



"Mad scientist" Dan Endean '09 keeps an eye on the St. Olaf machine.



What do you get when a dozen Oles  
devote 3,000 hours to creating a  
whimsical machine that takes more than  
200 steps to replace one light bulb?

## CHAMPIONS OF THE NATIONAL RUBE GOLDBERG MACHINE CONTEST.



By Kari VanDerVeen

PHOTOS BY TOM ROSTER + VINCENT WALTER

The headline in the Sunday edition of Lafayette, Indiana's newspaper, the *Journal and Courier*, said it all: "St. Olaf College Pulls Off a Rube Shocker."

The day before, a group of Oles had won the national Rube Goldberg Machine Contest held at Purdue University. The annual competition, which draws teams from colleges and universities across the nation, aims to bring to life Pulitzer Prize-winning cartoonist Rube Goldberg's drawings of complicated machines and gadgets that accomplish simple tasks. Using as many whimsical, entertaining, counterintuitive steps as possible, the machines must complete a task determined each year by contest organizers.

A first-time entrant in the March 28 competition, St. Olaf was the only liberal arts college in the contest and the only school without an engineering program. With a machine that took 239 steps to break a light bulb and replace it with 150 light-emitting diodes (LEDs) that spell out "St. Olaf," the Oles took the title at a competition dominated by teams from large public universities with top-notch engineering programs. *Popular Mechanics* magazine called St. Olaf "the competition's Cinderella story."

It was the perfect way to cap the more than 3,000 hours the Oles had spent designing and engineering their machine. They continued making adjustments to their contraption right up to the morning of the competition, knowing that in order to top the other teams they needed it to run flawlessly — not once, but twice — for the competition judges.

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"I don't think we had seen two back-to-back runs as good as the two we had on the day of the competition," says Dan Endean '09, one of the team's captains. "Everything came together at just the right moment."

Impressed with the complexity and ingenuity of the St. Olaf team's machine, the judges awarded St. Olaf the championship over teams from the University of Illinois, Ferris State University, Pennsylvania State University, Michigan Technological University, and the University of Texas at Austin. The judges weren't the only ones wowed — more than 1,000 audience members voted to give St. Olaf the People's Choice Award as well.

"I think the other teams were very surprised to hear that we don't have an engineering program," says Kay Pelletier '10. "I got the sense that no one really expected us to have a competitive machine. I think that just made us want to win, or at least place, even more."



#### DAVID VS. GOLIATH

THE RUBE GOLDBERG MACHINE CONTEST got its start in 1949 when two engineering fraternities at Purdue held the competition as part of the Engineer's Ball. In 1955, the fraternities stopped hosting the ball, and the competition died along with it. Nearly three decades later, the competition was resurrected after members of one of the fraternities found the original traveling trophy from the Rube Goldberg Contest. The annual competition eventually led to the first national Rube Goldberg Machine Contest in 1988, an event that has grown larger and more competitive each year. It is now one of Purdue's largest non-sports events.





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Past machine tasks have included marking and casting an election ballot, filling and sealing a time capsule with twentieth-century inventions, and assembling a hamburger. The task for this year's contest was to replace an incandescent light bulb with a more energy-efficient light-emitting design.

To win the national competition, students must design and construct elaborate contraptions with highly detailed themes. The St. Olaf students designed a machine with a "Mad Scientist" motif that depicted the Oles venturing into the lair of a "super villain" named Dr. Carleton Knight. Their journey involved a monorail, laser-activated gates, a winding path leading to a genetics lab, and an X-ray of one of the mad

doctor's less successful experiments, among many other things. Designing such a machine might sound like fun, but it's also a grueling exercise in concurrent engineering and mechanical know-how.

"The contest is wonderfully ironic," says Associate Professor of Physics Jason Engbrecht, who advised the team. "You have to make the machine complicated, so on some levels it might seem like a bad engineering exercise. But what students learn very quickly while working on this is that when you have 239 steps and you want them all to work, every step needs to be as simple as possible and follow outstanding engineering design to make the entire machine work."



Schools that have been perennial powerhouses in the Rube Goldberg Machine Contest, including Purdue, the University of Texas at Austin and Texas A&M, have engineering programs that are regarded as some of the best in the country. Teams often include graduate students, and a number of past competitors have had years of experience creating Rube machines, all of which meant that St. Olaf students entered the contest at Purdue looking like a David surrounded by Goliaths.

