

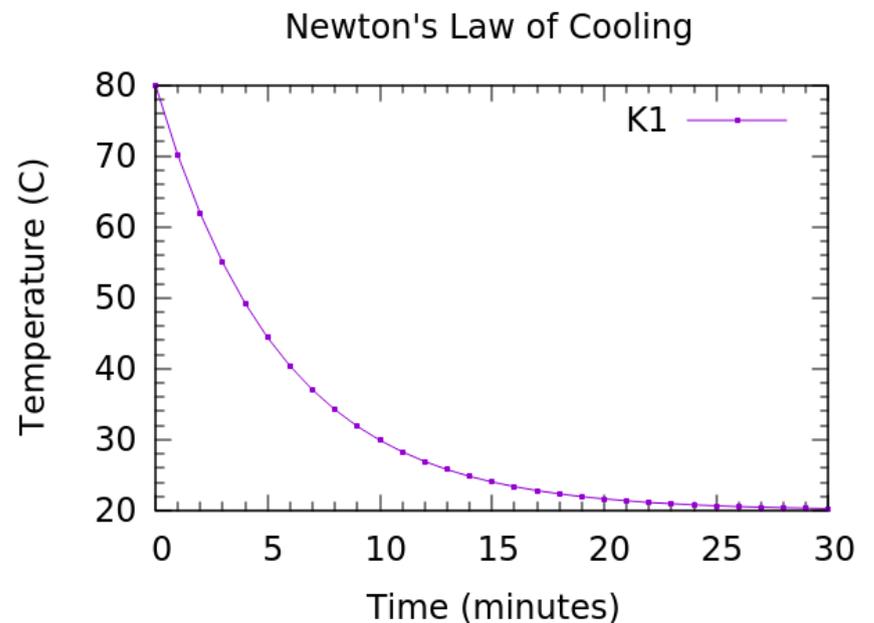
# Science Olympiad 2019

Teacher's Workshop

NMT

Nov 2, 2018.

## Thermodynamics



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# Description

Team size: Up to 2

Impound: Yes

Eye Protection: Required

Time: 50 minutes

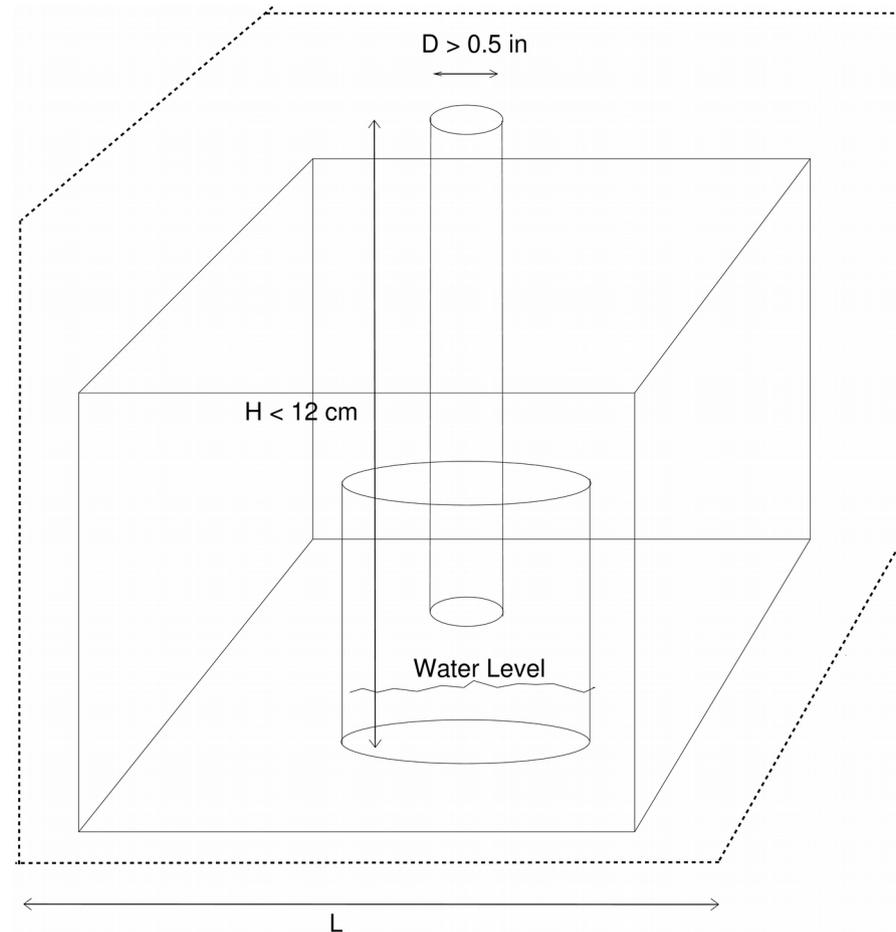
Event parameters: Rulers, Protractors, Templates  
Calculator and Notes (3-Ring Binder)

(2.b ... two stand-alone calculators of any type ...)

