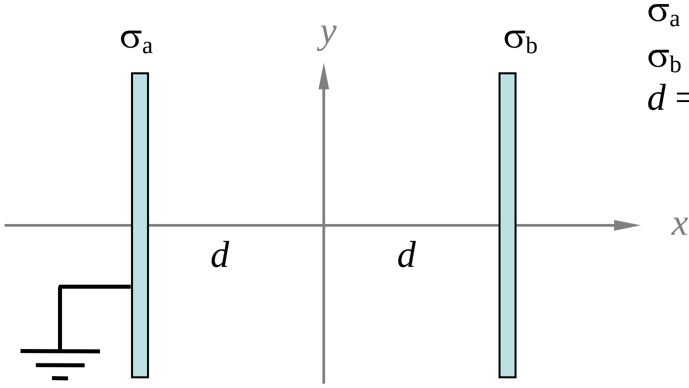
Discussion Question 4D

P212, Week 4

Superposition and Conductors

As we saw in the last problem, **superposition** is an extremely useful tool in potential problems. However, we have to be very careful with superposition when **conductors** are around … let's explore this!

Two thin plates of infinite area and made of insulating material are on either side of the origin and a distance d =±5 cm away from it. They carry uniformly-distributed surface charges with the values given below. In this problem, we will be concerned with the electric potential difference between the two plates. For convenience, we'll use the left-hand plate as our reference and set the electric potential to zero there. (This is indicated by the ground symbol in the figure.)



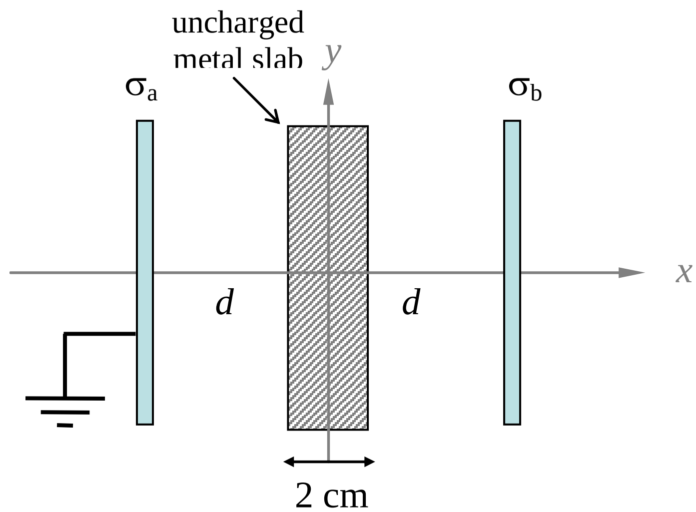
σ_a = -4 C/m^2
σ_b = +2 C/m^2
d = 5 cm

(a) What is the electric potential V_b of the right-hand plate?

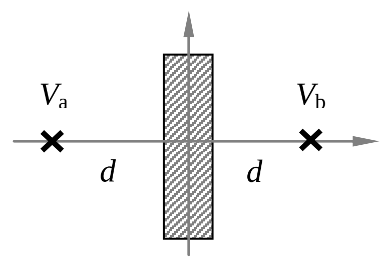
(b) Now suppose a positive point charge Q = +5 C is placed at the location (x,y) = (-5 cm, +2 cm). What is the electric potential difference ΔV between the points (x,y) = $(d,0)$ and $(-d,0)$ on the x axis? (Remember, **superposition** …)

Now get rid of the point charge. Instead, suppose that an uncharged metal slab of thickness 2 cm is placed parallel to the two plates and centered on the origin.

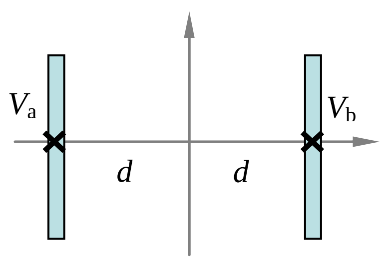
Does superposition still work?
YES … we just have to be a bit careful.



(c) If we considered the uncharged metal slab *all on its own, in isolation*, what potential difference $V_b - V_a$ would it cause between the two plates?



(d) If we considered the charged insulating sheets *all on their own, in isolation*, what potential difference $V_b - V_a$ would they cause between the two plates?



Pure superposition would suggest that adding these two contributions together gives the correct net result. But not quite …

(e) Calculate the *full* potential difference $V_b - V_a$ between the plates: find the electric field everywhere between the plates, and integrate it to find $V_b - V_a$.

(f) Can you explain why adding the results of (c) and (d) together did not work?