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An inflated basketball has a mass of 0.624 kg and a radius of 0.119 m. Find the effective gravity acting on the basketball, given a density of air of $1.2\ kg/m^3$, and $g = 9.8\ m/s^2$.

Solution: To solve this we need to take into account the buoyant force acting on the basketball, and then calculate an effective gravity.

By Archimedes' principle, the buoyant force (acting in the upward direction) acting on an object immersed in a fluid is equal to the weight of the fluid displaced by the object. In this case air is a fluid.

The weight of the air displaced by the basketball is equal to $V\rho g$, where $V = \frac{4}{3}\pi(0.119)^3$ - basketball volume

$\rho = 1.2\ kg/m^3$, $g = 9.8\ m/s^2$.

air density

The force of gravity acting on the basketball is equal to 0.624×9.8.

Therefore the sum of the forces acting on the basketball is:

$$\Sigma F = -0.624 \times 9.8 + V\rho g$$

(down is negative, up is positive)

The acceleration of the basketball can be determined by Newton's second law:

$$a = \frac{\Sigma F}{m} = \frac{-0.624 \times 9.8 + V\rho g}{m}, \quad m = 0.624\ kg$$

The acceleration (a) is equal to the effective gravitational acceleration. Therefore, $g_{eff} = -9.67\ m/s^2$

This is 1.3% diffrent from $g = 9.8 m/s^2$. This is a small difference so we can neglect the effect of buoyancy in projectile motion calculations for basketball shots. In fact, the buoyancy effect is often much less than 1.3% in terms of contribution relative to gravity, since a basketball is fairly light relative to its volume because its filled with air, unlike say a solid object.

The general equation for effective gravity is given by:

$$g_{eff} = \frac{-mg + V\rho g}{m} = -g + \frac{V\rho g}{m}$$

The heavier an object is relative to air, the smaller the term $\frac{V\rho g}{m}$ becomes.

Hence, $g_{eff} \to -g$

If an object's weight is equal to that of air, for the same volume, then $V\rho = m$ and $g_{eff} = 0$, and the object just floats without moving up or down.