Minimum Resolution
of Vernier SS Temperature Probe

Purpose

The purpose of this experiment is to measure the minimum temperature step (resolution) of the Vernier SS Temperature probe attached to a LabPro and compare it to the manufacturers specifications.

Method

Hook up the probe, LabPro, and computer using Logger Pro 3 software. Choose the calibration for °C. Measure the room temperature and see what minimum steps it displays with time as the temperature slowly changes.

Research

The Manufacturers specification sheet shows that the LabPro has a 12-bit A-D converter and should therefore be able to display a minimum resolution of 0.03°C.

Data

See next page

Conclusion

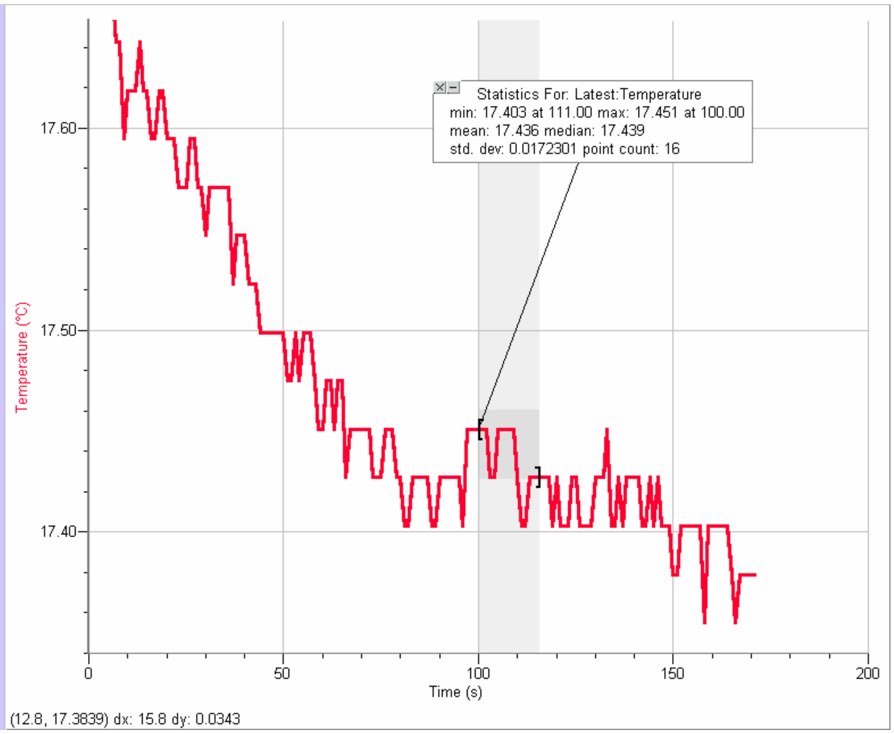
The data actually shows a consistent minimum decrease or increase of 0.024°C instead of the manufacturer specification of 0.03°C. This may only be because of rounding or safety margin. Both estimates are consistent.

Temp Resolution Experimental Data

Procedure:

1. Data was taken for 170 seconds until the temperature reading stabilized.
2. The graph scale was expanded until the minimum data step was obvious and measurable.

	Latest	
	Time (s)	Temperature (°C)
101	100	17.451
102	101	17.451
103	102	17.451
104	103	17.427
105	104	17.427
106	105	17.451
107	106	17.451
108	107	17.451
109	108	17.451
110	109	17.451
111	110	17.427
112	111	17.403
113	112	17.403
114	113	17.427
115	114	17.427
116	115	17.427
117	116	17.427
118	117	17.427
119	118	17.427
120	119	17.403
121	120	17.427
122	121	17.403
123	122	17.403
124	123	17.403
125	124	17.427
126	125	17.427
127	126	17.403
128	127	17.403
129	128	17.403
130		



Discussion of Data:

The data shows a consistent minimum step of 0.024°C.

