LigerBots

INFINITE RECHARGE

A Guide to the LigerBots, 2020

FIRST Robotics Team 2877

Newton North and South High Schools

Puma Level Sponsors

Panther Level Sponsors

Cheetah Level Sponsors

LIGERBOTS

Infinite Recharge

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FIRST Robotics Team 2877

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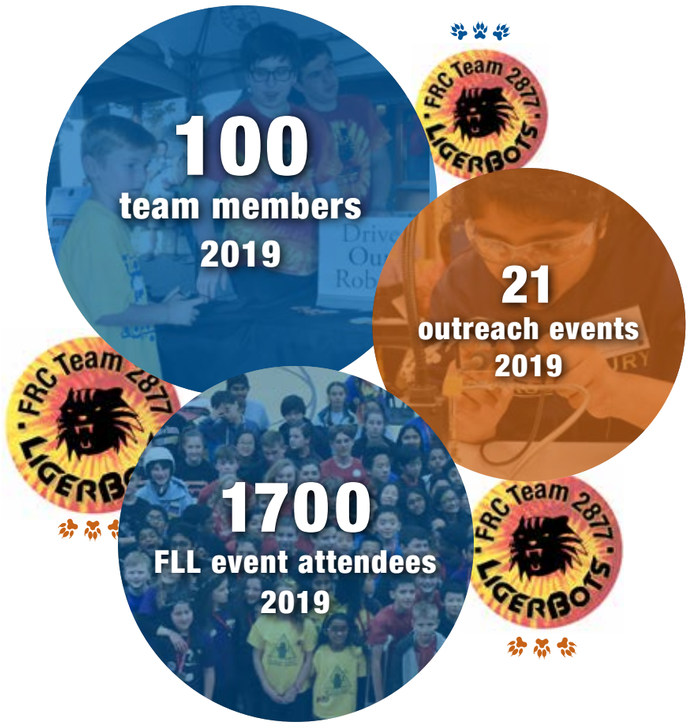


LigerBots at the FIRST Robotics world championship in Detroit, April 2018.

Executive Summary

Q: Briefly describe the impact of the FIRST program on team participants in the last 5 years.

A: Members develop technical and non-technical skills through project-based learning. We inspire team members towards STEAM careers, with a 100% graduation rate and over 71% of last year's graduates choosing STEAM majors. In addition to STEAM skills, our 57 registered team members learn life skills. One student says, "LigerBots has helped me be more confident in social situations and academic settings. . . . I've also learned how to be an advocate for myself and for the things I'm passionate about."

Q: Describe the impact of the FIRST program on your community within the last 5 years.

A: The LigerBots are dedicated to creating STEAM opportunities throughout our community. In the past five years, the Ligerbots have hosted or participated in a total of 133 events and have mentored several FLL teams. In addition to hosting the FLL Qualifiers and Eastern MA State Championship, with over 1,000 visitors and participants a year, we host an annual FLL Info Night that encourages team creation. One FLL parent said, "Thanks for inspiring my kids, they want to be just like you."

Q: Describe the team's innovative or creative methods to spread the FIRST message that are effective, scalable, sustainable, and creative.

A: Since 2015, we have hosted two annual FLL Competitions, the Qualifiers and MA E. Championship, with accompanying public STEAM expos featuring local companies and nonprofits. This and last year, 91 Girl Scouts attended and earned STEAM patches."Great job, I loved the competition and the kids had a blast," said one parent. In addition, we have educational flyers that can be downloaded and used by STEAM fairs around the city, and we have a strong media and community-engagement program.

Q: Describe examples of how your team members act as role models and inspire other FIRST team members to emulate.

A: The LigerBots created a Safety Animation video that was shown at all FRC competitions in 2018. We created a strategy alliance in New England, helping other teams scout and determine alliance pick strategy. We advise FRC teams worldwide by posting white papers on student-led projects. Our vision whitepaper alone has over 1,100 downloads and 6,300 views. In addition, students and mentors from other teams seek us out and one team member even chose to move to Newton just to be a part of our team.

Q: Team's initiatives to help start or form other FIRST Robotics Competition teams.

A: We assist many teams by showing them our process, posting our work online, and being active in FRC forums. One team in Virginia, #5804, said, "the code your team posted on GitHub has been incredibly helpful in determining the direction we want to go this year with our programming." In addition, we collaborated with team 6740 from Israel, and plan to have periodic conversations to discuss current projects. We also assisted Record Robotics with fundraising and operational advice.

Q: Describe the team's initiatives to help start or form other FIRST teams (including FIRST LEGO League Jr., FIRST LEGO League, & FIRST Tech Challenge).

A: The LigerBots host an annual FLL Info Night in June, with a targeted goal of expanding FIRST opportunities in Newton. At the event, we have an informational meeting for parents where we describe FIRST. We also engage children in STEAM activities, including marshmallow towers, brushbots, binary beads, and robot demos done by both us and local FLL teams. In 2019, we brought many families into the FIRST pipeline.

Q: Describe the team's initiatives on assisting other FIRST teams (including FIRST LEGO League Jr., FIRST LEGO League, & FIRST Tech Challenge).

A: The LigerBots host an annual FLL Info Night in June, with a targeted goal of expanding FIRST opportunities in Newton. At the event, we have an informational meeting for parents where we describe FIRST. We also engage children in STEAM activities, including marshmallow towers, brushbots, binary beads, and robot demos done by both us and local FLL teams. In 2019, we brought many families into the FIRST pipeline.

Q: Describe how your team works with other FIRST teams to serve as mentors to younger or less experienced FIRST teams (including FIRST LEGO League Jr., FIRST LEGO League, & FIRST Tech Challenge).

A: In addition to hosting an FLL Info Night to create more teams, we mentor and offer support to any local team who reaches out to us. This past FLL season, we mentored a new team, #38823, and coached #31761 on their presentation skills. We are also helping FRC team #246 recover after mentorship changes, coaching them on outreach skills, strategy, and scouting. We also added rookie team #7822 to our strategy alliance, teaching them how to scout. We use FTC kits for internal pre-season training.

Q: Describe your Corporate/University Sponsors.

A: We have an active sponsorship outreach process. This year we raised $18,000 in support from 14 sponsors by emphasizing our role in STEM education for both team members and the community. These include ALM Works, Ameresco, Ascensus, BAE Systems, Google, JT's Snowmobile, Honda Village, One Shield, PTC, Raytheon, Unflat Law and Mediation, The Village Bank, You-Do-It Electronics,Newton Schools Foundation.

Q: Describe the strength of your partnership with your sponsors with within the last five years.

A: We strengthen sponsor relations through monthly correspondence and attendance at their events. Each month, the LigerBots write a newsletter detailing progress and inviting sponsors to our events. Sponsors also demoed themselves at our FLL STEAM expo. One example is being invited to be tour guides and demo our robot at Newton Inspires, as a result of being sponsored by Newton Schools Foundation. The event encourages local experts to share their passions, with over 500 local residents.

Q: For FIRST Robotics Competition teams older than five years, briefly describe your team's broader impact from its inception.

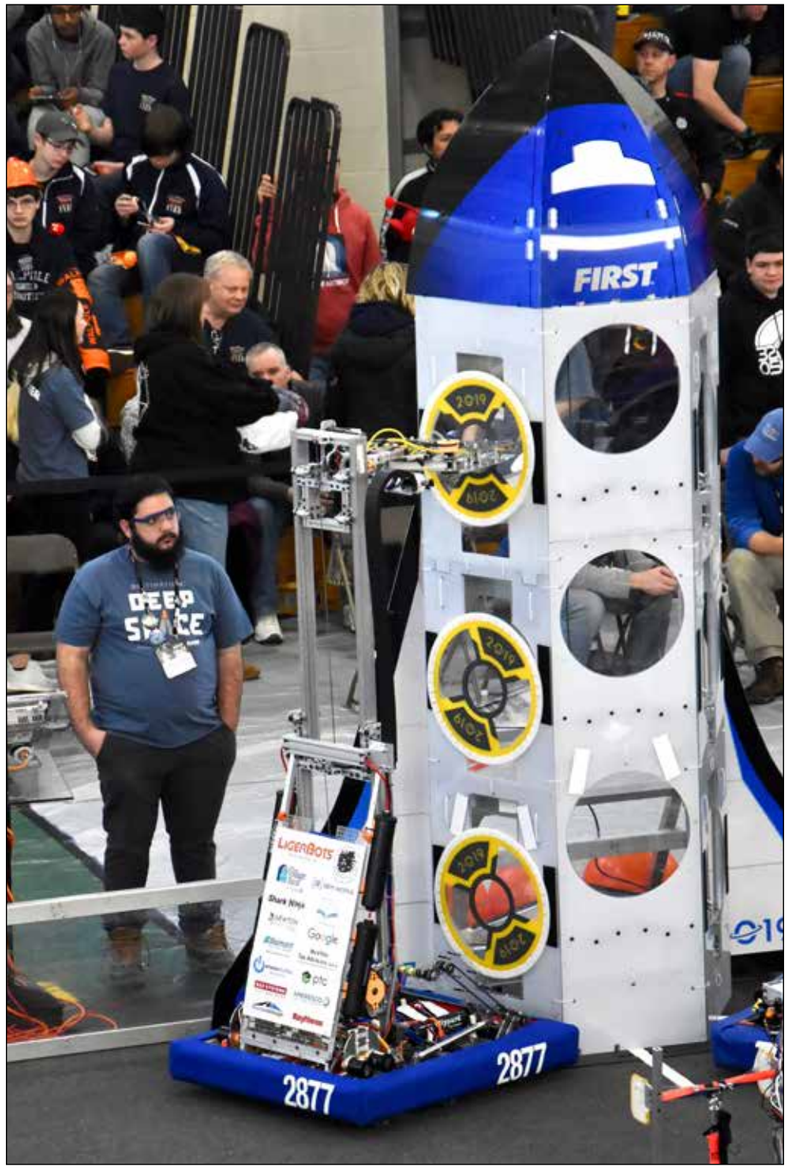
A: Since 2008, we have expanded as a team, boosting skills, mentors, and funding to become stronger and more influential in FIRST. We raised fundraising capabilities, engaged the community via social media, and invited elected officials to events. We established a mini-grant program to fund student ideas. This year, we focused on strategy and data analysis. We invited a computational biologist to mentor on data and analytics. Members now use R, Python, and Tableau for data analysis.

Q: Describe how your team would explain what FIRST is to someone who has never heard of it.

A: FIRST is a worldwide organization dedicated to spreading STEAM through robotics competitions. FIRST provides opportunities for hands-on education, beginning with FIRST LEGO League Jr., for elementary school students, and ending with FIRST Robotics Competition. FRC is a high school program that advances technical skills as well as critical marketing skills. To us, FIRST is an opportunity to turn professional, expanding career options and alternatives exponentially.

Q: Briefly describe other matters of interest to the FIRST judges, if any.

A: Over the summer of 2019, team members traveled to Washington DC to be a part of the FIRST New England Advocacy Conference. We also advocated on the state-level for $250,000 in funding to help smaller teams pay FIRST registration fees. Attending and participating in advocacy events helps us facilitate change on the national and state level and complements the work we do locally. We are registered to attend future advocacy events, and we encourage other teams to join us in advocating for STEM education.



While a referee watches, the LigerBots 2019 robot, Thanos, places a Hatch Panel on the high Port of the Rocket Ship during the South Eastern Mass. District Event, in March 2019.

LigerBots Lead in Project-Based Learning

"Give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking; learning naturally results."

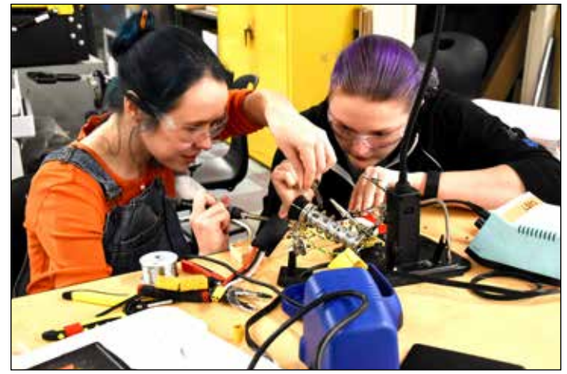
— John Dewey, nineteenth-century education reformer

Little girls scramble for position around a small table, frantically grabbing at pieces of colorful origami paper. Settling in, they look up at the LigerBot instructor, papers in their outstretched hands. They quickly follow the first few instructions, but then things go awry. One little girl shoves her paper at the instructor, pleading for help. Others crease the papers in random places. During this commotion, one girl scrunches up her face in thought. She clearly does not understand all the steps and even has to take a new sheet to start over. She patiently goes step by step, folding with great care, and finally completing the project. Then, she turns to her friends to help them. By the end of the session, all of the girls hold up their creations in triumph. From a single piece of paper, they learned the process of engineering.

As a team, we do more than build a robot; we strive to encourage students to become the next generation of leaders and thinkers. We seek to change the way students learn; our vision is to transform education through project-based learning.

Our goal is to become the recognized leader of project-based learning in Newton, Mass. To do that, we have created a system that uses hands-on projects to help team members build a strong and diverse set of skills. We then leverage those skills to advocate for project-based learning in the community by building a strong core of sponsors, educating the community, and establishing a sustainable FIRST LEGO League pipeline into our team. We share what we do in order to build and maintain the long-term strength of our team, foster a love for STEM and encourage project-based learning at home.

Carolyn helps Girl Scouts do origami at the FLL Eastern MA Championship maker fair.



Row 1: STEM advocacy—LigerBot delivers aTEDxBeaconStreet talk about FIRST as project based learning; STEM training—electrical mentor and CTO solder an electrical test bench. Row 2: sponsor relations—LigerBots outside Fowler High Precision after a successful sponsorship pitch; team outreach—LigerBot talks about the team to middle school students. Row 3: FIRST leadership— participants at the FLL Eastern MA Championship.

LigerBots Train Our Team Members

Our commitment to project-based learning starts as soon as students join the team. We spend our preseason teaching rookies core skills through hands-on activities. As a rookie, our current chief technical officer had trouble learning how to put together an FRC control system. To help, a mentor trained her with a virtual, magnetic electrical system. "We did it every day until I understood how to do it," she said. "Once I had nailed that, he let me play with the wiring on a previous year's robot." Now our CTO uses that same technique to teach current students and helps her parents with small electrical projects.

We start training each year by breaking rookies into groups; then, using previous FIRST games as a guide, we have students create game strategy and designs to teach them the engineering process. Each group then presents its designs to the rest of the team, which helps build presentation skills, as well as exposing the team to diverse engineering approaches.

Our broad preseason training has also resulted in more diverse tasks being tackled by team members because they understand the wide variety of ways to contribute to the team. For instance, our CMO recently learned to bend and mold polycarbonate to make a hinge, and our students who usually concentrate on technical projects regularly help with team fundraising and blog posts.

As a result of our training projects we have published two white papers on Chief Delphi that have received thousands of views and downloads: one on robot vision and another on the measurement of display latency. We have three more papers pending: one on molding polycarbonate, another on making an electrical test bench, and a third on making reversible bumper covers. We also share our robot code on GitHub and regularly take part in online forums.

LigerBots have a 100% graduation rate. Of the students that graduated in 2019, 100% were admitted to 4-year colleges and 71% are pursuing STEAM-based majors. Thirty-three percent cite our training in leadership, writing, presentation and business skills as benefits that they apply to their studies.

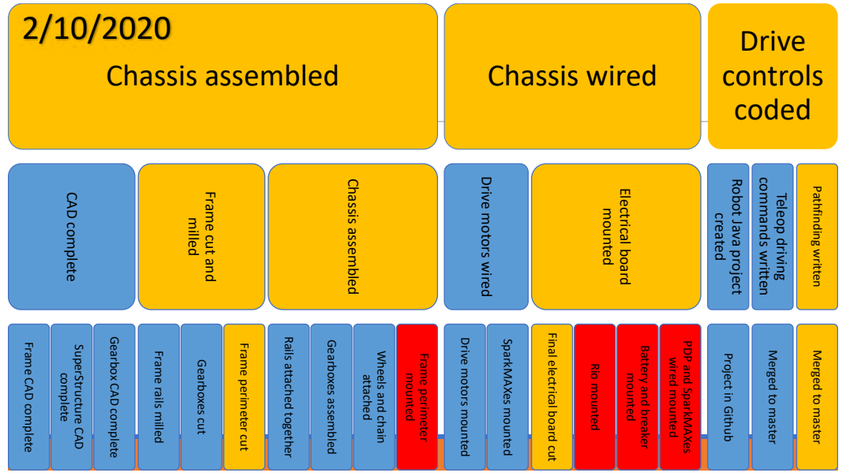
A LigerBot learns how to use a saw to cut the electrical board that goes on our "roadkill" test robot.

