepts in a setting that allows students to discover their significance.

To do this in less than 15 days, the scope of concepts has been carefully selected. *Only* those concepts that are well demonstrated by the activities are introduced. In some cases, obvious extensions have not been followed to the next concept. For example, the concept of *impulse* (another word with special meaning in Physics) has not been developed from collisions.

UNIT TIME CHART

PHASE ONE

DAY 1

- Introduce subject of skateboarding
- Student Guide pages 1–3
- Determine prior knowledge of skateboarding and mechanics—the physics of motion
- COOPERATIVE GROUP WORK RUBRIC
- HISTORY OF SKATEBOARDING
- VOUCHER 1
- Skate Park Safari — (optional)

DAY 2

- Assume roles and name teams
- Build the First Chute
- Recognize a basic definition of matter and energy
- Recognize transformations of energy
- FIRST CHUTE PLANS
- ENERGY

DAY 3

- Use First Chutes to explore potential and kinetic energy
- Study relationship between potential energy, kinetic energy, and speed.
- Measure the height of the chutes
- POTENTIAL ENERGY AND KINETIC ENERGY
- HOW TO MEASURE HEIGHT
- INVESTIGATION #1: First Chute Operations

PHASE ONE

DAY 4

- Use First Chutes to explore potential energy and kinetic energy
- Understand that force is a "push or pull" and that the force of gravity "pulls" objects towards the Earth
- Build an Improved Chute
- FORCE AND GRAVITY
- IMPROVED CHUTE PLANS
- MECHANICS LOG
- INVESTIGATION #2: Improved Chute Operations

DAY 5

- Continue to use chutes to discover the nature of potential and kinetic energy
- Understand that all matter has atoms that are wiggling and jiggling
- Begin to understand friction
- Build and measure a Quarter Pipe
- Learn to calculate loss of kinetic energy due to friction
- WHAT IS FRICTION?
- QUARTER PIPE AND HALF PIPE PLANS
- MECHANICS LOG
- INVESTIGATION #3: Calculating Friction

PHASE ONE

DAY 6

- Complete Challenges during which students apply what they have learned about transformation of energy and friction
- Realize that the sun is the source of almost all energy on earth
- ZAZOO

DAY 7

- Continue to use chutes and quarter pipes to discover the nature of potential and kinetic energy and of friction
- Continue to explore the relationship between potential energy, kinetic energy, and speed
- Begin to understand inertia
- Build a Street Spine with Catcher
- INERTIA, NEWTON, AND STREET SPINES
- GLUING
- STREET SPINE AND CATCHER PLANS
- MECHANICS LOG
- INVESTIGATION #4: Street Spine and Catcher Operations

UNIT TIME CHART

PHASE TWO

DAY 8	DAYS 9–10	DAYS 11–12
• Take a formative assessment • Make final accounting of Construction Cash • Plan Skate Parks using available Construction Cash • FORMATIVE ASSESSMENT • VOUCHER 2 • SKATE PARK PLANNER	• Teams build obstacles for their Skate Parks • Suspend Roles • RAMP PLANS • FULL PIPE PLANS • FLYBOX AND PYRAMID PLANS (WITH TURNER)	• Resume roles • Assemble and test the Skate Parks • Apply what they know about physics to adjust their park to maximize "flow" • MECHANICS LOG (optional) • INVESTIGATION #5: Constructing your own Obstacles

PHASE TWO

DAY 13	DAY 14
• Finish assembling and testing the Skate Parks • Determine the friction loss and retained energy within a continuous run of obstacles in their Skate Park • Name their Skate Parks • Create "ad" copy, posters, etc. to hype the skate parks • MECHANICS LOG (optional) • SKATE EXPO SCORE SHEET	• Determine possible scores and make final adjustments to their working Skate Park model • Work together to explain the physics behind their skate park design • MECHANICS LOG (optional) • ORAL PRESENTATION RUBRIC: Content • ORAL PRESENTATION RUBRIC

PHASE THREE

DAY 15	DAY 16
• Present working skate park models to an audience of "investors" • Run marble-skaters through their working models • Score their working models • INVESTOR'S VOUCHER • ORAL PRESENTATION RUBRIC: Content • ORAL PRESENTATION RUBRIC	• Debrief using KWL charts from Day 1 • Take final assessment • Accept awards (optional) • KWL charts (from Day 1) • FINAL ASSESSMENT 1 or 2 • AWARDS

11. Walk around the room watching teams work. Make note of team and individual cooperative behavior in order to award Construction Cash. The Student Guide (on page 8) lists the amount of Construction Cash teams can accrue when working according to the **Cooperative Group Work Rubric**. Adjust if necessary for your classroom situation.

12. Ask teams to share what they thought were the most significant events and why they chose them.

13. Have each team hand in their Student Guides so that you can place them into their Team Folders. Before the next class determine how much Construction Cash each team earned. Prepare VOUCHERS for each team.

TEACHING TIP

To make this task easier, specifically keep track of those students or teams who are **Exemplary** *and those who are not working to the* **Expected** *level. The rest will fall in the* **Expected** *range.*

Optional Extensions

1. For extra credit or Construction Cash that they can use in the simulation, allow teams to make a Skateboard History Time Line displaying the events they chose. See specific directions on page 58.

2. If you have access to computers in school, or if students have access to computers at home, have students complete the Skate Park Safari. See specific directions on page 60.

TEACHING TIP

Remind students that time lines must be drawn with equal intervals regardless of the number of events in a year.