Study of the drag forces over a falling body

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Abstract: In our project, we are willing to study how the drag forces affect a falling body. In order to do this, *we've taken the physics out of the classrooms* and we've gone to the Tibidabo Park. From the *Talaia* (a 50 m high attraction), we've thrown different objects with different shapes and masses, and we've filmed the falling to study it. After that we've compared the "real" fallings of the bodies with the "ideal" fallings (without drag forces) and we've determined that they have a great impact in the real movement.

Illustration 1: The Talaia, one of the most emblematic attractions of the Tibidabo

Introduction: When we were studying frictional forces affecting a body in movement over the floor at school (μ, *inclined planes, ...*) we asked ourselves: How do these forces work when the body in movement only finds air in its way?

Some weeks later, when we knew about the opportunity of doing an experiment in an amusement park with the help of a teacher of the UPC, we thought it was the perfect moment to study this.

Theory: We can find the position of an accelerated body by using the next identity:

$$x = x_0 + v_0 \cdot t + \frac{1}{2} a \cdot t^2$$

where x is the height, x_0 is the initial height, v_0 is the initial speed, t is the elapsed time and a is the value of the acceleration . By the other side, we have that $\sum F = m \cdot |\vec{a}|$ and $\sum F = |\vec{g}| m - b \cdot v^n$ where g is the value of the acceleration field of the Earth, *b* is a parameter which depends on the object and the properties of the fluid (in this case, air) and *n* is a coefficient that is 1 when the object is small (like the ones we throw in our experiment).

In the case that we have other forces, we have to consider them. The set of gases which forms the air produces the drag force.

Experiment description:

We went to Tibidabo park two weeks before the week of the experiment, once there we measured different size of the base of the Talaia so we could build a launcher (as we can see in the image). The purpose of the launcher was to avoid the crash of the objects with the base of the Talaia.

The group met at the high school to build some parachutes to test with different variables. We built different types of parachutes with different materials: paper and plastic.

We chose which objects we were going to launch. We let fall: balls of porexpan of different size and a teddy bear, called Tomy.


Illustration 2:The launcher at the Talaia.

The day of the experiment one member of the group couldn´t get on the top of the Talaia because someone had to record the fallings of the objects. The other members of the group, once in the top of the Talaia, used the fishing rod-launcher to let the objects fall while the other member was recording the experiment.

Results: We have measured the time of some fallings:

Object	Time (s) (± 0,5s)
Porexpan ball of 60cm diameter	4,0s
Porexpan ball of 20 cm diameter	3,5s
Porexpan ball of 10 cm diameter	5,0s
Tomy, our pet, the flying bear	5,0s

We had some problems with: the wind and bodies crashing against the attraction

We can compare this result with the speed that we would have without drag forces against the air:

$$0=50-\frac{1}{2}\cdot g\cdot t^2$$

$$g=9{,}8\,m/s^2\,;50\,is\,the\,height\,of\,the\,Talaia$$

$$\frac{100}{g}=t^2$$

$t\approx 3{,}19\,s$ As we can see, the time elapsed in most fallings was greater than this value, so we can say that drag forces greatly decrease the speed. Also while watching the videos we can see that the bodies start falling slowly and they greatly accelerate during the first second. But after the first second, they don't longer seem to get faster, so we can say that they reach their limit speed.

Conclusion: We can qualitatively see that the acceleration is slower when we take in account drag forces and that finally, the velocity stops increasing (terminal velocity). Also we've learned a lot about experimentation in real life: the problems you find while you do experiments which you have to solve at the moment, …

We had some limitations in our project that were: the level of mathematics needed was too much high for us (solve differential equations) and we didn't have enough time to test all our bodies.

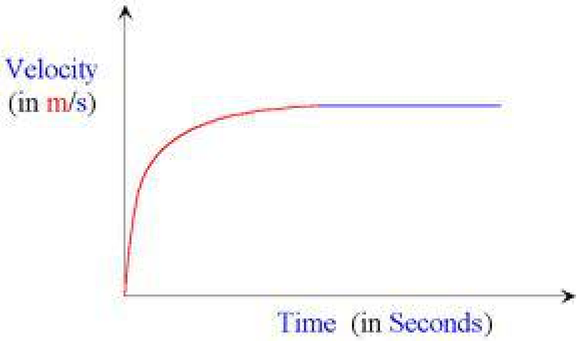

Illustration 3: Graph of the velocity of a falling body, which acquires a terminal velocity