# Filtration

## Filtration

- Filtration is a mechanical or physical process used to separate solids from liquids or gases by passing the mixture through a medium that allows only the fluid to pass while retaining the solid particles.

### Objectives of Filtration

1. **Clarification**: To remove suspended solids from liquids or gases, making them clear.
2. **Concentration**: To separate and collect solids from fluids, concentrating the solid particles.
3. **Purification**: To remove impurities or contaminants from liquids or gases.
4. **Product Recovery**: To recover valuable solid materials from liquid suspensions.
5. **Protection**: To protect downstream equipment from damage or contamination by solid particles.

### Applications of Filtration

1. **Water Treatment**: Removing particulate matter, pathogens, and chemical contaminants from water.
2. **Food and Beverage Industry**: Clarifying liquids such as wine, beer, and juices; removing impurities from cooking oils.
3. **Pharmaceuticals**: Sterilizing solutions by removing bacteria and other microorganisms.
4. **Chemical Processing**: Purifying chemical solutions and recovering catalysts.
5. **Environmental Engineering**: Air filtration to remove pollutants; wastewater treatment.
6. **Industrial Processes**: Oil filtration in machinery, filtration in mining operations, etc.

### Mechanism

- Filtration is the process of separating solid particles from a liquid or gas by passing the mixture through a medium (filter) that allows the fluid to pass but retains the solid particles.
- The main mechanisms of filtration include:
    1. **Surface Filtration**: Particles are retained on the surface of the filter medium.
    2. **Depth Filtration**: Particles are trapped within the filter medium.
    3. **Cake Filtration**: A layer of filtered particles (filter cake) builds up on the filter medium, enhancing filtration over time.

### Factors Influencing Filtration

1. **Particle Size and Distribution**: Larger particles are generally easier to filter, while a wide size distribution can complicate the process.
2. **Filter Medium Properties**: Pore size, surface area, and material of the filter medium affect the efficiency and type of filtration.
3. **Flow Rate**: Higher flow rates can lead to lower filtration efficiency as particles may pass through the filter medium.
4. **Viscosity of the Fluid**: Higher viscosity fluids are harder to filter.
5. **Temperature**: Temperature can affect fluid viscosity and the properties of the filter medium.
6. **Pressure Drop**: The difference in pressure across the filter medium influences the filtration rate.
7. **Solid Concentration**: Higher solid concentrations can lead to faster clogging of the filter medium.

# Theories of filtration

## 1. Poiseuille's Equation

- Poiseuille's equation describes the laminar flow of a fluid through a cylindrical pipe, often applied to describe the flow through the pores of a filter medium.

$$Q = \frac{\pi r^4 \Delta P}{8 \eta L}$$

**Where:**

- Q = flow rate
- r = radius of the pore
- ΔP = pressure drop across the filter
- η = viscosity of the fluid
- L = length of the pore

## 2. Darcy's Equation

- Darcy's equation describes the flow of a fluid through a porous medium, useful for understanding filtration through filter cakes and media.

$$Q = \frac{kA\Delta P}{\eta L}$$

**Where:**

- Q = flow rate
- k = permeability of the medium

- A = cross-sectional area
- ΔP = pressure drop across the medium
- η = viscosity of the fluid
- L = thickness of the medium

## 3. Carman-Kozeny Equation

- The Carman-Kozeny equation is an extension of Darcy's law that takes into account the characteristics of the filter cake, such as particle size and porosity.

$$\frac{\Delta P}{L} = \frac{180\eta(1-\epsilon)^2}{d_p^2\epsilon^3} \cdot v$$

**Where:**

- ΔP = pressure drop
- L = thickness of the filter cake
- η = viscosity of the fluid
- ϵ = porosity of the cake
- $d_p$ = diameter of the particles
- v = superficial velocity of the fluid

# Filter aids & filter medias

## Filter Aids

### Definition:

- Filter aids are inert, porous materials added to fluids or used as a precoat on filters to enhance filtration.
- They prevent clogging, improve flow rate, and enhance filtrate clarity.

