BalloonSat and LabPro:

High Altitude Balloon Experiments for High School Students

By Kim Mason and Dr. William V. Slaton

What is BalloonSat?

- Program that allows students to build payloads to send to high altitudes (83,000ft)
- Personalized program to interest students in earth and space sciences
- Grant funded by Arkansas Space Grant Consortium

Payload Regulations

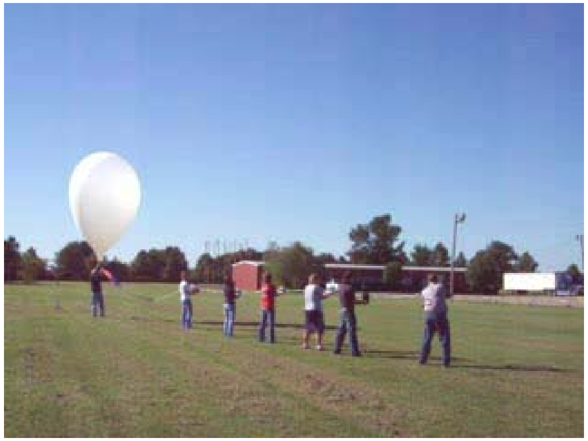
- Weight limit ~500g per payload
- Dimensions usually ~6x6x6", but not required
- Cannot contain hazardous chemicals or anything that could possibly break a load bearing line

Our Equipment

- LabPro (used remotely)
- Temperature Sensor ($\pm$.17°C)
- Pressure Sensor ($\pm$.05kPa)
- Total Mass~822g
- Collection rate:

  1.8 readings/sec (max amount of remote data possible)

Launch Video



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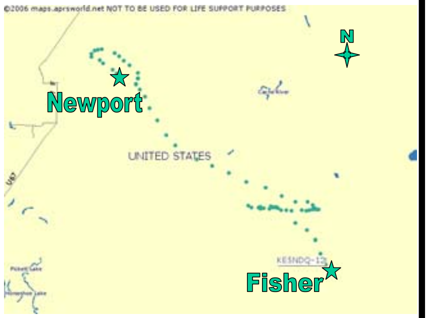
Flight Specifications

- Released from ASU Newport at 10:00am
- Landing near Fisher, AR at 11:40pm

Picture from BalloonSat flight ABS-04



Distance traveled: 15miles

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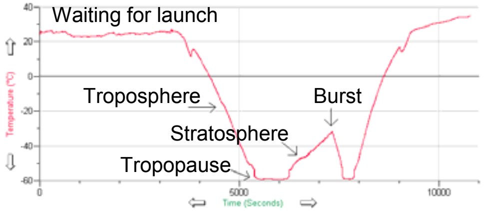
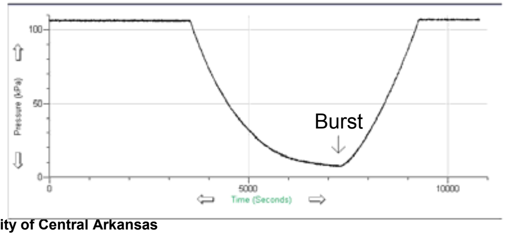
Preliminary Results





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Initial GPS Data

Date & Time UTC	Latitude / Longitude Decimal Degrees	Speed miles per hour	Course Degrees	Altitude feet	Odometer miles	π
2007-09-29 14:57:31	35.6455 -91.1948	12	319	3018	0.0	Geocode
2007-09-29 14:58:30	35.6485 -91.1980	16	334	4442	0.3	Geocode
2007-09-29 15:00:37	35.6538 -91.2053	12	307	7096	0.8	Geocode
2007-09-29 15:01:29	35.6563 -91.2082	11	349	8549	1.1	Geocode
2007-09-29 15:02:12	35.6563 -91.2082	11	349	8549	1.1	Geocode
2007-09-29 15:03:29	35.6588 -91.2143	9	325	11433	1.4	Geocode
2007-09-29 15:04:29	35.6612 -91.2145	9	24	12837	1.6	Geocode
2007-09-29 15:06:31	35.6633 -91.2122	3	97	15603	1.8	Geocode
2007-09-29 15:07:29	35.6638 -91.2093	5	93	16998	2.0	Geocode
2007-09-29 15:08:31	35.6643 -91.2067	1	64	18362	2.1	Geocode
2007-09-29 15:09:18	35.6643 -91.2067	1	64	18362	2.1	Geocode
2007-09-29 15:11:29	35.6617 -91.1965	20	130	22729	2.7	Geocode

Ed Robert's GPS Data

GPS Data uncertainty= ±200ft

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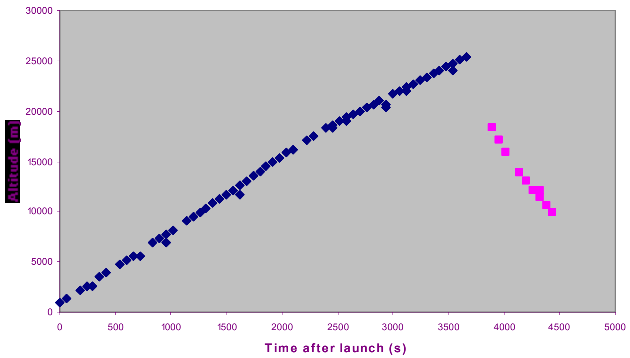
GPS Altitude Data



