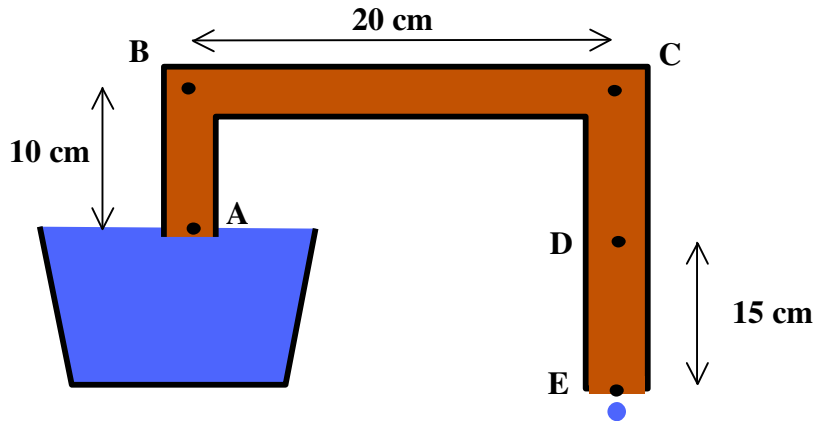


## Soil Water Potential (II): The Soil Water Characteristic Curve (or Water Retention Curve)

First, a review of what we've done so far in the form of a worked problem. Suppose we have the following:



What are the total, gravitation, and matrix potentials at points A-E?

Step 0) Make a table

Step 1) Choose a gravitational reference point (if one is not supplied), and fill in the gravitational potential column, points A – E.

Step 2) If the system is at equilibrium, you know the total potential is the same everywhere. If the system is not at equilibrium, do steps 3-5.

Step 3) Identify the pressure potential at points A and E, and write these in.

Step 4) From  $g$  and  $P$  components of potential at points A and E, calculate the Total potential.

Step 5) Darcy's law assures us that, for a uniform soil under steady-state, saturated flow, the drop in total potential is linear. Given this, calculate the total potential at points B, C, and D. **Attention:** this linear gradient only applies to the *soil*! If some of the tube is just filled with water, assume equilibrium within the water-only parts. We'll see why in a few classes.

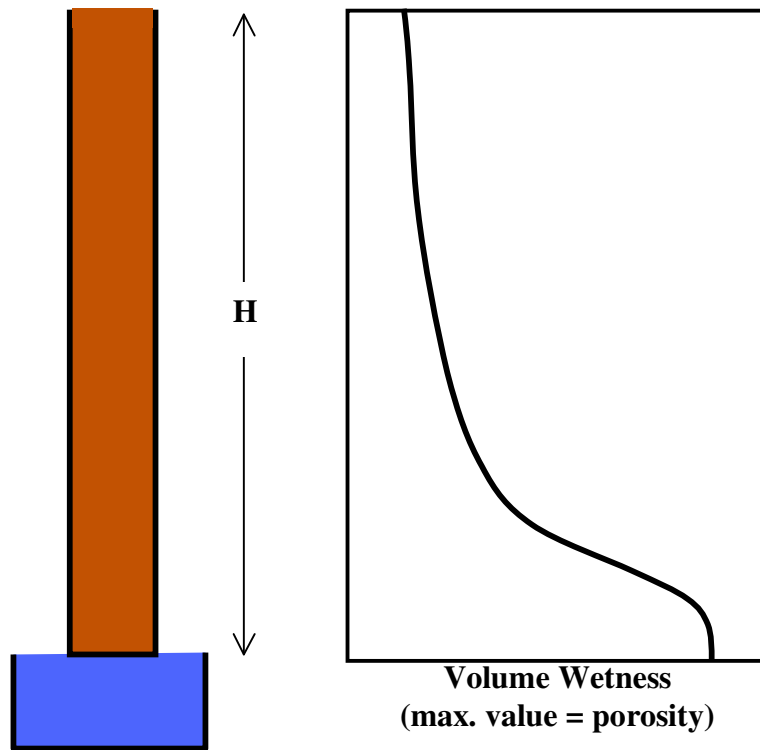
Step 6) From the  $T$  and  $g$  components of potential at points B – D, calculate the matric potential.