Row 1: learning to solder; watching previous years' games to learn strategy. Row 2: doing a PB&J robot coding exercise; learning photography for a STEAM activity flyer; learning shop safety. Row 3: making practice bumpers; taking apart the old robot. Row 4: improving public speaking; making an FTC robot; practicing the bending of metal sheets using heat.

LigerBots Train Team Members in Many Skills

- ***Shop safety.*** Keeping our fingers and eyes intact as we work on the robot.
- ***Basic training.*** Functioning of the basic sensors available to use on the robot; soldering wires, tracing wire paths, connecting pneumatics, disconnecting connectors, and using CAD to find measurements.
- ***Use of machines.*** Using the band saw, hand drill, mill, and drill press.
- ***Precision manufacturing.*** Improving our ability to cut and mill pieces of metal precisely into specific parts
- ***First Tech Challenge (FTC) robot.*** Building two FTC drive trains and a game piece manipulator for programming, mechanical, and electrical practice.
- ***Programming.*** Coding with last year's code and Arduinos, as well as the basics of vision tracking.
- ***Electrical.*** Soldering, crimping, building prototype boards, CADing electrical layouts, and learning electrical physics principles.
- ***NASA Mars rover project:*** Following NASA published plans to build a Mars rover, as an aid to learning basic design and manufacturing strategies.
- ***H-drive project.*** Using newly-learned skills to re-build an H drive.
- ***Custom gearboxes.*** Creating custom gearboxes in order to practice use of the band saw, machining on the CNC, and assembling parts.
- ***Game Strategy.*** Watching robot games online and at live events prior to our own competitions to learn how to evaluate robots for their potential as alliance partners when we compete.
- ***Technical writing***. Writing white papers, using LaTeX, that convey technical information about LigerBots projects in a concise, informative, and persuasive manner.
- ***Elevator pitches.*** Constructing a spontaneous, 60-second speech about the LigerBots and FIRST, to use whenever someone asks us about the team. Practicing it in pairs and presenting to the team.
- ***Grant writing and sponsorship.*** Writing formal grant proposals to potential sponsors and approaching sponsors that don't have a formal grant process.
- ***Writing for publicity.*** Writing for different formats: blog posts, sponsor relations, media relations, government relations, and FIRST awards applications. Using tools such as MailChimp.
- ***Leading an outreach event.*** Organizing the logistics for a LigerBots robot demonstration and outreach table.
- ***Photography.*** Composing photographs and using the "exposure triangle," as an aid to documenting team projects. Using Flickr to keep all of our photos organized.
- ***Video editing:*** Shooting and editing video for FIRST award submissions, robot videos and other special projects.
- ***Graphic design.*** Creating graphical documents for team marketing and publicity, using Adobe Creative Suite.
- ***Sewing.*** Cutting and sewing soft materials to prepare for making bags and robot bumpers in build season.

LigerBots Manage Our Projects



A flame chart showing the state of chassis development tasks on Feb. 10, 2020.

Alex marks a task as "blocked" on the team whiteboard.

The LigerBots use detailed project management for all of our tasks. With the help of a mentor with expertise in project management we have developed a way to track and control our business projects and robot manufacturing progress during the robot build season. We create Trello and flame chart schedules for our various technical projects. For our technical and non-technical projects, all team members contribute to a hands-on system that employs sticky notes and a white board right in our work area. Students sign up for individual tasks and follow them through from "not started," to "in progress" to "done," moving the sticky notes for their tasks to different columns on the board as they progress. A column for "blocked" projects helps us clear our bottlenecks. This system helps us finish our robot earlier than in previous seasons so that we can go on to testing it before competition. LigerBots students transfer their new sophistication in planning projects to their academic work and other extracurricular activities, and by teaching it to others.

We Build a New 120-Pound Robot Every Year

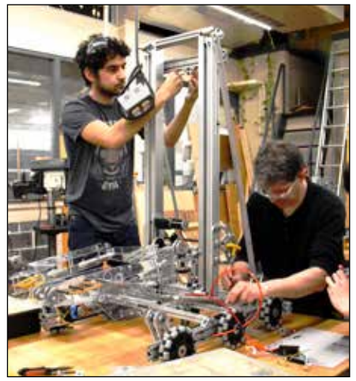
All of the LigerBots fall training in engineering and marketing skills pays off during the most exciting and demanding part of our year, the winter robot build season.

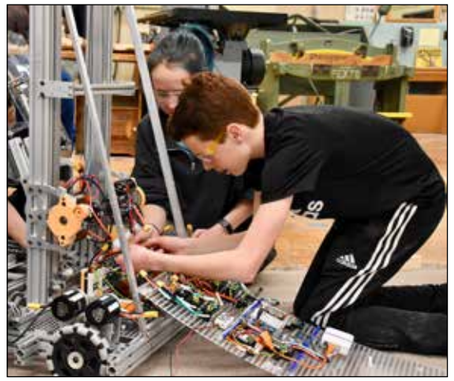
The LigerBots start the build season by including the entire team in a "three-day design" process right after the new FIRST Robotics game is announced in early January. Engineering concepts and game strategy that emerge from our three-day design groups are reconciled by leaders of our mechanical, electrical and software build groups and a final product is designed. Then we order our wood, metal, plastic, and cloth materials and set to work in the shop at Newton South High School building our robots and mockups of the game field elements.

New rules from FIRST allow us to work on our robot right up until the day of competition, rather than having to stop after six weeks and put the robot into a giant plastic bag, as before. This new rule has allowed us to save the money and time necessary to build a second robot for continued testing after the first robot was "in the bag." We spend the monetary savings on better raw materials and tools, and the time on perfecting our competition robot.

During build season our marketing and awards groups are just as busy as the engineers. We finalize sponsor acquisition for the competition season and write and design website pages and printed materials, including this booklet, that recognize the sponsors. Outreach also continues. Our awards group prepares a written submission and an oral presentation to compete for the Chairman's Award, which goes to the team at each competition that best exemplifies the principles of FIRST Robotics.

2019 build season. This page, left to right: Using a paper playing field mockup and coins to work out game strategy during three-day design; discussing how our robot could hold both the "cargo" ball and the "hatch" disk game piece at one time. Opposite page, row 1: testing a "cargo" ball intake mechanism; testing the cargo intake after adding a metal bar to help the ball stay in the arms. Row 2: successful test of "hatch" disk intake and retention on the "roadkill" test robot; testing robot vision code on the intake mechanism; building the "rocket" field element mockup. Row 3: assembling the elevator; adding the electrical board; bagging the robot on the last day of the build season. Row 4: drilling holes in an aluminum sheet for the robot perimeter; cutting a piece of polycarbonate for new robot arms; testing "Cargo" game piece placement by the robot on the last day of build, as a student takes shots for our robot reveal video.





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info@ligerbots.org ▪ www.ligerbots.org ▪ #FRC2877 ▪ The LigerBots ▪ @ligerbots ▪ @ligerbots_frc2877

LIGERBOTS DESIGN PROCESS

Preseason Training and Improvements

Hands-on Projects

- LigerBots preseason training starts with projects that get new members working hands-on in the shop, with robot components, as fast as possible. In the fall, LigerBots run training sessions in many of our 20 team skill areas, including 10 in technical areas. Examples from 2019 include:
  - Following NASA-published plans to build a model Mars rover, as an aid to learning basic design and manufacturing strategies.
  - Building a custom computer numerical controlled (CNC) mill to improve our ability to precisely cut metal and polycarbon plates.
  - Writing software, using the previous year's robot code and Arduinos, and instruction in the basics of vision tracking.

LigerBots co-head coach teaches a rookie to solder.

Game Analysis

- Veteran LigerBots choose videos of matches from the previous several seasons of robot games. Team members, especially rookies, are invited to watch these videos in a group and think about robot design and game strategy before the new build season.

LigerBots veteran teaches a rookie to use the CNC mill to precisely drill a hole in a metal sheet.

Improvements to Manufacturing Processes

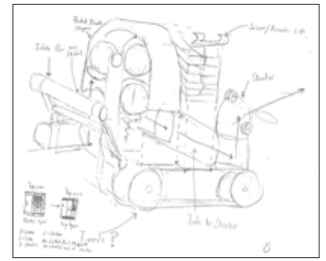
- Installing a digital readout on one of our school's manual mills, improving the precision of manufactured parts.
- Restoring an idle CNC mill in one of our schools, creating the capability to make precision metal parts.
- Investing in a crossfeed table and crossfeed vice for use on the drill press, increasing the speed and accuracy of drilling holes.
- Using the team-built CNC router to quickly and precisely cut polycarbonate sheets for prototypes and final mechanisms.
- Using 3D printing to manufacture complex parts suitable for solving many design problems.
- Using team-built electrical and pneumatic test benches to help us prototype electrical wiring and pneumatic mechanisms.
- Learning how to accurately bend aluminum and heat treat it so that it does not lose its strength.

Design process flyer (front).

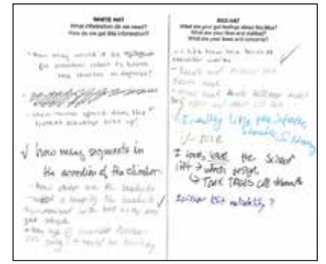
Iterative Robot Design

Design Week

- ***Day 0:*** Right after the game kickoff, the team's build leaders and strategy group meet to discuss potential robot capabilities and advantages. They compile a list that is released to the rest of the team.
- ***Days 1 and 2:*** We break into small groups to brainstorm potential robot mechanisms. Each group writes up detailed documentation for its mechanism.
- ***Day 3:*** We use the "six hats" process to continue our iterative design. Team members anonymously write and share six categories of reaction to the mechanism designs created on days one and two. White hat: facts we have and need. Red hat: gut feelings. Yellow hat: perceived strengths. Black hat: perceived weaknesses. Blue hat: how to start implementation. Green hat: alternatives and potential improvements. This written process helps speed up our design decisions and makes sure that all of our ideas are documented and accessible to the whole team.
- ***Day 4:*** Our build leaders meet to review team reaction to mechanism designs and decide which mechanisms to prototype. Other team members are encouraged to listen to the discussion so that they learn how to lead the process in the future.
- ***Days 5–7:*** We split into build groups to start prototyping.



Sketch of a potential 2020 robot design.



White and red hat critique on above robot sketch.

Robot Design and CAD

- Game strategy determines our priorities. The robot is built to best fit our strategy, rather than the strategy changing to accommodate the robot we build.
- Students design and CAD the robot structure and begin prototyping mechanisms starting on day 5 of design week.
- After design week, mechanism groups begin detailed design and CAD of each promising mechanism.
- A CAD model of the entire robot is completed as quickly and thoroughly as possible.

Prototyping and Continuous Improvement

- Prototypes are built of materials as identical as possible to materials used in the final mechanisms, allowing more realistic test results.
- LigerBots continue to test, redesign, and prototype mechanisms. The 2020 climbing mechanism had eight iterations.

Two LigerBots working on a mechanism to transfer a ball from a hopper to a shooter.

Project Management

- Mechanism groups with individual student leaders form during build season, allowing every LigerBot to concentrate on and feel ownership for one part of the robot. Fluidity of groups ensures the team's needs are always filled.
- A new project management system, centered around a Kanban/Scrum task board, allows students to find tasks that need completing and track progress.
- The task board is supplemented by daily progress meetings and weekly group integration meetings, ensuring that the team is working towards its goals and that no group is falling behind.

LigerBots task board.

Design process flyer (back).

LigerBots Compete

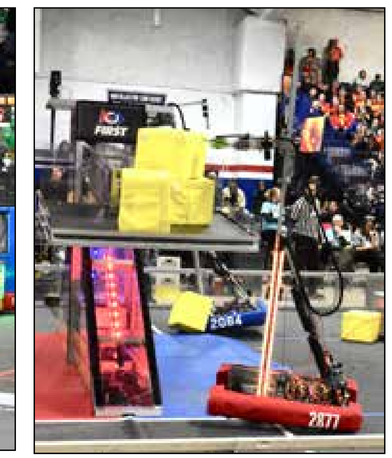
FIRST Robotics competitions are the big payoff for all of the LigerBots training and build season work. At these competitions our robot performance, our driving skill and strategy, our awards preparation, and our marketing efforts are all put to the test. We enter two district (first tier) events every year. When we do well at these events we go on to compete at the New England District Championship, and, if we do well there, we go to the FIRST World Championship in Detroit. The LigerBots have made it to the World Championship four times in our first ten years. In 2018 we finished sixth out of 68 teams in our division and advanced to the division semifinals before falling to the eventual world champion alliance.

FIRST Robotics qualifying matches are played by two randomly selected alliances of three teams each, on a playing field about the size of a basketball court. We have a different alliance for each qualifying match. Our alliance drive teams guide our robots around the field to earn points cooperatively and to keep the other alliance from scoring. Everyone on our team sits in the stands to cheer on our robot. Our scouts take notes on every team's robot performance so that we can choose partner teams wisely if we become an alliance captain during the playoffs.

Our pit technicians repair our robot between matches when something breaks. We also lend tools and materials and repair the robots of other teams in the FIRST spirit of "coopertition."

During competitions team members stand in our repair pit and talk to FIRST judges about the robot and about our team's organization and activities. LigerBots also give a formal presentation to compete for the prestigious Chairman's Award, which sends the winning team automatically to the next level of competition no matter how its robot performs. Every year our efforts have resulted in at least one award for our team, for a total of 28 awards during our first eleven years.

2018 competition season. This page, left to right: FIRST official waves the LigerBots flag before a match; LigerBots cheering in the stands. Opposite page: Row 1: The competition field at the NE District Championship; placing the robot on the field. Row 2: The Red alliance, ready to start a match; 2018 robot, Chronos, placing a "cube" on the "scale" for points; repairing the robot between matches. Row 3: The drive team in the pit; talking to the public in the pit; talking to FIRST judges; Row 4: receiving the Engineering Inspiration award.



Our Strategy Council Helps Us Improve

Computational biologist Noam Shoresh from the Broad Institute talks to the LigerBots about data analysis.

The LigerBots strategy council communicates with other FRC teams, does data analysis, game strategy, design strategy, and scouting.

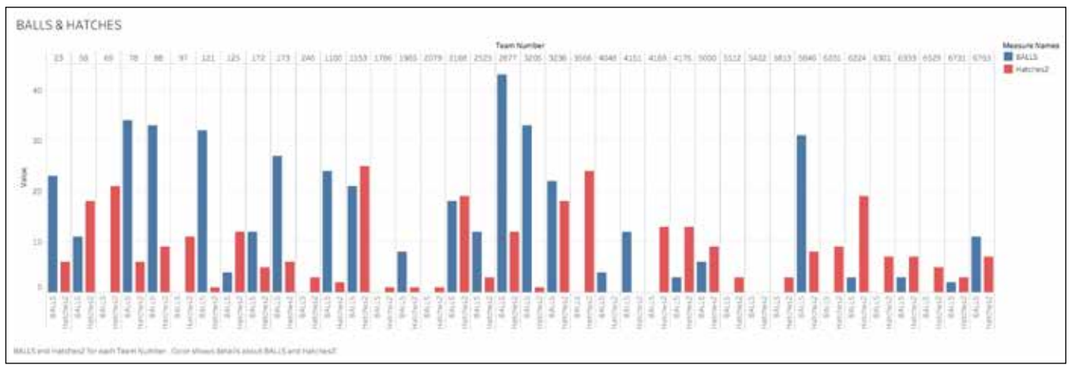
Our ongoing alliance with local FRC teams collects data about other teams at competition, observing matches and then sharing the data within our scouting alliance. We use these scouting data to improve our robot drive team's game strategy, and to optimize our picks of alliance partners when we make it to tournament playoffs as an alliance captain.

