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Conservation of energy - Energy is the basis of all physics, yet its exact definition is elusive. We don't really begin to understand energy until the latter half of the 18th century when heat energy was intensively studied; the industrial revolution was the result. The rise of mechanical machines was based on the new knowledge and understanding of heat energy. Less obvious, but just as important, were the beginnings of electrical energy at the same time, but the two remained as separate studies. In the 1840's, however, that changed when James P. Joule studied both; he discovered that mechanical energy, heat energy, and electrical energy are interchangeable and are simply transferred without being created or destroyed. Or simply, energy is conserved. I've always thought of energy as a nothingness that can do something (cause motion). It is much like the human spirit; both are present but can not be truly grasped, or both are elusive.

What follows are some of my favorite demos to show reasonably well, conservation of energy; if they worked perfectly you would have perpetual motion! But, of course, they don't, but do show a high percentage of transfer with only small "loses". The number of demos on the same theme, however, is endless.

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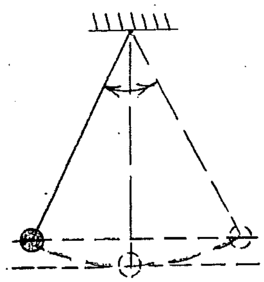

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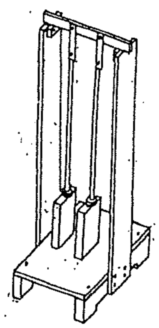

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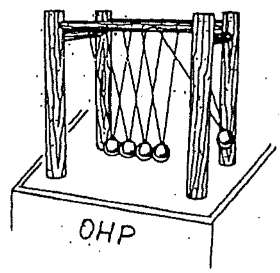

(a) If one thinks KISS, the first demo on conservation of energy is probably the pendulum with a strong nylon thread and a 1" dia. brass sphere. Air resistance (drag) and visibility are always factors to consider in choosing the "ideal" size of the bob (1.).

(b) A mass (500 gm or 200 gm?) hung on a flexible spring that will oscillate smoothly makes a very nice "energy" demo. In the late 20th century, there was a quality, tapered spring available made just for this purpose. It had "stiffer" coils at the top to support the weight of the lower coils in the spring as well as the hanging mass. It evened out the expansion (elongation) between the coils, top and bottom. It was a steel spring, brass-coated. This demo's explanation is much more complicated because you are now dealing with gravitational potential energy and the spring's elastic potential energy simultaneously. The kinetic energies involved are likewise entangled. Despite the complex explanation, the demo is very pleasing to watch (2.).

(c) See "Resonance pendulums" elsewhere on this website. Conservation of energy is well-displayed using this apparatus. The transfer of energy between the pendulums is dramatic (3.).

(d) Although the "Original Swinging Wonder" with its swinging steel spheres is best at demonstrating the Law of Conservation of Momentum, it smultaneously is very good at demonstrating the Law of Conservation of Energy (4.). See "Demonstrations with the OHP" elsewhere on this website; it explains an effective way to display the apparatus to a classroom audience.

(e) Many years ago,expensive, metal tracks like those pictured below were commercially available for these energy demos. Today, however, we have the inexpensive Mattel Hot Wheels products that are almost as good and are definite attention-getters. Two different, but related, set-ups will be explained.

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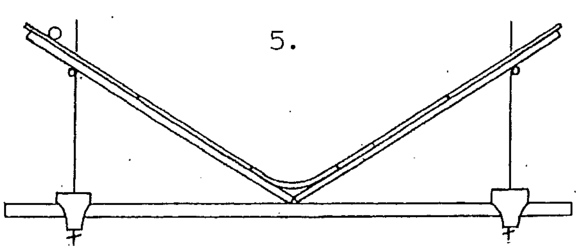

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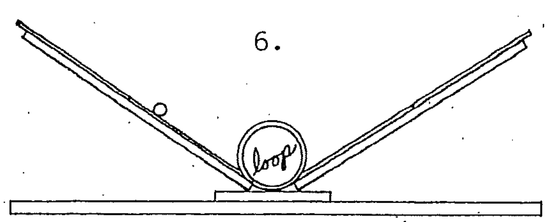

