

Michigan Science Olympiad: *Thermodynamics*

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Event Overview

- Two major parts in Thermodynamics section of SO
 1. Written test
 2. Insulating device demonstration

 - Scoring (Total 100 Points)
 1. Written test – **45 Points**
 2. Insulating device demonstration:
 - Plot Score – **10 Points**
 - Prediction Score – **25 Points**
 - Heat Retention Score – **15 Points**
 - Ice Bonus – **05 Points max**
- } **55 Points**
3. Penalties
 - Violation of competition rules
 - Rules Manual, 2018 Science Olympiad, Thermodynamics, Section 4
 - Violation of demonstration device construction rules
 - Rules Manual, 2018 Science Olympiad, Thermodynamics, Section 3

Event Overview Description

- Student team **must** bring:
 - Insulating device
 - Identical 250 mL beakers, quantity 2
 - Splash proof eye protection
 - Plots (need to submit in advance)
 - Writing utensils
- Students **may** bring following supplies
 - Calculators
 - Reference material in **one** 3-ring binder
 - Parts, supplies, tools, thermal probe
- Maximum 2 students per team allowed



Impound

- Impound will occur between 7:30 AM – 8:30 AM on the day of the competition (March 17, 2018)
- **Impound is required for:**
 - Insulating device -- Parts, supplies, tools
 - Two Identical beakers
 - Plots – (1 set; will not be returned back)
 - Not available during the insulation device demonstration / competition
 - If desired, teams can bring additional copies of plots in their binder for use during the competition
- **Not required to be impounded:**
 - Eye Protection -- Calculator -- Notes
- After completion of the impound, initial water temperature and volume of water for the insulating device demonstration will be announced.

Insulating Device

- Designed, built, and calibrated before the competition
- Div. C - 15.0 cm cube, Div. B – 20.0 cm cube
- No electrical components, chemical reactions or other energy sources
- Provision to accommodate one removable standard 250 mL beaker
 - Two unmodified beakers
 - Both beakers must be exactly identical, no difference
- For insertion of temperature probe, insulating device must have a hole on the top with the following specs:
 - Diameter: **1.5 cm**
 - Distance between top of hole to top of beaker: **Less than 2.5 cm**
 - The hole **must** remain open and unobstructed during the competition
- Devices that do not meet these requirements will not be tested

Insulating Device: Construction Materials



- Permissible materials of construction include, but not limited to:
 - Non metals:
 - Wood (sawdust is OK),
 - Paper Cardboard,
 - Plastic Rubber
 - Natural or synthetic materials:
 - Wool Cloth
 - Feathers Bubble Wrap
 - Metals:
 - Aluminum Aluminum foil
 - Steel Copper
- Following materials are **not allowed** for the construction
 - Fiberglass, asbestos, mineral wool
- Check www.soinc.org for updates

Insulating Device Tips

- For performance, consider the basic mechanisms for heat transfer
 - Conduction Convection
 - Radiation Evaporation / condensation

- Consider how the heat will flow out of the hot water filled beaker
 - Limit internal convection via small air spaces
 - Look up R values of materials: [wikipedia.org/wiki/R-value_\(insulation\)](http://wikipedia.org/wiki/R-value_(insulation))
 - How can the radiative

- Consider reliability and ease of use
 - Compatibility between hot water vapor and construction materials
 - Sturdy construction will help with repeated testing
 - Must be able to support self weight and the weight of the water
 - Must be able to disassemble for inspection and reassemble quickly

- Material Resources
 - Balsa Wood www.lonestar-balsa.com
 - Free sawdust from Lowe's, Home Depot
 - Craft store

Plots

- Provide up to 4 graphs, for scoring, demonstrating the performance of the device for various starting temperatures and quantities of water.
- Scoring of Plots (10 points)
 - 2 points for including data spanning at least one variable range listed in Section 4(a) of Rules Manual, 2018 Science Olympiad, Thermodynamics
 - 2 points for including at least 10 data points
 - 2 points for proper labeling (e.g. title, team name, units)
 - 0.5 points for each graph or table turned in (up to 2 points total)
 - 2 points for including a labeled device picture or diagram
- More than 4 plots can be provided, but, they will not add to the teams score

Insulated Device Demonstration

- Initial water bath between **60 to 90 °C**,
 - The exact value of initial temperature will be announced after the impound but before the competition
 - Initial water bath temperature will be the same for all teams
 - The event supervisors will provide the water to test the insulated device performance of each team
- The volume of water for competition testing will be between **50 to 150 mL (Div B)**, **50 to 150mL (Div C)**
 - The exact volume of water will be announced after the impound but before the competition; it will be in increments of 25 ml
 - All teams will perform testing using the same volume of water
 - Supervisors will fill the insulated device beaker and external beaker of each team using 200 ml catheter tip syringe
- **Optional ice water** for bonus points: Ice water can be requested in increments of 10 ml up to a maximum of 50 ml volume
- The two 250 ml beakers will be filled with the same volume of water under identical conditions. One beaker will be inserted in the insulated device and the other will be placed on the table under ambient conditions adjacent to the insulated device