# Description

Teams must construct an insulating device prior to the tournament that is designed to retain heat and complete a written test on thermodynamic concepts.

# Construction (critical parameters )



Division B:  $L = 20 \text{ cm}$ ;  
Divicion C:  $L = 15 \text{ cm}$ .

# Scoring

Part		Points
Test Score	(TS)	[0, 45]
Chart Score	(CS)	[0, 10]
Heat Score	(HS)	[0, 20]
Prediction Score	(PS)	[0, 25]
Final Score = TS + CS + HS + PS		[0,100]

# Test Score

$TS = 45 \times \text{Test's Pointage} / \text{Highest Pointage (from all Teams)}$

# Chart Score

- 1) **2 points** for including data spanning at least one variable range listed in 4.Part I.a.

volume of water (State):

75 - 125 mL, 25 mL increments;

cooling time: Div. B: 25.0 mins;

Div. C: 20.0-30.0 mins,

1-minute increments.

# Chart Score

2) **2 points** for including at least 10 data points in each data series

Example of a data series

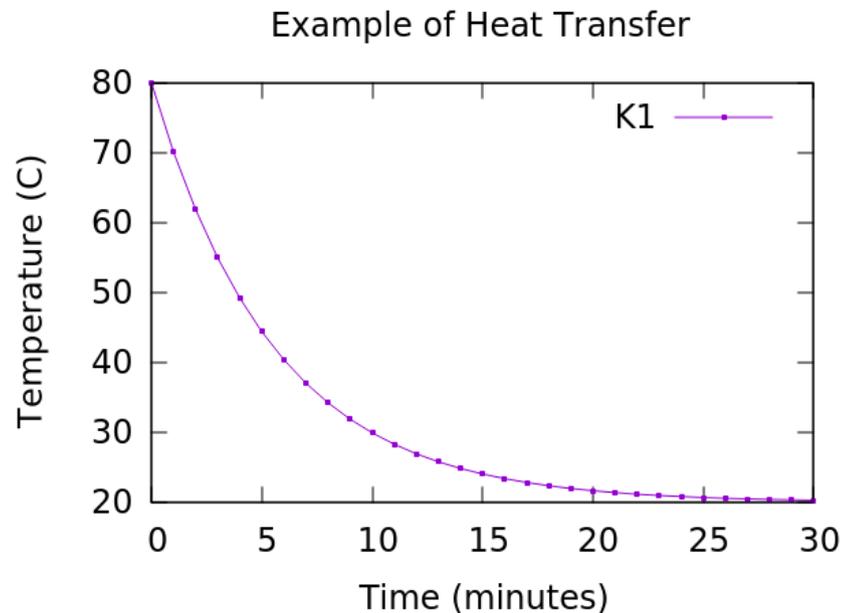


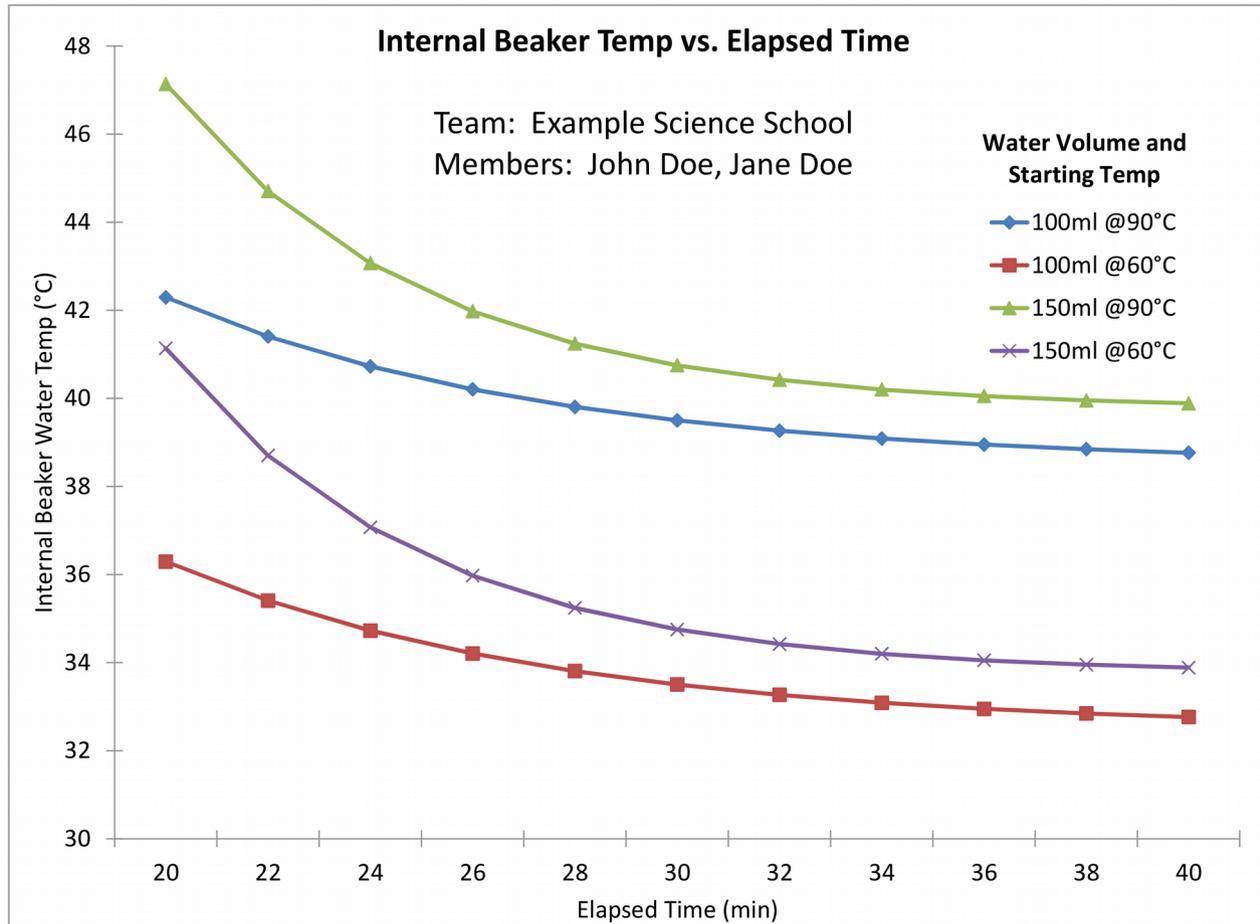
