

Detector Building 2018 Trial Event Rules
Inquiry Committee

1. **DESCRIPTION:** Teams must design, build, program, and test an instrument that will measure changes in temperature and display the measurement using the appropriate units.

A TEAM OF UP TO: 2

IMPOUND: Yes

EYE PROTECTION: None

APPROXIMATE TIME: 10 minutes

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 to test each device's ability to detect and signal changes in temperature at a set standard as well as across a changing temperature range.

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 (e.g. TI Innovator, Raspberry Pi, Arduino), a display, LED lights, an alarm, and a sensor/probe that produces a voltage dependent on the physical stimulus provided. The device may be 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 be made water proof for total immersion. Sensor/probe may not be constructed using pre-calibrated, preassembled sensors/probes (e.g. Vernier, PASCO).
- 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 respond differently to two different ranges of the designated environmental condition through the use of LED lights and/or an alarm. The exact ranges of the environmental condition detected will be provided to the competitors at the start of their 10-minute time.
- e. Teams will also need to submit a Design Log with their device at Check-In. This Design Log should contain:
 - i. A detail drawing or illustration of the device identifying all the components and their function.
 - ii. An explanation of the programming language used, a written copy of the programming code that is used to operate the device, and an indication of, as well as a source for, any programming code that was not originally written or developed by the competitors.
 - iii. The mathematical modeling function and the calculations used to convert the sensor/probe output voltage into the calibrated output shown on the device display.
 - iv. A written practice log that details at least 10 trials of the device for 2 different ranges of the environmental condition indicating the range of the environmental condition detected, the time it took to detect that condition, and the responses, or alarms, produced.
- f. Each device, and associated impounded items, must be labeled so the event supervisor can easily identify to which team they belong.
- g. 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:**

- 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. Teams are given 10 minutes to set up their device and complete 3 trials:
 - i. detection of an unknown constant (e.g.; the temperature of a water bath)
 - ii. detection of a broad-range of changing temperature (e.g.; the change in temperature of a water bath from 20°C to 35°C)
 - iii. detection of a narrow-range of changing temperature (e.g.; the change in temperature of a water bath from 35°C to 40°C)

- d. Devices activated for any trial before the end of the 10-minute time period will be able to complete the trial.
- e. At no point during a trial may the device be connected to a power supply.
- f. Teams may adjust their device before each trial (e.g. adjust the program, reset an alarm, clean a detector, charge the device) within their 10 minutes providing the device continues to meet specifications.
- g. A trial will begin when the Team activates their device and continue until the device detects the identified environmental measurement or range (i.e. the specified temperature). At that point, the event supervisor will stop the 10-minute timer and record the measurement value displayed on the device as well as the value measured by an appropriate device provided by the event supervisor. The values will be recorded to the precision of the device.
- h. The event supervisor will then reset conditions to allow for a second trial. Once the environment is ready the 10-minute timer will restart and competitors will be able to make any adjustments or reset their device. Upon completion of the second trial, the 10-minute timer will be stopped and preparations made for a third trial.
- i. At any point where the specified environmental value or range have been exceeded without the detector performing the indicated alarm the team can notify the event supervisor that they would like to declare a Failed Run. The team can then deactivate their device and make adjustments through the 10-minute timer still continues.
- j. The supervisor will review with teams the data and timing recorded on the scoresheet.
- k. Teams who wish to file an appeal must leave their design log and sensor with the event supervisor.

5. **SAMPLE TASK:**

The students could build their detector using a TI Innovator hub as the microcontroller, a TI NSPIRE calculator as the display device, and a LM19 Analog Temperature Sensor. The event supervisor would start the team's trials by having them use their device to measure the temperature of an unknown solution. After recording the data from this trial, the event supervisor tells the team that the device needs to identify when the solution has a temperature between 25°C and 40°C. The timer begins and the participants would program their device to flash a green LED when the solution has a temperature between 25°C and 40°C. Once the run is completed and data recorded, the timer stops and the event supervisor would then tell the participants that the device now needs to detect when the solution has a temperature between 70°C and 75°C. The timer begins and the participants would program their device to flash a red LED when 70°C is exceeded and stay flashing until 75°C is exceeded. Once the run is completed, the timer stops and the event supervisor would then record the data and share results with the participants.

6. **SCORING:**

- a. Team with the lowest Total Score wins.
- b. A Total Score for each team will be determined as follows:
 - i Unknown Score: The percent error during the unknown measurement trial x 40 points
 - ii Broad-Range Score: The percent error during the broad-range trial x 20 points
 - iii Narrow-Range Score: The percent error during the narrow-range trial x 40 points
- c. Devices determined to be in violation of construction rules 3.b or 3.c will not be tested.
- d. If there is a tie, the lowest average percent error across all three trials should be used to break it. If a second tie-breaker is needed the time remaining on the 10-minute event timer should be used.
- e. Teams that do not successfully complete the three trials will be ranked behind teams that do complete the three trials.

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/>