The Longest Parachute Jump

Example Project

Overview

The longest parachute jump ever made was accomplished by Colonel Joseph W. Kittinger, Jr. of the United States Air Force on August 16, 1960. Colonel Kittinger—who was at the time a captain—jumped from a gondola held aloft by a helium balloon 102,800 ft above the New Mexico desert (roughly 20 miles).[1] A first-hand narrative of his jump appeared first in *National Geographic Magazine*, in a story entitled "The Long, Lonely Leap," and later in a book by the same title. In this project, you will use Newton's equations of motion, dimensional analysis, and a model of atmospheric pressure to model his jump, developing plots of his height and velocity versus time and comparing them with data obtained from Kittinger's crew on the ground.

Assignments

1. Obtain a copy of the National Geographic article: J. W. Kittinger, "The Long, lonely leap," *National Geographic* **118** (1960) 854–873. If you do this in Evans library, please re-shelve the volume after making your copy.

2. Use regression and the data included at the end of this assignment to develop a model of atmospheric temperature as a function of height above sea level.

3. Use dimensional analysis to determine a general form for the force due to air resistance on a falling body.

4. In (3) you should have found that the force due to air resistance depends on—among other variables—air density, ρ. Use the following information to develop a model for air density in the atmosphere.[2] Temperature T, pressure p, and density ρ can be connected by Boyle's law,

$$\rho = \frac{1}{R}\frac{p}{T},$$

[1]Later, Colonel Kittinger would volunteer for three combat tours in Vietnam and serve as commander of the 555th "Triple Nickel" Tactical Flyer Squadron. He was shot down on May 11, 1972 and spent eleven months in captivity as a POW. As if that wasn't enough excitement for one life, between September 14–18, 1984, he set the world record for the longest solo balloon flight.

[2]In Table 1, the temperature is measured in degrees Celsius, while in the following relations it is generally measured in Kelvin.

where $R = 287$ m^2/s^2/K is the gas constant for air. Finally, the hydrostatic equation for the change in pressure with rising altitude is given by

$$\frac{dp}{dt} = -\rho g.$$

5. According to Kittinger's article, his stabilization parachute opened after 16 seconds, at a height of 96,000 feet. Explain why this is an unlikely claim.

6. Use Newton's Second Law of Motion to write down an ODE modeling Colonel Kittinger's jump, and use data from the *National Geographic* article to find values for any unknown constants that appear in your model. Solve your model in MATLAB, and create a stacked plot with Colonel Kittinger's height versus time on the upper plot and his velocity versus time on the lower plot. Plot the data points of his jump as circles. (**NOTE:** In the *National Geographic* article, the diameter of the Beaupre stabilization parachute was given as 6 ft. The actual diameter was 3 ft.)

7. According to your model, what was the maximum velocity Kittinger achieved during his jump. Compare this value with the maximum velocity given in the article.

8. According to your model, what was Kittinger's velocity when he landed. Is this reasonable?

Data

Though atmospheric temperature varies seasonally, the following data will give a model sufficient for modeling Kittinger's jump.

Height	0	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500
Temperature	15	12	9	5	2	-1	-4	-8	-11	-14	-17	-21
Height	6000	6500	7000	7500	8000	8500	9000	9500	10000	10500	11000	
Temperature	-24	-27	-30	-34	-37	-40	-43	-47	-50	-53	-56	
Height	11500	12000	12500	13000	13500	14000	14500	15000	15500	16000		
Temperature	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56		
Height	16500	17000	17500	18000	18500	19000	19500	20000	20500	21000		
Temperature	-56	-56	-56	-56	-56	-56	-56	-56	-56	-56		
Height	21500	22000	22500	23000	23500	24000	24500	25000	25500	26000		
Temperature	-56	-56	-56	-56	-56	-56	-56	-56	-55	-53		
Height	26500	27000	27500	28000	28500	29000	29500	30000	30500	31000		
Temperature	-52	-50	-49	-47	-46	-45	-43	-42	-40	-39		

Table 1: Tabulation of atmospheric temperature at heights above sea level.