DETECTOR BUILDING

See General Rules, Eye Protection & other Policies on www.soinc.org as they apply to every event.

1. **DESCRIPTION: Teams will build a durable Conductivity Device that will accurately measure and display both voltage and concentrations of NaCl in parts per million (ppm) from 0 to 5000 ppm of different water samples.**

   A TEAM OF UP TO: 2 **EYE PROTECTION:** None

   IMPOUND: No **APPROXIMATE TIME:** 50 minutes

2. **EVENT PARAMETERS:**
   a. Each team may bring one participant-constructed, **conductivity**-sensing Device with a laptop or a calculator for programming/display, two calculators of any type, and one 2" or smaller three-ring binder, as measured by the interior diameter of the rings, containing information in any form and from any source. Sheet protectors, lamination, tabs and labels are permitted.
   b. **Event Supervisors should supply distilled water for participants to rinse their probes between tests, and will provide standardized saltwater samples in 4 oz souffle cups with approximately 7 cm mouth with an approximate depth of 5 cm with a removable lid.**
   c. **Regional Competition will test 3 unknown concentrations. State and National Competition will test 4 different concentrations.**
   d. Teams 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.

3. **CONSTRUCTION PARAMETERS**:
   a. Devices must be built using a microcontroller or microcontroller board (e.g., TI Innovator, Raspberry Pi, Arduino, Micro:bit), a display, LED lights, and a participant-built sensor/probe. The sensor must produce a voltage which varies according to the **concentration** of the water. The Device may be connected to a laptop and/or calculator. WiFi/Internet connection is not allowed at any time during competition.
   b. **The sensor must be student constructed from fundamental electronic components such as resistors, capacitors, wire, and DIP package integrated circuits. All supporting circuits must be assembled on a breadboard. No preassembled integrated circuit PCB boards are allowed. The sensor and wires/cables, together, must be a minimum of 30.0 cm in length, and narrow enough to fit through an opening of 7.0 cm. The end must be immersible up to 5.0 cm in water.**
   c. **The Device may use code libraries from any source.**
   d. **The Device must have a digital display that clearly shows voltage, and the salt concentration in ppm to the nearest unit value. This can be displayed on a laptop or calculator. If the team chooses to use a laptop for display purposes it CANNOT be used for the Written Test portion of the event.**
   e. **The Device must also be able to indicate the specific concentration zone using three separate LEDs - one red, one green, and one blue. RGB LEDs may be used but must be wired for only one color. The exact concentration range of each zone will not be revealed until teams enter to compete, and may be different for different rotations. At States / Nationals, zones may require more than one color to be displayed at the same time.**
   f. Teams must not use electrical outlets at any time during the competition. If the Device is not powered by a connected laptop or calculator, then the Device must be powered by commercially available batteries. Multiple batteries may be connected in series or parallel as long as the total input voltage does not exceed 12 volts as calculated using each battery's voltage (as labeled by the manufacturer), **and the expected voltage output to the probe does not exceed 3.3 volts.**
   g. Each Device must be clearly labeled with the team name and team number.

4. **DESIGN LOG:**
   a. Teams must submit a Design Log with their Device.
   b. **This Design Log should contain the following 7 Sections:**
      i. A top-down photograph of the Device with labels identifying all the components and detailing their functions. This section should also include a brief summary explaining how the Device was constructed.
      ii. A data table with at least 10 trials showing the sensor voltage reading versus the corresponding **in ppm using their fixed resistor(s) in the voltage divider. If multiple fixed resistors are tried, include the data and graphs of all potential resistors.**

iii. Scatter-plot graph of this data with **concentration in ppm on the Y-axis** and voltage on the X-axis.
iv. Function graph of **the** mathematical model supported by the data overlaid on scatter-plot of the data.
v. Equation of the above **the** mathematical model used to convert measured voltage to the corresponding **concentration in ppm** highlighted for easy identification.
vi. **Printout of the program with its code highlighted showing this exact mathematical equation or its code implementation converting voltage to ppm.**
vii. **On the same program printout, highlight the code that will illuminate the appropriate LED(s) according to their assigned concentration ranges.**