Response Time for Changes in Atmospheric Temperature for the Vernier SS Temperature Probe

Purpose

The purpose of this experiment is to measure how fast the temperature reading of this probe will stabilize with small changes in the temperature of the surrounding still air.

Method

Hook up the probe, LabPro, and computer using Logger Pro 3 software. Choose the calibration for °C. Place it in an area with no air movement or heat sources. Lightly hold the end of the probe in order to raise its temperature slightly. Release it and graph the temperature to see how fast the temperature reading drops and stabilizes to the constant room temperature. Our results will have to give both the temperature difference and the closeness to final temperature.

Research

The Manufacturers specification sheet shows that the probe has response times of:
95% of full reading in 11s,
98% of full reading in 18 s, and
100% of full reading in 30 s.
This appears to be a latent response time to changes in the temperature of the probe itself and does not give us an indication of how long it will take the probe's temperature to reach equilibrium with the air it is in.

Data

See next two pages.

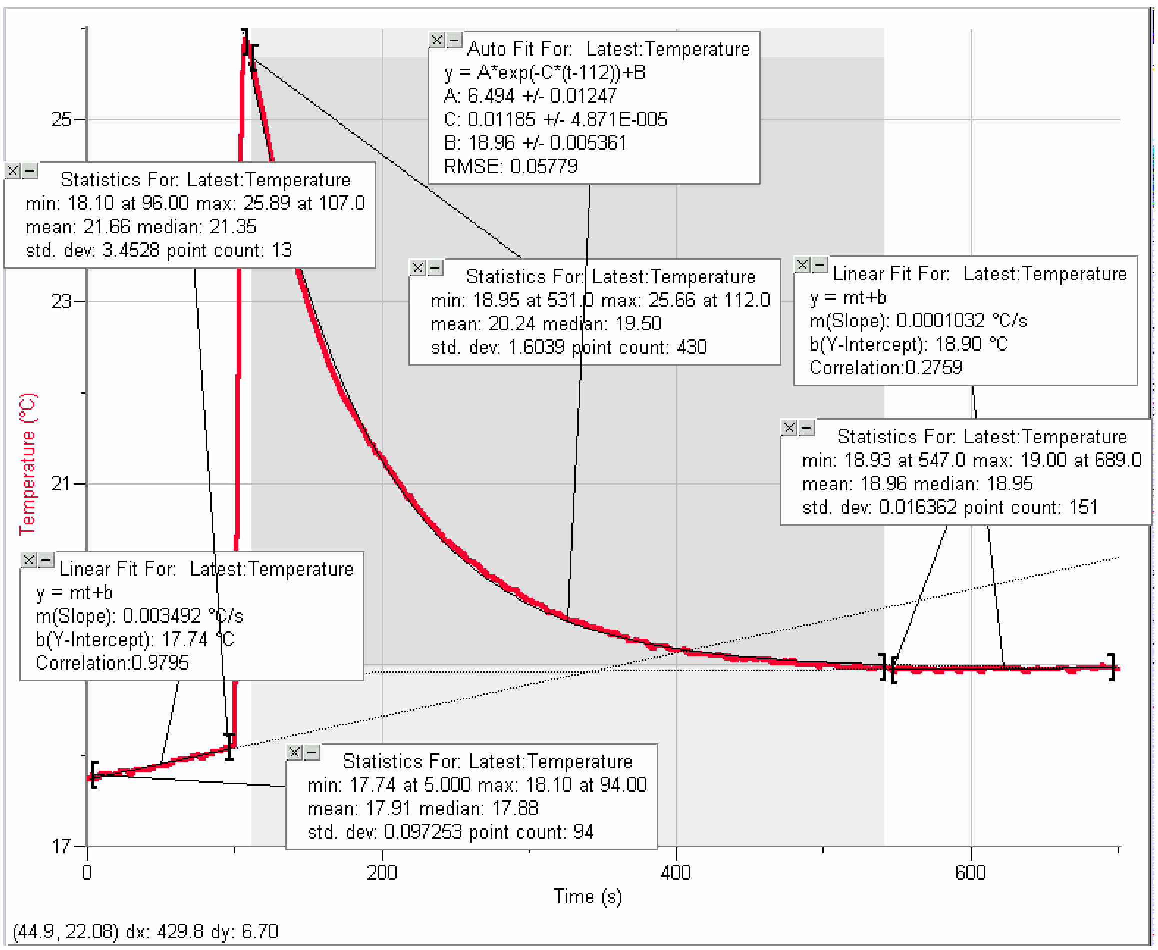
Conclusion

Reaching equilibrium with still air is much slower than direct contact.
A air temperature change of 5°C takes 6 minutes for the probe reading to be within its resolution limit of the actual air temperature. This is a fairly large temperature change and will not often be experience as part of Balloon Fest type experiments.
The probe has a half-life of 58 seconds. Whatever temperature drop happens over 58 seconds can be doubled in order to estimate the true temperature.

Temp Response Experimental Data

Procedure:

1. Baseline data was taken for 100 seconds.
2. The probe tip was held lightly between thumb and forefinger for 7 seconds, raising the temperature 7.8°C.
3. The probe was then allowed to cool in still air to room temperature.



Discussion of Data:

1. The first 100 seconds show an average room temperature of 17.9°C. However it also indicates a slow increase in room temperature.
2. The next 11 seconds show the results of touching the probe tip for 7 seconds. It shows a very rapid response for direct contact.
3. The next 420 seconds shows the slow exponential cooling of temperature in still open air. 6.9°C in 420 s (7 minutes)
4. The last 140 seconds show that the probe reading has stabilized at 19.0°C