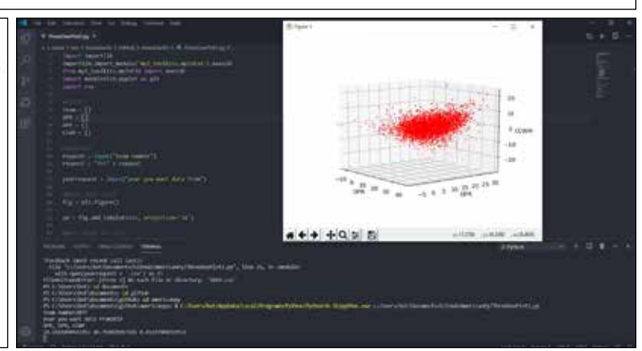
Scouting requires six people in the stands for the entire competition. By scouting together, each team needs to contribute fewer members. Sitting in the stands together as we scout and sharing our data also allow us to grow our connections with other teams.

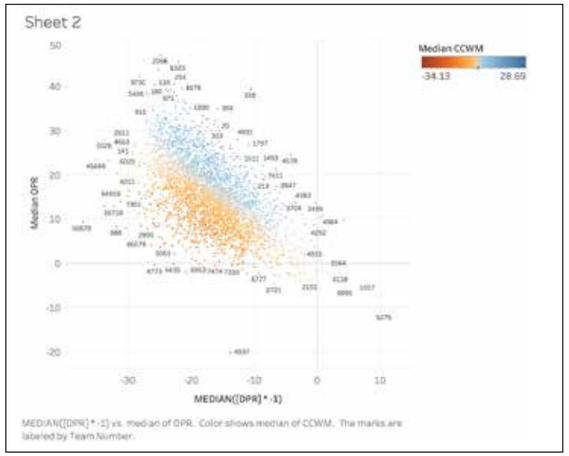
We also use our analyses of game strategy, rules, and design to help train our team members. During the preseason we train rookies to understand the basics of an FRC game, and how we operate as a team. Rookies watch and analyze previous season robot games.

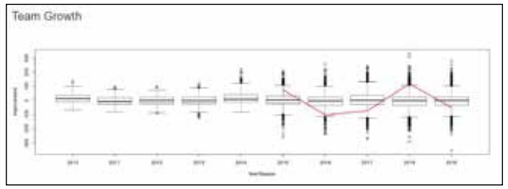
We focus on analyzing robot types and game strategy, and on predicting game outcomes in both qualitative and quantitative ways. When the game is announced at "kickoff," the strategy council compiles multiple documents, including a comprehensive guide to build season for rookies, and critical numbers that save our student engineers time and energy during the robot build process.

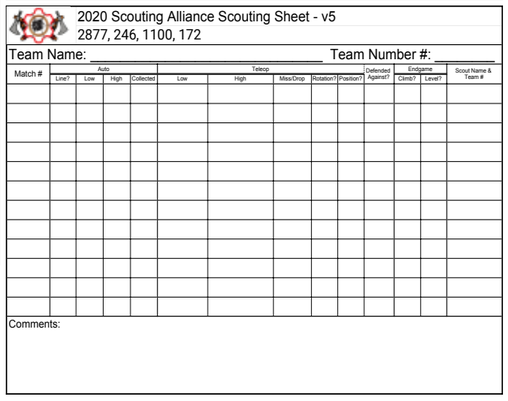
The strategy council also focuses on data analysis, using R and Python. We have been mentored in this process by Noam Shoresh, a computational biologist from the Broad Institute in Cambridge, MA. We share our results with our FRC scouting partners and have posted the blank scouting sheet we developed for our alliance on FRC's Chief Delphi and on our scouting alliance's Discord, two of the forums that FRC teams use to exchange information. One of our ongoing projects is to rank the New England teams using analysis of statistics like offensive power ratings (OPR).





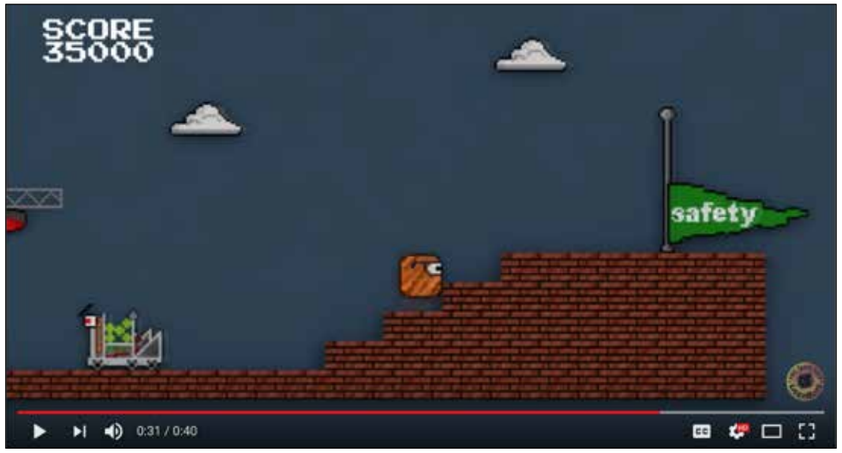






Rows 1-3: data from the 2019 season. Row 1: number of balls and hatches scored by each team's robot. Row 2: correlation between powder coating a robot and its playoff alliance pick number; 3D representation of all teams' offensive power rating (OPR), defensive power rating (DPR), and calculated contribution to win margin (CCWM). Row 3: graph of OPR against DPR with coloring based on CCWM; LigerBots' worldwide rank growth analysis. Row 4: logo and scouting sheet for our 2020 joint scouting project with three other teams.

LigerBots Win the Safety Animation Contest



In 2018 the LigerBots won our first international award—first place in the world-wide FIRST Robotics Safety Animation competition. Our winning video was shown at many FIRST Robotics competitions to about half a million spectators over the 2018 season. These animated videos combine an educational message about safety with creative art and imagery.

How We Made the Video

In order to follow the retro-1980s arcade theme of the 2018 FRC challenge, we developed a story that combined safety principles with elements of our very own video game. We designed characters and scenery and brought them to life with 3D animation. Finally, we added arcade-style music and sound effects along with a voice-over narration by a LigerBots team member to accompany the visuals.

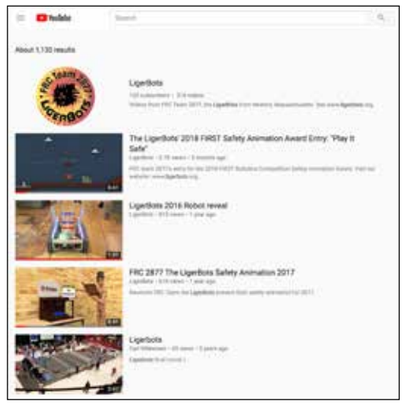
Rising to the Animation Challenge

According to LigerBots' animator Vivek, the biggest challenge was fitting the story into only 40 seconds—the maximum time allowed by rule. The deadline also provided an obstacle, forcing us to make fast decisions and to start the animation process early.

"It took considerable work," said Vivek, "but I'm excited about what it means for our team. It got me thinking about STEM vs STEAM and how the 'A' Art factor ties into the work we do."

We are proud of the work the team did to win this prestigious award and hope that our video will have a lasting impact on the community by encouraging safe practices.

The public can subscribe to our YouTube channel to see this video and all the rest of our team videos.



LigerBots YouTube channel.

LigerBots FIRST Awards

Year	Event	Award
2019	New England Championship Central Mass District	Dean's List Finalist Entrepreneurship
2018	Worldwide competition Greater Boston District North Shore District	Safety Animation Engineering Inspiration Imagery
2017	Rhode Island District WPI District	Entrepreneurship Gracious Professionalism
2016	New England Championship WPI District Boston District	Innovation in Control Entrepreneurship Innovation in Control
2015	New England Championship Northeastern District UMass Dartmouth District	Chairman's Competition Finalist Chairman's
2014	Northeastern District WPI District	Competition Finalist Spirit Competition Winner Creativity
2013	Boston Regional	Creativity
2012	Boston Regional WPI Regional	Gracious Professionalism Gracious Professionalism
2011	WPI Regional	Website Dean's List Finalist
2010	Boston Regional WPI Regional	Team Spirit Imagery
2009	Hartford Regional Boston Regional	Rookie Inspiration Highest Rookie Seed Rookie All-Star Highest Rookie Seed

The Chairman's Award is the most prestigious award that FIRST offers, honoring the team that best displays the values and goals of FIRST, while also being a role model for other teams. In 2015 the LigerBots won the Chairman's Award at both the district and NE Championship levels, which qualified the team to compete at the FRC World Championship in St. Louis.

The Engineering Inspiration Award celebrates outstanding success in advancing respect and appreciation for engineering within a team's school and community. The LigerBots won this award in 2018 for the team's extensive STEM outreach efforts.

The Entrepreneurship Award recognizes a team that has developed a comprehensive business plan to scope, manage, and achieve team objectives. Judges chose the LigerBots in 2016 and 2017 for the team's work in expanding professional relationships with sponsors, acquiring new business mentors, creating a comprehensive business plan, and developing a detailed student leadership structure.

The Safety Animation Award is given to one team worldwide that produces the best 40-second animated video combining an educational message about shop safety with creative art and imagery. The LigerBots' winning 2018 video was shown internationally at many FRC competitions.

The Innovation in Control Award celebrates an innovative control system or application of control components—electrical, mechanical, or software—to provide unique machine functions. The LigerBots won at both the district and NE Championship levels in 2016 for its robot's adjustable-tipped ball-shooting mechanism and vision-control software.

LigerBots Promote FIRST LEGO League

In 2015, the LigerBots hosted an FLL competition and STEM fair. Feedback from FLL coaches was so positive that New England FIRST asked us to host the Massachusetts East Championship. Since 2016, the team has organized, coordinated, and staffed two competitions each academic year. This year, 34 FLL teams took part in the Newton Qualifier, and 48 competed in the Championship. All events include robots from other FIRST programs.

In addition to our work, we also havehad staffing help from FRC 246 Overclocked, Newton South High School's Science Team, and the Newton North High School Computer Programming Club, helping build relationships with other STEM programs both inside and outside of FIRST.

We measure the success of our FLL competitions in two ways: the income the competitions generate and the feedback from those who come. Our FLL competitions attract about 1700 people annually, and help us earn more than $5,000 from a combination of food sales and team registrations. Our feedback from coaches, parents, students, and volunteers is overwhelmingly positive. One parent commented, "I just wanted to thank everyone for all their hard work making this a success. My son will definitely be back, and our younger son is likely to participate." Another parent said, "Every single LigerBot was helpful and friendly. They did a great job of representing their team, their teachers, and their school. Well done!" One even thanked us for inspiring his kids stating "they want to be just like you."

Every year, we host an FLL info night in June to encourage the creation of more teams in Newton. We set up engaging STEAM activities, including brushbots, LEGO towers, and binary beads bracelets, while the parents listen to an overview presentation about FIRST. We have recently facilitated the creation of three FLL teams, as well as an FLL Jr. team, bringing more than 20 families into the FIRST pipeline.

Three of our students have helped mentor the SuperNovas, a Newton-based team that was created at our FLL info night. LigerBots mentors taught the basics of programming, robot design, essay writing, and public speaking.

The LigerBots have also had a long term mentor relationship with Newton's all-girl team, the Day Dragons. We recently helped the Day Dragons make it to the FLL world championship by coaching them on their project presentation. This year, four former Day Dragons are some of our most enthusiastic new LigerBots.

LigerBots mentor a presentation by the Day Dragons FLL team.

Visitors make crayons at the LigerBots FLL Info Night.

Row 1: team Astra RSM competes; awards ceremony. Row 2: limbo line before an awards ceremony; LigerBots with mentee FLL team the SuperNovas. Row 3: parents photograph their FLL teams in front of the LigerBots/FLL backdrop.

LigerBots FLL Maker Fairs Get Girls into STEM

All of our FLL competitions include a STEAM (Science, Technology, Engineering, Art and Math) maker fair that brings in outside organizations to share their knowledge with the community. Since 2018, the Newton Girl Scouts have used our event to replace their canceled STEAM fair, learning STEAM skills through activities like origami, binary beads, handling 3D printed molecules, and "coding" our PB&J robot. Deb Terman, the face of Newton Girl Scouts, has said, "The K-5 girls had a lot of fun at the STEAM event. They were engrossed in the individual activities." We train LigerBots members to teach the activities to students, and our team learns how to share their STEAM knowledge in a way that everyone can understand.

Working with the Girl Scouts is part of our overall effort to achieve gender balance in STEM. In 2017, our team ran a "Girls + Tools" event, which inspired local middle and high school girls to get more involved in engineering opportunities. Each attendee milled a smiley face out of metal stock, then wired and soldered LED lights.

The LigerBots also have helped put together a day-long Women In STEM event at Newton North High School, which celebrates the accomplishments of women in STEM fields with the goal of inspiring girls to pursue STEM careers. LigerBots mentors give presentations about their professional work, and student team members take a hands-on approach to organizing the event.

Displaying a smiley face made at the LigerBots "Girls + Tools" event.

Exhibitors at Our Recent FLL Maker Fairs

- *Brandeis Maker Lab*
- *Code Ninjas*
- *Einstein's Workshop*
- *Empow Studios*
- *Gamewright*
- *Green Newton*
- *Hatch Makerspace*
- *IRobot*
- *Johnson String Instrument*
- *Made@MassChallenge*
- *Massachusetts National Guard*
- *MassBay Community College STEM*
- *Microsoft*
- *New Art Center*
- *New England Model Engineering Society*
- *New England Optical Association of America*
- *New England R2 Builders*
- *Newton Free Library*
- *NuVu*
- *Orimagi.io*
- *Prospect Hill Forge*
- *Rise Robotics*
- *Robosall*
- *Russian School of Math*
- *SharkNinja*
- *Society of Women Engineers*
- *Star Wars 501st Legion*
- *Students for a Greener World*
- *Woobo.io*
- *LigerBots STEAM activities*

Girl Scouts at the FLL E. MA Championship maker fair with: Row 1: Kevin Osborne, Maker; Gamewright. Row 2: Code Ninjas; Newton Free Library. Row 3: Code Ninjas; LigerBots slime. Row 4: Johnson String Instrument; Hatch Makerspace.

LigerBots Maker Fairs are Engaging









Row 1: Brandeis MakerLab; LigerBots slime; LigerBots outreach robot. Row 2: LigerBots PB&J robot (top); Star Wars 501st Legion (bottom); LigerBots slime; R2 Builders. Row 3: LigerBots 3D printer; Empow Studios.

At FLL Tournaments LigerBots Fill Many Roles






Row 1: judging for FLL Jr.; refereeing. Row 2: selling food; staffing safety desk and lost and found. Row 3: MCing; resettting game table; running audio/visual.

LigerBots Engage with Our Community

The LigerBots participate in outreach events in order to accomplish three goals: to spread the messages of FIRST; to promote project-based learning; and to give team members experience in sharing STEM ideas with the community. Students learn to communicate the messages of FIRST by practicing giving speeches and presenting them at outreach events.

We take our STEM activities for children and informational flyers about these activities to outreach events. These include brush bots, origami, paper airplanes, slime, binary beads and PB&J robot.

Since 2015, we have averaged 28 outreach events per year, and we are on track to meet that standard this year. These events range from bigger community events like Newtonville Village Day to smaller gatherings like Cub Scout meetings.

We also regularly participate in the Newton Inspires event, the annual fundraiser for the Newton Schools Foundation (NSF). Entrepreneurs, lawyers, and engineers in our community come to the event to learn about the growth and innovation going on in Newton. We use this to maintain a strong relationship with NSF, our parent organization and one of our biggest supporters.

2019 Newton Memorial Day parade.

Row 1: Memorial Day flag planting on veterans' graves at the Newton Cemetery; Newton Free Library STEAM event. Row 2: Newtonville Village Day; Newton Inspires. Row 3: Boston STEM Fair; Cub Scouts meeting.