Yet the St. Olaf students had a unique advantage against their competition: a liberal arts education that had trained them to analyze situations from every angle, think outside the box, and find creative solutions. St. Olaf team members were more than just aspiring engineers — their majors range from physics and biology to music and religion. The team includes members of six campus music ensembles, a theatre participant, and a Rossing Physics Scholar. The eleven-member team also includes five women, an impressive number in an engineering competition dominated by men. Most important, the St. Olaf students were out to have fun. The Oles named their team “The Saturday Morning Social Hour Featuring Barry and the Jets,” a reference to the long hours team members had devoted to rebuilding and refining the machine almost every Saturday during the spring semester. It also played off the title of a popular Elton John song while using the first name of Barry Costanzi '09, the team member who introduced the machine to the crowd at Purdue.

Reuben Lucius Goldberg was known for his amazing cartoons that depicted inventions using everyday objects to construct complex machines that performed simple tasks.

To emphasize their “evil genius” theme and capture extra points for team spirit, at the competition the Oles donned lab coats, wore crazy bow ties with flashing lights, pulled on yellow rubber gloves, and sported wacky hairdos held in place with black and gold spray. They held up signs, shouted “Um Ya Ya” while the machine ran, and put on sunglasses when the LEDs on the St. Olaf sign lit up. Yet for all their outward team spirit, several of the team members admit they were holding their breath during the machine’s runs at the competition. Roughly half of the team members stood next to the machine to hold up “Um Ya Ya” signs, so they couldn’t see how each step progressed.

Eleven students built the mad-scientist-themed machine as part of an engineering class. In a competition dominated by men, the St. Olaf team included five women. Organizers of the Rube Goldberg Machine Contest declared St. Olaf the 2009 champion.





"Watching the machine run always put me on pins and needles, but being unable to see and relying only on listening to each step was excruciating," Pelletier says. "I knew the sounds of the machine inside and out, but my heart stopped with each silent moment. I don't think I've been that nervous for anything else in my life."

Each team must complete two runs for the judges, but they can void one run before it is completed. The first run of St. Olaf's machine had two errors right off the bat, so the team voided it near the finish. The next two runs were a different story, with each of the more than 200 steps operating flawlessly.

"When it was over, we were ecstatic, sharing hugs of relief and congratulations all around," Pelletier says. "It was a once-in-a-lifetime experience."

### SERIOUS SCIENCE

THE PROCESS OF BUILDING a Rube Goldberg machine offers lessons in planning, problem solving, and teamwork that closely mirror a real-world engineering environment. Although the machines feature whimsical themes, they incorporate serious science and require students to turn textbook lessons into tangible contraptions.

The St. Olaf students began building their machine in September as part of a course taught by Engbrecht. Six months before the competition at Purdue, the machine was little more than various parts scattered on rows of long tables in a basement room of the old Science Center on campus. The team's goal was to have a fully functioning prototype of the machine by the end of the semester. "We built the whole machine and

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figured out what we liked and didn't like," Endean says.

They realized early on that some ideas — such as having the machine write "St. Olaf" in liquid neon in a fish tank filled with water — worked much better in principle than in practice. "It's one thing to have an idea on paper about how something will look or work, but it's another thing to try to figure out how you are actually going to make it work," says Marin Krause '10. "A lot of it was trial and error."

At times some of the team members with the least engineering experience helped the most science-minded students step back and think about a solution from a different angle. "There were times when I had no idea how to fix a problem, but one of the other people on the team would come up with the most interesting solution that worked just perfectly," says Endean. "A music major might not know how to wire a circuit, but they might know what we need to build to make sure this bow and arrow can hit its target."

The team's persistence in creating steps that were fun to



### How many liberal arts students does it take to change a light bulb?

The champion Rube Goldberg Machine Contest team, from left, BACK ROW: **Barry Costanzi '09** (physics and math majors), Buffalo, Minnesota; **Tom Hildreth '10** (physics, math), Wheaton, Illinois; **Corwin Haapala '10** (physics, math), Minnetonka, Minnesota; **Joe Scaramuzza '10** (physics, math, religion), Belle Plaine, Minnesota; **Marin Krause '10** (biology, statistics concentration), Plymouth, Minnesota; **Bern Youngblood '10** (physics, Russian area studies), La Grande, Oregon; **Abbey Holt '10** (math, chemistry, biology), Shoreview, Minnesota; and Associate Professor of Physics **Jason Engbrecht**, the team's adviser.