Insulated Device Demonstration



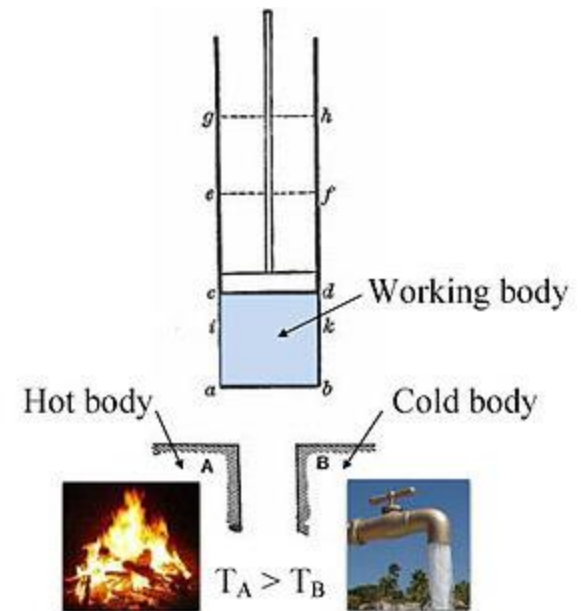
- Cooling time between
 - 20 and 40 minutes Div C
 - 30 minutes Div B
- Temperature Measurement
 - Event supervisor(s) will measure final temps of both beakers of each team at the end of the cooling period
 - Event supervisor will use their own thermocouple based instrument for temperature measurement
 - To reduce team-to-team variation in temperature measurement, same instrument will be used for all teams

Insulated Device Demonstration

- Teams will be given about 5 minutes to setup / prepare devices
- Teams will have water placed in their device in sequence
- Teams may place up to 50mL of optional ice water in their device
- Teams close and secure their device
- Teams may measure the starting water temperature with their own thermometer (temperature prediction is 25 points)
- Teams must provide ending water temperature prior to starting the written test
 - Teams may use duplicate plots / notes to predict the final temperature
- Nothing is placed under, in or around the external beaker

Part II: Written Test

- Written test will occur after all teams have been loaded with water
- All teams will have the same time for the Written Test (minimum of 20 minutes)
- Test will consist of at least five (5) questions from each of the following areas
 - Temperature scales, conversions, and definitions of heat units
 - Thermal conductivity, heat capacity, specific heat, latent heat, phases of matter, entropy, and enthalpy
 - Thermodynamic laws and processes (e.g. Carnot cycle, efficiency, adiabatic, isothermal)
 - History of Thermodynamics



Annotated color version of the original 1824 Carnot heat engine showing the hot body (boiler), working body (system, steam), and cold body (water), the letters labeled according to the stopping points in Carnot cycle.

Binder

- 3 Ring Binder (nothing can fall out)
 - “Cheat Sheet”
 - Constants
 - Equations
 - Detailed sections
 - Temperature conversion
 - Heat units
 - Thermal conductivity
 - Heat capacity
 - Specific heat
 - Laws of thermodynamics
 - History of thermodynamics
 - Thermodynamic processes
 - Definitions and terminology



Suggested References

- Websites:

- Soinc.org Thermodynamics Event pages
- Scioly.org student forums / wiki / test exchange
- Wikipedia (Star evolution, spectral classification, radio astronomy, etc.)

<https://www.soinc.org/thermodynamics-b> and <https://www.soinc.org/thermodynamics-bc>

<https://store.soinc.org/us/Digital-Test-Packets/c/2723?resetallfilter=1>

<https://www.soinc.org/sites/default/files/example%20keep%20the%20heat%20-%20thermodynamics%20plots%20111008.pdf>

<http://en.wikipedia.org/wiki/Thermodynamics>

<http://www.ohio.edu/mechanical/thermo/>

<http://scienceworld.wolfram.com/physics/topics/Thermodynamics.html>

<http://www.khanacademy.org/video/thermodynamics--part-1?playlist=Physics>



Preparing for Competition: Workshop



- There will be a thermodynamics workshop on Jan 13th from 12:00 to 3:00 at Southlake High School.
- The workshop intends to cover:
 - Thermodynamics event overview
 - Building your thermodynamics device
 - Principles involved in building device
 - Test subjects overview
- Interactive
- Questions and answers
- Demonstration of a Thermodynamics device, filling and testing of device
- Hints for existing thermo devices

Preparing for Competition: Sample Kit



- For the convenience of the participating teams a thermodynamic competition sample kit has been prepared
- A limited Quantity of thermodynamics kits are available for purchase at a cost of **\$35**
- Kit includes
 - Beakers 2-Plastic or 3-Glass beakers
 - Syringe for filling device
 - Top hole check gauge
 - Flash Drive
 - Event overview information
 - Example tests
 - How to build your device
 - Reference material