Maryland Engineering Challenges
2024 Robot Challenge

Now in its 28th year!

High School Level – Grades 9 to 12

Middle School Level – Grades 6 to 8

April 27 (virtual) or 28 (in person), 2024

Sponsored by the:
IEEE Baltimore Section

IEEE
Advancing Technology for Humanity

Engineer Contacts:
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The robot challenge is an engineering challenge. This teaches students key aspects of an engineering project and is not just a kit building exercise. These are typical of all successful engineering design projects in industry.

First, teamwork is required. Each leg requires a participant to operate it. More importantly, there are aspects of the project that required different skills: either wood cutting and drilling or CAD modeling, mechanical assembly, soldering, and creative artwork. Emphasis in scoring is placed on both neatness in assembly and creativity in creating a decorative and original robot.

Beyond that, a written report, bill of materials (what did you put into it), project planning timeline, and project notes are all important aspects of the challenge.

Participants are interviewed to discuss not only what was built, but what each member contributed and what was learned from the process.

Significant features for 2023-2024

1) **The Robot Challenge is available for both Middle School and High School students. They participate together, but Scores and Awards are kept separate.**
2) **These are Walking Robots, and students build them from scratch. The project offers 2 options, one that allows students to build the robots with wood parts that they fabricate hands-on in a wood-shop; or they may elect to use CAD to program the parts and create them in plastic with a 3-D printer. If team does not have access to a 3-D printer, the organizers provide this service at no additional cost. The cost of a 2-leg robot kit is $69.75. 4-leg robots require 2 kits. Shipping will be added to the cost of the kits based on the actual UPS charge.**
3) **Robots can have 2 or 4 legs and must be decorated with an external body. Students are required to prepare a Written Report documenting their experience, compete with other teams at a Track event where the robots have to climb over hurdles, and they must also make an Oral Presentation to a panel of professional engineers and answer questions about their project.**
4) **There are multiple levels of challenge.**

Operation	2 Leg Robot	4 Leg Robot
Manual: all operations are controlled by closing switches. There are four switches per leg that control leg up, leg forward, leg down, and leg back.	Recommended for first time participants, especially Middle School students. Requires 2 team members, one per leg.	Requires 4 team members, one per leg.
Automation: a controller is used to sequence the operations. The controller may be either purchased with the robot kits as an add on, a kit to build your own controller may be purchased, or you may build your own controller from scratch.	Manual control operation must be completed first and then a 2nd run for automation. The operation is automated, but the team participants use the switches from the manual operation to guide the robot where it may drift off. This adds a level of complexity best suited for advanced High School students using the purchased controller. Building your own controller, either from a kit or from scratch, should only be tried in the 2nd year a team competes, as that will take extensive time to build.	
Autonomous: the automation controller has additional feedback using switch connections on the legs for guidance.	Manual operation first, then automated operation runs must be completed before the autonomous operation is attempted on the third run.	

5) **On Saturday, April 27, the Challenge will be held Virtually, and participants can be from Maryland or out-of-state; whereas on Sunday, April 28, it will be held in-Person at the Baltimore Museum of Industry (BMI), which is located at 1415 Key Highway, Baltimore, MD 21230 (near the Inner Harbor).**
6) **There will be no distance restrictions for the High School and Middle School teams wishing to participate in the Robot Challenge this year. Those within driving distance of the BMI will be able to participate on Sunday In-person, whereas teams in (or outside) the US, and those in Rural areas, will be able to participate Virtually (On-line) on Saturday.**
7) **Teams can choose whether to build a wood robot in a wood-shop, or use CAD to program a 3-D printer and make the robot with plastic parts using the 3DP option. This year there will be a single kit for both options.**
8) **The choice of materials for their robots are:**
   A. The Classic Wood robot, as was built in the past, requires students to work in teams and learn to use tools and build up ingenuity in a woodshop; and

B. The 3DP robot requires students to learn CAD techniques, and eliminate the wood shop. Writing 3-D programs that directly create the parts allows the students to take turns working on their own (if necessary), and this way they can still be part of a team, but they can build the robots at school or at home without special tools.

