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# A4_8 Basil and Ratigan's Critical Clash in the Clouds!

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**Abstract**

We recreate Basil's DIY balloon airship as can be seen in Walt Disney's 1986 animated mystery *Basil the Great Mouse Detective*. We determine whether or not Basil could capture the malevolent felon Professor Ratigan by calculating the speed of the balloon airship and comparing it to that of the Victorian airship *La France*. We calculated a speed of $2.45\text{ms}^{-1} \pm 0.38\text{ms}^{-1}$ which is insufficient to match the speed of *La France* ($6.00\text{ms}^{-1}$) [1]. We conclude that Ratigan is the "King of Mousedom"!

## "Basil of Baker Street!"

In Walt Disney's classic *Basil the Great Mouse Detective*, the notorious evil villain Professor Ratigan escapes the clutches of the infamous Detective Basil and his assistant Doctor Dawson on a dirigible with his peg-legged henchman Fidget. On this dirigible, Ratigan is propelled across Victorian London and chased by Basil the detective and his comrades on a DIY balloon airship. We recreate Basil's unique mode of transport and determine whether or not he could have captured the diabolical Ratigan by comparing the velocity of his ship to that of a Victorian era dirigible.

## Ratigan's Sinister Schemes...

Our airship must be able to lift Basil, Doctor Dawson and Mr Flaversham. Since they are mice, we will assume a mass of 0.020kg [2] for each mouse. It is important to consider that because of the nature of the helium fuelled balloon ship, it is sensitive to even slight variations in mass. It must also support a matchbox gondola (we assume a mass of 0.010kg) as well as the mass of the balloons themselves.

We will assume that the airship contains balloons filled with helium and that they have a spherical geometry.

## Basil's Magnificent Balloon Ship!

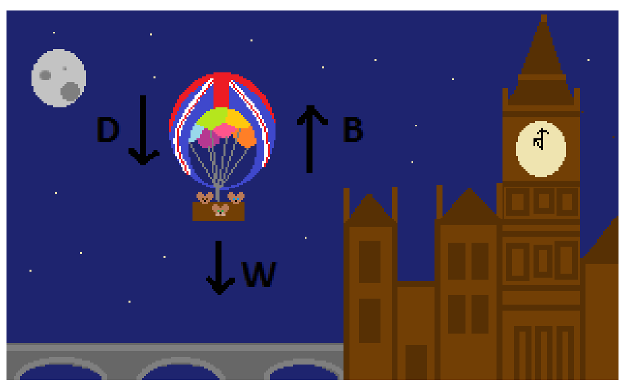


Figure 1: Forces upon Basil's balloon ship (not to scale).

Figure 1 demonstrates the forces acting upon the balloon airship during vertical ascension. We must consider the weight of the airship and passengers, the aerodynamic drag upon the airship and the upwards buoyancy force. For the airship to lift, we need positive buoyancy and hence the lift force $B$ must be greater than drag force $D$ and weight $W$ combined as given by Equation 1.

$$B > (W + D) \quad (1)$$

Equation 1 can be rewritten as Equation 2 by substituting the relevent equations in for $B$, $D$ [3] and $W$

$$\rho_{\text{air}} V g > (M + \rho_{\text{He}} V) g + \frac{1}{2} \rho_{\text{air}} C_d A v^2 \quad (2)$$

where $\rho_{\text{air}}$ and $\rho_{\text{He}}$ are the densities of air ($1.292\text{kgm}^{-3}$ [4]) and helium ($0.178\text{kgm}^{-3}$ [4]) respectively; $V$ is the volume of a sphere; $g$ is the gravitational acceleration; $M$ is the mass of the gondola and passengers; $C_d$ is the drag coefficient ($\approx 0.5$ for a sphere [5]); $A$ is the cross-sectional area and $v$ is the average velocity of the airship.

We can rearrange Equation 2 to Equation 3 so we can find the velocity of the balloon ship.

$$\sqrt{\frac{2(\rho_{\text{air}} V g - (M + \rho_{\text{He}} V) g)}{\rho_{\text{air}} C_d A}} > v \quad (3)$$

We estimate the diameter of the airship in the movie to be 6 mice $\pm$ 0.05 mice $\sim$ 60cm $\pm$ 0.5cm, assuming the body length of a mouse to be 10cm [6]. This was done by comparing the size of Basil on the airship to the size of the total number of balloons on the airship using a ruler. This error can be propogated through Equation 3 using error combination formulae to determine the error in the velocity.

Using Figure 2, we can see that the mass of an individual mouse must not exceed 0.038kg otherwise the balloon ship will not rise at all. The error in the velocity is constant since the only variable with error is the radius of the balloon. With a mouse mass of 0.020kg we find the vertical velocity of the balloon to be $2.45\text{ms}^{-1} \pm 0.38\text{ms}^{-1}$.

**Corrupt Conclusions...**

We calculated the average speed of Basil's balloon ship to be $2.45\text{ms}^{-1} \pm 0.38\text{ms}^{-1}$. The *La France* dirigible, a non-rigid airship utilised by the French Army towards the latter end of the Victorian era, flew at a speed of $\approx 6.00\text{ms}^{-1}$ [1]. We shall assume that Ratigan's dirigible flew at the same speed. It is clear by comparing the two speed values that Basil would not have captured Professor Ratigan ($6.00\text{ms}^{-1} > 2.45\text{ms}^{-1}$). Figure 2 tells us that, even if the mice were massless the balloon ship would still not have caught up. Therefore due to the failure of Basil, we declare that Ratigan is the "King of Mousedom".

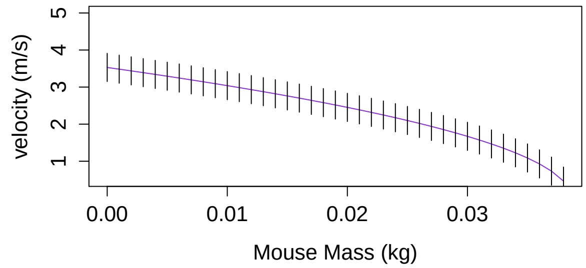


Figure 2: Velocity against mouse mass. We can see that the mass of an individual mouse cannot exceed 0.036kg.

**References**

[1] `http://www.blimpinfo.com/wp-content/uploads/2012/01/First-Fully-Controlled-Flight-of-an-Airship.pdf` accessed on [14/11/16].

[2] `http://www.informatics.jax.org/mgihome/other/mouse_facts1.shtml` accessed on [12/11/16].

[3] `http://physics.info/drag/` accessed on [12/11/16].

[4] `https://en.wikipedia.org/wiki/Lifting_gas` accessed on [30/11/16].

[5] `http://arc.id.au/CannonballDrag.html` accessed on [30/11/16].

[6] `https://en.wikipedia.org/wiki/House_mouse` accessed on [12/11/16].