

Detector Building 2019 Trial Event Rules
Tech Committee

1. **DESCRIPTION:** Teams must design, build, calibrate, program, and use the instrument to measure the specified property and display value using the appropriate units.

A TEAM OF UP TO: 2

IMPOUND: Yes

EYE PROTECTION: None

APPROXIMATE TIME: Normal Rotation

2. **EVENT PARAMETERS:**

- a. Teams must bring their device, design & testing log, any tools required, and whatever resources (e.g. laptop) needed to program their device to respond to the changing environmental conditions.
- b. Event supervisors will provide the necessary equipment or materials to allow teams to verify their sensor calibration.

3. **CONSTRUCTION PARAMETERS:**

- a. Each year, the environmental condition (e.g. Light Level, Sound Level, Motion, pH, CO₂ concentration, O₂ concentration) to be measured will be identified in the Event Rules. The environmental condition to be measured will be the same for all teams and at all tournaments. At each tournament, the event supervisor will inform the teams which ranges the device should be programmed to detect. These ranges will be the same for all teams at that tournament.
- b. Devices should be built using a microcontroller or microcontroller board (e.g. TI Innovator, Raspberry Pi, Arduino), a display, LED lights, an alarm, and a sensor/probe that ultimately produces a voltage dependent on the physical stimulus provided. The device maybe connected to a laptop, or other handheld device, powered by battery without built-in/internal environmental sensors/probes that functions as a display or programming interface device. The sensor/probe should withstand environmental conditions as specified that year. Sensors must be constructed from fundamental electronic components (e.g. thermistors, photodiodes, strain gauge). Under no conditions can a ensor/probe be constructed using pre-calibrated and/or preassembled sensors/probes (e.g. Vernier, PASCO, preassembled circuit boards or kits).
- c. The device, and any associated elements, must function on an independent power supply. No element can be plugged into an electrical outlet at any time during the competition.
- d. The device must be calibrated to detect the selected environmental condition for that year. In addition, the device must be able to respond differently to multiple ranges of the designated environmental condition through the use of output devices as specified that year. (e.g. LED, Alarms) The exact ranges of the environmental condition detected will be provided to the competitors at the start of their rotation.
- e. The sensor may have physical specifications as to size and length as determined each year and will be specified in the rules for that year.
- f. The device can not be connected to Wi-Fi or use prebuilt libraries to auto correct sensor's readings.
- g. Teams will also need to submit a Design Log with their device at Check-In. This Design Log should contain:
 - i. A detailed illustration, picture or schematic of the device, including the sensor's construction, identifying all the components and their function.
 - ii. A written practice log that contains a data table from a minimum of 10 trials showing both the raw voltage data collected and the corresponding real world values along with a graphical representation of these results.
 - iii. The mathematical equation used to model this data, and a mathematical justification for the use of this model.

- iv An explanation of the program that clearly shows the use of this mathematical model within the program which converts raw voltage data into readings with appropriate units, a written copy of the code that is used to operate the device, and an indication of, as well as a source for, any code that was not originally written or developed by the competitors.
- h. Each device, and associated impounded items, must be labeled with team number and name so the event supervisor can easily identify to which team they belong.
- i. Competitors must be able to answer questions regarding the design, construction, programming, and operation of the device per the Building Policy found at www.soinc.org.

4. **THE COMPETITION for 2019:**

This year the environmental condition to be measured will be temperature. Following the guidelines outlined in the Construction Parameters above, each team will build a durable temperature sensing device that will accurately measure, and display temperatures anywhere between and including 0°C -100°C. Along with the numerical display of the temperature in degrees Celsius, the device must also be able to indicate a temperature zone using an RGB or individual LEDs with a color scheme such as, blue for “Cold” temperatures, green for “Moderate” temperatures, and red for “Hot” temperatures. The exact starting and ending temperature of each zone will be posted at the time of the team’s rotation.

- a. The device, power supply, spare parts, design log, and other materials must be impounded before the start of the competition. Tools need not be impounded.
- b. Only competitors and event supervisors are allowed in the impound and competition areas. Once competitors enter the event area, they must not leave or receive outside assistance, materials, or communications.
- c. At no point during a trial may the device be connected to a power supply.
- d. The probe this year must be waterproof, capable of withstanding water temperatures from the freezing to boiling points of water (based on elevation of your location), be a minimum of 30 cm in length, capable of being submerged to a depth of 10 cm, and small enough to be placed through an opening of 15 cm.
- e. As the teams enter the room for their rotation they will be given back their device, their testing logs, a scoring sheet, and the standard thermometer that will be used to evaluate the accuracy of their device.
- f. Within the timed rotations, but before their first actual temperature determination, the students will be allowed to verify their device’s calibration using a provided standard thermometer. The teams will then be allowed to make any necessary adjustments to their code, and will be expected to alter their LED code to match the posted temperature zones.
- g. Once ready, the teams will proceed to each of the four different stations where they will use their device to determine the exact temperature. The event supervisor(s) will record the temperature as shown on a digital display in degrees Celsius along with the actual temperature as determined by the supplied standard thermometer, along with the LED color.
- h. The event supervisor(s) will determine the accuracy of the temperature using the standard thermometer given to each team for temperature verification at the beginning of the rotation. The temperature reading on the student’s device will be used to score the LED correctness.
- i. Once the run is completed, the event supervisor will then record the data and share results with the participants.

- j. Once the four stations have been completed the team's sensor will be placed in near boiling water for three minutes to check the device's durability. Any device that fails during this test or at any of the four stations will retain their points but be placed in Tier 2.
- k. Teams will answer a 10-15 question assessment over the theories behind this event. Questions will range from resistance and/or voltage and temperature relationships, LED operations, the process of calibration, and construction parameters. These questions can be answered at anytime during the rotation and the score will be used for the sole purpose of breaking ties.
- l. Teams who wish to file an appeal must leave their design log and sensor with the event supervisor.

5. **SCORING:**

- a. The team with the highest Total Score wins.
- b. A Total Score for each team will be determined as follows:
 - i. Impounding of a working temperature sensor with functional LED indicators and visual temperature display is 50 points
 - ii. Impounding of a design log as described in construction rules 3.e (up to 40 points max.)
 - (a) Compliance to Construction Parameter 3e.i 10 pts.
 - (b) Compliance to Construction Parameter 3e.ii 10 pts.
 - (c) Compliance to Construction Parameter 3e.iii 10 pts.
 - (d) Compliance to Construction Parameter 3e.iv 10 pts.
 - iii. Accuracy of temperature at the four stations (40 points max)
 - (a) +/- 0.2 degree 10 points
 - (b) +/- 0.5 degree 8 points
 - (c) +/- 1.0 degree 6 points
 - (d) +/- 1.5 degree 4 points
 - (e) +/- 2.0 degree 2 points
 - (f) > +/- 2.1 degree 0 points
 - iv. LED indicating correct color at the four stations (5 points each for a total of 20 points max)
- c. If there is a tie, the highest score on the 10-15 question assessment will be used to break the tie.
- d. Teams that do not successfully complete the four stations and the final durability test will be ranked behind teams that do.
- e. Devices determined to be in violation of construction rules 3.b or 3.c will not be tested.

Recommended Resources:

TI-Innovator Hub:

<https://education.ti.com/en/products/micro-controller/ti-innovator>

Raspberry Pi:

https://en.wikipedia.org/wiki/Raspberry_Pi

<https://www.raspberrypi.org/help/videos/>