LigerBots Connect with Our Government

We connect regularly with government officials to advocate for our team and for STEM learning.

During the Newton mayoral election in 2016 the LigerBots workshop became a stop on every candidate's campaign trail. Newton Mayor Ruthanne Fuller became a LigerBots fan, driving our robot at outreach events and inviting us to her office to celebrate a successful season. We regularly email with members of the city council and also take part in community events such as the annual Memorial Day parade.

Our influence reaches Beacon Hill and Capitol Hill. This year we met with Massachusetts state senator Cynthia Creem, and with state representatives John Lawn, Kay Khan, and Ruth Balser.

At the federal level, we played a crucial part in passing Act H. R.500, which directs the Department of the Treasury to mint and issue 350,000 $1 silver coins in commemoration of Space Shuttle Challenger astronaut Christa McAuliffe. In the summer of 2018 we worked with 25 teams at the FIRST National Advocacy Conference in Washington D.C., advocating successfully for the reauthorization of the Perkins Act, as well as for fully funding the allocation for the Every Student Succeeds Act. These provide funding for STEM education in schools around the country. We lobbied the offices of Senators Warren, Senator Markey, and Representative Capuano, and talked directly to Representative Kennedy.

As active members of the FIRST Southern New England Advocacy Conference we contributed to the effort to pass Massachusetts Amendment #238, which would have given FIRST teams 250k total in Massachusetts state funds.

Our elected officials share in our successes. Newton School committee member Matthew Miller responded to our FIRST safety animation award, "Your video was well done, and the execution was insanely creative. I have always been a huge LigerBots fan. Keep on making Newton proud. You all ROCK!!!"

From training to FLL, everything we embark on ensures that the LigerBots remain the core of project-based learning in Newton and an advocate for STEM throughout the country.

FIRST Robotics teams at the 2018 National STEM Advocacy Conference in Washington, D.C. The LigerBots are at the left in the middle of the group.

Row 1: with MA representative Joe Kennedy, III at the 2018 National STEM Advocacy Conference in Washington, D.C.. Row 2: with Massachusetts state representative Ruth Balser at the Massachusetts State House during the FIRST 2019 Southern New England Advocacy Conference; Massachusetts state senator Cynthia Creem views a test of our 2020 robot. Row 3: Massachusetts governor Charlie Baker gets an explanation the LigerBots pit during a Boston University FRC competition; Newton mayor Ruthanne Fuller drives the LigerBots robot at the Just Think Expo.

LigerBots Do Outreach Everywhere!

Events with LigerBots sponsors

- *Whole Foods/Newton Schools Foundation fundraiser*
- *PTC LiveWorx*
- *Robo Madness, at Google*
- *Sponsor pitch at Fowler High Precision*
- *Sponsor pitch at OneShield*

LigerBots and FIRST events

- *Girls + Tools Night*
- *FLL Info Night*
- *Newton FLL Qualifier + maker fair*
- *Eastern MA FLL Championship + maker fair*
- *Mentoring FRC 6740, Glue Gun & Glitter*
- *Assisting Newton's Law of Mass FTC team*
- *Field trip to the Museum of Science and Industry*
- *Field trip to studio of maker Todd Cahill*

School events

- *Just Think! Expo*
- *Newton North and South club fairs*
- *Women in STEM Day at Newton North*
- *Newton South High School parents' night*
- *Newton South science department open house*
- *Bowen Elementary School science day*
- *Cabot Elementary School Invention Invasion*
- *Weston Field School robot demo*

Government Relations

- *FIRST National Advocacy Conference*
- *Southern New England Advocacy Conference*
- *Mayoral candidate visits to our workshop*

Community events

- *Newtonville and Newton Highlands village days*
- *Newton Inspires*
- *Newton/Needham Innovation District maker space talks*
- *Cambridge Carnival and Robot Zoo*
- *Newton Festival of the Arts*
- *Boston STEM Fair*
- *Forest Avenue Cleanup*
- *Flag planting at Newton Veterans Memorial*
- *Newton Memorial Day parade*
- *Tour de Newton*
- *Newton Free Library STEAM Expo*
- *Newton Free Library Think Big girls' STEM event*
- *Talk at a retirement community*
- *Demo at Cub Scout meeting*
- *Girl Scouts STEAM patch workshop*
- *Girl Up Boston Coalition Steminist Saturday*
- *Boston Greenfest*
- *WaterFire Moon Landing 50th Anniversary*

Tech events

- *Booz Allen Ideas Festival*
- *Electronic Components Industry Association events*
- *MA STEM Summit*
- *Robotica*
- *Robo Madness*
- *From Global to Local MIT education conference*
- *MIT IDE Inclusive Innovation Awards*
- *RoboExpo at Pheasant Lane Mall, Nashua NH*
- *MIT Blueprint high school hackathon*

Row 1: visit to the Field School of Weston; Newtonville Village Day. Row 2: Cambridge Science Festival; MIT IDE Inclusive Innovation Awards. Row 3: Tour de Newton; Electronic Components Industry Association (ECIA) conference.

LIGERBOTS
FIRST Robotics Team 2877
Newton North and South High Schools

140 Brandeis Road, Newton Centre, MA 02459
info@ligerbots.org ▪ www.ligerbots.org
#FRC2877 ▪ The LigerBots
@ligerbots ▪ @ligerbots_frc2877

About the LigerBots

The LigerBots is FIRST Robotics Competition (FRC) team 2877. FIRST ("For Inspiration and Recognition of Science and Technology") is an international organizer of competitive robotics events whose mission is to lead students toward careers in science, technology, engineering and mathematics (STEM). The LigerBots is a non-profit organization that provides students with the skills they need to prepare for the jobs of the future and become the next generation of engineers and business people. The team combines students from Newton North and Newton South high schools to spread the message of STEM education in the community and help students develop their problem solving and critical thinking skills while they pursue their interests in business and robotics.

LigerBots do intensive technical and outreach training each fall, and have six weeks each winter to build a 120-lb. robot that can compete in the spring in a new game designed by FIRST each year. The LigerBots pride ourselves on our dedicated student leadership infrastructure and variety of mentors, who include scientists, engineers, programmers, marketers, publicists, financial consultants, project managers, and graphic designers. The team's ability to offer these opportunities to high school students is dependent on its generous sponsors. The LigerBots is always looking for new sponsors and donors to help sustain the team. Major sponsors are identified on all LigerBots materials, including marketing documents, the competition pit, the website, and the robot itself.

Sponsor or donate to the LigerBots: *info@ligerbots.org, www.ligerbots.org*

The LigerBots at the 2018 FIRST World Championship in Detroit

Puma and Panther level sponsors

Puma and Panther level sponsors

NEWTON PUBLIC SCHOOLS · ptc · OneShield SOFTWARE Business Solutions. Simplified. · BAE SYSTEMS INSPIRED WORK · NEWTON SCHOOLS FOUNDATION EDUCATE · INNOVATE · INSPIRE · Raytheon · Google · alm works · The Village Bank

Outreach flyer (front).

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Be a LigerBot, Mentor a LigerBot

Who is on Our Team

- We are composed of students from Newton North and Newton South high schools
- We have adult mentors and coaches, including parents of team members and other STEM and business professionals. We are always looking for adult mentors who have expertise in mechanical and electrical engineering, programming, marketing, publicity, finance, project management, and graphics

LigerBot and mentor work on mock playing field elements

Our Role in FIRST Robotics

- We design and build a robot with a different function every year, and participate in two to four FIRST competitions
- We have made it four times to the FIRST World Championship, including in 2018
- We organize the Newton FLL Qualifier and the Eastern MA FLL State Championship for elementary and middle school students, and we mentor FLL teams

FIRST Opportunities for Younger Students

- FIRST Lego League (FLL) is robotics for students in grades 4 – 8. Email: fll@ligerbots.org
- FIRST Lego League Jr. is for students in grades 1 – 3. Website: www.juniorfirstlegoleague.org

Be a LigerBot, mentor a LigerBot: *info@ligerbots.org, www.ligerbots.org*

The 2019 pit crew with Thanos, the LigerBots 2019 robot

The Engineering and Business Skills We Learn

- Mechanical engineering
- Electrical engineering
- Programming
- Computer Aided Design
- Gracious Professionalism
- Entrepreneurship
- Finance
- Time management
- Leadership
- Teamwork
- Event planning
- Public speaking
- Graphic design
- Writing
- Mentorship

The Rhythm of Our Year

- *Fall and late spring:* Pre- and post-season. We plan projects, do team-building, technical training, fundraising and STEM outreach to our community. Team meetings at Newton South High on Mondays 6:30 p.m., and at Newton North High on Thursdays at 6:30 p.m.
- *Winter:* "Build" season. We design and build a robot over a six-week period, Jan. – Feb. Meetings Mon. – Sat. at Newton South High School
- *Spring:* Competition season. We compete against other FIRST teams with our robot, weekends in March and April.

Outreach flyer (back).

LigerBots Are in the Public Media

Students use our training in communication to publicize the LigerBots activities and events. Members learn to explain the team and activities through various forms of media, including learning how to be interviewed and how to write press releases and blog posts.

The team has been featured in the NewtonSTEM newsletter 60 times since 2015, and in a two-page photo spread in our local paper. We have also been interviewed by TES, one of the largest teacher publications in the world. We maintain regular updates on social media channels and our blog, which we use to consistently tell the story of the team. Since 2015, the team has produced 126 blog posts, featuring photos and stories about the team's activities. Parents and students alike can learn about the LigerBots and the messages of FIRST through these blog posts.

We also had media success in 2018 when a team member made our safety animation, which won the safety animation award.

NEWTON TAB | Wednesday, December 12, 2018 C1

Newton LigerBots to host robotics competition

The Newton LigerBots, Newton North High School's robotics team, will host the FIRST LEGO League Massachusetts State Championships on Dec. 15.

On Nov. 17, 300 middle and elementary schoolers from half of Massachusetts competed in the Eastern Massachusetts State Qualifier robotics competition and maker fair, hosted by the LigerBots. The competition gave 24 teams the chance to compete for a spot at the upcoming championships.

Each FIRST LEGO League team spent months building and programming robots to perform tasks as laid out by FIRST, an international organization that uses robotics competitions to inspire K-12 students in science, technology, engineering and math.

This year's game, called "Into Orbit," has a space theme and, in addition to the work on their robots, students created projects designed to solve real-world space exploration problems.

Those not competing explored the maker fair, which featured hands-on activities and displays from organizations including Hatch, Empow Studios, Newton Free library, R2 Builders, Johnson String Instruments and SharkNinja. There were reconstructions of Star Wars robots, vacuum bots in pieces and moving around the floor, instrument lessons and 3D printing.

The LigerBots also staffed activities of their own at the maker fair, including button making, paper airplanes, origami, painting robots and lessons in binary. The team also demonstrated a few their own robots.

The student teams took turns setting up their robots to execute automated commands. They also activated contraptions, maneuvered objects and shot across the field to earn as many points as possible. After a difficult round, students rushed to troubleshoot and improve for their next attempt.

Teams attempted to orient a collection of solar panels. Their presentation skills were put to the test as they walked judges through their design and construction process for their robots. Teams also had to research an issue plaguing engineers today in space travel and brainstorm a solution. Students prototyped, budgeted and created professional pitches for their ideas.

Seven of the winners of the Newton Qualifier will be joining 600 of their peers at the upcoming FIRST LEGO League Eastern Massachusetts State Championship. The event will take place from 9 a.m. to 3 p.m. Dec. 15 at Newton North High School. Free. For information: http://ligerbots.org.

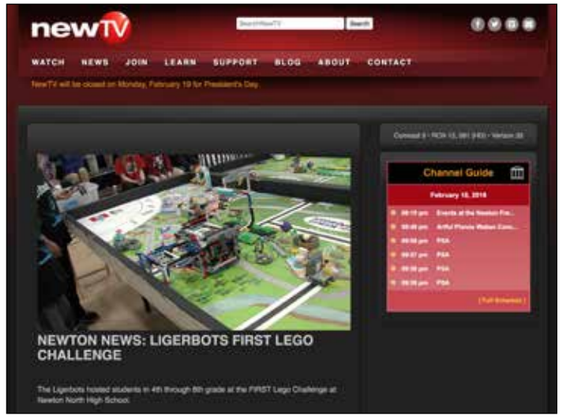
Teams compete at the Eastern Massachusetts State Qualifier robotics competition and maker fair, hosted by the Newton LigerBots. [COURTESY PHOTO]

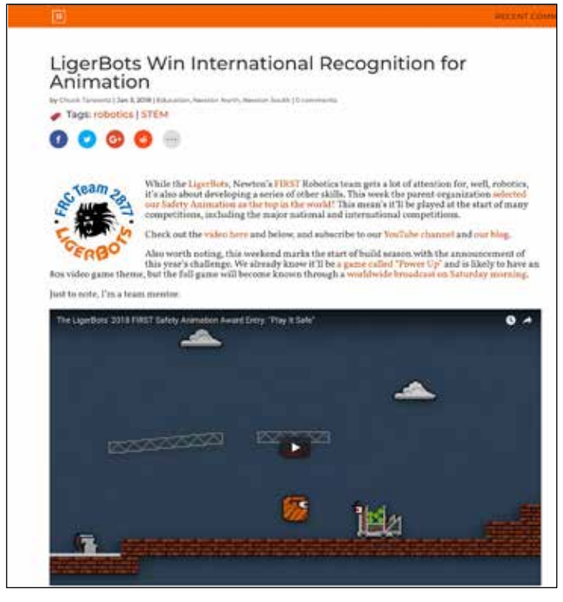
Students limbo at the Eastern Massachusetts State Qualifier robotics competition. [COURTESY PHOTO]

Students interact with reconstructions of Star Wars robots at the Eastern Massachusetts State Qualifier robotics competition and maker fair, hosted by the Newton LigerBots. [COURTESY PHOTO]

The Newton LigerBots hosted the Eastern Massachusetts State Qualifier robotics competition and maker fair on Nov. 17. [COURTESY PHOTO]

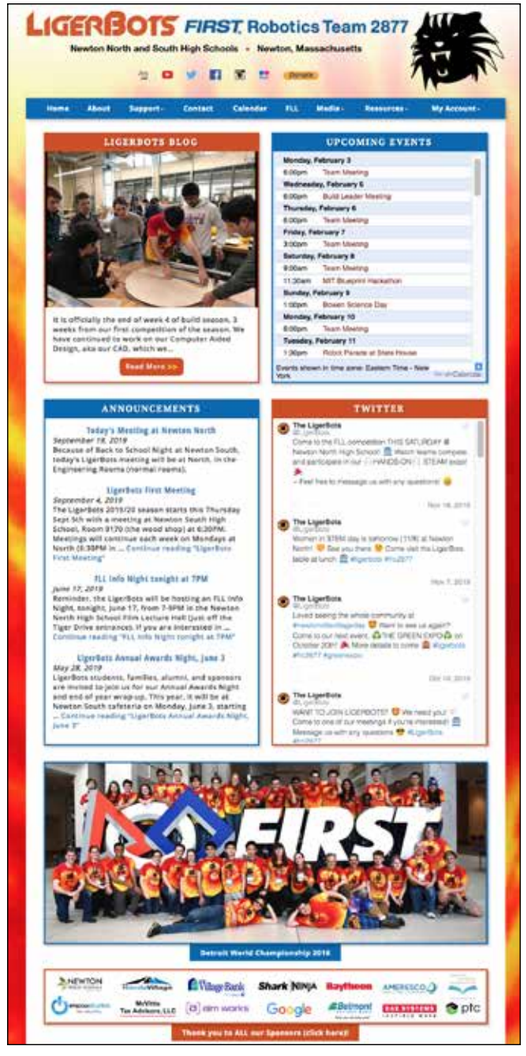
LigerBots in the Newton TAB.





