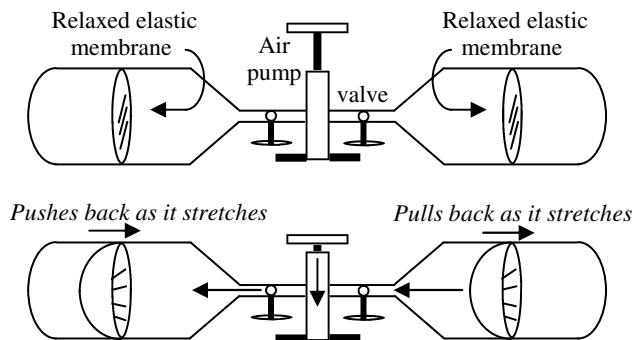
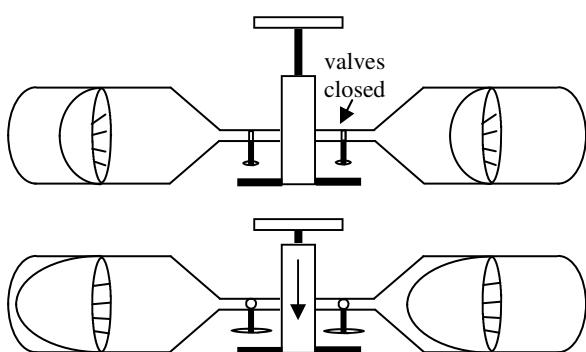


# PreAP Electrostatics 13

Imagine an air pump connected to two air tanks, one on each side. Each air tank has an elastic membrane (like a balloon) inside of it. The entire system is sealed. The air pump can supply a maximum of 2 atmospheres of pressure and can only push to the left.



The valves are then closed so that no air moves in or out of either tank and a larger pump is placed in the system. The new pump can supply 6 atm (atmospheres) of pressure.



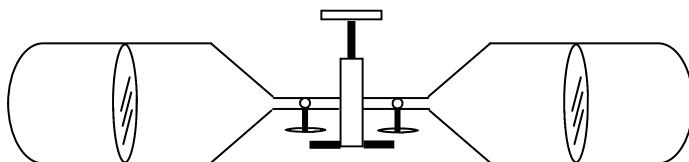
We could keep replacing the pump with stronger and stronger pumps and get more and more air moved, but the size of the tank keeps constant. Eventually we could rupture the tank with too much pressure.

While the tanks are pressurized, we have potential energy. We could connect to something like a windmill and use this as mechanical energy. But for now we will discharge the tanks back to neutral by connecting them to each other with a pipe.

10. Describe what happens and draw the direction of the air flow.

11. How does the flow of air coming from the tank differ from that of the pump (especially over time)?

Instead of a bigger pump, though, there is another way to store more air: bigger tanks, with more air capacity. We have changed the physical characteristics of the tanks. Also, let's put back our original, smaller pump.



12. What will be the final back pressure of the tanks when it stops filling?
13. Will the total amount of stored air in the left tank be greater, less than, or equal than with the smaller tanks?

So, with greater capacity (larger tanks) you can store more air with the same pump pressure.

14. If the left tank increased by 3 liters of air, what is the change of air in the right tank?
15. What is the net change of air for the entire system?
16. If we again switch to the larger pump, will the capacity of the tanks increase?
17. If we switched to the larger pump, will the amount of air moved to the left tank increase?

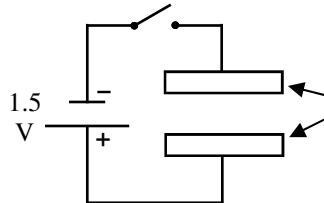
1. right to left
3. zero—pump hasn't pushed yet.
4. Zero—it is moved to the left, but same air.
5. 2 atm, same as max pressure of pump.

6. new pump can push harder (6 atm)
7. NO—tanks are the same size.
8. More pressure = more air moved.
9. when it equals 6 atm (the pump's maximum pressure)

11. pump's air is constant. Tank's air will decrease over time.

12. 2 atm
13. greater, bigger tanks.
14. -3 liter
15. 3-3 = 0 total
16. No, the pump doesn't change the tank
17. Yes, of course.

If you haven't already realized it, the pump represents the battery and the tanks represent a capacitor. Electrical capacitors work very similarly in many aspects. Obviously, it is not air that is moving.



18. What does move in an electrical circuit?

*Instead of tanks, the simplest capacitors have two metal plates.*

19. What is the charge of each plate before the switch is closed?

20. Do electrons flow out of the positive or out of the negative side of the battery?

21. So, label with -'s the side of the capacitor that becomes negative.

22. Just as in the tanks, where do these electrons come from?

23. Objects that lose electrons become:

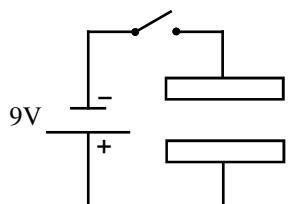
24. Label the other plate with +'s.

25. Just like with the tanks, when will the capacitor stop charging?

26. What will be the final voltage across the capacitor plates?

27. Let's pretend that the charge on the negative plate ( $Q_{\text{neg}} = -3\text{C}$ ). What is the charge on the positive plate?

28. What is the net charge of the capacitor?



*Then the battery is replaced with a larger battery.*

29. Has the capacitance of the capacitor increase?

30. What will happen to the amount of charge ( $Q$ ) on the plates?

31. When will the capacitor stop charging?

32. What will be the net charge of the capacitor?

33. How would you discharge the capacitor?

34. What happens when the capacitor is discharged?

35. Thinking back to the tanks, how could you increase the capacitance of the capacitor?

18. Electrons, silly!

19. neutral

20. Out of neg side.

21. Put -'s on the top plate

22. The other plate

23. Positive

24. +'s on lower plate

25. When = V battery

26. 1.5 V

27. +3C

28. 0 C (neutral)  
[always]

29. No, plates are still  
the same size  
(\*see below)

30. Will increase again

31. When it reaches 9V

32. Neutral, always.

33. Connect two plates  
with a wire.

34. Electrons flow  
back to the + plate.

35. Make the plates  
larger

\* - Note: Putting a bigger battery across a resistor doesn't change that resistor, it just forces more current thru the resistor. The only way to change its resistance is to change the resistor with a different one with different physical characteristics. A capacitor works the same way: it is just a device in a circuit. Putting a bigger battery onto a capacitor doesn't change the capacitor, it just force more charge from one plate to the other. To change the capacitance you have to replace the capacitor with a different one that has different physical characteristics: bigger plates (larger tanks) or closer plates.