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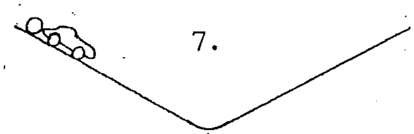

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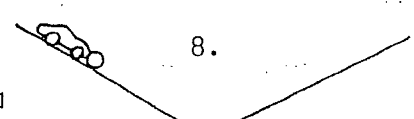


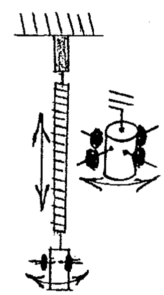
(1) Start with the simple potential- kinetic energy interaction of "hill and valley" (5.). My Mattel set had 24" long track, so 4 regular sections and one 14" center section (cut from a 24") were pieced together as shown. They were centered on two, 4' long, 3/4" pine sticks, 2" wide and held down with small C-clamps on each end. The sticks rested on rods attached to ring stands. Choose your best Hot Wheel car and place it on the track at different locations for each trial. Now replace the car with a 3/4" dia. steel sphere. Does it make a difference? Hot Wheel cars are fast but consume a lot of energy.

(2) Set up a simulation of a popular amusement park ride (6.). Now you insert the Mattel "loop" accessory between the two 4' sticks. (The "loop" requires one 24" section of track.) I made a plywood platform, 6 3/4" x $10\frac{1}{2}$", and attached the "loop" accessory to it. I used 2 small, right angle alum. pieces and small bolts to fasten the "loop" to the plywood. A more permanent attachment could be made with hot glue. The platform should be attached (C-clamped?) to the table top to provide more rigidity.
Place the car on the track at different locations for each trial. When does it stop making it completely through the loop? Now replace the car with the steel sphere. Does it make a difference? The one great fault with the plastic, thus flexible, loop is the lack of rigidity that the old metal loops had. Work is done (energy used up) on flexing the loop's track, and the track never "restores" or gives the energy back to the car or sphere. Maybe you can figure out how to stiffen the loop's track and conserve more energy. Good luck.

(3) Something extra. Going back to set-up (1) and using diagram (7.), place the car and sphere on the track as shown. Let them go. Notice the difference in speed and the distance covered. Moment of inertia is much involved here; it is much greater in the large, heavy steel sphere. The Hot Wheel car's wheels have almost no moment of inertia, so their tiny, light wheels can rotate much faster. Now set up the car and sphere as in diagram (8.), and let them go. Why does the sphere go much higher up the track than usual? The faster car is constantly pushing (adding energy to) the slower steel sphere; thus, the car is losing energy (and distance).

(f) The Wilberforce pendulum - Still an intriguing apparatus to watch a century later, the Wilberforce pendulum (not a conventional, swinging pendulum) demonstrates the transfer of energy from an oscillating, elongating spring to an oscillating, rotating attached mass (9.). It is usually a commercial item, but with instructions from an old TPT magazine(s), one can be fabricated. The commercial version usually has a light, flexible spring (treat it with care!) and a hanging mass of about 200 gm with 4 protruding, threaded rods sticking out of its side with a thin nut on each rod. Moving the nuts closer to or farther from the center of the mass changes the rate of its rotary oscillation. This item is one of a kind; it is not essential but is one worth having if you have some "mad money" to spend.

9.



Presentation: Pull (stretch) the spring and mass straight down and carefully let go. As the spring contracts, the mass will begin to twist (rotate) back and forth. This rotation absorbs (gains) energy from the spring; the spring begins to lose energy and shortens its elongation while the mass begins to rotate faster and farther. Soon the point is reached when the spring stops elongating entirely, and the mass's rotary oscillation is maximum. A moment later, the rotary oscillation of the mass begins to lessen while the spring begins to oscillate and elongate again. When the spring's elongation is maximum, the mass's rotation is minimum. The energy transfer (conservation) can last several minutes; it is dramatic, fun to watch.