Soil Water Energy

The movement of soil water is due to two forces:

Gravity

Capillarity

Gravity moves water downward

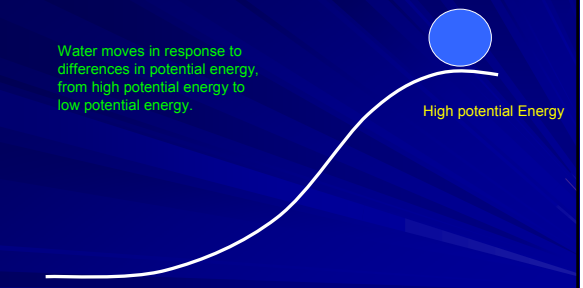
Capillarity moves water in all directions.

Potential Energy

Energy waiting to be used or exploited

Gravitational Potential Energy

Water moves in response to differences in potential energy, from high potential energy to low potential energy.



Gravitational Potential Ψ_g

The potential energy of a unit quantity of water.

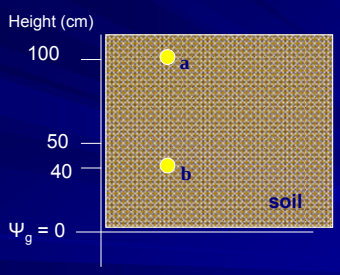
Unit quantities: volume
mass
weight
= mg

$$\Psi_g = mgh$$

$$\frac{\Psi_g}{mg} = h \text{ (cm)}$$

The greater the height, the greater the potential energy.

Gravitational Potential



Independent of soil properties

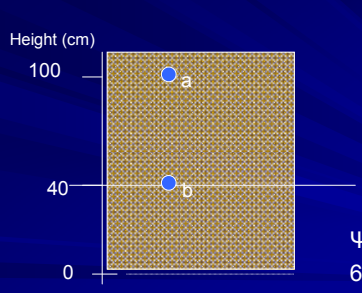
P_{ga} = 100 cm

P_{gb} = 40 cm

Reference level

Difference in energy determines movement

Gravitational Potential



Ψ_{ga} = 60 cm

Ψ_{gb} = 0 cm

Reference level (Ψ_g = 0)

$\Psi_{ga} - \Psi_{gb}$

60 - 0 = 60 cm

Gravitational Potential

1. Gravitational potential energy is due only to the height of an object (water) above some reference point.
2. Gravitational potential energy is independent of soil properties.

Capillary Potential Energy

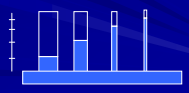
(Matric Potential Energy)

Matric Potential

"suction" potential - capillarity

Narrow capillary tube – high capillary rise $h = \frac{0.15}{r}$
- strong force
- compared to free water

Small particles, small pores



Applies to **unsaturated** soils

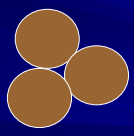
Primary Factors in Matric Potential

Texture, Density → Pore Size Distribution

Moisture Content → Which Pores are Filled

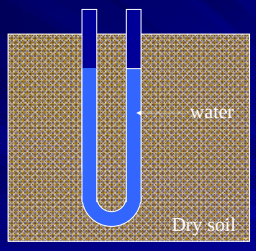
Capillarity and Soil Texture

Small pores
Strong suction
Strong capillarity



Large pores
Weak suction
Weak capillarity

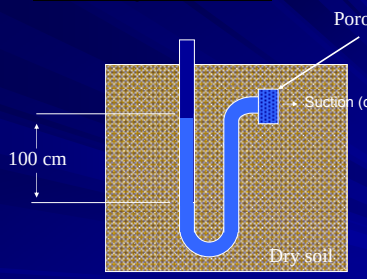
Capillary Potential Energy



Suction potential energy

Matric potential energy

Capillary Potential

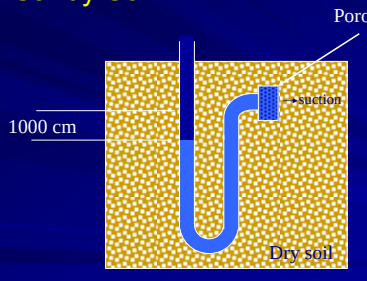


Ψm = -100 cm
(suction)

Vertical distance between the surface of the water and the porous cup.

Soil Texture

Sandy Soil

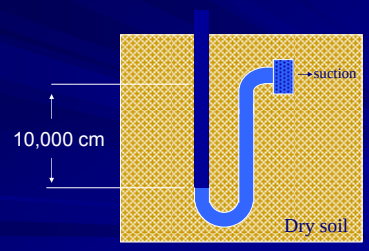


ψ_m = -1000cm
(suction)

Vertical distance between the surface of the water and the porous cup.

Soil Texture

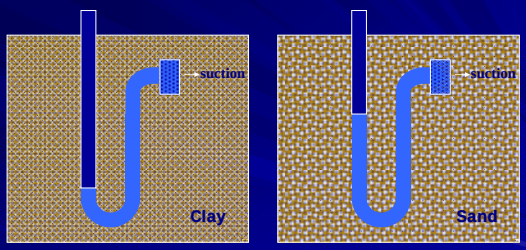
Fine-textured soil



Ψ_m = -10,000 cm
(suction)

Vertical distance between the surface of the water and the porous cup.