Analysis of cooling rate:

1. 90% of the cooling (to within 0.7°C) was accomplished in 200 s or 3 1/3 minutes.
2. 95% of the cooling (to within 0.35°C) was accomplished in 260 s or 4 1/3 minutes.
3. 99% of the cooling (to within 0.07°C) was accomplished in 330 s or 5 ½ minutes.
4. The best fit exponential curve for this data is T=6.5 exp(-0.0119(t-112)) +19.0. This fits the expected form of $T = T_0 \exp(-\lambda t) + T_f$
5. The T_0=6.5 reflects the total temperature difference. The t-112 is because the clock was already at 112s before we started cooling. The T_f =19.0 represents the final temperature. This leaves the λ = 0.0119 factor.
6. λ is called the decay constant. It defines the rate or speed that temperature reaches equilibrium. It is determined by the density of air, the relative wind, and the thermal mass of the probe. A useful form of λ is the half-life or time it takes the temperature to change half way. It is the same time for the next halfway point. In other words it takes two half-lives to drop to within ¼ of the final temperature and three half-lives to drop to within 1/8 and so on.
7. The fraction (or percentage) of temperature drop that has occurred by time t (measured from the start of cooling) is then given as:
   $P = (T - T_f)/T_0 = \exp(-\lambda t)$

The half-life is the time it takes to reduce the temperature halfway to its final temperature. Thus P = ½ and $t_{1/2} = \ln(1/2) / -\lambda$ = 58 seconds.
Every 58 seconds the temperature difference drops halfway.

Resolution of Barometer

Purpose

The purpose of this experiment is to measure the minimum pressure step (resolution) of the Vernier Barometer attached to a LabPro and compare it to the manufacturers specifications.

Method

Hook up the barometer, LabPro, and computer using Logger Pro 3 software. Choose the calibration for units of atmospheres. Measure the room pressure and see what minimum steps it displays with time as the pressure slowly changes.

Research

The Manufacturers specification sheet shows that the LabPro has a 12-bit A-D converter and should therefore be able to display a minimum resolution of 0.0029 in Hg = 0.0001 atm = 0.0098 kPa.

Data

See next two pages.

Conclusion

The data shows a consistent minimum step of 0.0095 kPa. This is consistent with the manufacturers specification.
The random variation over a range of about 0.06 kPa is representative of the precision for this probe. This is more limiting than the resolution.