You should have a table like this (all data in cm):

Point:	Total potential =	Gravitation potential +	Matric potential
A	0	0	0
B	-2.72	10	-12.72
C	-8.18	10	-18.18
D	-10.91	0	-10.91
E	-15	-15	0

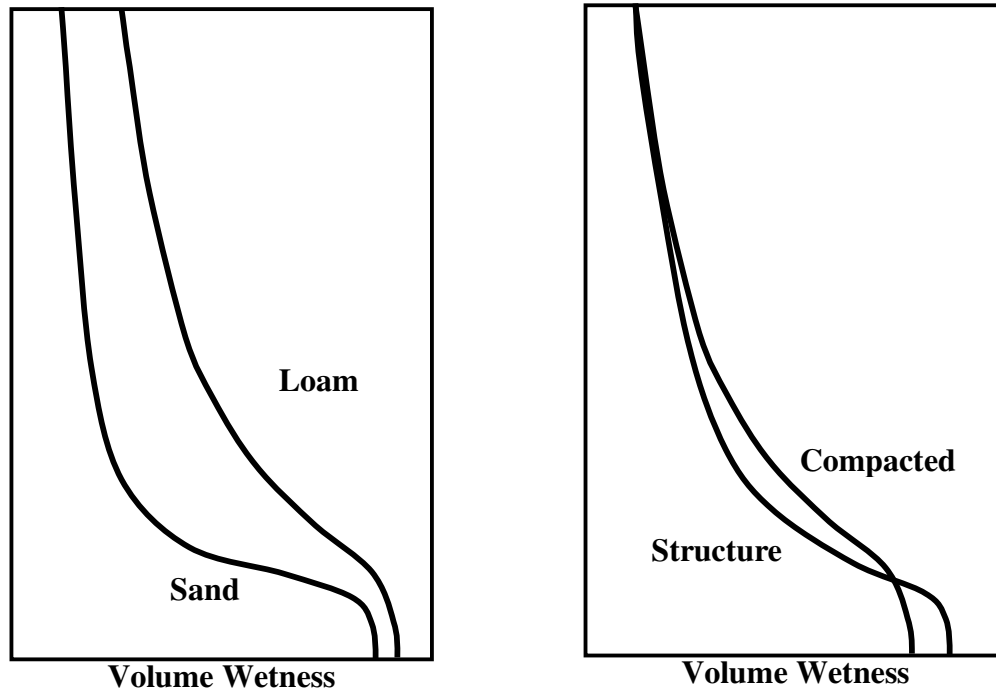
What would happen if I made a hole in the top of the tube between points B and C? The matric potential is negative there, so air would move in and displace the water. The flow rate would decrease. Why? Consider Darcy's law:  $q = -K (dP / dL)$ . The total gradient across the whole column stays the same. But some of the formerly water-filled pores are now air-filled, so they don't carry water any more. The system as a whole will conduct less, so  $K$  and  $q$  will decrease. In response, the gradient will no longer be linear: more will be needed around C, where the lowest  $K$  will be, and so less will be available at the two ends. The entire system will respond to air.

Now suppose we turn the tube so that it stands straight up, make it (say) 10 m tall, and wait for the system to come to equilibrium. Now we use our gamma-ray device to measure volume wetness along the whole tube, and plot it. We get this:



This function, the relationship between volume wetness and total potential, is variously called the theta-psi curve, the soil water characteristic, the soil water characteristic curve, the water retention curve, the water release curve, and several others.

The soil water characteristic is related to both texture and structure:



What does the shape mean? In practice, the curve is generated by saturating a soil core, then measuring either its water content or the amount of water it loses, as you decrease its potential (how we do that is for the next lecture). So the amount of water lost within a given potential drop relates to the volume of pores that will drain at that potential.

It is only a small leap (for a physicist) to suppose that we could use the information in the water characteristic curve to construct a pore size distribution for the soil! Pretend the soil is made up of capillary tubes, and for each potential we can calculate the equivalent radius via the capillary equation (which you should know by now!) ... in fact, we could even calculate the saturated hydraulic conductivity from this population of capillary tubes, using Poiseuille's law (which you also should know)! ... But it turns out that this approach doesn't work very well – neither the calculation of hydraulic conductivity, nor even the calculation of the pore size distribution. Why?

1) the soil isn't really a bunch of capillary tubes, and non-circular pores act differently for capillarity than for conductivity. Recall that for flow, the effective  $R$  for a non-circular tube is approximated as cross-sectional area / wetted perimeter, but for capillary rise the relevant  $R$  is the harmonic mean ( $\text{capillary pressure} = \gamma * (1/R_1 + 1/R_2)$ ) – so non-circular pores will deviate from the expectation.

2) The capillary equation implies that all the water in a pore is held by capillary forces, but at the dry end most of the water is actually sorbed, in thin films and pendular structures (capillary wedges). So this water is not held in an "equivalent" pore size, and the translation from SWC to pore size distribution doesn't apply.

3) The phenomenon of hysteresis (see next class) means that there is a non-unique relationship between potential and wetness. The actual wetness seen at a given potential

depends on how the system arrived at that potential. But it isn't clear which SWC curve we should use – draining or wetting – nor how Poiseuille would handle the difference between them.