FRONT ROW: **Dan Endean '09** (physics, math), Holland, Michigan; **Kay Pelletier '10** (physics, math), White Bear Lake, Minnesota; **Christin Strandli '09** (physics, math), Stavanger, Norway; and **Katie Wisdom '10**, (math education, music), Boise, Idaho.

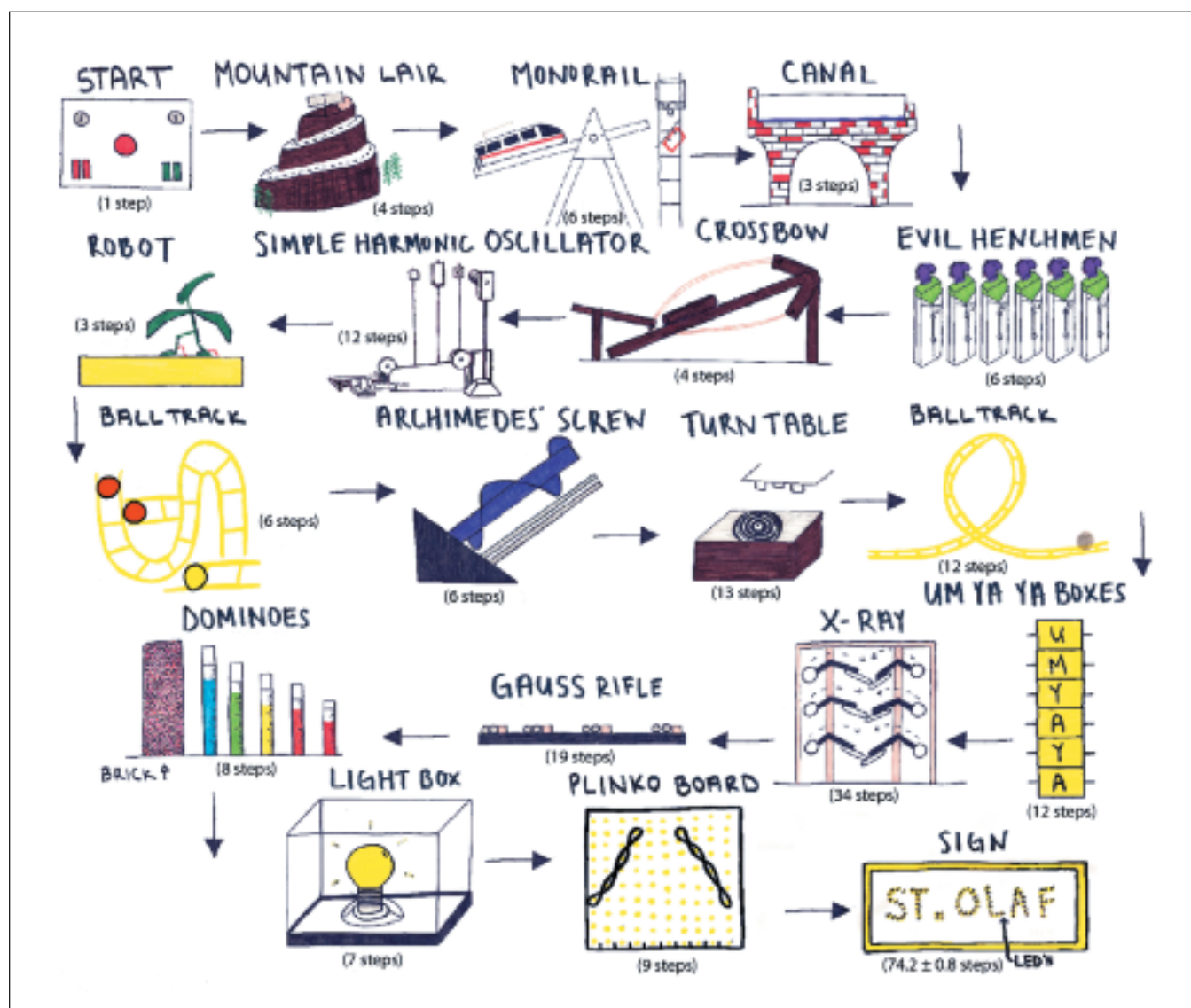
watch yet feasible to build paid off. One of the Oles' most impressive engineering feats was building a record player from scratch that, as it spins, allows lasers to fire through pre-drilled holes. The lasers — which light up acrylic rods on the turntable so the audience members can see them in action — are then picked up by light sensors. The light sensors trigger a circuit that passes an electrical current through a nichrome wire, which in turn burns through fishing line, allowing a gate to open and release a ball.

