OPTOMECHANICAL COMPONENTS

LEGO blocks prop up optics

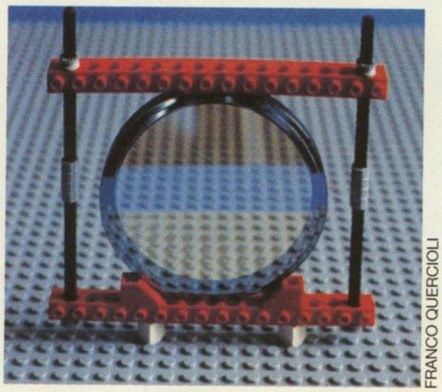
Sometimes equipment that is convenient, cheap, and "good-enough" is preferable to expensive precision components. Franco Quercioli and others at the Istituto Nazionale di Ottica (Institute of Optics; Firenze, Italy) are developing optomechanical components using just such a system—LEGO bricks. The group has developed a variety of optical components built from LEGO blocks and some homemade components that are good enough for teaching and even for some research applications (see photo on p. 26).

Properties of LEGO

The brightly colored building toys have surprisingly useful mechanical properties. Anyone who has played with LEGO blocks knows that the plastic pieces are uniform, light, stick together well, and are sturdy enough to endure even the harshest treatment by children. The bricks are molded from ABS (acrylonitrile butadiene styrene) plastic to geometric tolerances of 0.02 mm and weigh less than 1 g; the force needed to separate two blocks ranges from 1.5 to 3.5 N. In addition to the basic bricks, a range of other elements in the company's DACTA and TECHNIC product lines include rods, beams, plates, axles, gears, pulleys, hinges, bases (that is, tables), and several sensors and actuators. Some components can be made using only standard LEGO parts, while for others, the researchers machined Plexiglas rods and screws.

Quercioli's group is not the first to use LEGO parts for technical applications. The annual autonomous-robot competition at the Massachusetts Institute of Technology (Cambridge, MA) provides students with standardized kits from which to build and program robots. The bodies of the robots are built of LEGO parts, including electric motors. In the 1998 competition, robots were designed that were durable enough to intentionally drive off ledges and attack other robots.

The basic components used on an optical table tend not to move as much as a mobile robot, but do need to be stable. Quercioli's group has made holders, translation and rotary stages, *x-y-z* positioners, tilters, laboratory jacks, posts, bases, rails, and breadboards. Using these components, the group has also built more-complex systems, including microscopes and interferometers.



FRANCO QUERCIOLI

Brightly colored LEGO blocks have been used to build a lens holder that can carry a pellicle beamsplitter, for instance.

Among the devices demonstrated was a two-mirror beam director that allows fine adjustments to the direction and height of a reflected beam. "Its mechanical stability," say the researchers, "is comparable with that of a metal-made equivalent component."[1] In fact, because LEGO components are designed to be modular, they can be more convenient for adapting to specific needs than regular mounts. Another elegant component is a self-centering mount designed for standard LEGO elements, including hinges that fasten three beams together, and spring-loaded axles that push on the edge of a circular filter.

Linear and rotary translation stages are loaded with either small springs or rubber bands. While the reproducibility of these positioners is not as good as that of precision stages, the positioners are good enough to be used in a Twyman-Green interferometer that the group made from the LEGO components. The success in building this interferometer and the ease of aligning it—a process that took only about 3 min—led the group to build a Mach-Zehnder interferometer, "the most complicated system that we have built thus far," say the researchers.

The researchers write, "The versatility of the LEGO system and the ease with which complicated components and setups can be realized are sometimes almost astonishing." The designs developed by the group thus far are prototypes.

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REFERENCE

1. F. Quercioli et al., *Appl. Opt. 37*(16), 3408 (June 1998).

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