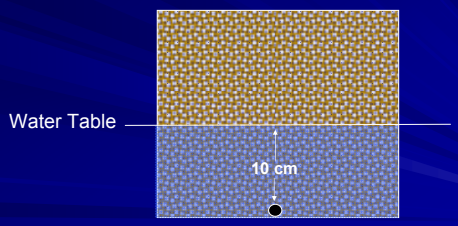
Soil Texture



Submergence Potential

Submergence Potential (ψ_s)

Equal to the distance below a free water surface



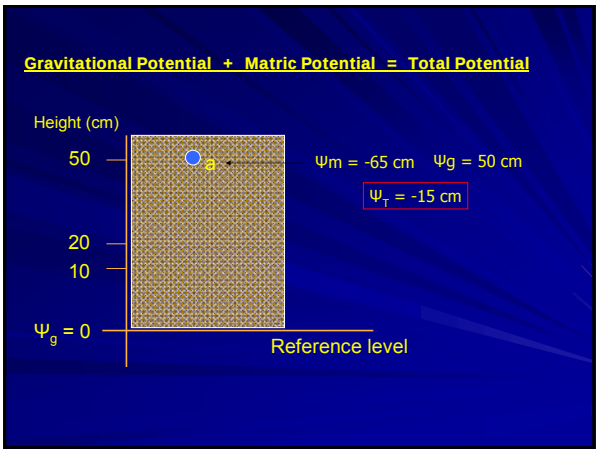
Units of Potential

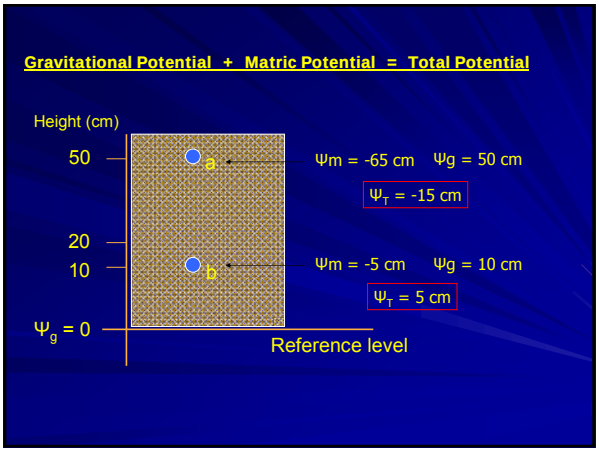
Centimeters of water
Bars
Pascals

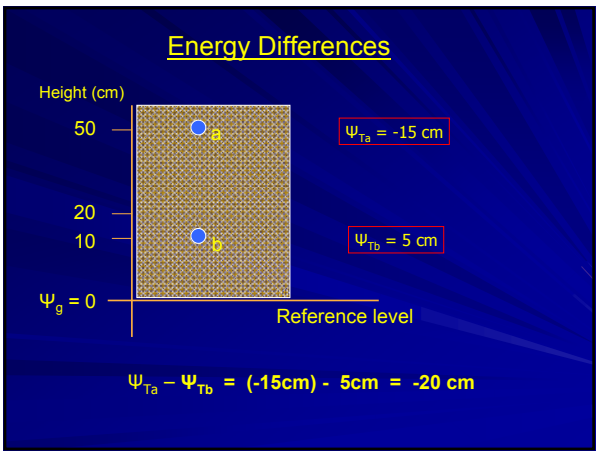
1 bar = 1020 cm water (4°C)
1 KPa = 10 cm water
1 bar = 100 kPa

Total Potential Energy is the sum of the gravitational, submergence, and matric potential energies.

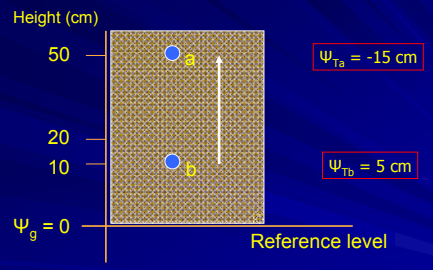
$$\Psi_g + \psi_m + \psi_s = \psi_T$$


Gravitational Potential + Matric Potential = Total Potential
Height (cm)
50
20
10
Ψg = 0
a
Ψm = -65 cm Ψg = 50 cm
ΨT = -15 cm
Reference level


Gravitational Potential + Matric Potential = Total Potential
Height (cm)
50
20
10
Ψg = 0
a
Ψm = -65 cm Ψg = 50 cm
ΨT = -15 cm
b
Ψm = -5 cm Ψg = 10 cm
ΨT = 5 cm
Reference level


Energy Differences
Height (cm)
50
20
10
Ψg = 0
a
ΨTa = -15 cm
b
ΨTb = 5 cm
Reference level
ΨTa – ΨTb = (-15cm) - 5cm = -20 cm

Which way will water move?



$\Psi_{Ta} - \Psi_{Tb}$ = (-15cm) - 5cm = -20 cm

Determining the Direction of Water Flow

1. Sum the individual potentials at each point
2. Determine if there is a difference in potential
3. Point A – Point B
4. Water moves from high to low energy
   (look for the higher energy)

Positive → Point **A** to Point **B**

Negative → Point **B** to Point **A**