9) **All Written Reports will be judged on-line with teams submitting their reports in .pdf format.**
10) **Awards will be presented in the 2-leg and 4-leg robot categories for Best Overall Robot Performance (this includes teams doing automation and autonomous operation), Best Performance using Manual Control, and Best Performance by Middle School Teams. There will also be awards for the most artistic robot, and for the team that completes the course in the shortest time.**

The Project requirement is to:

1. Build a Walking Robot with the parts and documentation provided (additional components and features can be used if they do not violate conditions on page 3a of the Robot Manual). Robot components can be built either in a wood-shop with shop tools, or using CAD and a 3-D printer (this service can be provided).
2. Document the process and submit a report to a panel of Engineer judges (this is known as the Written Report, and contributes 25% to the total score).
3. Compete with other teams to show the Robot's ability to complete the course in the fastest time (known as the Performance or Track Run it contributes 40% to the total score). Control of the robots can be Manual, or they can be Automated or Autonomous – bonus points are awarded for these enhancements.
4. Present Orally to a panel of Engineer judges (this is known as the Oral Presentation, and is worth 15% of the total score). These judges also review the workmanship of the robot built per item 1, and can award up to 20% of the total score.

Important Dates

Teachers' & Coaches Information Sessions

- ⇒ **Wednesday, November 1, 2023 at the BMI** **4:00 PM to 7:00 PM**
- ⇒ **Saturday, January 20, 2024** **via Zoom** **10:00 AM to 2:00 PM**

This event is designed for Teachers and Mentors interested in coaching a team and learn more details about the project. Find out from the presentation if this Challenge is a good fit for your students. The Training is not a requirement for this project but is strongly recommended, particularly for first-time participants. There is no cost. Registration is strongly encouraged (by 10/30, 1/18 respectively). Both sessions will include some CAD and automation instruction. The November event is a good opportunity to pick up kits without paying shipping costs. Contact Jessica Celmer at challenges@thebmi.org , or Don Herres at d.herres@ieee.org.

Register for the Robot Workshops from this link: https://bit.ly/2024RobotWorkshopRegistration

Preparations & Registration

Registration:

- **Deadline: March 15, 2024**
- **Register for participation and to obtain the Robot Kits and Manuals:** https://bit.ly/2024RobotChallenge, Team numbers will be assigned by IEEE lead after team has been registered.

- **Registration will generate a response e-mail that should be carefully saved and stored, so it can be updated or corrected by clicking the "Edit Response" block. Then update the arrival time at the Robot Challenge Event – information will be sent to teachers in March.**
- If you lose access to editing your team registration, contact challenges@thebmi.org

Teams may choose to build the Classic Wood Robot, or a plastic robot using 3-D printed parts. The classic wood robot requires a school wood-shop and shop tools for shaping the wood parts, whereas the 3-D plastic robot can be built at school or at home with just basic tools. The actual 3-D printing can be done at school if the school has a 3-D printer; or if teams submit their CAD software, IEEE will fabricate the parts at no additional cost. The project cost will be the same for either option, and the Registration fee covers all expenses other than the "D" size Alkali batteries (we suggest students pay for these themselves to assure they will be careful with them).

Kits may be picked up from the IEEE representative or shipped via UPS. Please contact Don Herres at d.herres@ieee.org to arrange for the date, time and place. If kits need to be shipped to other locations, a shipping charge will be added to the cost of the kits. The project should be scheduled so that the robots can be completed approximately 2 weeks before the Robot Challenge Event (for information on how to do this, see later).

• Note that by signing up for participation in the project, each team is committing to participate in the Robot Challenge Event, as this portion of the project represents a major part of the educational adventure. Photographs and video will be recorded during the Robot Challenge Event for training and documentation (non-commercial) purposes - it will be assumed that all participants give their consent to appearing in these pictures. Any team or team member not wishing to appear in such pictures should notify the organizers in writing

Written Report Due

⇒ **Friday, April 19, 2024 Prior to 4:00 PM**

Written Reports should be delivered electronically, and will represent 25% of the total points awarded. At this time, one member of each Team should update their on-line Registration, using the following link: https://bit.ly/2024RobotChallenge

The Robot Challenge Event - teams must select which event by Friday, March 15, 4:00 PM

⇒ **Saturday, April 27, 2024 (Virtual) 8:45 AM to 3 PM**

⇒ **Sunday, April 28, 2024 (In Person) 8:45 AM to 3 PM**

⇒ **Sunday, April 28, 2024 (Virtual) Awards for both events 5PM**

Teams are assigned starting times based on their registration preference. They do not need to stay the entire time.