Table 1: 100 ml Data Chart.

Time (minutes)	Temperature (C)	Time (minutes)	Temperature (C)
0.0	80.0	16.0	23.5
1.0	70.1	17.0	22.813262
2.0	61.9	18.0	22.349834
3.0	55.0	19.0	21.962746
4.0	49.2	20.0	21.639423
5.0	44.0	21.0	21.369361
6.0	40.4	22.0	21.143787
7.0	37.2	23.0	20.955371
8.0	34.2	24.0	20.797993
9.0	31.9	25.0	20.666540
10.0	29.9	26.0	20.556741
11.0	28.3	27.0	20.465029
12.0	26.9	28.0	20.388425
13.0	25.8	29.0	20.324440
14.0	24.8	30.0	20.270995
15.0	24.0		

# Chart Score

- 3) **2 points** for proper labeling (e.g. title, team name, units)
  
- 4) **0.5 points** for each graph or table turned in (up to 2 points total as long as they are not the same)
  
- 5) **2 points** for including a labeled device picture or diagram

# Chart Example



# Heat Score

$$HS = 20 \times (\text{lowest } k \text{ of all teams}) / k,$$

where  $k$  is from Newton's law of cooling:

# Newton's law of Cooling

$$\frac{dT}{dt} = -K(T - T_r)$$

where  $K$  is a constant and  $T_r$  is a reference temperature.

