

Fluids Pressure and Depth

A fluid is a substance that flows easily. Gases and liquids are fluids, although sometimes the dividing line between liquids and solids is not always clear. Because of their ability to flow, fluids can exert buoyant forces, multiply forces in a hydraulic systems, allow aircraft to fly and ships to float.

The topic that this page will explore will be pressure and depth. If a fluid is within a container then the depth of an object placed in that fluid can be measured. The deeper the object is placed in the fluid, the more pressure it experiences. This is because is the weight of the fluid above it. The more dense the fluid above it, the more pressure is exerted on the object that is submerged, due to the weight of the fluid.

The formula that gives the **P** pressure on an object submerged in a fluid is:

$$\mathbf{P = \rho \cdot g \cdot h}$$

where

- **ρ (rho)** is the density of the fluid,
- **g** is the free-fall acceleration
- **h** is the height of the fluid above the object

If the container is open to the atmosphere above, the added pressure must be included if one is to find the total pressure on an object. The total pressure is the same as absolute pressure on pressure gauges readings, while the gauge pressure is the same as the fluid pressure alone, not including atmospheric pressure.

$$\mathbf{P_{total} = P_{atmosphere} + P_{fluid}}$$

$$\mathbf{P_{total} = P_{atmosphere} + (\rho \cdot g \cdot h)}$$

A **Pascal** is the unit of pressure in the metric system. It represents 1 newton/m²

Example:

Find the pressure on a scuba diver when she is 12 meters below the surface of the ocean. Assume standard atmospheric conditions.

Solution:

The density of sea water is $1.03 \times 10^3 \text{ kg/m}^3$ and the atmospheric pressure is $1.01 \times 10^5 \text{ N/m}^2$.

$$P_{\text{fluid}} = \rho g h = (1.03 \times 10^3 \text{ kg/m}^3) (9.8 \text{ m/s}^2) (12 \text{ m}) = 1.21 \times 10^5 \text{ Newtons/m}^2$$

$$P_{\text{total}} = P_{\text{atmosphere}} + P_{\text{fluid}} = (1.01 \times 10^5) + (1.21 \times 10^5) \text{ Pa} = 2.22 \times 10^5 \text{ Pa} = 2.22 \times 10^2 \text{ kPa (kilo Pascals)}$$

Exercises :

1. What is the pressure experienced at a point on the bottom of a swimming pool 9 meters in depth? The density of water is $1.00 \times 10^3 \text{ kg/m}^3$.
2. The interior of a submarine located at a depth of 45 meters is maintained at normal atmospheric conditions. Find the total force exerted on a 20 cm by 20 cm square window. Use the density of sea water given above.
3. How many atmospheres is a depth of 100 meters of ocean water?
4. If the weight density of pure water is 62 pounds/ft³, find the weight of water in a swimming pool whose dimensions are 20 ft by 10 ft by 6 feet.
5. An airplane in level flight whose mass is 20,000 kg has a wing area of 60 m². What is the pressure difference between the upper and lower surfaces of its wing? Express your answer in atmospheres.