The Event will be held virtually on Saturday, April 29, and is open to teams from anywhere.

Sunday, April 30, will be in person at the Baltimore Museum of Industry and is for teams able to travel to Baltimore. Teams may choose to participate either day, but they will need to make their choice by March 15.

On Sunday will we provide a repair station for teams encountering technical difficulties. Teams planning to compete virtually can be from anywhere, but note that technical advice will only be available on-line. Those experiencing difficulties should be asking their mentors for help.

The Robot Challenge Event

On Saturday, April 27, the Robot Challenge Event will be held Virtually, whereas on Sunday, April 28, it will be done in-person at the Baltimore Museum of Industry

The events will be similar but not identical; the following details will apply, though the times may be subject to change.

- ⇒ Both days: 8:45 a.m. to 3:00 p.m. Awards, Virtual, Sunday 5 PM.
- ⇒ If team registers for Saturday, April 27 they may request an early or late start, and will be assigned a time they should be ready to begin the Track event. They will require two camera-people for the team, and the camera-people will be required to sign on to the Zoom web-site 15 minutes before the team's start time. Detailed instructions will be provided.
- ⇒ If team registers for Sunday, April 28, they can register for an 8:45 AM, 9:30 AM, or 10:15 AM starting time, but every member of the team should plan to arrive at the Museum at least 30 minutes earlier so their arrival times should be 8:15 AM, 9:00 AM, or 9:45 AM to register their team, pick up documentation, and have their team photo taken. If a robot scheduled for an 8:45 AM start is having structural or electrical difficulties or cannot walk, the team should plan to arrive at 8 AM – that is the time the Museum doors will open.
- ⇒ Technical advice is available on-line for teams at least 3 days before the Virtual event on Saturday, but a team continuing to experience serious electrical or mechanical difficulties with their robot should plan to attend early on Sunday as that is the only day when there will be on-site experts to offer repair assistance and spare parts.
- ⇒ Any team unable to arrive for any of the above starting times, should contact **Don Herres** **no later than April 19, 2024.**

The Virtual Track and Oral Presentation portion on Saturday can either be done at your school or it can be done in students' homes on a table or floor.

Questions about Challenge specifications or judging should be sent to the Engineer Contact:

Don Herres

Museum questions?

Jessica Celmer challenges@thebmi.org or 410-727-4808 ext.113

Details

THE CHALLENGE

Project simulates what a practicing engineer would experience while working on an engineering project. In addition to building a walking robot, there is the required artistic creation of the outer body of the robot, as well as the need to demonstrate both written and verbal communication skills. 8 levels of challenge are available, and all registered teams must participate in the Challenge Event to be held on April 27 and 28, 2024. Teams may choose to build a wood robot in a school wood-shop, or they can develop the CAD software to form the Robot body and the Control Units in plastic, using a 3-D printer.

Objective: Design and build a free-standing motor-powered robot that walks under direction. The robot body can have any form, 2 or 4 legs, and have the ability to go over uneven terrain. Each leg shall be controlled by one student using two independent motors; the control and co-

ordination of the motors, and the smoothness and speed of the robot, will be factors considered by the judges. If wheels are used for any purpose, they should not touch the table surface or be visible. Manual control of the robot is a basic requirement, but extra credit (up to 15 points) will be given for any form of add-on automation that furthers the above goals. Every team must do a Run using Manual Control, then additional runs are required for those teams doing automation and autonomous control, for extra credit. The robot shall have an external body that is artistic and appealing. Kits can be obtained from IEEE, and range from $69 for a 2-leg robot with manual control (for 2 to 4 students), to an additional $198 for a 2-leg automation controller (other prices available upon request). Programming for most automation options is in C++.