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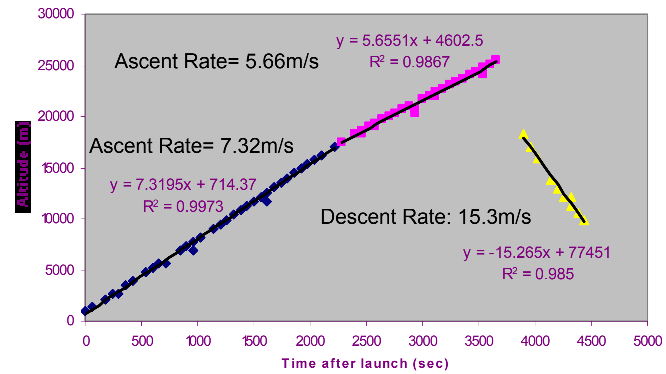
GPS Altitude Data



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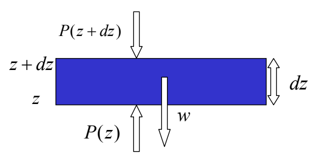
Pressure and Altitude



Using Newton's second law

$$AP(z) - AP(z+dz) - \rho A dz g = 0$$

$$\frac{dP}{dz} = -\rho g$$

$$\rho = \frac{mP}{kT}$$

$$\frac{dP}{dz} = -\frac{mg}{kT} P$$

$$\int_{P_0}^{P} \frac{dP}{P} = -\frac{mg}{kT} \int_0^z dz$$

$$\ln\left(\frac{P}{P_0}\right) = -\frac{mgz}{kT}$$

$$\frac{P}{P_0} = e^{-\frac{mgz}{kT}}$$

$$P = P_0 e^{-\frac{mgz}{kT}}$$

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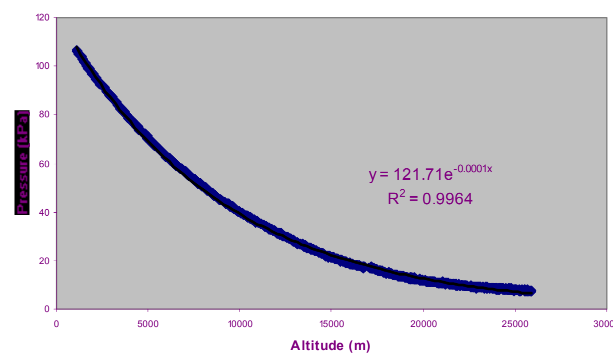
Pressure vs Altitude



$$P = P_0 e^{-\frac{mgz}{kT}} = P_0 e^{-\frac{(.029\,kg/mol)(9.8\,m/s)z}{(8.315\,J/molK)(250\,K)}} = P_0 e^{-.0001z}$$

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Temperature and Altitude

Using the equipartition theorem, the first law of thermodynamics, and the differential of the ideal gas law:

$$\frac{f}{2}\frac{dT}{T} = -\frac{1}{V}\frac{NkdT - VdP}{P}$$

Rearranged becomes:

$$dT = \frac{2}{2+f}\frac{T}{P}dP$$

Using the barometric equation:

$$\frac{dP}{dz} = -\frac{mg}{kT}P$$

We can get the change in temperature:

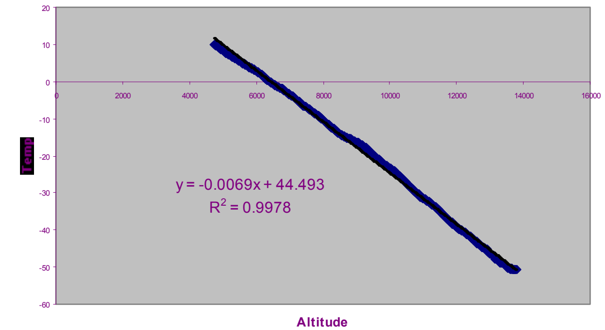
$$dT = -\frac{2}{f+2}\frac{mg}{k} = -\frac{2}{f+2}\frac{Mg}{R}$$

So finally,

$$\frac{dT}{dz} = -\frac{2}{7}\frac{(0.029\,kg/mol)(9.8\,m/s^2)}{(8.315\,J/molK)}$$

$$\frac{dT}{dz} = -.0098\,K/m = \boxed{-9.8\,K/km}$$

Temp vs Altitude



Predicted: dT/dz=-9.8°C/km

Measured: dT/dz=-6.9 °C/km

Future Plans

- Involve other LabPro accessories:
  - Thermocouple
  - Microphone
  - Magnetic Field Sensor
  - CO2 Gas Sensor
  - O2 Gas Sensor
  - Relative Humidity Sensor
  - Garmin eTrex Vista Cx

Funding from Arkansas Science and Technology Authority

Additional Information

Contact Information:

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BalloonSat Website:

http://www.arkballoons.com/