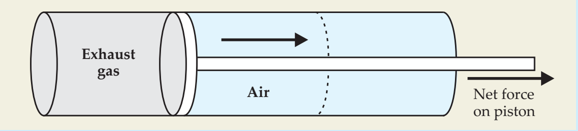
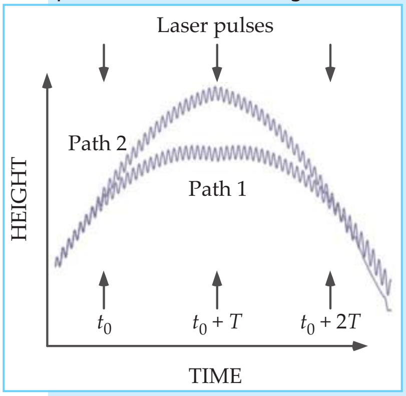
These items, with supplementary material, first appeared at http://www.physicstoday.org.

Tiny power boost from an entropy engine. In a combustion engine, work is produced from heat liberated by burning the fuel. In hydrocarbon fuel cells, the fuel is directly converted into electricity. Both types of engines, however, waste heat and emit gas byproducts that are considered useless—or even pernicious, as in the case of the greenhouse gas carbon dioxide. But Martin



Gellender, an environmental officer for the state government of Queensland, Australia, makes the case for exhaust gases as an energy source: In a conceptual paper, he explores the overlooked entropy increase that occurs when concentrated gases isothermally mix with air. As illustrated in the schematic, if an exhaust gas mixture containing, for example, CO_2 at a high concentration is separated from air by a piston–membrane barrier that selectively blocks CO_2 passage, the concentration gradient performs work on the piston until the CO_2 concentrations on both sides are equal. According to Gellender's calculations, a secondary entropy engine could theoretically recover up to 7% of the fuel's energy and could provide a power boost to the primary engine: up to 1.5% for combustion engines and up to 3.5% for fuel cells. He says that new fuel-cell designs and material advances could lead to a practical entropy engine that reduces the fuel consumption of power plants. (M. Gellender, *J. Renew. Sust. Energy* **2**, 023101, 2010.) —JNAM

Gravity affects how atoms interfere, just as relativity predicts. Among its marvelous consequences, general relativity asserts that a stationary clock at Earth's surface will run slower than one high in a tower where the gravitational potential is weaker; the phenomenon is called gravitational redshift (see the article by Neil Ashby, PHYSICS TODAY, May 2002, page 41). Now Holger Müller (University of California, Berkeley and Lawrence Berkeley National Laboratory) and colleagues report that the redshift idea, first experimentally confirmed 45 years ago, has passed its strictest test yet. In its analysis, the group reanalyzed a 10-year-old experiment that used atom interferometry to determine the gravitational acceleration. In that earlier work, an upward-directed atom interacted with a pair of laser pulses that put it in a superposition of states with differing momenta. As the figure shows, the phase of the atomic wavefunction evolves along each of the two paths, but with a lower frequency along the bottom path. A second pair of pulses tweaked the atom so that the diverging paths would reconverge; an experimental measurement of the probability that the atom is observed at the convergence point yields the phase difference between the two paths. As Müller and company discuss, the earlier-measured phase difference receives contributions due to the relative motion of the atom in its different states and from the laser interactions, but the two effects cancel. The total phase difference is attributable to the redshift. And to better than one part in 10^8, it is precisely what is predicted by general relativity. (H. Müller, A. Peters, S. Chu, *Nature* **463**, 926, 2010.) —SKB



Modeling human balance. The human body is an incredibly complex dynamical system, which makes it an increasingly appealing subject for nonlinear dynamicists. For example, even when we stand upright, we are not motionless—the body oscillates continuously at a low amplitude. But as we lean farther from the vertical, our response becomes more complicated. In the language of dynamical systems, the upright position is an attractor: As long as the body is in the vicinity of that position, it will be drawn upright. The various leaning positions from which one can right oneself constitute what's called the basin of attraction. The boundary of the basin separates the upright attractor from another attractor—the floor. If we lean too far, we fall down. Studying the self-righting ability of judokas and other elite athletes, María Zakynthinaki of Madrid's Institute for the Mathematical Sciences and colleagues at the Technical University of Madrid have shown that even when the basin of attraction of a person is rotated or skewed—due to athletic training, repetitive work motions, or injuries—the boundary of the basin can nevertheless be characterized by just four experimental parameters: the maximum lean from which one can regain balance in the general forward, backward, left, and right directions. Moreover, the researchers present a method for measuring and describing a person's basin geometry mathematically, which should prove useful for further modeling and simulation of balance. (M. S. Zakynthinaki et al., *Chaos* **20**, 013118, 2010; **20**, 013119, 2010.) —RJF

Geometrically frustrated boron. Boron's next-door neighbor in the periodic table, beryllium, forms a simple metal lattice at 0 K. Boron's other next-door neighbor, carbon, forms another simple structure at 0 K, graphite. As for boron itself, its most stable form at absolute zero is unknown. Compounding the mystery, the lowest-energy phase that experimenters have found, the β-rhombohedral phase, is stunningly complex and defect riddled: Each hexagonal unit cell has 423 atomic sites; on average only 320 of them are occupied. Now, Tadashi Ogitsu of Lawrence Livermore National Laboratory and his collaborators have explained why the stable β-rhombohedral phase has so many empty sites. If boron were simple, the defects—vacancies and interstitial atoms—would disappear as boron attained its perfect crystalline structure. But according to Ogitsu's calculations, which he carried out on a Livermore supercomputer, the defects actually stabilize the β-rhombohedral phase. It turns out the defect sites in the crystal are arranged in a particular geometric configuration, a double-layer expanded kagome lattice (see figure). Ogitsu and his collaborators realized that the problem of how boron atoms fill empty sites is essentially the same as another problem: how antiferromagnetically coupled spins align themselves on an expanded kagome lattice, whose ground state is degenerate and disordered. Like spin ices and ordinary water ice, boron's β-rhombohedral phase is geometrically frustrated. Ogitsu notes that the hopping of defects between nearly degenerate configurations can also account for some of boron's peculiar and long-puzzling transport properties. (T. Ogitsu et al., *Phys. Rev. B* **81**, 020102, 2010.) —CD