Website: www.RobotChallenge.com Contains a lot of information about the project, FAQs, the latest version of the Robot Challenge Manual (password-protected), and helpful hints. There are also Photos and Results of previous Challenges.

ENGINEERING TEAM REQUIREMENT

Each team should have 2-8 students (2 to 4 for 2-leg robots, 4 to 8 for 4-leg robots). There is no limit to the number of teams a school may have.

High School and Middle School students at Public, Private and Home schools, and Science and Scout Clubs are eligible to participate.

SPECIFICATIONS AND SUPPLIES

The competition involves four main components, the construction of the entry, a written report, the robot's performance on a course with hurdles each robot must climb over as it meets in competition with other entries, and an oral presentation before a panel of judges (which may include an optional video presentation). Verbal communication skills, workmanship, teamwork, and artistic creativity will be evaluated throughout the event and will influence the team's scores. The Institute of Electrical and Electronic Engineers (IEEE) provide instructions, drawings, training materials, and mentors for the basic electrical equipment. Each team will be responsible for creating the robot body and building the power unit, control units, and shipping container. If the team is building 3-D printed plastic parts, they need to become familiar with CAD software, and send us the .stl file for review before the parts get printed if their teacher or coach is not able to do so. Teams should contact their mentors by e-mail at 2 week intervals (or if they have a problem). Students will need to provide the D-cell batteries and practice coordinating the operation of the motors so that the robot learns to walk

Kit prices are shown below. If shipping is required, it will be the UPS cost.

- The cost for 2-leg kits is expected to be $69. A 4-leg robot is twice as much work, and is more challenging to operate. For a 4 leg robot, use 2 kits. Students may develop their own Automation boards (possibly using Arduino parts), they may purchase kits they can assemble themselves (manual provided), or they can purchase pre-assembled and tested kits that are re-usable and can be used for autonomous operation. Classic DIY

Automation kits are: $99 for 2-leg, $133 for 4-leg robots; pre-assembled (re-usable) Automation Controller board kits: $198 for 2-leg, $269 for 4-leg robots. Other kits and one-year lease prices are available by request.

- In the event a school or group has a 3-D printer with an 8" x 5" base, the CAD approach should not present a problem. If a school does not have a 3-D printer, IEEE will provide one set of 3-D parts per team at no cost.
- Kits have a wood block and a piece of plywood that can be shaped and drilled in a wood-shop for those schools wishing to develop hands-on experience for their students. This approach is best for developing in-person teamwork.
- Robot kits will be available in November, earlier by special request. Teams are requested to try to complete their projects 2 weeks before the competition date in April. To meet the mid-April completion objective, coaches will need to determine how many hours a week the students will need to work on the project, then use the figures below to estimate when the students should begin, based on the following:
  A 2-leg manually controlled Robot requires 21 hours*. If students can work:
  3 hours a week (7 weeks): start mid-February.
  2 hours a week (11 weeks): start mid-January
  1 hour a week (21 weeks): start mid-November
  * These numbers can vary based on student skills, the number of students in a team and their absences (we have tried to allow for winter and spring breaks and snow days). Building the robot body with a 3-D printer may reduce this figure by 4 hours, but it will require a knowledge of CAD, which itself will require instruction time, so the time taken will probably be about the same.
- Teachers and Coaches <u>doing this project for the first time are strongly advised to build just the 2-leg robots with manual control.</u>
- Allow up to 28 hours for a 4-leg manually controlled robot. Allow 6 hours for automation plus an additional 5 hours for autonomous operation. Use of the DIY automation kits involves building the controller from scratch and will require 12 additional hours. Note that the pre-assembled Controller is required for autonomous operation.
- Teams planning to automate their robot would need to start <u>significantly earlier</u> than the dates shown above.
- As mentioned earlier, teams ordering kits are expected to participate in the Robot Challenge on April 27 or April 28, 2024.