In other steps, the students used seemingly simple physics theories to create eye-catching elements. One of the machine's crowd-pleasing elements is a bow and arrow step in which a projectile hits a falling object in mid-flight, illustrating the laws of gravity. The Oles also demonstrated the nature of the magnetic force law by including a Gauss rifle, a mechanism that uses a magnetic chain reaction to launch a metal ball at a very high speed.

"Each element worked perfectly at least once. Different things kept going wrong. We had to do a lot of troubleshooting."

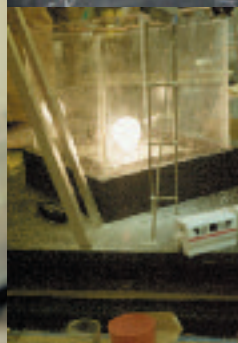
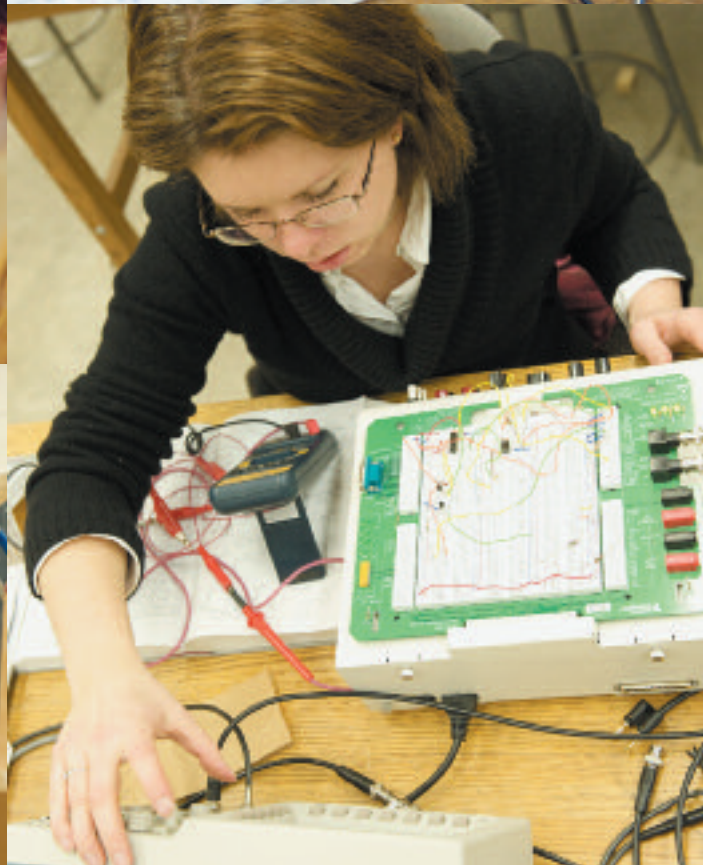
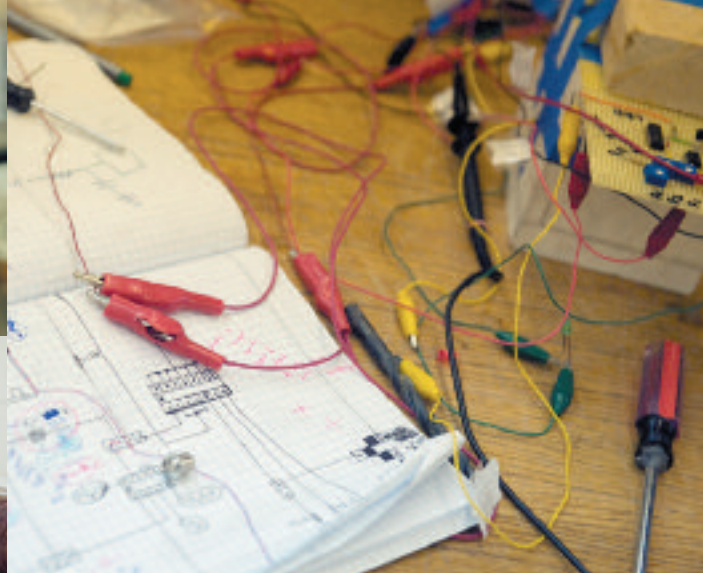
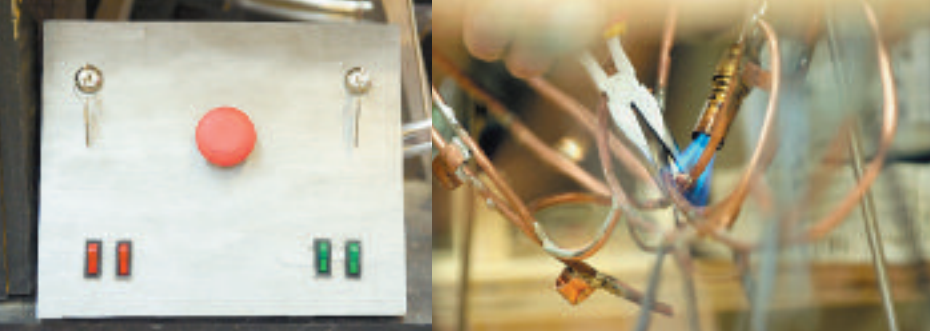
— KATIE WISDOM '10