$$T(t) = T_r + (T_0 - T_r) \exp(-K(t - t_0))$$

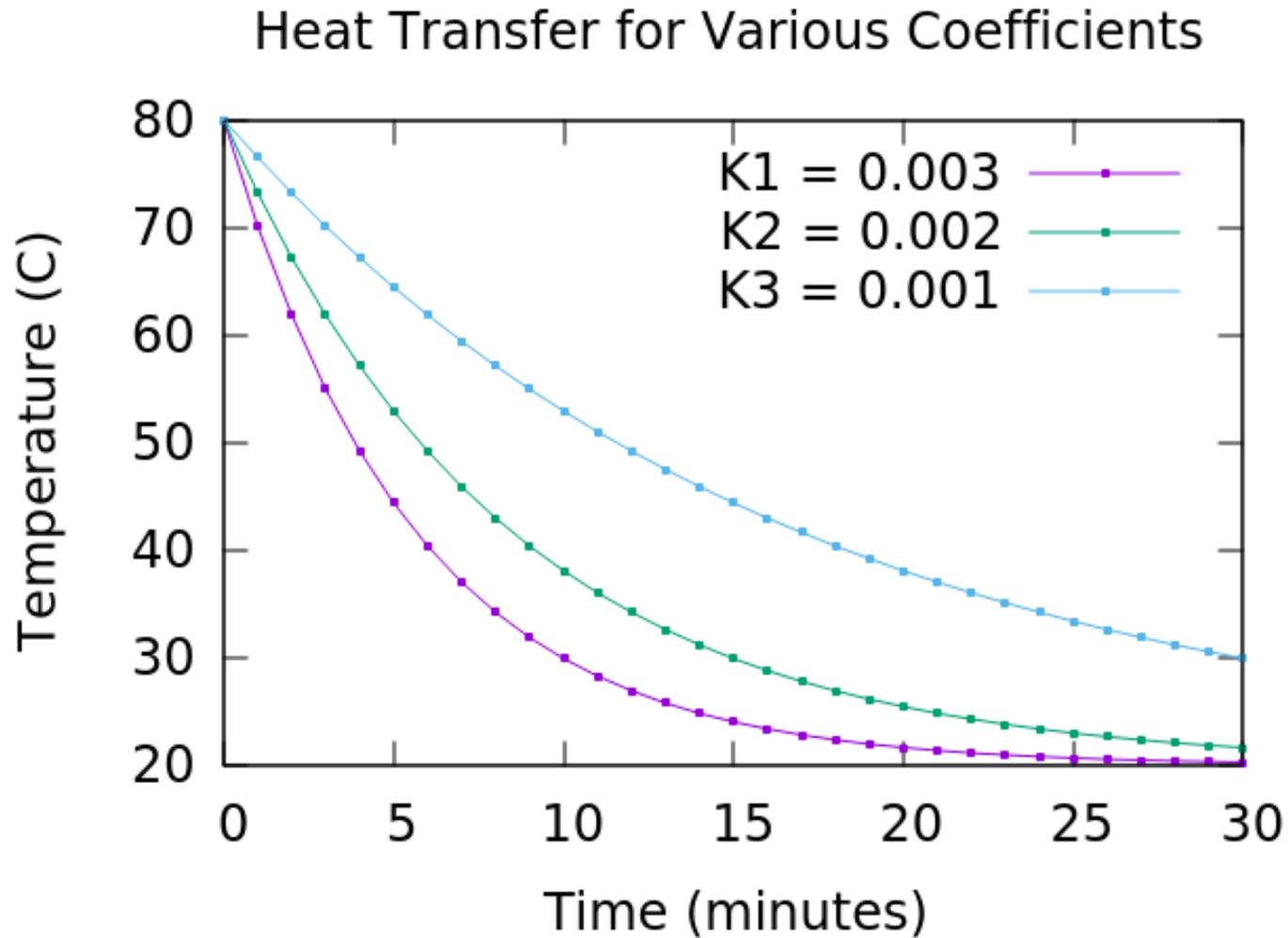
$$K = \frac{1}{t_f - t_0} \ln\left(\frac{T_0 - T_r}{T_f - T_r}\right)$$

Where  $T_f = T(t_f)$

# Heat Score

$$k = - (1 / \text{cooling time}) \times \ln((\text{start water temp} - \text{room temp}) / (\text{final water temp} - \text{room temp}))$$

# Newton's law of Cooling



# Prediction Score

$$PS = 25 - 2.5 * \text{abs}(\text{prediction} - \text{final temp}).$$

The minimum PS possible is 0 points.

# Penalties

- Competition violations:

$$PS \times 0.9; \quad K \times 1.1$$

- Construction violations corrected during part I,  
or missing impound:

$$PS \times 0.7; \quad K \times 1.4$$

- Unsafe Operation or Non-conforming  
Insulation at start of part I:

