### Terms and Interpretations

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
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<tbody>
<tr>
<td>( \theta_{\text{pwp}} )</td>
<td>Permanent wilting point water content</td>
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<tr>
<td>( \theta_{\text{fc}} )</td>
<td>Field capacity water content</td>
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<tr>
<td>( \phi )</td>
<td>Porosity</td>
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<tr>
<td>( \psi_{\text{ae}} )</td>
<td>Pressure at which air enters the system (top of the capillary fringe)</td>
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<tr>
<td>( p_0 )</td>
<td>Atmospheric pressure; underground, the definition of water table</td>
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<tr>
<td>( \theta = \phi )</td>
<td>Saturation point</td>
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Unsaturated Flow: Movement of Soil Moisture

Water molecules attract each other so that at the surface there is a net downward pull on the molecule. The net effect is **surface tension**.

\[ \gamma = 72.7 \text{ dyn/cm for water and air [F/L]} \]
\[ \gamma = 29 \text{ dyn/cm for benzene} \]
\[ \gamma = 430 \text{ dyn/cm for mercury} \]

Energy/L² – the energy required to increase the area. Unlike a membrane, the surface tension doesn’t change with expansion.

Surface tension depends on:

- The substances
- Any solutes
- Temperature
- Gas Pressure
Consider a bubble of air in water:

\[ \Delta P = 2\gamma/R \]

Blowing air into the bubble decreases the pressure.

\[ \gamma_{SL} = \gamma_{GS} + \gamma_{LS} \cos(\alpha) \]

\[ \cos(\alpha) = \frac{\gamma_{SL} - \gamma_{GS}}{\gamma_{LS}} \]

GS = gas-solid
SL = solid-liquid
LG = liquid-gas
Capillary Rise

\[ \Delta P = \frac{2 \gamma \cos(\alpha)}{r} \]

When the height of the meniscus is at steady-state, then the hydrostatic tension must balance the effect of surface tension.

\[ h \rho g = \frac{2 \gamma \cos(\alpha)}{r} \]

Retention Curves or Soil Moisture Characteristic Curves

A bundle of capillaries (hydrophyllic) all of the same length with pressure adjusted at the bottom. The bundle contains a range of radii. Measure average water content as the suction is gradually increased at the bottom. Plot suction versus water content.
Pore space in rocks and soil is much more complex geometrically but analogous phenomena give rise to characteristic retention curves for a given sample material.

The shape of the retention curve for a given porous material is influenced by:

1. Texture and Structure
   a. Particle-size distribution
   b. Pore-size distribution
   c. Particle shape
   d. Specific surface

2. History of wetting and drying – Hysteresis
   a. Non-wetting phase entrapment
   b. Swelling and shrinking
   c. Ink-bottle effect – Haines Jump