Another step used a simple harmonic oscillator, a system that employs harmonic motion and magnetic induction to trigger the start of a car moving along a track. Using an ice auger — something that added a little Minnesota flavor to the machine, as a producer from the local NBC affiliate noted when his crew visited campus — the team even created an



The competing teams had one task: Replace an incandescent light bulb with a more energy-efficient light-emitting design as inefficiently as possible. St. Olaf team members composed this diagram for judges at Purdue University, showing each of the machine's major elements and how many steps it takes to complete the individual components. Each team received forty points for the theme of their machine and the extent to which it embodied the spirit of Rube Goldberg's cartoons, and sixty points for how smoothly the machine operated during the competition.







The Oles had a functioning prototype by the end of the fall semester, but the real work had just begun. “I slept [in the lab] a few nights,” says Oregon native Bern Youngblood ’10 (top), who spent much of his break between Interim and spring semester toiling over the machine.

Hundreds of curious students, faculty, and local residents (bottom) came to Regents Hall for an early demonstration of the machine, including Rube Goldberg’s grandson, who filmed the team’s progress as part of a docudrama about the competition.

Archimedes’ screw that catches billiard balls and takes them from the machine’s lower level to an elevated track.

Once the team had its list of steps in place, they broke into groups of three to four students, and each group took on the task of constructing several of the machine’s steps. By the end of the fall semester, the Oles had put together a prototype that looked like an oversized Mouse Trap board game. Nearly six feet wide and six feet long, with tracks and turntables that extended another six feet into the air, the machine worked in the roughest sense of the word. Team members knew they would need to put in long hours when they returned from Interim to produce a machine that could compete at Purdue.

