

How many balloons are needed to lift a 40-lb child off the ground?

To solve this determine the amount of buoyant lift force for a typical helium balloon and then divide 40 pounds by this force to get the number of balloons needed. A typical amusement park helium balloon might have a lifting capacity of 10 grams (0.01 kg). So to lift a 40 pound child (18.2 kg) it would take $18.2/0.01 = 1820$ balloons. That's a lot of balloons!

A useful exercise is to perform a more involved calculation. First calculate the volume of helium inside a typical balloon, and then determine the lift force of this volume of helium based on Archimedes' principle. Next, subtract the mass of the balloon. This will give you the lift force of the balloon.

Example:

Assume the volume of a balloon is a sphere. And let's say the radius of a typical balloon is 15 cm (0.15 m). The volume of a sphere is $(4/3)\pi(0.15)^3 = 0.0141 \text{ m}^3$. The density of helium is 0.166 kg/m^3 at 20 degrees Celsius and at atmospheric pressure. The density of air is 1.2 kg/m^3 at these same conditions. By Archimedes' principle the buoyant force acting on this volume of helium is $(1.2 - 0.166) \times 0.0141 = 0.0146 \text{ kg}$. To find the lift force for the balloon subtract the mass of the balloon from 0.0146 kg. This will give you the approximate lift force of the balloon. This lift force is approximate because the shape of a balloon is not exactly spherical.

Can a lead balloon fly?

Thin lead foil is available at a thickness of $0.006" = 1.52 \times 10^{-4} \text{ m}$. Let's see if you can make a floating balloon out of this, using helium as the gas inside the balloon.

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balloon) \times (balloon wall thickness) \times (density of lead) = $4\pi(0.15)^2 \times (1.52 \times 10^{-4}) \times (11340) = 0.49$ kg. This is much greater than the buoyant lifting force provided by the helium, which is 0.0146 kg. So a normal sized lead balloon cannot float.

A helium filled lead balloon would have to be much bigger in order to float. Let's calculate how big.

Use the same equations as before but this time solve for the required radius R of the balloon.

The lift force acting on the volume of helium in the balloon is $(1.2 - 0.166) \times (4/3)\pi R^3$. The mass of the balloon is $4\pi R^2 \times (1.52 \times 10^{-4}) \times (11340)$.

The lift force of the balloon is equal to $(1.2 - 0.166) \times (4/3)\pi R^3 - 4\pi R^2 \times (1.52 \times 10^{-4}) \times (11340)$. Set this equation equal to zero to find the minimum balloon radius R . Solving for R we find that minimum $R = 5$ m. This is a big balloon!