Solutions to Activity 1: Height of the Green Building

1 Height of the Green Building

1.1 Newton’s Method

The height of the Green Building \((z_{top})\) using Newton’s method can be found using the basic kinematics relation (neglecting air resistance):

\[
z_{top} = \frac{1}{2} g t^2
\]

where \(t\) is the time, in seconds, that the object takes to free-fall. For example, if your measured time was 4.5 seconds, your calculated height of the Green Building should be:

\[
z_{top} = \frac{1}{2} \left(9.8 \frac{m}{s^2}\right) (4.5s)^2 = 99.2m
\]

This estimate is a little higher than the actual height of the Green Building, which may be attributed to the inaccuracies in our measurements of how long it took the objects to fall, in addition to the possibility that the objects didn’t begin with a velocity of zero (i.e. if they were thrown a bit, and not simply dropped).

1.2 Pascal’s Method

Pressure is related to the weight of air pushing down above us, so as one travels higher in the atmosphere, pressure decreases. We measured a pressure difference between the roof of the Green Building and the ground of about 10 hPa = 1000 Pa; the pressure at the top was 1006 hPa while the pressure at the bottom was 1016 hPa. If we then assume the density of the atmosphere over the height of the Green Building to be approximately constant at 1.2\(kg/m^3\), we can use the hydrostatic balance relation to measure the height:

\[
z_{top} = \frac{\Delta P}{g \rho_o} = \frac{1000Pa}{\left(9.8 \frac{m}{s^2}\right) \times 1.2kg/m^3} = 85.0m
\]

This estimate is a little lower than expected, but correct for the pressure difference that we measured. Our weather station on the roof of the Green Building is around 310 ft (94 m). The station is 3 or 4 m off the rooftop, so an approximate "actual" value for the height is around 90 m.
2 The Pressure around the Green Building

2.1 Vertical Variation of Pressure

A typical \( \frac{\Delta P}{\Delta z} \) value would be about \( \frac{10\text{ hPa}}{85\text{ m}} = 0.12\text{ hPa/m} \) for the case of the Green Building.

2.2 Horizontal Variation of Pressure

We didn’t do this measurement because the weather conditions were deteriorating, but a typical \( \frac{\Delta P}{\Delta L} \) value may be about \( \frac{0.2\text{ hPa}}{200\text{ m}} = 0.001\text{ hPa/m} \) for the case around the Green Building. The above results show that the vertical variations of pressure in the atmosphere are much greater than horizontal variations along the surface. However, the small horizontal variations of pressure along the surface are very important for determining our weather.

3 The Wind around the Green Building

3.1 The Wind at the Bottom

When we released the balloons, the ones that actually rose floated straight up until they cleared the buildings, indicating nearly calm conditions at the bottom of the Green Building. Typically, winds at the surface range from 7-20 mph in the Boston area. To see the latest weather observations and forecast for Boston (Logan Airport), visit the National Weather Service website at www.weather.gov and search "Boston, MA".

3.2 The Wind at the Top

When we released the balloons, they floated towards the Southwest, indicating a Northeast wind (wind from the Northeast). We measured winds of 10-15 mph with gusts higher with the portable weather station. With the reduced friction, wind speeds on the Green Building roof will exceed those of the surface at any given time, and wind direction will also be more uniform.

4 Cloud observations

We observed stratus and nimbostratus clouds. These mid-low level clouds covered the entire sky, giving overcast and rainy conditions.