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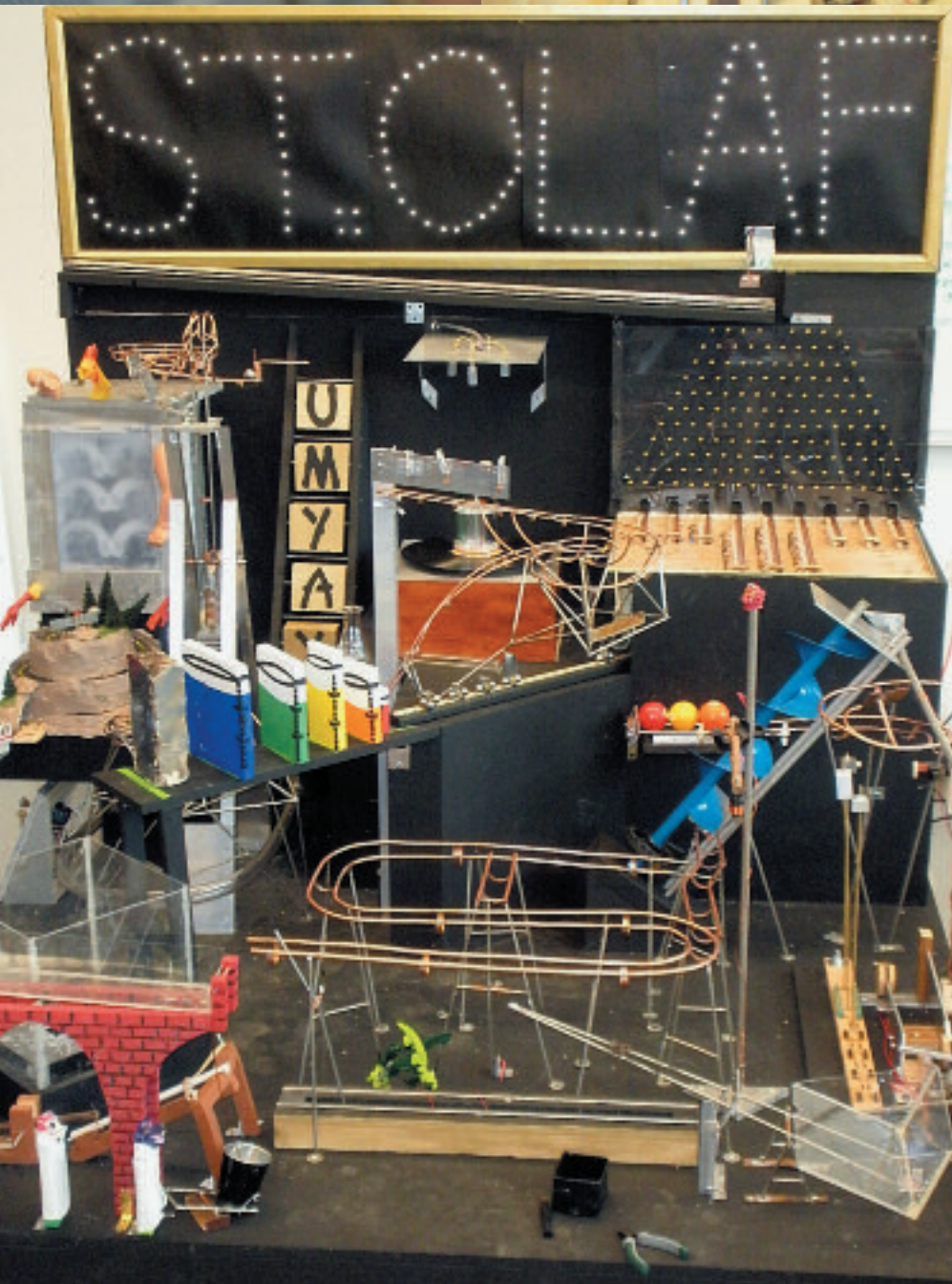
#### STUDENT INGENUITY

TO MAKE THEIR MACHINE run consistently, the Oles dismantled and reconstructed many of the elements of their prototype. Knowing that they also had to leave enough time so that they could add paint and other decorative pieces that would make the machine look impressive in addition to running well, several team members began making the Rube lab their second home. “It’s all for honor and glory at this point,” was Costanzi’s way of putting it while working on the machine in February. Dedicated team members devoted their Friday evenings and almost every Saturday — showing up at 9 a.m. and sometimes staying until the wee hours of Sunday morning — during spring semester to working on the machine.

As the team refined the machine and added additional steps, they found themselves in a race against time in order to have everything perfected by the competition day. Adding even more pressure to their timeline, the team made plans to demonstrate their machine for the St. Olaf community two







The St. Olaf team built a spinning turntable that rotates an LP record with three holes. When lined up perfectly, these holes emit laser beams that open three gates to allow a ball bearing to roll down a copper track, eventually triggering a sign with the letters “U-M-Y-A-Y-A.” As the machine’s sequence ends, metal balls filter through a Plinko board triggering tiny LED lights that spell “St. Olaf.”

weeks before the competition at Purdue. They scheduled the demonstration to serve as their own sort of regional competition, which all teams must win in order to compete in the national Rube Goldberg Machine Contest. Because there isn’t a regional competition near St. Olaf, the team was given a bye this year and used the Regents Hall demonstration to give the machine a serious trial run in front of an audience.

As Engbrecht introduced the team to the waiting crowd, he pointed out that constructing the machine was no small task. Then he turned it over to Costanzi, who began his introduction of the machine by posing an age-old question: “How many liberal arts students does it take to change a light bulb?”

Following an explanation of the villain theme, the team set the machine in motion. The audience “ooohed” and “aaahed” when some of the most impressive steps operated flawlessly, and they laughed in delight when a ball flipped down a row of six wooden boxes, revealing that “Um Ya Ya” had been painted on the backsides. When the machine came to a finish, the audience burst into applause.

The run had been almost flawless. Team members had only needed to make one slight intervention, down from the two they had needed to make during a test run earlier that morning.

“We have a trend here,” Engbrecht pointed out. “The next time, it should work perfectly.”

Which, of course, is exactly what it did at Purdue. 🦅

KARI VANDERVEEN is a communications specialist at St. Olaf College.

*Readers can view a video of the Oles competing at the national Rube Goldberg Machine Contest at [stolaf.edu/news](http://stolaf.edu/news).*