Buoyancy

Upward force on an object in a fluid due to the fluid is called Buoyant Force (F_B).

Archimedes Principle
↓
F_B = Weight of displaced fluid

$$F_B = F_g$$
$$= mg$$

is $\rho = \frac{m}{V}$

* $$\boxed{F_B = \rho V g}$$

Ex 1:

Determine the buoyant force on a spherical balloon of radius 0.3m that is suspended in air.

$\rho_{air} = 1.29\ kg/m^3$

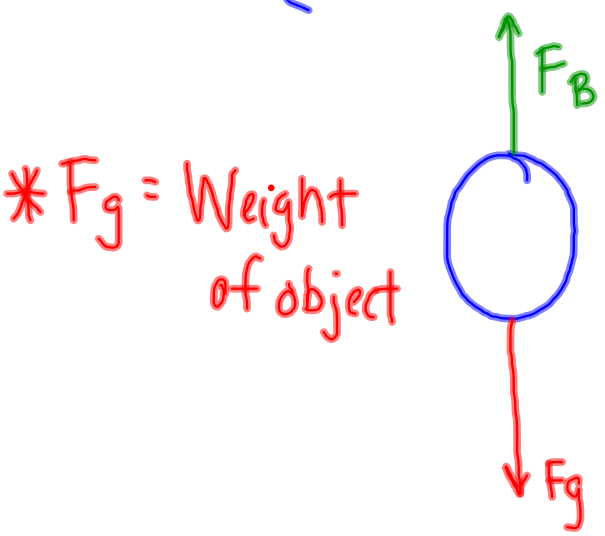
$F_B = 1.43\ N$

Ex 2:

An iron sphere of density 7860 kg/m^3 and diameter 25 cm is submerged in water. Find the buoyant force.

$F_B = 630.8$ N

Sink or Float?



* F_g = Weight of object

if $F_B > F_g$, FLOAT

if $F_B < F_g$, SINK

Ex 3:

A spherical balloon of radius .5m is filled with Helium ($\rho = 0.179\ kg/m^3$). The mass of the balloon material is 75g.

a) What is the weight of the balloon?

$$m_{balloon} = m_{material} + m_{He}$$

$$= 0.075\,kg + \rho V$$

$$= 0.075\,kg + (0.179)\left(\tfrac{4}{3}\pi(.5)^3\right)$$

$$m_{balloon} = 0.168\ kg$$

$$F_g = (0.168)(9.81) = \boxed{1.65\,N}$$

b) Find the buoyant force on the balloon.

$\rho_{air} = 1.29\ kg/m^3$

$$F_B = (1.29)\left[\tfrac{4}{3}\pi(.5)^3\right](9.81)$$

$$\boxed{F_B = 6.63\,N}$$

c) Sink or float??

$$F_g < F_B \quad \text{FLOAT!}$$

$$1.65 < 6.63$$

d) How much additional mass can this balloon handle?

$$\frac{4.98\,N}{9.81} = \boxed{0.5\ kg}$$

$$F_B = F_g$$

$$6.63 = 1.65 + x$$

$$4.98\,N = x$$

d) How much additional mass can this balloon handle?

$F_B = F_g$

$6.63 = 1.65 + x$

$4.98N = x$

$\frac{4.98N}{9.81} = \boxed{0.5\ kg}$

Ex 4:

Find the minimum radius of a He filled balloon that can lift a 60 kg person. Ignore the volume of the person.

$\rho_{He} = 0.179\ kg/m^3$

$\rho_{air} = 1.29\ kg/m^3$

use $F_g = F_B$

$F_B = \rho_{air} V g$

$F_g = F_{balloon} + F_{person}$

$= \rho V g + mg$

$\rho_{He} V g + mg = \rho_{air} V g$

$(0.179)V(9.81) + (60)(9.81) = (1.29)V(9.81)$

$V = 54\ m^3$

$\frac{588.6}{10.9} = \frac{10.9V}{10.9}$

$V = \frac{4}{3}\pi r^3$

$54 = \frac{4}{3}\pi r^3 \rightarrow \boxed{r = 2.3\ m}$

Ex 5:

An object weighs 50 N (F_g) in air. It weighs 45 N (F_{app}) when completely submerged in water.

a) Determine the mass of the object.

$$m = \frac{F}{g} = \frac{50\,N}{9.81} = 5.1\,kg$$

b) What is F_B?

$$F_B = F_g - F_{app}$$

$$F_B = 5\,N$$

c) Determine ρ of the object

$$\rho = \frac{m}{V} = \frac{5.1}{5.1 \times 10^{4}}$$

$$F_B = \rho V g$$

$$5 = (1000)V(9.81)$$

$$V = 5.1 \times 10^{-4}\,m^3$$

$$\boxed{\rho = 10{,}000\,kg/m^3}$$