Wobbling, staggering Tinkertoy robots give insight into how humans walk

By Susan Lang

It doesn't have a brain or a heart, and its walk is a little like the scarecrow's, but a small headless, armless, trunkless two-legged robot toy, developed at Cornell, can walk, wobble, hobble, limp, stride and stagger. But it can't stand still in any position without falling over.

The fact that this robot, made of plastic Tinkertoy parts and a few odds and ends, is stable in motion is giving mechanical engineers here new thoughts about human walking.

Michael J. Coleman, a lecturer in mechanical engineering, said the little walker, by using gravity on a gentle slope "performs repeatable, chattering, human-like stable steps without falling over." Said Coleman, who earned his doctorate in February, "We believe this is the first two-legged, statically unstable 3-D passive-dynamic walker that can walk stably down a slope without any control system whatsoever."

With help from Andy Ruina, director of the Human Power, Biomechanics, and Robotics Laboratory at Cornell, Coleman stumbled on the walker's design while preparing for his doctoral defense. "In fact, it is one of the few devices of any kind that is dynamically stable near a statically unstable configuration and doesn't have fast spinning parts," said Ruina.

"Playing, with no hopes of success, we placed the toy on a ramp. Surprisingly it took a few serendipitous, if not very steady or stable steps. After some nonquantifiable tinkering, we arrived at the functioning device," Coleman and Ruina wrote in the April 6 issue of *Physical Review Letters*, in which they describe their contraption. Their work also was presented recently at a conference in Germany on the mechanics of walking.

"How humans walk with their top-heavy, upright trunk atop two relatively spindly legs is not well understood," explained Coleman in Ruina's third-floor lab where

Nicola Kountoupes/University Photography

Michael Coleman, left, a lecturer in mechanical engineering, and graduate student Mariano Garcia display their Tinkertoy walkers outside Kimball Hall, March 31.

Vancouver, B.C., now at the Insitu Group in Underwood, Wash., who argued that human stability and balance were likely governed by the laws of mechanics and not necessarily driven primarily by the brain. McGeer developed various stable 2-D walkers but could only find unstable 3-D walking motions.

Coleman constructed the Tinkertoy device as follows: he stuck two green rod legs,

models and computer simulations did not predict the success of the walker, and their computer models are still too simple to explain it. "It does, however, highlight the possibility that uncontrolled dynamics may not just contribute to fore and aft balance in walking but also to side-to-side balance," said Ruina, an associate professor of theoretical and applied mechanics, who is also interested in the energetics of rowing, bik-

walking. Gomes and Camp also performed walking robot experiments.

Coleman and Ruina believe their work, which McGeer likened to the development of airplanes from motorless gliders, will help provide key insights into the mechanics of walking. It could also have important implications for designing better powered and controlled biped robots, building better artificial legs and improving rehabilitation