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P2_2 Can Airheads Blow Minds?

T. Griffiths, D. Vasudevan, K. Herlingshaw, M. Phillips

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

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Abstract

The possibility of using helium gas inside the human head to make a person float was investigated using buoyancy and the ideal gas law. The volume of helium required to float was calculated as 63.7m^3. When compressed down to the approximate size of a human head the pressure exerted was calculated as 2.23x10^{9}Pa. Since this was enough to destroy the skull, the minimum volume that the gas could be compressed to was calculated as 0.0678m^3.

1. Floating the airhead

1.1 Theory

Helium balloons are currently used as an effective method to launch devices, such as weather-monitoring systems, into the atmosphere without requiring an engine. Helium has a density of 0.179kgm^{-3}, far lower than the density of air at 1.290kgm^{-3}[1]. As a result, helium is lighter than air and, with enough volume, can be used to lift objects. In this paper we investigate whether "airheads" could float by filling the human head with helium gas. We consider the most literal form of an airhead, modelling the head as a flexible spherical balloon filled with helium gas atop a typical human body.

A body immersed in a fluid will move with constant velocity when the upward-acting buoyant force, F_b, is equal to its weight, W, as given by Newton's second law, and will therefore rise when $F_b > W$ [2]. The buoyant force on such an object is given by

$$F_b = \rho_f g V$$

where ρ_f is the density of the fluid, g is the acceleration due to gravity and V is the volume of the body [3]. In this particular scenario the weight of the body is given by the human body itself, plus the mass of helium gas, which can be calculated as $\rho_{He}V$, where ρ_{He} is the density of helium and V is its volume, as given above. It is expected that the volume of helium required to float will be much larger than that of the human body, so we consider V solely as the volume of helium.

The net force on the airhead is given by

$$F_{net} = \rho_A g V - (\rho_{He} V + m) g$$

where ρ_A is the density of air and m is the mass of the airhead's body. The airhead will float when the net force is positive and the inequality

$$\rho_A g V > \rho_{He} g V + mg \quad (1)$$

is satisfied. This can be rearranged to give the minimum volume of helium required to lift the airhead off the ground.

1.2 Results

Using equation 1, taking the density of air and helium as above and the mass of the airhead's body as 70.8kg (the average mass of a European male [5]), the minimum volume of helium required to cause the airhead to float was calculated as 63.7m^3. This was calculated to be 2.09x10^4 times larger than a typical human head, which was determined to have a volume of 3.05x10^{-3}m^3, assuming it is a sphere of radius 0.09m.

2. Compressing the airhead

2.1 Theory

Since we deduce that the volume of helium required to float the airhead will be very large, we investigate the possibility of shrinking this volume to the size of a typical human head while no longer being required to float. This compression will result in a large pressure increase on the inside of the head. Assuming that the helium is an ideal gas, the ideal gas law can be applied, given by

$$PV = nRT \quad (2)$$

where *P* is the gas pressure, *V* is its volume, *n* is the number of moles of gas, *R* is the ideal gas constant and *T* is the gas temperature [4]. The number of moles of gas can be calculated from the fractional ratio of the mass of the gas to its molar mass. For a thermodynamic process such as this the ideal gas law can be used for the initial and final states, giving a rearranged form of

$$P_1V_1/T_1 = P_2V_1/T_2 \quad (3)$$

where P_1, V_1 and T_1 are the pressure, volume and temperature of the first state and P_2, V_2 and T_2 are the pressure, volume and temperature of the second state, respectively. Assuming that the temperature remains constant, this can be simplified further and rearranged to calculate changes in volume for a given pressure change and vice versa. We examine the effect a volume change would have on the human skull and whether it would be able to withstand the increased pressure from compressed helium gas. During this scenario, since the airhead is not required to float the change in density due to compression is not considered.

2.2 Results

This volume of helium equated to a mass of 11.4kg and hence the number of moles was calculated to be 2850mol. Substituting this into equation 2, along with the volume of helium and an assumed temperature of 288K (15^{o}C), resulted in a pressure of 1.07x10^{5}Pa. This was substituted into equation 3 as P_1, along with the volume of helium as V_1 and the volume of the human head calculated above as V_2 to give a new pressure of 2.23GPa.

The average pressure a human skull can withstand was found to be around 100MPa [6]. This means that the skull would be blown apart by the pressure of helium gas inside the head. This maximum pressure was used in equation 3 to calculate the minimum volume that the head could have before it was blown apart, which was found to be 0.0678m^3, 22.2 times larger than the size of the head calculated originally.

3. Discussion

With the required volume of helium gas it is entirely possible to make an airhead float and to compress this gas down to a reasonable size. However, these calculations rely on several unrealistic assumptions. First and foremost, it is impossible to inflate a person's head since it is not flexible and would cause severe trauma to the organs contained within. Secondly, the head and particularly the skull, is not perfectly spherical and the skull is slightly smaller than the head, so the volumes calculated for these are not completely accurate. From these limitations, it seems more feasible to suggest that this lifting be performed by some form of balloon around the head. Since the original volume of helium is completely unrealistic for a personal balloon this would have to be compressed as above.

References

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