### Common Types:

1. **Diatomaceous Earth** – Fossil-based, highly porous, used for fine filtration.
2. **Perlite** – Expanded volcanic glass, lightweight and inert.
3. **Cellulose** – Fibrous, supports cake structure, often blended with other aids.
4. **Activated Carbon** – Adsorbs dissolved impurities, used for decolorization and odor removal.

## Filter Media

### Definition:

- The filter medium is the barrier through which the fluid passes, retaining solids and allowing liquid or gas to flow through.

### Types of Filter Media:

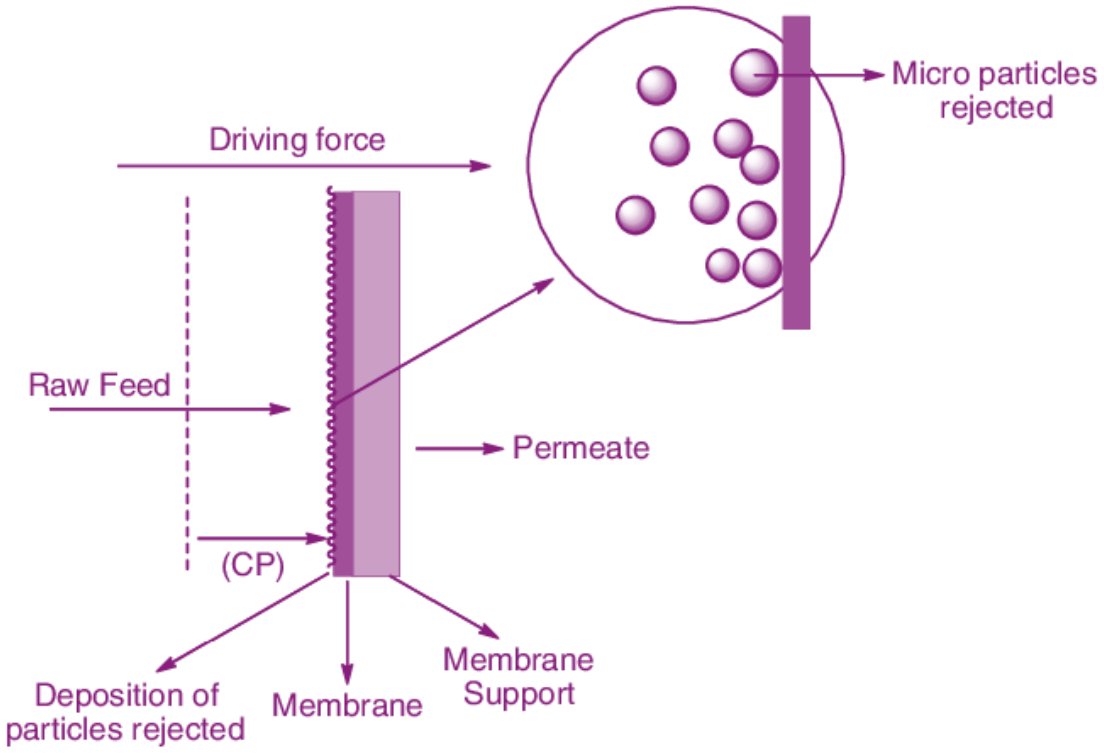
1. **Cloth Filters** – Woven fabric (cotton, nylon); used in bulk and industrial processes.
2. **Paper Filters** – Cellulose-based, disposable, used in labs and simple filtrations.
3. **Membrane Filters** – Precise pore sizes (micro to nano), used for sterile and fine filtration.
4. **Sand Filters** – Graded layers of sand; used in water treatment.
5. **Ceramic Filters** – Chemically and thermally resistant; used in hot or corrosive environments.
6. **Metal Filters** – Woven or sintered metal; reusable in high-pressure and high-temperature systems.

## Membrane Filters

### Principle

- Membrane filters operate on the principle of selective permeability, allowing certain molecules or particles to pass through while retaining others.
- They use a thin, semi-permeable membrane for filtration.

### Construction




1. **Membrane**: Made from materials like cellulose acetate, polyamide, or polysulfone.

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