Clockwise from upper left: NewTV reporter interviews LigerBots at Just Think Expo; reporting on the FLL E. MA Championship on the NewtonSTEM.org website; David Pogue of PBS series NOVA *interviews LigerBots at the PTC LiveWorx conference; reporter from TES teachers' resource website interviews team members; a story on the Village 14 website about the LigerBots' winning safety animation; NewTV story about the FLL Eastern MA State Championship.*

LigerBots Create Our Own Media

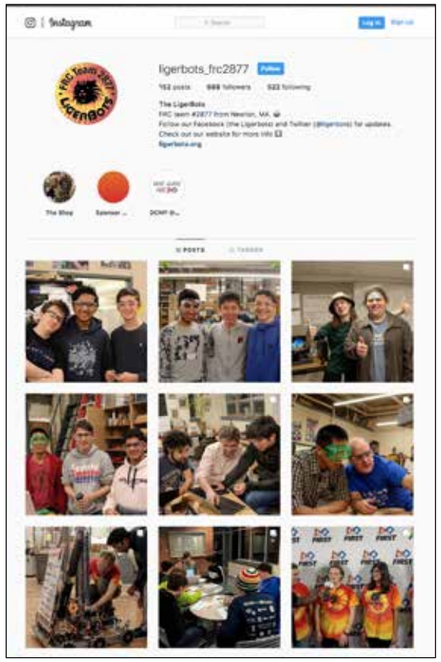


LigerBots website home page.

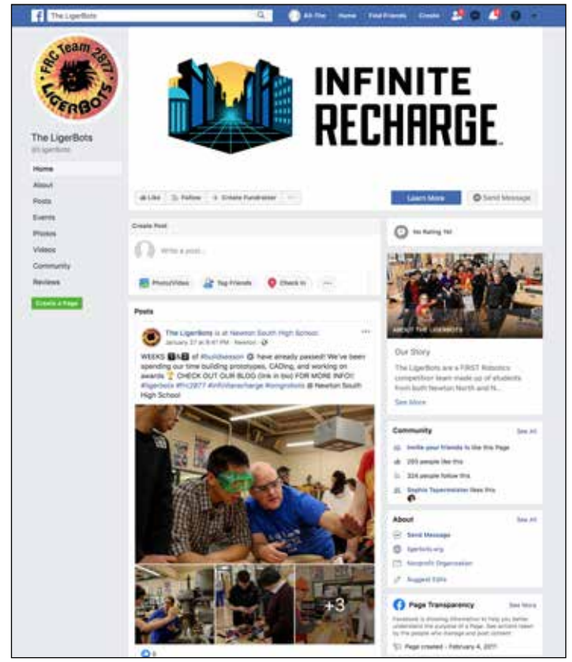
LigerBots Media

- *Website blog posts*
- *Press releases*
- *Media interviews*
- *TED Talks*
- *Twitter*
- *Instagram*
- *Facebook*
- *Flickr photo album sharing*
- *YouTube videos*
- *Supporter updates*
- *Discussions at our outreach tables*
- *Printed marketing and outreach materials*

Part of a 2020 blog post.



LigerBots Instagram page.



LigerBots Facebook page.

LigerBots Twitter feed.

LigerBots Connect with Our Sponsors

In order to sustain our robotics ventures, our extra projects, and outreach events, the LigerBots rely on support from our sponsors. We train students, both business-focused and technical-focused, on how to build and manage sponsor relationships. We run an annual training session in making a brief "elevator pitch" about the team. And we write a monthly supporter update with detailed descriptions of team activities over the past month, complete with photos of these activities.

An important part of our sponsor relations is students having direct relationships with individual sponsors. This involves both emailing contacts and giving pitches face-to-face.

LigerBot practices her elevator pitches with another team member.

LigerBots make a pitch to win over new sponsor OneSheild.

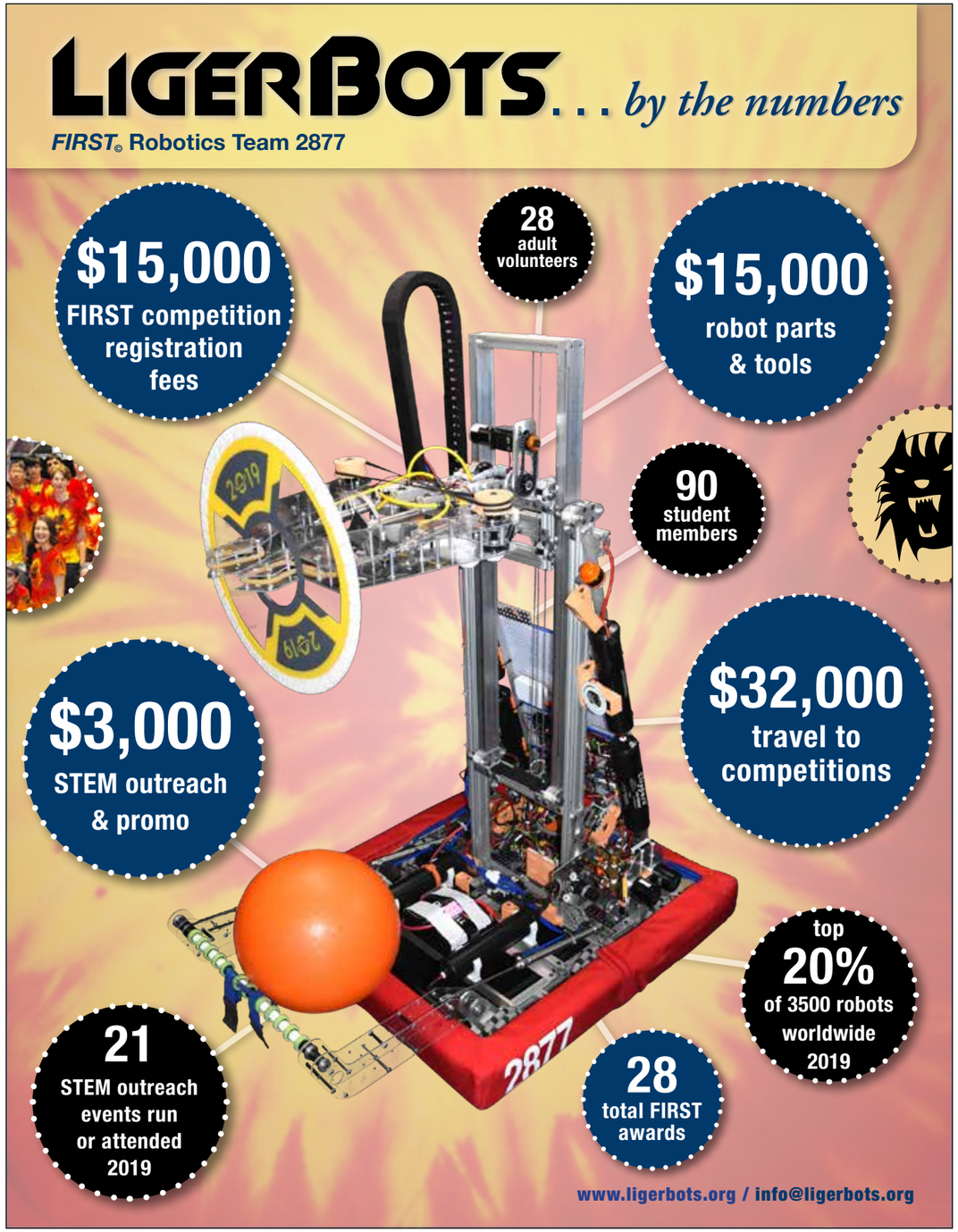
LIGERBOTS
FIRST Robotics Team 2877
Newton North and South High Schools

Dear LigerBots Supporter,

November saw the LigerBots hosting one of our most exciting events of the year, the FIRST LEGO League (FLL) Newton Qualifier robotics competition and maker fair—a mashup of sporting event, science fair, family reunion, and dance party! About 300 competitors, spectators and members of the public attended the event at Newton North High School, as 23 teams of students in grades four to eight competed with their LEGO robots in this year's space-exploration-themed FLL game, called "Into Orbit." The teams also displayed research projects on space-based themes.

Clockwise from upper left: LigerBots-mentored team the Supernovas react to their robot's progress; the LazerRobotics drive team waits for referee Jeffrey's verdict on their points earned; the Day Dragons collect an award from the judges; the competing teams with the LigerBots; some of the Brattle Street Bobcats with their Into Orbit project

Supporter update sent via MailChimp.



LigerBots outreach infographic, showing team fundraising needs in a year we go to the FRC world championship.

LIGERBOTS

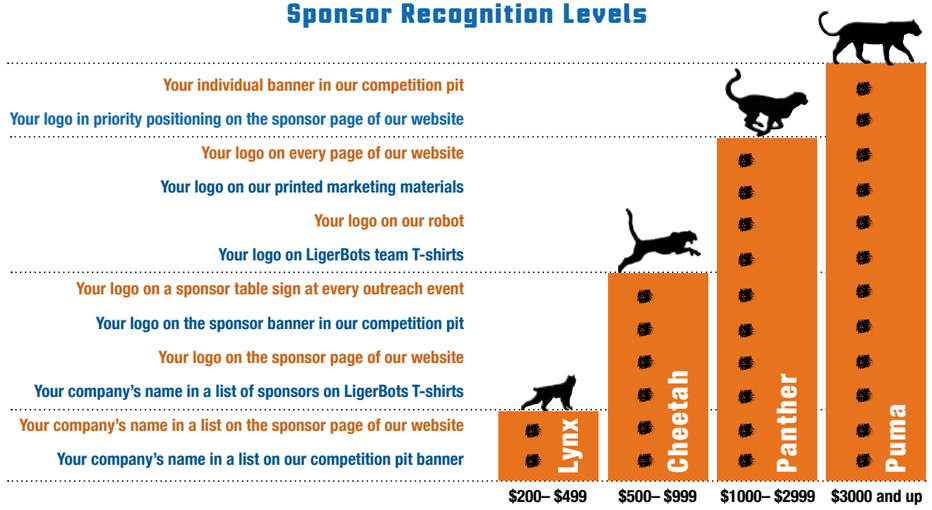
FIRST® Robotics Team 2877

Newton North and South High Schools

140 Brandeis Road, Newton Centre, MA 02459
info@ligerbots.org ▪ www.ligerbots.org
#FRC2877 ▪ The LigerBots
@ligerbots ▪ @ligerbots_frc2877

Support project-based learning that gives Newton students the skills they need to be contributors and leaders in technology.

Sponsor Recognition Levels



Examples of Sponsor Logos on LigerBots Materials

Left to right: team outreach flyer, 2019 t-shirt back, 2019 competition pit, 2019 robot, website sponsor page

How to Sponsor the LigerBots

To sponsor, please email the LigerBots chief marketing officer at cmo@ligerbots.org

The LigerBots, Newton's award-winning high school FIRST Robotics team

Supporter recognition flyer, (front).

The LigerBots are proud to recognize our sponsors at every event we attend. Thousands of people will see your brand and your support for STEM learning.

The Exposure You Will Get

Educational Events We Typically Attend

- American Assoc. for the Advancement of Science annual meeting
- Boston STEM Fair
- MASS STEM Summit in Worcester, MA
- Electronic Components Industry Assoc. annual meeting
- Assoc. for Unmanned Vehicle Systems International "Robotica" conference
- Xconomy's conference "Robo Madness: AI Gets Real"
- MIT's edtech conference "From Global to Local"
- Cambridge Carnival and Robot Zoo
- Newton Mayor's STEM Night
- "Just Think!" Expo at Newton North High School
- Newton Free Library STEAM Expo
- "Newton Inspires" speaker night
- STEM promotion visits to Newton elementary schools and Cub Scout troops
- Club fairs and science open houses at Newton North and South high schools

LigerBots at the 2019 Newton Newtonville Village Day

FIRST Robotics Competitions We Typically Enter or Run

- FRC district competitions: attend two every year
- FRC New England Championship: qualified last five years
- FRC World Championship in Detroit. 30,000 attendees. LigerBots attended 2009, 2014, 2015, and 2018.
- Newton Qualifier FLL Competition, plus maker fair: run by the LigerBots, 500 attendees.
- Eastern NE FLL Championship, plus maker fair: run by the LigerBots, 900 attendees.

Community Events We Typically Attend or Run

- Newtonville Village Day
- Newton Highlands Village Day
- Newton Memorial Day Parade
- Newton Harvest Fair
- Maker Fair at Newton FLL Qualifier and E. MA FLL Championship

How to Sponsor the LigerBots

To sponsor, please email the LigerBots chief marketing officer at cmo@ligerbots.org

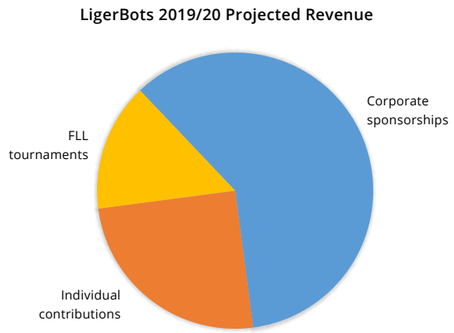
LigerBots at the 2019 Newton Memorial Day parade

Supporter recognition flyer, (back).

LigerBots Fund Our Activities

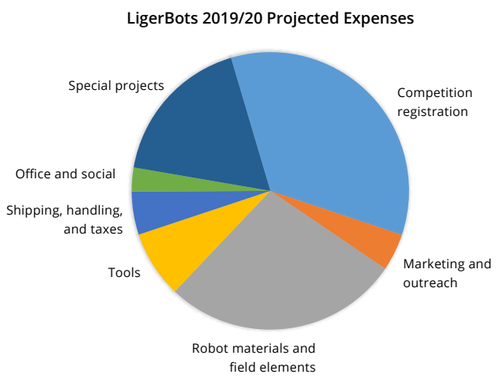
REVENUE DETAIL	2016/17 Actual	2017/18 Actual	2018/19 Actual	2019/20 Budget	2019/20 Projected
Corporate Sponsorships	$18,600	$20,500	$23,100	$15,000	$18,000
Individual Contributions	2,922	5,800	4,800	4,000	6,800
Gifts In Kind	500	1,500		1,000	
FLL Tournament (net)	4,492	4,685	2,500	2,500	5,200
Newton Public Schools	4,000		4,000		
Total Revenue	$30,514	$32,485	$34,400	$22,500	$30,000
Total Expenses	20,289	32,427	29,965	25,250	28,800
Net Income[1]	**$10,225**	**$58**	**$4,435**	**($2,750)**	**$1,200**

1. When fundraising exceeds the budget we consider additional special projects and activities not in the original budget.



EXPENSE DETAIL	2016/17 Actual	2017/18 Actual	2018/19 Actual	2019/20 Budget	2019/20 Projected
Competition Registrations	$5,650	$10,365	$9,650	$10,000	$10,000
Business & Marketing	969	1,689	1,050	850	950
Outreach (Advocacy Conferences)[1]		1,250	1,265	300	300
Robot Materials	7,653	8,618	8,900	6,650	6,750
Tools	1,822	2,873	1,750	1,000	2,250
Field Elements	107	193	50	250	700
Shipping, Handling & Tax	998	1,120	1,425	1,200	1,450
Office & Social	1,371	809	775	800	800
Travel Support[2]		1,900	900		
Special Projects	1,718	3,610	4,200	4,200	5,600
Total Expenses	**$20,289**	**$32,427**	**$29,965**	**$25,250**	**$28,800**

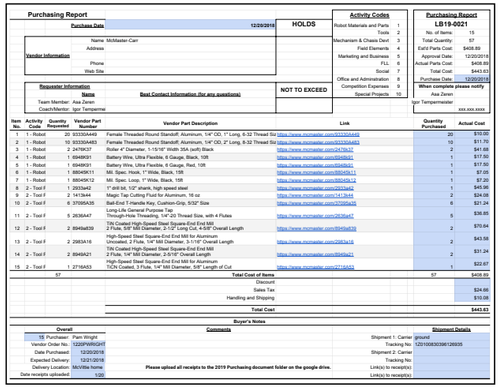
1. A decision whether to participate in the FIRST National Advocacy Conference again will be made after competitions.
2. For coaches for FIRST National Advocacy Conference, or for team members when the whole team travels to major competitions.