$$HS = PS = 0.$$

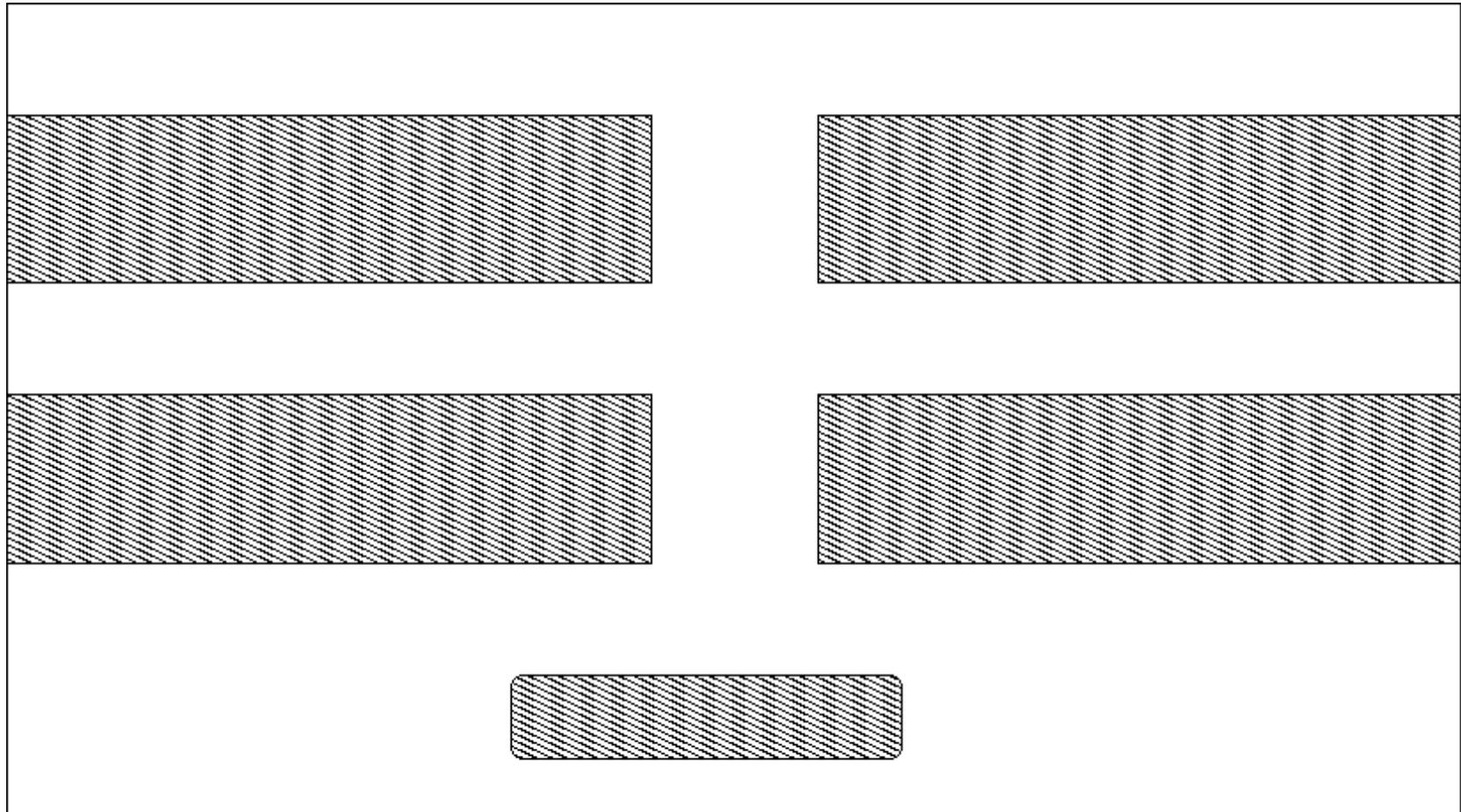
# Tie Breakers

1) Best Test Score (TS),

2) Best Prediction Score (PS),

3) Best Heat Score (HS).

# Room Setup



# Running the Event

Impound	8:00 to 9:00	All Teams
Teams 1-8	9:00 to 9:50	
Teams 8-16	10:00 to 10:50	
Teams 16-24	11:00 to 11:50	
Teams 22-Rest	11:00 to 11:50	?

- Maximum number of teams per session 8.
- Team number according to Official List (?).
- Impound is mandatory.

# Running the Event

- All teams have 25 minutes to Complete the written Test.
- Teams start the written test immediately after they make their final prediction.
- Teams interrupt work on the written test, to record Final Temperature.



# Written Test

- History of Thermodynamics
- Temperature, units conversions
- Phase transitions, latent heat
- Heat Transfer, thermal conductivity, heat capacity
- Thermodynamics laws, Processes
- Division C: Radiant Exitance, Entropy, Enthalpy.

# Resources

<https://www.soinc.org/thermodynamics-c>

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