JUDGING GUIDELINES

I. **Design Development and Fabrication** (Competition value: 20 points)*

The team must use the parts provided in the kit, substitutions are not allowed, but additions are permitted. Wheels (if used, though not recommended) may not touch the table or be visible. Except for flexible electrical wiring, Robot should be free-standing and isolated from the students controlling it. Creativity and Artistry are important factors, and the robot body must be designed such that the team can fully expose all parts of the body and mechanism for inspection by the judges.

* Awarded during the Oral Presentation, based on the judges' findings – see below.

II. **Written Report** Competition value: 25 points

Points will be awarded for creativity, originality, neatness, grammar, sketches, photos, and the Robot's artistic body covering. A Gantt Chart is very helpful for showing the difference between the original schedule and the actual dates resulting from the problems encountered.

III. **Performance Demonstration** Competition value: 40 points

The course will be a single track on an 8 foot table or floor, with the start and finish lines 6 feet apart. Two half-inch high hurdles (known in a hardware store as a "quarter-round") will have to be climbed over. All robots will first race in manual mode. Points will be awarded for the time taken, the smoothness of the robot's movements, and the coordination and cooperation of the operating team. Points are lost if team members touch their robot or cross the Boundary lines. In the event that some degree of automation has been added, the robot shall run a second or third time in that mode for bonus points.

On Saturday the event will be done virtually, and it can either be done at your local school, or on a kitchen table or floor. Each team will be furnished with a cardboard Track (which they can decorate for extra points), and the two hurdles. On Sunday, extra points will be given for the decoration of the shipping containers.

IV. **Oral Presentation to Judges** Competition value: 15 points

a. The judges are looking for a **formal prepared presentation** where every team member is expected to participate. They may bring in a video on their laptop so long as the clip does not exceed 3 minutes. Judges are looking for a description of the project and the difficulties they encountered and had to overcome. Students may also fill in the gaps between when the Written Report was submitted up though and including the results of the Track Run and what they learned from it. Judges will ask questions and grade the students on their answers.

b. Review of Fabrication* Competition value: 20 points

Judges are looking for the quality of the fabrication of the robot including the soldering. They will need to examine the robot closely, and may need to expose all the parts to do so.

CURRICULUM TIES-- Maryland Engineering Challenges comply with the listed sections of the Next Generation Science Standards

Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.1 The student will explain why curiosity, honesty, openness, and skepticism are highly regarded in science.	**In preparing for the challenge, students will:** • Recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues. 1.1.1 • Modify or affirm scientific ideas according to accumulated evidence. 1.1.2
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.2 The student will pose scientific questions and suggest investigative approaches to provide answers to questions.	**In researching project designs, students will:** • Identify meaningful, answerable scientific questions. 1.2.1 • Formulate a working hypothesis. 1.2.2 • Defend the need for verifiable data. 1.2.8
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.3 The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.	**In constructing their projects, students will:** • Develop and demonstrate skills in using lab and field equipment to perform investigative techniques. 1.3.1 • Demonstrate safe handling of the chemicals and materials of science. 1.3.3 • Learn the use of new instruments and equipment by following instructions in a manual or from oral direction. 1.3.4
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.4 The student will demonstrate that data analysis is a vital aspect of the process of scientific inquiry and communication.	**In testing their projects, students will:** • Analyze data to make predictions, decisions, or draw conclusions. 1.4.2 • Describe trends revealed by data. 1.4.6 • Determine the sources of error that limit the accuracy or precision of experimental results. 1.4.7

Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.5 The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.	**In composing their reports, students will:** • Demonstrate the ability to summarize data (measurements/observations). 1.5.1 • Explain scientific concepts and processes through drawing, writing, and/or oral communication. 1.5.2 • Use, explain, and/or construct various classification systems. 1.5.7 • Communicate conclusions derived through a synthesis of ideas. 1.5.9
Core Learning Goals: Science - Goal 1: Skills and Processes - Expectation 1.7 The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.	**In reflecting on the engineering process, students will:** • Identify and evaluate the impact of scientific ideas and/or advancements in technology on society. 1.7.2 • Investigate career possibilities in the various areas of science. 1.7.5 • Explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments. 1.7.6

GOOD LUCK TO YOUR TEAM!