SPECIAL PROJECTS DETAIL 2019/20

Project Name	Budgeted	YTD	Status
Complete upgrade to MPCNC[1]	$2,500	$2,500	Completed
Scouting program[2]		100	Evaluating technology
Technology development and training	200	100	Started
Mars rover	500	285	Started
Outreach robot	1,000		Projected
Future Special Projects[3]	TBD		Projected
Total Special Projects	$4,200	$2,985	

1. Additional 2020 spending to complete a project funded and started in 2019.
2. Identified and started during 2020 season with a budget of $400.
3. To be identified and budgeted after competition season.



Purchasing Report — Purchase Date: 12/20/2019 — HOLDS

Vendor Information: Name: McMaster-Carr; Address; Phone; Web Site

Requester Information: Name: Asa Zeren; Team Member: Asa Zeren; Coach/Mentor: Igor Tempermeister; Best Contact Information (for any questions); NOT TO EXCEED

Activity Codes: Robot Materials and Parts 1; Tools 2; Mechanism & Chasis Devt 3; Field Elements 4; Marketing and Business 5; FLL 6; Social 7; Office and Administration 8; Competition Expenses 9; Special Projects 10

Purchasing Report LB19-0021: No. of Items: 15; Total Quantity: 57; Est'd Parts Cost: $408.89; Approval Date: 12/20/2019; Actual Parts Cost: $408.89; Total Cost: $443.63; Purchase Date: 12/20/2019; When complete please notify: Asa Zeren, Igor Tempermeister, xxx.xxx.xxxx

Item No.	Activity Code	Quantity Requested	Vendor Part Number	Vendor Part Description	Link	Quantity Purchased	Actual Cost
1	1 - Robot	20	93330A449	Female Threaded Round Standoff, Aluminum, 1/4" OD, 1" Long, 6-32 Thread Size	https://www.mcmaster.com/93330A449	20	$10.00
2	1 - Robot	10	93330A453	Female Threaded Round Standoff, Aluminum, 1/4" OD, 2" Long, 6-32 Thread Size	https://www.mcmaster.com/93330A453	10	$11.70
3	1 - Robot	2	2479K37	Roller 4" Diameter, 1-15/16" Width 35A (soft) Black	https://www.mcmaster.com/2479k37	2	$41.66
4	1 - Robot	1	6948K91	Battery Wire, Ultra Flexible, 6 Gauge, Black, 10ft	https://www.mcmaster.com/6948k91	1	$17.50
5	1 - Robot	1	6948K93	Battery Wire, Ultra Flexible, 6 Gauge, Red, 10ft	https://www.mcmaster.com/6948k93	1	$17.50
6	1 - Robot	1	8804K11	Mil. Spec. Hook, 1" Wide, Black, 15lb	https://www.mcmaster.com/8804k11	1	$7.05
7	1 - Robot	1	8804K12	Mil. Spec. Loop, 1" Wide, Black, 10ft	https://www.mcmaster.com/8804k12	1	$7.20
8	2 - Tool #	1	2933A42	1" drill bit, 1/2" shank, high speed steel	https://www.mcmaster.com/2933a42	1	$45.96
9	2 - Tool #	2	1413A44	Magic Tap Cutting Fluid for Aluminum, 16 oz	https://www.mcmaster.com/1413a44	2	$34.06
10	2 - Tool #	6	37095A35	Ball-End T-Handle Key, Cushion-Grip, 5/32" Size	https://www.mcmaster.com/37095a35	6	$21.24
11	2 - Tool #	5	2636A47	Long-Life General Purpose Tap, Through-Hole Threading, 1/4"-20 Thread Size, with 4 Flutes	https://www.mcmaster.com/2636a47	5	$36.65
12	2 - Tool #	2	8949a839	TiN Coated High-Speed Steel Square-End End Mill, 2 Flute, 5/8" Mill Diameter, 2-1/2" Long Cut, 4-5/8" Overall Length	https://www.mcmaster.com/8949a839	2	$70.64
13	2 - Tool #	2	2983A16	High-Speed Steel Square-End End Mill for Aluminum, Uncoated, 2 Flute, 1/4" Mill Diameter, 3-1/16" Overall Length	https://www.mcmaster.com/2983a16	2	$43.56
14	2 - Tool #	2	8949A21	High-Speed Steel Square-End End Mill for Aluminum, 2 Flute, 1/4" Mill Diameter, 2-5/16" Overall Length	https://www.mcmaster.com/8949a21	2	$31.24
15	2 - Tool #	1	2716A53	High-Speed Steel Square-End End Mill for Aluminum, TiCN Coated, 3 Flute, 1/4" Mill Diameter, 5/8" Length of Cut	https://www.mcmaster.com/2716a53	1	$22.67
		57				57	

Total Cost of Items: $408.89
Discount
Sales Tax: $24.96
Handling and Shipping: $10.08
Total Cost: $443.63

Buyer's Notes

Overall: 15; Purchaser: Pam Wright; Vendor Order No.: 123PWRIGHT; Date Purchased: 12/20/2019; Expected Delivery: 12/21/2019; Delivery Location: McVitie home; Date receipts uploaded: 1/20

Comments: Please upload all receipts to the 2019 Purchasing document folder on the google drive.

Shipment Details: Shipment 1: Carrier: ground; Tracking No.: 1Z0100830396126935; Shipment 2: Carrier; Tracking No:; Link(s) to receipt(s); Link(s) to receipt(s)

A LigerBots purchase order.

Our mission

The LigerBots aim to become the recognized leader of project-based learning in Newton. We value creating leadership and learning opportunities for students and inspiring the community as much as we value the quest to build a winning robot.

Our financial plan

The team supports its activities via corporate sponsorships, individual contributions, and operating FLL competitions. We also apply for, and have received funding from the Newton Public Schools for competitions at the district level and beyond.

Our special projects

We seek to fund a budget beyond the base requirement of competition fees and robot parts. Special projects, which are funded through a "mini-grant" process, let team members develop financial skills while working on challenging and engaging projects. Any student or mentor can propose a special project. Some of our recent special projects have been:

- ***Scouting tablets:*** Purchased tablets to be used during competition to track the performance of other teams.
- ***Clamping and marking tools:*** Increased the accuracy of our work through use of better tools.
- ***Mars rover:*** Built a model Mars rover as an aid to learning basic design and manufacturing strategies.
- ***Vision project:*** Assessed multiple cameras and processors to determine what will work best for robot vision during competition.
- ***Servos:*** Tested several kinds for torque and speed.
- ***CNC mill:*** Built a new CNC router to increase speed of cutting metal and polycarbonate plates.
- ***Pneumatic test bench:*** Built a test bench to help us prototype pneumatic mechanisms.
- ***Backdrop for FLL team photos:*** Purchased a step-and-repeat logo backdrop for publicity at our FLL tournaments.

Managing the budget

Our team treasurer reports weekly to the coaches and execs. Sponsorship proposals and revenue are tracked by the fundraising team. Our purchasing system allows team members to specify items for purchase and approval and our Treasurer to easily track spending. Purchase orders are shared on Slack so the entire team sees and can participate in purchasing decisions. Financial operations are overseen by our financial mentor and one of the head coaches.

Our financial mentor works with a team member on the budget.

Grant Number	GR20-001	**Budget $**	$400
Name	AJ Chau	**Date**	January 10
Title	Scouting Tablets (x7)		

Grant summary (what do you want to do and why):
We would like to use tablets for electronic scouting. This year half of the scouting alliance has stated that they would prefer electronic scouting. 1100 (T-hawks) has a lot of experience with these and will be at our first event (Northern CT) to help guide us through their usage, although hopefully we can figure it out ourselves. They use the same tablets, and are developing the scouting app. The tablets will also likely have other potential uses outside of scouting.
Timeline (how long will it take and/or when will it happen):
Longest shipping time looks to be the tablet case, at just under 2 weeks. We would like to have these a week or two before competition.
Personnel (who will do the work)
Daniel, AJ, Amanda, Matthew, Charlotte, Michelle
Other considerations (equipment, space, transportation, safety, etc)
We need a minimum of 6 tablets to scout. The 7th is for the head scout, and will also serve as a last resort backup. We're also going to need a large battery pack to last an entire scouting day. Cases and screen protectors will also probably be a good idea, if we end up using them extensively. Also shipping may not be free. We also want a sharpie since we can't find the silver one anymore (we use the black sticky notes)

Budget	$400	**Project total**	$385.27
Item	Quantity	Unit price	Item total
Tablets	7	$39.99	$279.93
Battery Pack	1	$29.95	$29.95
Tablet Case	7	$4.49	$31.43
Glass Screen	3	$9.99	$29.97

A LigerBots mini grant proposal for tablets to be used when scouting other teams at competitions.

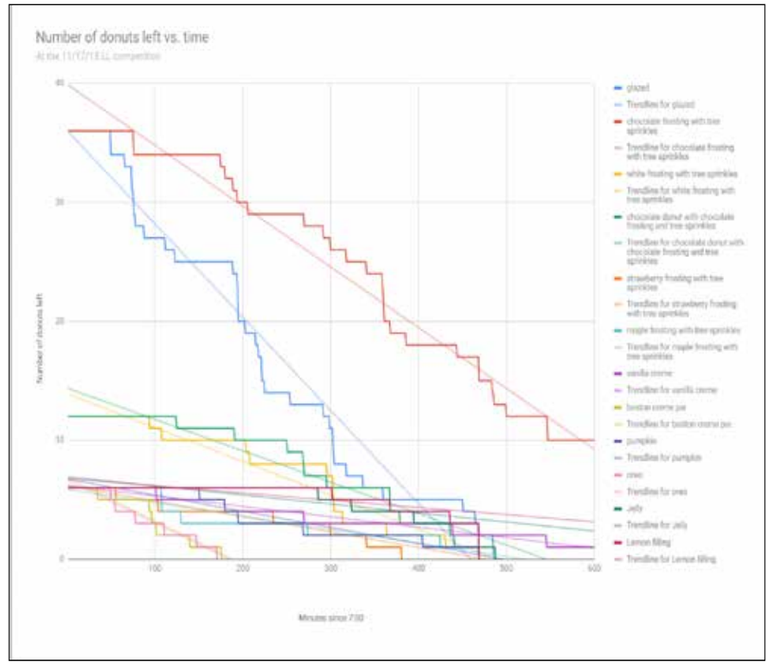
LigerBots Do Special Projects: Donut Data

Clara, Jordan and Ben look over the stats on Ligerbots donut purchases.

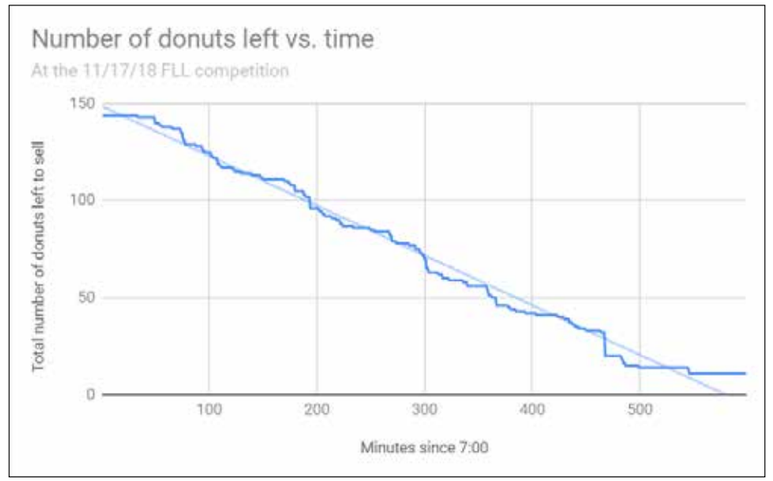
The LigerBots sell lots of donuts at our FIRST LEGO League competitions. This tasty snack seems to hit the spot with our FLL teams, their families, and our maker fair visitors during the long and exciting day at Newton North High School. But we often run out of certain kinds of donuts, and end the day with other kinds left unsold. Before the 2018 FLL Newton Qualifier our team COO, who usually helped staff the concession stand, became curious about which donut types sold the fastest and which the slowest, and at what times of day. He figured that analyzing this information could help the team make good decisions at our future FLL tournaments about which kinds of donuts to buy for resale.

During the Newton Qualifier our COO took data. The LigerBots at the concession stand had a lively discussion, trying to predict when the most donuts would be sold. Although many team members believed that more donuts would be sold in the morning than in the late afternoon, it turned out that they sold at a fairly consistent pace throughout the day. Jordan found that although the donuts that sold out first were Oreo and Boston cream pie, the donut that sold at the fastest rate was plain glazed!

This project was a great blend of the STEM and marketing skills that we learn on the LigerBots.

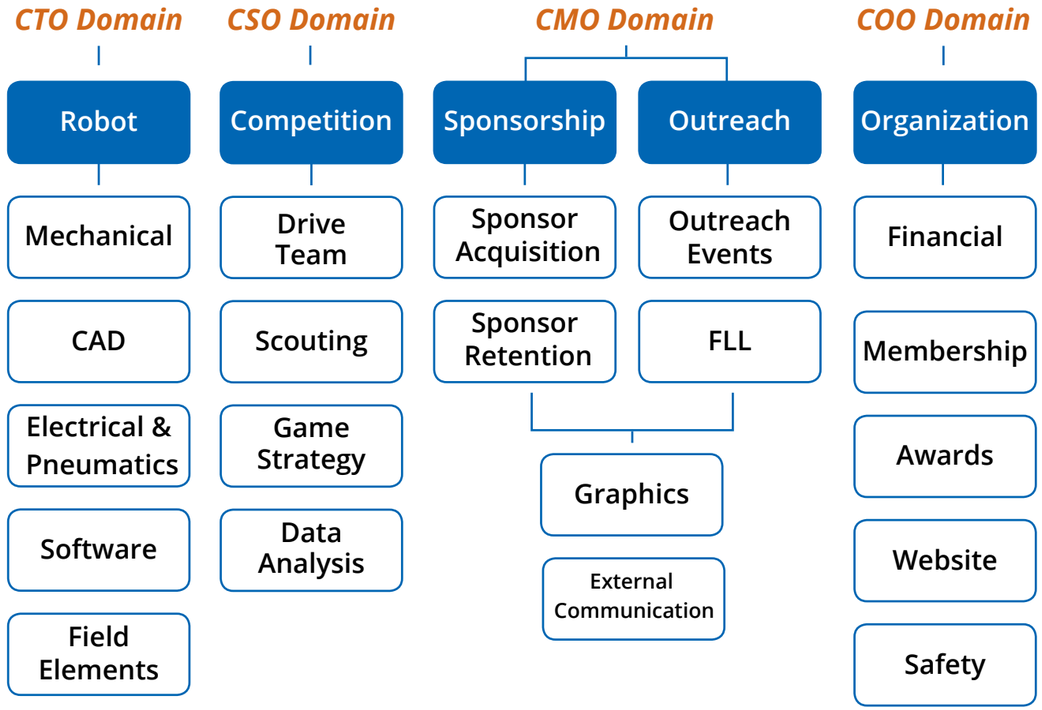


This graph shows all types of donuts in one line, demonstrating that donuts sell at a constant rate throughout the day, and not significantly faster in the morning.



In this graph the slope of the trend line can be viewed as the rate at which each doughnut type was sold. Ironically, the doughnut type that had the most left over at the end of the day (chocolate frosting with tree sprinkles) sold at approximately the second fastest rate. We should buy fewer of the chocolate frosting donuts in the future even though the fast sales during the Qualifier gave the illusion that we would need more.

LigerBots Student Leadership Structure



Group leaders gather in front of the task board at the end of a meeting to report on the day's progress.