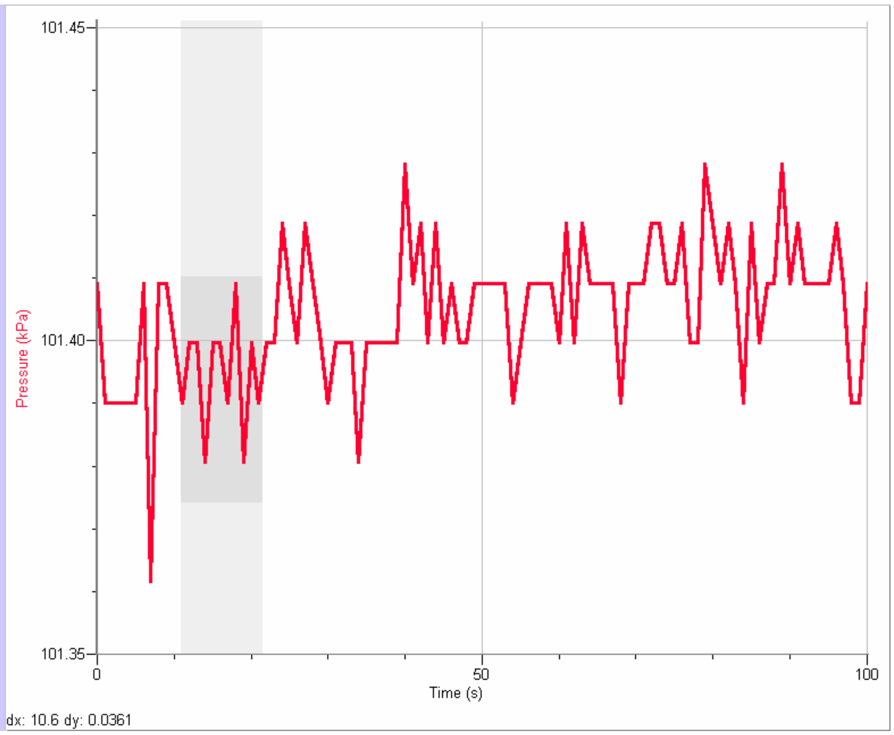
Resolution: 0.01 kPa
Precision: ± 0.03 kPa

Barometer Resolution
Experimental Data

Procedure:

1. Data was taken for 100 seconds.
2. The graph scale was expanded until the minimum data step was obvious and measurable.

	Latest	
	Time (s)	Pressure (kPa)
1	0	101.4091
2	1	101.3901
3	2	101.3901
4	3	101.3901
5	4	101.3901
6	5	101.3901
7	6	101.4091
8	7	101.3615
9	8	101.4091
10	9	101.4091
11	10	101.3996
12	11	101.3901
13	12	101.3996
14	13	101.3996
15	14	101.3806
16	15	101.3996
17	16	101.3996
18	17	101.3901
19	18	101.4091
20	19	101.3806
21	20	101.3996
22	21	101.3901
23	22	101.3996
24	23	101.3996
25	24	101.4187
26	25	101.4091
27	26	101.3996
28	27	101.4187
29	28	101.4091
30		



Discussion of Data:

The data shows a consistent minimum step of 0.0095 kPa.

Sensitivity to Wind of a Barometer within a Gondola

Purpose

The purpose of this experiment is to see just how sensitive a barometric measurement is to a wind of up to 10 knots directed into the open face of a gondola.

Method

Hook up the barometer, LabPro, and computer using Logger Pro 3 software. Choose the calibration for units of kPa. Measure the room pressure and see what minimum steps it displays with time as the pressure slowly changes.

Research

The Manufacturers specification sheet shows that the LabPro has a 12-bit A-D converter and should therefore be able to display a minimum resolution of 0.0029 in of Hg or 0.0001 atm.

Data

Conclusion