c. **If a 3-D printer, laser cutter, CNC machine or similar device was used as a tool to build the team's device, or any component thereof, the following information must also be supplied in the log.**
i. **Information about the tool hardware, software, materials, and supplies used**
ii. **Details of the source of any digital files (e.g.; CAD, STL, OBJ) utilized by the tool including but not limited to when and where the file was obtained, including the web address if downloaded from the internet**
iii. **Descriptions of how the team constructed the final device from the tool created components**

d. **All submitted logs will be returned to teams.**

5. **<u>THE COMPETITION</u>:**

Part I: Device Testing

a. Only participants and Event Supervisors are allowed in the competition areas. Once participants enter the event area, they must not leave or receive outside assistance, materials, or communication.
b. **For Regional Tournaments the Event Supervisors will provide each team with three labeled samples of unknown concentrations; 4 samples will be provided at State/Nationals.**
c. Teams may modify their code (e.g., alter the LED code to match the posted **concentration zone**) during the setup time.
d. **At all Tournaments, teams will have 10 minutes to set up their Device and modify their code.**
e. **After the setup/calibration time, the teams will rotate through the three different stations at Regional, and four at State/National where they will use their Device to measure the Concentration of each labeled sample. Each team will be allowed a maximum of 2 minutes for each of the 3 or 4 sample determinations. The Event Supervisor will record the voltage and the concentration in ppm to nearest whole number displayed by the Device, along with the LED color displayed at each station.**
f. **Event Supervisors should exchange concentration samples at the end of each round to prevent contamination. Actual concentration will not be revealed until the end of the day's competition.**
g. Teams who wish to file an appeal regarding Part I must leave their Design Log and Device in the competition area.

Part II: Written Test

a. Teams will be given a written test to assess their knowledge of the theories behind the event. Teams may use the entire time block to take the written test. The written test will be limited to the following topics:
i. **Voltage divider and the effect of different fixed resistors and the output voltage recorded.**
ii. **The effect of temperature, van Hoff factor, and electrolysis on the reported results.**
iii. **The conversion from the analog reading and voltage.**
iv. **The relationship between concentration units like TDS, mg of NaCl, Molarity, and ppm.**
v. **Theory of LEDs, working principles, and applications.**
vi. **The process of calibration - working with raw data and determining real world relationships.**
vii. **Operational knowledge of basic Device components.**

b. Unless otherwise requested, answers must be in metric units with appropriate significant figures.
c. While working on the written test teams are not allowed to use any laptops they may have brought with them.

6. **SCORING:**
   a. The team with the highest Total Score wins.
   b. A Total Score for each team will be determined as follows:
      i. **Total Concentration Accuracy Score (Maximum 60 points-45 at Regional). Accuracy Score = 60/45 pts - (total of the relative error of the 3 or 4 concentration measurements x multiplier)**
         (1) **Maximum relative error x multiplier per station is 15.0**
         (2) **Regional Multiplier = 20**
         (3) **State Multiplier = 30**
         (4) **National Multiplier = 40**
      ii. **Correct LED colors (Maximum 12-16 points) 4 points are awarded for the correct LED colors (as determined by the concentration measured by the Device) at each station.**
      iii. Design Log (Maximum 28 points) 4 points are awarded for each correct section of the Design Log as well as being able to answer questions about each section.
      iv. Written Test (Maximum 30 points)
   c. Tiebreakers: a) the lowest sum of the total **Relative Error**; b) highest written test score**; c) shortest time for the written test.**
   d. Teams with any construction or competition violations will be ranked behind teams without violations.

Recommended Resources: The Science Olympiad Store (store.soinc.org) carries a variety of resources to purchase for this event; other resources are on the Event Pages at soinc.org

This event is sponsored by Texas Instruments