Appendix: STEAM Activity Flyers

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3D Printer

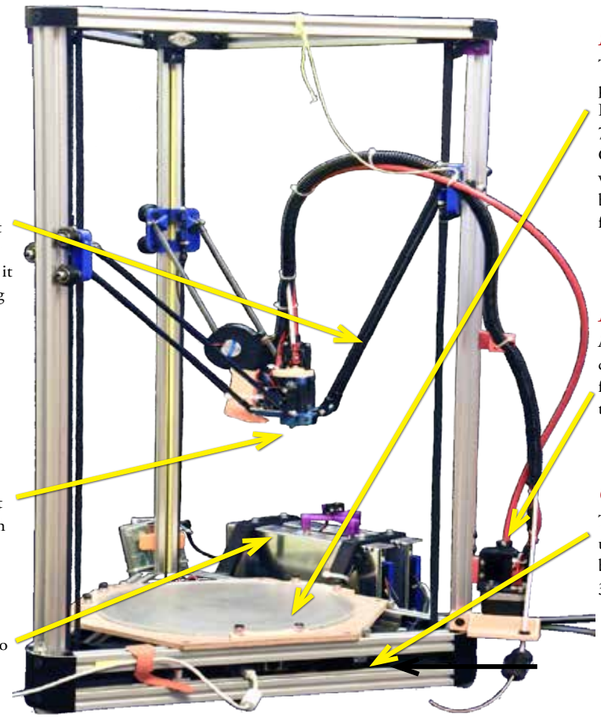
What is a 3D Printer? What do we use it for?

A 3D printer is a machine that allows us to "print" plastic structures by spitting out thin layers of melted plastic that stack. The LigerBots use a 3D printer to create prototypes or specific pieces with weird shapes we can't find on the market. We can code the shape we want using the program Delta 3D. Because it's taller than usual, this custom built 3D printer allows us to easily create large, complex pieces.

Translation Stage
A platform that moves, controlled by a computer, depositing plastic to the right location. The stage can move in any direction (not just up and down or side to side) because it is programmed using polar coordinates.

Hot End
Melts the plastic at between 215 and 260 degrees Celsius in order to deposit it. This piece is very light, which allows it to move quickly with little force.

Power Supplies
Two separate parts that supply voltage to the printer.



Heated Bed
The platform that the printer prints on. It is heated between 70 and 100 degrees Celsius to prevent warping the hot plastic by having it cool too fast.

Extruder
A motor/gearbox combination that forces plastic through the hot end.

Control Board
The small computer underneath the heated bed that controls the 3D printer.

Outreach STEM activity: 3D printer.

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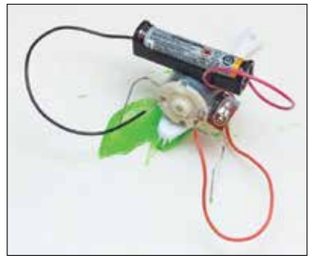
Brushbots

What is a brushbot?

A brushbot is a small mechanism made to paint and amuse. It is composed of a simple circuit, containing a battery, switch, and motor. You can dip it in any color, and watch it run around the page, creating a beautiful masterpiece!

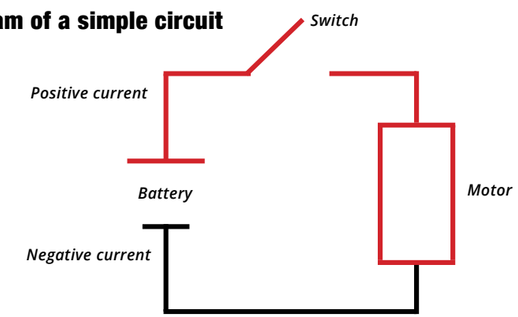


How a brushbot works

An electrical circuit consists of a power source (battery) connected by wires to one or more elements such as switches, motors, resistors, lightbulbs, etc. When the switch is closed, electrons flow out of the negative end of the battery, through the switch, through wire coils inside the motor, and back into the positive end of the battery. The motor turns because the electrical current creates a magnetic field, which interacts with a permanent magnet that is also part of the motor. The motor vibrates instead of turning smoothly because of a small off-center mass attached to its shaft. When the switch is opened, current cannot flow and the motor stops turning.

The paper clips are used to stabilize the brushbot and keep it upright, so that it can paint without hinderance! Changing the angles of the paperclips makes the brushbot move in different patterns.

Diagram of a simple circuit



Outreach STEM activity: brushbots (front).

How to make a brushbot

Materials

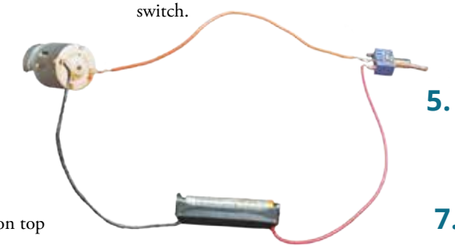
- *Paperclips*
- *Toothbrush head*
- *Toothbrush motor*
- *AA or AAA battery holder*
- *AA or AAA battery*
- *2- or 3-prong switch*
- *22-28 AWG spare wire*
- *Wire strippers*
- *Hot glue gun*
- *Hot glue*
- *60-40 solder (optional)*
- *Soldering iron (optional)*

Steps

1. Strip the wire from the negative end of battery holder and attach to one pin of the motor.

2. Strip both ends of a piece of scrap wire and attach one end to the other pin of the motor and the other end to one pin of the switch.

3. Strip the wire from the positive end of the battery holder and attach to the other pin of the switch.



Product of steps 1, 2, and 3

4. Bend paperclip and glue it onto the toothbrush head.

5. Glue switch onto the other side of the toothbrush motor.

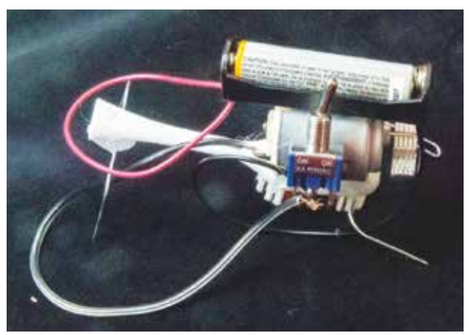
6. Glue the toothbrush motor on top of the toothbrush head.

7. Glue battery holder on the side of the toothbrush motor.

Tips and Tricks!

- *Separate wires and twist together after to get good connection*
- *Solder the wires together (optional, but highly recommended. Use 60-40)*

Results—Give 'em a name, dip in paint, and watch 'em skitter!



Finished product

Brushbot in action

Outreach STEM activity: brushbots (back).

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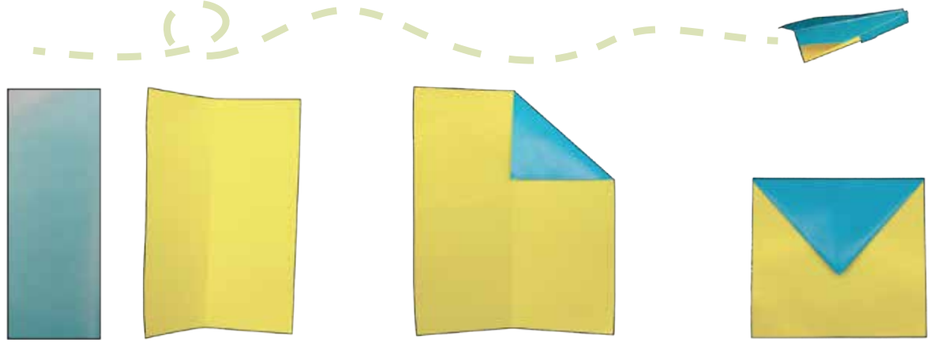
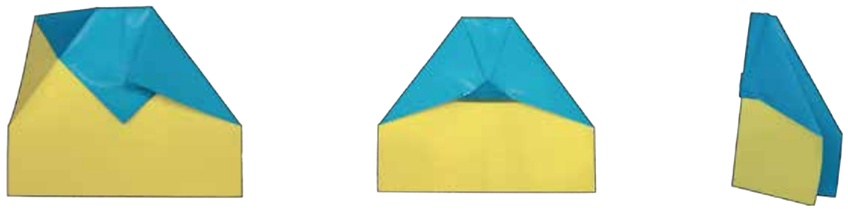
Dart Paper Airplane



1. Fold paper in half and unfold

2. Fold the corners to the middle line

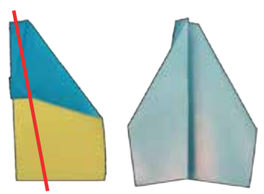
3. Fold the triangle down



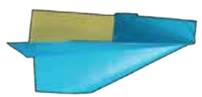
4. Fold the corners down to the line, 1 inch from the top!

5. Fold the little triangle up

6. Fold the whole plane in half



7. Fold in half and unfold



8. Fold the other side to match the wings

When You're Done

- *Look at the back of the plane. Does it look like this?*

- *Make the wing tips have this curve*

Outreach STEM activity: paper airplanes (front).

Aerodynamics: The Science Behind Airplanes and Other Things that Fly

Paper airplanes obey the same laws of physics as anything that can fly: a jet, a bird, or a Frisbee. (This includes a sailboat "flying" across water, into the wind.) The four physics principles that affect flight are thrust, drag, lift, and gravity. These forces work together. Lift and drag are called aerodynamic forces because they exist when an object moves through the air. Gravity and thrust are external forces that can act on the airplane independent of the airplane's interaction with the air.

Thrust

Before the air can exert a force on an object, something has to cause the object to move. That's the thrust. For your paper airplane, the source of thrust is the throw. For an engine-equipped airplane, the source of thrust is the engine.

Drag

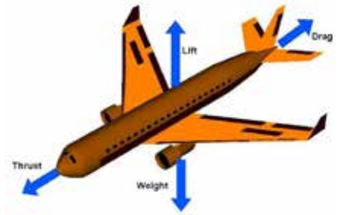
Drag refers to forces that oppose the motion of an object through the air. Friction caused by air moving over the surface of a plane causes drag. In order for the plane to stay aloft, drag must be overcome by thrust. The paper airplane in this flyer has flat wings, but curved wing tips that help prevent drag. Commercial, engine-driven airplanes, which have curved wings, also have these curved tips.

Lift

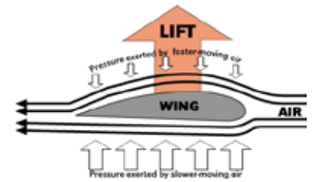
Lift is the upward force on the airplane, caused by Bernouilli's Principle, which states that an increase in the speed of a fluid (like air) occurs simultaneously with a decrease in pressure. (For more details, see "How Wings Work," below.)

Gravity

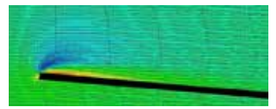
Just as drag opposes thrust, gravity (weight) is always working against lift, trying to pull objects in flight back down to earth.



The four physics principles that affect flight



Bernoulli's Principle



Air pressure during flow over a flat wing.

How Wings Work

Air flows over the top and the bottom of a wing as it flies. In order to create lift, there has to be more pressure on the bottom of the wing than on the top. This can be created either by the wing being curved on the top and flat on the bottom, or by angling a wing that is flat on both sides into the wind created by forward motion. (Picture holding your hand out a car window and feeling it pushed upward.)

There is a longer distance for the air to flow over the top of a curved wing than over the flat bottom. But the air from the top and from the bottom of the wing have to meet at the back of the wing. If the air on the top lags behind the air on the bottom, a lack of molecules will be created at the back end of the wing where the air hasn't flowed yet. To prevent this from happening, the air on the top speeds up so that it reaches the back of the wing at the same time as the air from the bottom. As they speed up, the molecules spread out, causing a reduction in air pressure.

The higher pressure on the bottom pushes upward harder than the lower pressure on the top pushes down, so the plane rises.

When we give a flat wing the correct "angle of attack," a bubble of air is created at the front of the wing top and a vortex (circular flow of air) is created at the back of the wing top. This causes the flat wing to behave just as if it were a curved wing, increasing the speed of air across its upper surface, decreasing air pressure, and creating lift.

A stall occurs when the speed of an airplane is too low to maintain the air pressure difference between the top and the bottom of the wing. Then, it cannot offset the force of gravity. The plane no longer has lift, and falls to the ground.

Outreach STEM activity: paper airplanes (back).

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Slime

Ingredients

- *1.5 tsp. baking soda*
- *1 Tbsp. contact lens solution that contains borax*
- *4 fluid oz. Elmer's glue*
- *food coloring*
- *plastic cup or bowl*
- *popsicle sticks for stirring*

1. Pour the glue into your cup or bowl.

2. Add your choice of food coloring and mix with a popsicle stick.

3. Add the baking soda and mix again.

4. Add contact lens solution and mix until the slime gets harder to mix.

5. Take the slime out of the cup and knead it with both hands.

6. Stretch and check for consistency. If sticky, add 3/4 tsp contact lens solution.

Outreach STEM activity: slime (front).

Slime Activities

1. *Confirm that your slime is a liquid.* Put your slime into three or more containers with different shapes. Observe how the slime moves around and takes the shape of its new container.

2. *Test and change the viscosity of your slime.* Observe the rate at which the slime stretches towards the table when you hold it up high and let gravity pull it towards the ground. See if you can figure out how to make it more stretchy or more bouncy by adding more baking soda or more contact lens solution. Add a few drops of contact lens solution (acidic) and observe how your slime becomes more liquid. Then add a little baking soda (alkaline) and observe how the slime becomes more viscous again.

3. *Test the response of your slime to "shear force."* Drop your slime onto a hard, smooth surface (like a floor or table) from high up to see how much it bounces from different heights. Slowly squish it onto the surface with the palm of your hand with varying degrees of force to see how it gets harder or easier to spread. Rip your slime abruptly into two pieces to observe how it tears.

Test and change the viscosity of your slime.

Test your slime's response to "shear force."

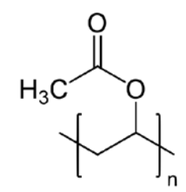
The Science Behind Slime

Slime is a cross-linked polymer. It is made from the reaction between glue containing long-chain polyvinyl acetate molecules and contact solution containing borax.

The molecules in glue look like strands of spaghetti. These molecules can slide past each other only with difficulty, so the glue doesn't gush from the bottle, it has to be squeezed out. Borate ions in the contact solution react to link the long glue molecules to each other, making even bigger molecules. The strands of spaghetti become one big mass that we know and love as slime.

The cross-linked polymer traps a lot of water, so slime is wet. You can adjust the consistency of slime by controlling the ratio of glue to borax and baking soda. If you have more glue, the slime will be more liquid (less viscous.) If you have more borax or baking soda, the slime will be more solid (more viscous.)

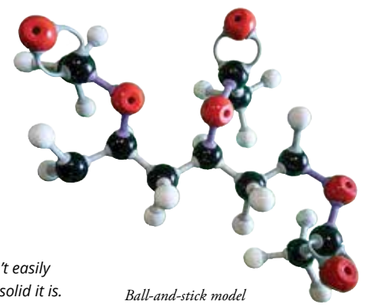
Slime thickens with force, but breaks when torn. Slime is a "shear thickening" fluid, meaning that the more force that is applied to it the thicker (more viscous) it becomes. If you drop slime it acts like a solid and bounces, but if you slowly squish slime it acts like a liquid and stretches. However, if you tear slime apart it will break abruptly. Squishing allows the cross-links to break and re-form, but tearing severs the cross-links between the molecules faster than the connections can re-form.



Line structure of a polyvinyl acetate monomer.

Here is some chemistry, for more advanced understanding:

- *Adding baking soda (sodium bicarbonate) to glue increases the speed of (catalyzes) the reaction between the polyvinyl acetate and the water in the glue. This reaction creates polyvinyl alcohol.*
- *The contact lens colution contains borate ions, created in several chemical steps when borax is mixed with water at the contact lens solution factory.*
  - *Borax + water = sodium ions + tetraborate ions.*
  - *Tetraborate ions + water = boric acid.*
  - *Boric acid + water = borate ions + hydrogen ions.*
- *Each borate ion reacts with two polyvinyl alcohol chains, linking them so they can't easily move. (This is called "cross linking.") The more cross links the slime has, the more solid it is.*



Ball-and-stick model of polyvinyl acetate.

Outreach STEM activity: slime (back).

