Porosity measurement on core sample in a laboratory normally needs to **measure pore volume and bulk volume of the core sample**. The total porosity (Absolute Porosity) can be obtained either from core samples or from well logs that could involve effective porosities. Generally, the obtained porosity values using direct methods are more accurate. Therefore, it's used to rectify and calibrate with indirect methods such as log-derived porosity data.

The following Porosity, given the symbol $\varnothing$ can be calculated using

$$Porosity = \frac{Pore\ Volume}{Bulk\ Volume} = \frac{Bulk\ Volume - Matrix\ Volume}{(\text{Grain} + \text{Pore volume})}$$

$$\emptyset = \frac{V_p}{V_b} = (V_b - V_m)/V_b$$

:

where:

V_p pore space volume,
V_m matrix (solid rock) volume, and
V_b bulk volume ($V_p + V_m$).

Bulk volume (V_b) can be calculated using below equation, cylindrical core, or by fluid displacement methods, or directly by volume displacement.

$$V_b = \pi r^2 l$$

Porosity will rely on the average form of the particles and the packed method. This sequentially will reliant on deposition method for a long time period such as solid particles of sand dumped progressively on riverbeds (clastics), or evolution and degeneration of biological materials (carbonates). Reservoir engineers are usually concerned in connected porosity (Effective Porosity), which is defined as the total volume of connected pores to total bulk rock volume. Where the hydrocarbon pore volume is defined as the total rock volume that occupied with hydrocarbon. It is known by the equation:

$$HCPV = V_b \cdot \varnothing \cdot (1 - S_{WC})$$

where:
S_{wc} is the connate water saturation.

The following are the general conventional range and view of Porosity: 0–5% Negligible, 5–10% Poor, 10–15% Fair, 15–20% Good and 20–25% Very Good. Once more, the effective porosity can be defined as the total porosity minus the fraction of the aperture filled by shale or clay. In pure clean sands, total porosity is equivalent to effective porosity (Interconnected Pores). Effective porosity can be defined also as the aperture that contains hydrocarbon and non-clay water. Therefore, the description of effective porosity is the total porosity less volume of clay-bound water.

The following shows the total porosity as a function of effective porosity for a shaly sand model:

$$\varnothing_t = \varnothing_e + V_{sh}\, x\, \varnothing_{sh}$$

$\varnothing_t$ = total porosity, fraction; $\varnothing_e$ = effective porosity, fraction; V_{sh} = volume of shale, fraction; and $\varnothing_{sh}$ =shale porosity, fraction. It's difficult to determine the shale porosity from well logs because the selection of the 100% shale unit can be incorrect. Hence, the estimated from the above equation is attained by changing shale porosity $\varnothing_{sh}$ with total porosity $\varnothing_t$:

$$\varnothing_t = \varnothing_e + V_{sh}\, x\, \varnothing_t$$

Example 1
10.10 cm Core sample long with 3.80 cm was carefully cleaned and dried. The core was saturated with 100% brine that has a specific gravity of 1.03. The saturated core weight is 385 g and dried sample weight is 355 g. Determine the porosity of the core sample.

Additional example: 9.5 cm core sample long with 2.80 cm was carefully cleaned and dried. The core was saturated with 100% brine that has density of 1.20 g/cc. The saturated core weight is 360 g and dried sample weight is 320 g. Determine the porosity of core sample.

Example 2
An oil reservoir has initial pressure is the same to its bubble point pressure of 1000 psia, and the gas oil ratio is 500 SCF/STB at reservoir temperature of 150 °F and the gravity is 35° API with gas specific gravity is 0.63. The following are additional reservoir data available:

- Effective porosity = 18%
- Reservoir area = 550 acres
- Connate water saturation = 20%
- Average thickness = 15 ft
- Formation volume factor = 1.49 bbl/STB

Determine the specific gravity of the oil
Determine the initial oil in place in STB.

the mathematical techniques used for calculating the averaging porosity:
(1) If there are vertically variants in porosity but does not show big deviations in porosity parallel to the bedding planes;

Arithmetic average $\varnothing = \Sigma \varnothing_i / n$

Or

Thickness weighted average $\varnothing = \Sigma \varnothing_i h_i / \Sigma h_i$

(2) If there is any alteration in the depositional environment, that can create significantly different porosities over the reservoir area;

Areal weighted average $\varnothing = \Sigma \varnothing_i A_i / \Sigma A_i$

Or

Volumetric weighted average $\varnothing = \Sigma \varnothing_i A_i h / \Sigma A_i h_i$

Where, n is total number of core samples, A is reservoir area, $\varnothing$ is porosity, and h is thickness of core sample.

Example 3
The reservoir has porosity variation along the three reservoir sections. The average reservoir porosity and the area for each section as follows.

Calculate the Areal weighted average porosity?

Section	Avg. Porosity (%)	Area (ft^2)
1	13	160,422,211
2	20	302,140,285
3	27	10,550,111
Total		473,112,607

$\varnothing = \Sigma \varnothing_i A_i / \Sigma A_i$

Example 4

Determine the arithmetic average porosity and thickness weighted average porosity for the below reservoir data measurements?

Core No.	Porosity (%)	Thickness (ft)
1	8	1.3
2	10	1
3	15	1.1
4	9	2
5	11	2.1
6	13	1.5

Arithmetic average $\varnothing = \Sigma \varnothing_i / n$

Thickness weighted average $\varnothing = \Sigma \varnothing_i h_i / \Sigma h_i$