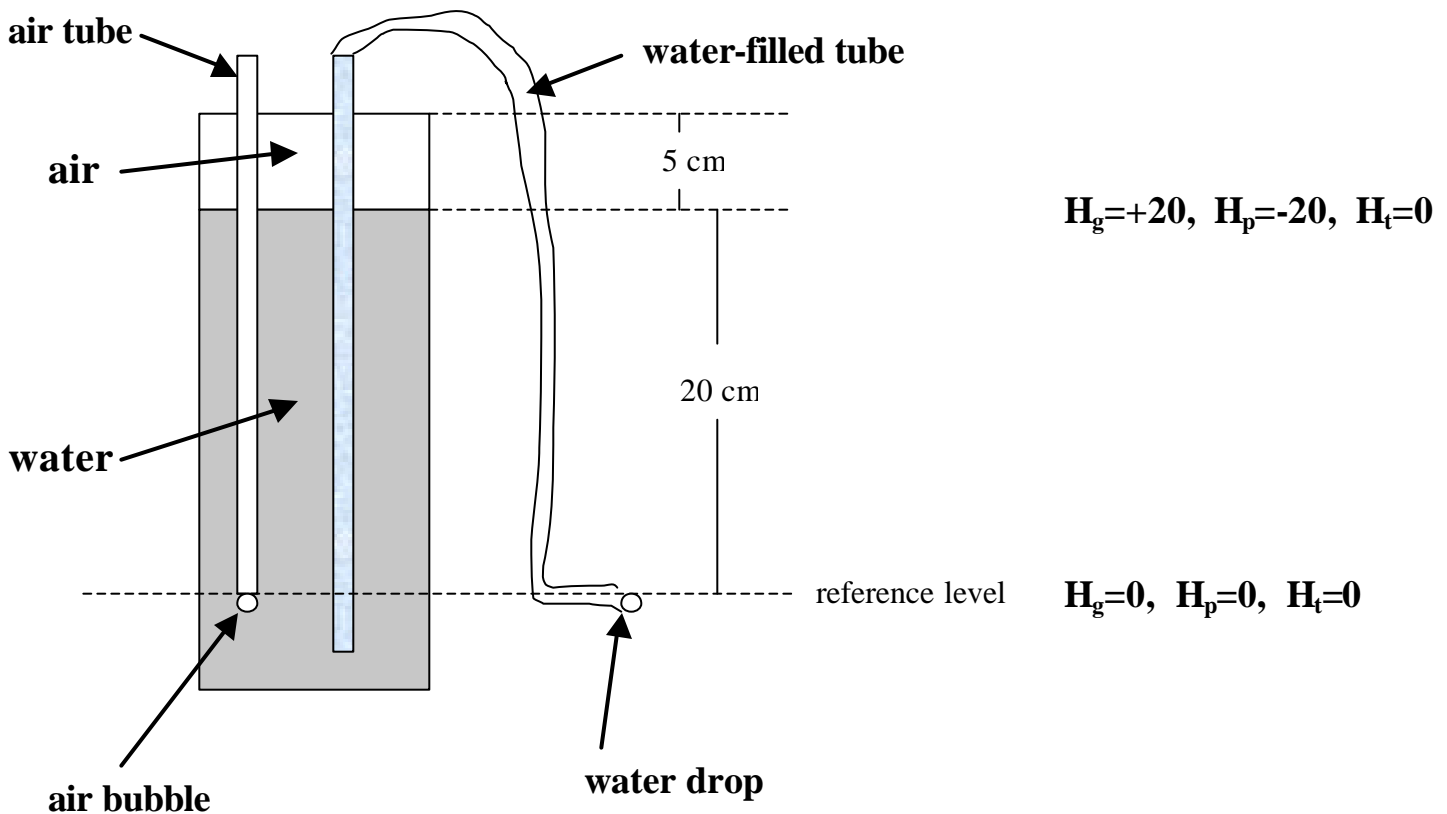


How a Mariotte bottle (constant head device) works



Principles of how device works using gravity, pressure, and total heads at 2 locations within the bottle:

1. H_g is gravity head, H_p is pressure head, and H_t is total head.
2. Lets start by adjusting the water-filled outflow tube so that a water drop is just about to drip from the tubing but just hangs on the end. There will also be an air bubble at the end of the air tube.
3. For these conditions, the whole system is considered to be in hydraulic equilibrium, meaning that there is no water flow.
4. When a system is at hydraulic equilibrium, the total head (sum of the gravity head and the pressure head) must be exactly equal everywhere in the system.
5. Let us calculate the gravity, pressure, and total heads at 2 places in the bottle: at the bottom of the air tube and at the interface between the water and the air.
6. For the heads at the bottom of the air tube, we define that level as the reference level for gravity so the gravity head is equal to zero. Since at that level the water drop at the end of the tubing is in equilibrium with the atmosphere, the pressure head is also zero. Thus, the total head (sum of H_g and H_p) must also be equal to zero. Since the system is at equilibrium, the total head is everywhere zero.
7. Next, lets go to the interface between the water and air in the bottle. The gravity head is +20 cm because the interface is 20 cm above the reference level. At the beginning,

you may not know the value of the pressure head there. However, you know that the total head must be equal to zero. Thus, you can calculate the value of the pressure head at the air/water interface.

$$H_t = H_g + H_p \quad \text{or} \quad H_p = H_t - H_g$$
$$H_p = 0 - 20 = -20 \text{ cm}$$

Thus, you can see that the pressure at the interface and thus in the air space is a negative pressure or a vacuum. The negative pressure is exactly equal to the height of the water in the bottle above the level of the air tube.

8. If you lower the level of the water-filled outlet tube to a new level, the system is no longer at equilibrium and water will begin to flow because there is now a total gradient. The head difference is the distance from the bottom of the air tube to the outlet of the water-filled outlet tube. However, the head will always remain the same as the water level in the bottle drops.
9. What would be the vacuum in the air space if the water level drops down to 10 cm above the bottom of the air tube?
10. This same approach of looking at pressure, gravity, and total heads can be applied to water flow in soils.