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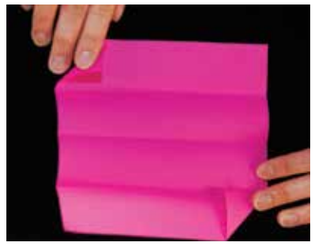
Origami Double Pyramid

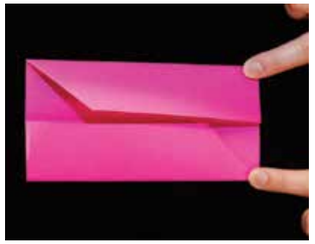
Making a Sonobe Unit

1. Fold paper in half and then unfold

2. Fold edges to center crease and then unfold



3. Fold corner flaps to newly made creases



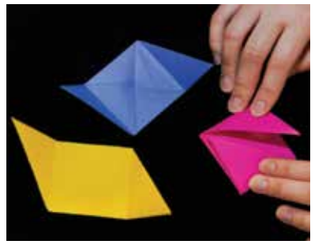
4. Refold edges to middle line

5. Fold left side up to top and right side to bottom

6. Tuck bottom left flap into upper flap

7. Tuck upper right flap into lower flap

8. Flip almost completed sonobe unit

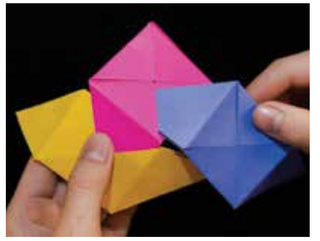


9. Fold flaps to center line, unfold. Repeat steps 1-9 three times

Outreach STEM activity: origami (front).

Combining Sonobe Units into a Double Pyramid

10. Tuck a triangular flap perpendicular into a center flap.

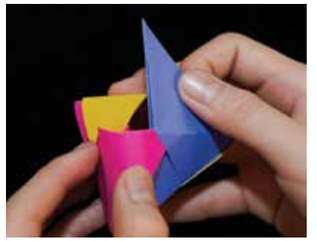


11. Tuck the third flap perpendicular to the second flap.

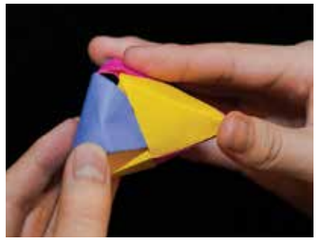
12. Tuck the first flap perpendicular to the third flap, making a pyramid.

13. Flip.

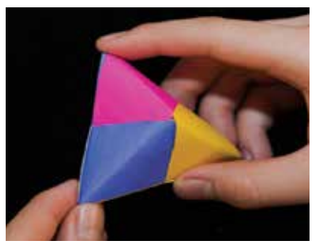
14. Tuck one of the top flaps into the flap to the right.



15. Tuck that flap into the flap to its right.



16. Tuck the third flap into the first flap (right).



17. Make sure everything fits snugly, and congratulations, you're done!

Fun Facts about Double Pyramids

- *The origami double pyramid is made of Sonobe units. Sonobe units are parallelograms that have two pockets into which to tuck other units. They are named for 1960s origamist Mitsunobu Sonobe.*
- *The double pyramid is the simplest figure Sonobe units can be combined to make. Using more units, origamists can make cubes, stellated octahedrons, stellated dodecahedrons, and even more complex shapes! See what you can make with Sonobe units!*
- *Sonobe units are a great example of modular design, an approach that subdivides a system into smaller parts that can be independently created and then used in different systems. It is useful in robotics, graphics, architecture, and many other STEM fields.*
- *Double pyramids are common in chemistry. Molecules like phosphorus pentaflouride and sulfur tetraflouride have this shape*

Outreach STEM activity: origami (back).

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Mini-Lightsabers

Make a working replica of the classic weapon from Star Wars!

Supplies

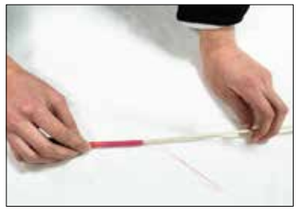
- *LED finger lights*
- *Clear, colored straws*
- *Black, electrical tape*
- *Scissors*
- *Metallic Sharpies*
- *Glue*
- *Clear plastic, acetate, or tinsel*
- *Wooden skewer or chopstick*

Supplies

1. Twist the tiny cap off an LED light.

2. Cut a straw of the same color as the finger light to 3.5–4" long.

3. Twist straw onto light. If it does not fit, cut two small slits in straw. Fit between light & plastic case. Glue if needed.



4. Use a skewer to insert a small strip of acetate into the open end of the straw.

5. Put cap from LED onto end of straw. Glue if needed. Remove rubber band from finger light.

6. Wrap the light and the beginning of the straw with electrical tape.

7. Cut out a space for the on/off switch.

8. Decorate the black hilt of your lightsaber with metallic Sharpies.

Outreach STEM activity: mini-lightsabers (front).

We all know that, in the Star Wars universe, lightsabers are the powerful swords used by both the Jedi and the Sith. But what you may not know is that there is some hidden light physics, also known as optics, working inside the saber. Discover the science behind the forceful blade!

The Real Science Behind the Star Wars Lightsabers

The lightsabers in the fictional Star Wars universe are pretty complex devices, but they essentially boil down to a few key elements: a power source, a photon emitter to create light, a crystal to focus the light into a blade, a blade containment field to loop the energy back into the hilt, and a negatively charged opening in the hilt to "catch" the beam of energy as it loops back around.

Our real-world mini light sabers run on electrical power from a battery in the finger light. The light source is an LED (light-emitting diode). When you push the switch on the finger light, you are making the wires touch. This closes the circuit, allowing current to pass through the LED and light it up. Circuits with LEDs have to have a resistor to limit the amount of current coming out of the battery, because the LED burns out if subjected to high current.

To imitate the effect of focusing light onto the blade of a lightsaber, we use clear, colored plastic straws to diffuse (spread out) the light rather than focus (concentrate) it. Diffusers in the hilt help channel light along the length of the drinking straw "blade "to create the effect of even more even light.

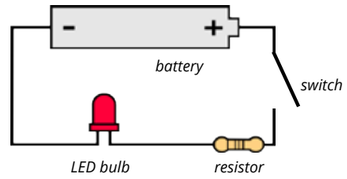


Diagram of a switch circuit

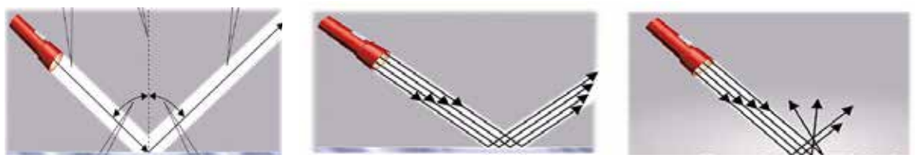
More About Light

Light is a type of energy called "electromagnetic radiation," which can be thought of as either a wave or as little packets of energy called "photons." Light is created when the atoms inside an object gain energy and release it as light. In the sun, the energy comes from nuclear reactions. In our light saber circuit, the energy comes from a battery. The light's energy level is its color. (Blue light has more energy than red light.)

When light hits a surface, its energy can be absorbed (soaked into the surface), reflected (bounced off the surface), or deflected by refraction (have its speed, and therefore direction, changed when the light hits material with a different density).

Diffusion occurs when light strikes a rough surface and reflects back in many different directions. (The visibility of objects is primarily caused by the diffusion of light from light-emitting sources like the sun and light bulbs.) Since the light is scattered as it hits surfaces, it does not have the intensity of direct light.

Diffusion happens inside a finger lightsaber: the saber's light source is directed at the end of the cap, which contains little pieces of plastic that reflect the light in all directions. The straw glows when the light is reflected in many directions inside of the straw. You can see the light because the straw is transparent—it allows light to pass through.



The law of reflection (left) states that light is reflected at the same angle at which it strikes a surface. In regular reflection, (middle) the surface is smooth, so all of the light strikes and reflects together, at the same angle at each point on the surface. In diffusion (right) the surface is rough, so the angle at which light strikes and reflects is different at each point on the surface.

Could Lightsabers Ever Really Be Made?

In the Star Wars universe, a lightsaber creates energy, focuses it, and contains it. That's science fiction. Could we ever actually build a lightsaber with the science and technology tools we have today? Maybe so! A few years ago, researchers from MIT and Harvard accidentally created a lightsaber (sort of). For the very first time, they found that they could bind photons together, forming what they called "photonic molecules" when the photons interacted. This was the discovery of a possible new state of matter. So, there may be hope for a real lightsaber in your lifetime!

Outreach STEM activity: mini-lightsabers (back).

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Solar Ovens

Create and learn about an oven that's sustainable, easy to make, and fun to use!

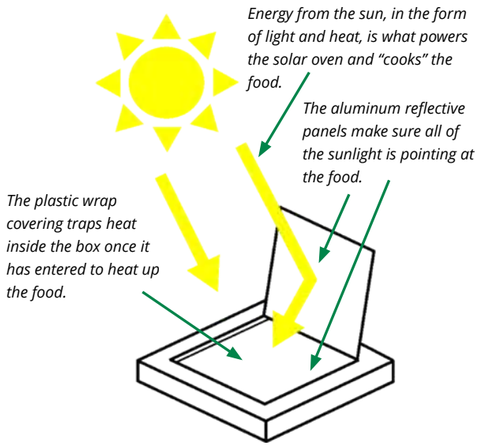
As climate change worsens, we need to turn to more sustainable sources of energy. Figuring out how to do this requires a lot of engineering! Scientists have come up with solar ovens, an efficient and environmentally-friendly cooking device. Today, you will understand the science behind them and make one yourself!

What is a Solar Oven and How Does it Work?

A solar oven is a cooking device that uses the power of the sun to cook food. The sun gives off energy in the form of light but also in the form of heat. This heat can be used to cook food, albeit very slowly. If you've ever left a candy bar out in the sun for too long, you know what happens: it melts. How do we focus the sun's energy so that cooking is faster? We could turn a box, with food inside, to face the sun, and add reflective panels that reflect all of the light onto the food item. To keep the heat inside, we could add a clear covering to the top so that light from the sun can get in, but the heat trapped inside cannot get out. The heat from solar energy will be able to cook the food, just like an oven that uses an energy source like electricity or gas!

Because the internal temperature of a solar oven can vary greatly, depending on box materials, size, and light intensity, the solar oven described here should not be used to cook meat or any other food that has to reach a minimum temperature to be safe to eat.

Solar Oven at Work



The Greenhouse Effect and Climate Change

- *In our solar oven, the heat is kept inside by the plastic film. This is called the greenhouse effect, when light and heat from the sun can enter, but cannot get out. You've felt this if you've ever been inside a greenhouse: it's what keeps it warm!*
- *However, this effect can also have severe consequences. Factories are producing gases that rise up in the atmosphere and stay there, creating a thick layer that does not allow heat to escape the Earth. This will have horrific impacts on our world and the environment. To combat this, we should be more energy-efficient. Start by using a solar oven at home instead of a regular oven, by following the instructions on the back!*

Outreach STEM activity: solar ovens (front).

How to Make a Solar Oven

Materials

- *Small box*
- *Marker*
- *X-acto knife*
- *Tape*
- *Aluminum foil*
- *Plastic wrap*
- *Popsicle sticks*

1. Find a box large between 1.5 and 3 inches thick.

2. Trace a cutout on the lid, leaving a one-inch margin.

3. Have an adult cut line with X-acto knife.

4. Open the box and make sure the cutout can move.

5. Make eight small tape rolls and set aside.

6. Put four of the tape rolls on the bottom of the box.

7. Cut aluminum foil to size of box.

8. Press foil firmly to bottom of the box.

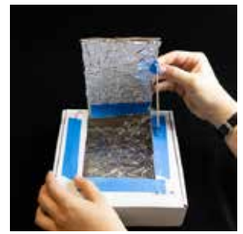
9. Put the other four rolls on the back of the cutout.

10. Cut aluminum foil to size of cutout.

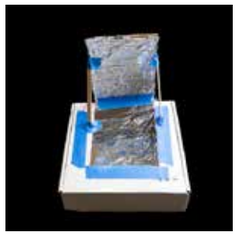
11. Press foil firmly to back side of cutout.

12. Cut a piece of plastic wrap to fit cutout.

13. Tape plastic wrap to lid of box to cover cutout.



14. Use popsicle sticks to prop up cutout.



15. Voilà, a solar oven!

Outreach STEM activity: solar ovens (back).

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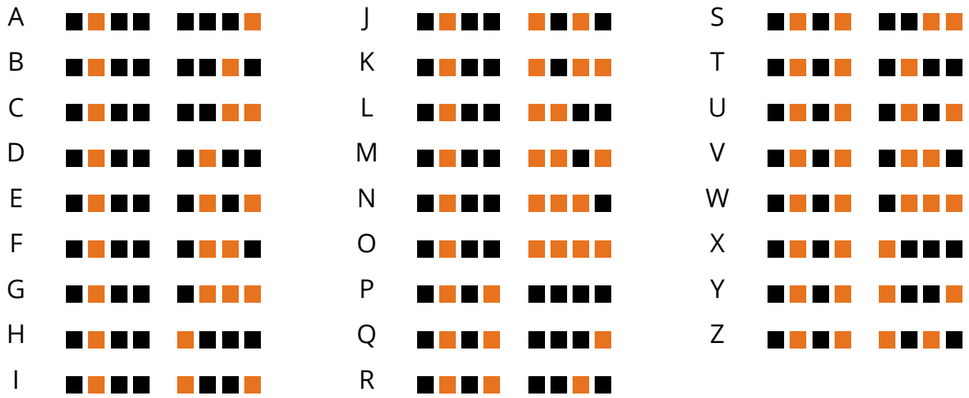
Binary Bracelets

A Bracelet that Spells out a Word in Binary



1. Write out the letters of a word you want to put on your bracelet.
2. Tie a knot in one end of the elastic string to keep the beads from sliding off when you add them.
3. Slide beads onto the elastic in the order of the letters, according to the table above.
4. Make sure the order is right.
5. Tie a knot on the second end of the elastic to keep the beads from sliding off.
6. Tie a knot connecting the two ends of the elastic, cut off excess elastic, and your bracelet is ready to put on your wrist!
7. Count how many bytes are in your bracelet! (Hint: It equals the number of letters in the bracelet!)

What is Binary?

- *Humans use a "base 10" numbering system because we count things using our 10 fingers. Each finger represents a digit from 0 to 9. Each number in our base 10 number system is made of a string of digits from 0 to 9.*
- *Computers, however, use a binary system. They count in "base 2" because their switches have only two options: off and on. In binary code, there are only two digits: 0 and 1. Zero represents "off" and 1 represents "on." In binary each number is represented by a string of 0s and 1s. Every 0 or 1 in the string is called a "bit," and a string of 8 bits is called a "byte." Back in 1963 each letter of the alphabet (along with all of the other symbols on a keyboard) were assigned a standard byte, as shown in the table above. Black represents 0 and orange represents 1.*

Sample bracelet that reads "liger"

Outreach STEM activity: binary bracelets.

How I Use My LigerBots Skills Out in the World

"I learned how to fix pretty much everything in my house, including my car headlights. My neighbor who's an artist hired me for a summer job to drill holes precisely to hang pictures on his walls."

– Samy Rosenberg

"I have been able to apply for internships and to volunteer for nonprofits based on the leadership skills I learned as co-CMO and on the strategy council."

–AJ Chau

"I learned a lot of stuff about graphic design—what looks good and what doesn't, the importance of double checking everything, and how printing works, which actually helped me to fix my own printer. It also helped me do a better job checking for errors on my math tests."

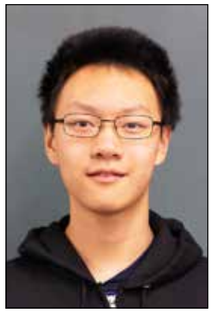
– Frank Liu

"LigerBots has helped me with advocating for myself, especially with teachers and with my peers in group projects. It has also helped me make friends with people I would never have been friends with before, like a girl in the year below me in one of my classes at school."

– Maya Lobel

"I have learned how to problem-solve in different situations, and when I'm stuck, I don't immediately ask for help. I have learned how to tutor myself."

– Michelle Yu



" Using the skills I have learned from building field elements, I was able to visualize and design what I needed to build for my brother's cello racks."

– Daniel Feng

"In LigerBots, a lot of things I have learned in physics have physical representations, which helps me understand the things I'm learning in my classroom."

– Yonik Rasamat

"I learned about communication, which is really important for school, extracurricular activities, sports, college, jobs, and family stuff. If everyone's not on the same page, nothing's going to get done."

– Ethan Schindler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