THERMODYNAMICS C – SoCal Trial Event

1. **DESCRIPTION:** Teams must construct an insulated device prior to the tournament that is designed to retain heat. Students must also complete a written test on thermodynamic concepts.

   A TEAM OF UP TO: 2 **EYE PROTECTION**: **C** **IMPOUND:** No **APPROX. TIME:** 50 Minutes

2. **EVENT PARAMETERS:**
   a. **All reference materials to be used during all parts of the competition must be initially secured in a 3-ring binder so that regardless of orientation, none can fall out.**
   b. **Competitors may bring writing utensils and any type of calculators for use during any part of the event.**
   c. Competitors must bring their insulating device, 2 identical 250 mL Pyrex (or similar brand name) beakers, plots, and parts/supplies.
   d. Event supervisors must supply the hot water, devices for transferring measured volumes from the water source to the team's beakers, and thermometers or probes (recommended).
   e. Prior to the day of the competition, the team must calibrate their devices by preparing plots (either on separate graphs or overlaid on the same graph) showing the relationship between elapsed cooling time and ending water temperature for various quantities of water and starting water temperatures. If hand drawn, they must be on graph paper. All plots must be properly labeled and marked to identify the team.
      i. Teams may submit up to 4 plots for scoring. Teams may be asked by the supervisor to submit them prior to the tournament.
      ii. Teams are encouraged to have a duplicate set to use, as those submitted may not be returned.
      iii. Students must be prepared to answer questions about the data collection and how the plots are used.
      iv. Example plots are available on the Thermodynamics Lab page on www.soinc.org
   f. ~~The team's device, parts and any supplies (beakers, tools, notes, plots, etc.) must be impounded before the event starts. Eye protection does not need to be impounded. Appeals by teams will not be processed after they remove their device from the competition area unless the appeals committee has released it.~~
   g. **Competitors must wear eye protection during Part I. Teams without proper eye protection must be immediately informed and given a chance to obtain eye protection if time allows.**
3. **CONSTRUCTION:** The device must fit within a 15.0 cm x 15.0 cm x 15.0 cm cube.
   a. Devices may be constructed of and contain any materials except for the following prohibited materials: any type of foam (plastic, metal, expandable glue, etc.), bubblewrap, commercial insulation.
   b. Within the device, students must be able to easily insert and remove a 250 mL standard, unaltered, empty Pyrex (or similar brand name) beaker that they supply (height ~1.4 times the diameter).
   c. The device must also easily accommodate the insertion and removal of a thermometer/probe into the beaker via a hole at least 1.5 cm in diameter all the way through directly above the beaker. The top surface of the hole must be less than 2.5 cm above the top lip of the beaker. The hole must remain open and unobstructed during the competition.
   d. Devices must be inspected to ensure that there are no energy sources (e.g., no electrical components, small battery powered heaters, chemical reactions, etc.) to help keep the water warm. At the event supervisor's discretion, teams must disassemble their devices at the end of the testing period in order to verify the materials used in construction.
   e. All parts of the device must not be significantly different from room temperature when brought into the event venue.
4. **THE COMPETITION:**
   a. **Part 1: Device Testing**
      i. During the event, the event supervisors must announce the temperature of the source water bath (60 to 90^{o}C), the volume of water to be used (50 to 150 mL, in 25 mL increments at Regional competitions, 10 mL at State competitions, 1 mL at the National competition) and the amount of cooling time allowed (20 to 40 mins). These variables must be the same for all teams.
      ii. The event supervisor must also announce the current room temperature.

iii. Teams must be given 5 minutes to setup/modify their devices at the start of the competition. Devices that do not meet the construction specs must not be allowed to be tested until brought into spec.
iv. Each team, in a staggered sequence, must have the set amount of water poured into each of their 2 beakers, one of which they must then insert into their device, the other must be placed on an open surface next to the device. Nothing must be placed under or immediately around the external beaker. Teams may secure and/or close access panels with fastening materials after inserting the beaker. Event supervisors must record the time each team receives their water. Teams may utilize their own thermometers to measure the starting water temperature in their beakers.
v. Teams may elect to add up to 50 mL of water from an ice bath to their internal beaker immediately after receiving the hot water for bonus points. Each team may choose their own volume.
vi. Teams must use their plots to calculate the temperature of the water in their beaker at the end of the cooling time. They must provide the event supervisors with their estimate prior to beginning part 2.
vii. At the end of the cooling period, the event supervisor must record the temperature in each beaker to the best precision of the available instrument. Supervisors may leave thermometers/probes in the devices and the un-insulated beakers for the entire cooling period. Otherwise they must first insert a thermometer/probe into the un-insulated beaker, wait at least 20 seconds, and record the resulting temperature. The event supervisor must then wipe any residual water off the thermometer/probe and repeat the same process with the beaker inside of the students' device. Multiple thermometers/probes may be used at the supervisor's discretion.

b. **Part 2: Written Test**
i. Students must take a test on thermodynamic concepts during the remaining time after all devices have been loaded with water. All teams must have the same amount of time to take the test.
ii. The test must be worth 50 points.
iii. Topics may include: temperature conversions, definitions of heat units, thermal conductivity, heat capacity, specific heat, the laws of thermodynamics, the history of thermodynamics and thermodynamic processes.

5. **SCORING:** High score wins.
a. All scoring calculations are to be done in degrees Celsius.
b. Penalties: 4 points each time a Competition section requirement is violated; 10 points for each Construction section requirement violation; ~~25 points for missing impound.~~
c. One of the submitted plots, selected by the event supervisor, must be scored as follows:
i. Partial credit may be given. The max Plot Score possible is 10 points.
ii. 2 points if labeled with school and student's names.
iii. 2 points for appropriate title of plot and X and Y-axis labels.
iv. 2 points for appropriate units and axis increments.
v. 1 point for each data plot on a graph or graphs turned in (up to 4 total).
d. The final score is the sum of five components minus penalties (a scoring spreadsheet is at soinc.org):
i. Test Score = max of 50 points
ii. Plot Score = max of 10 points
iii. Heat Retention Score = ((internal beaker water temp / external beaker water temp) - 1) x 25 points
iv. Prediction Score = (1-(abs (final internal beaker water temp - predicted internal beaker water temp) / final internal beaker water temp)) x 50 points
v. Ice Water Bonus = (volume of ice water in ml / 4) points
vi. If the heat retention score is negative, it must be set to zero for scoring purposes.
e. Scoring Example: A team gets 22 out of 25 questions on the test correct, submits 4 accurately labeled plots, predicts a final internal beaker temp of 35.0 degrees C, and adds 40 mL of ice water. The actual final internal beaker temp was 32.1 degrees C and the external beaker had a final temp of 27.0 degrees C.
Test Score = (22 / 25) x 50 = 44; Heat Retention Score = ((32.1 / 27.0)-1) x 25 = 4.7;
Plot Score = 10; Prediction Score = (1-(abs (32.1-35)/32.1)) x 50 = 45.5;
Ice Water Bonus = 40 / 4 = 10 points; Total Score = 44 + 10 + 4.7 + 45.5+10 = 114.2.