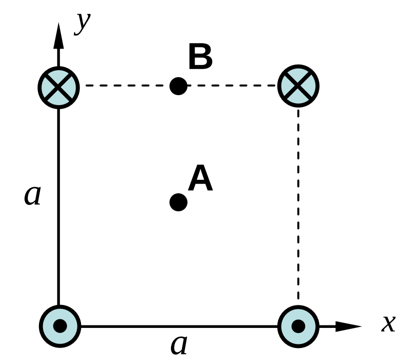
Discussion Question 8B
P212, Week 8
The Magnetic Field due to Current Loops and Infinite Wires

In lecture 14, the B field of an **infinite straight wire** was presented: $B = \dfrac{\mu_0 I}{2\pi r} = \dfrac{2\times10^{-7} I}{r}$. The derivation of this formula from the Biot-Savart law is given in Appendix A of the lecture notes. We won't go through it here, since you will soon learn a *much* easier way to obtain the same result (Ampere's Law!). Instead, let's just use the formula, and our knowledge of the *direction* of the magnetic field around a wire.



a = 15 cm
I = 2.5 A

Four long parallel wires are located at the corners of a square of side a. Each wire carries a current I. The top two currents are directed into the page, and the bottom two out of the page.

(a) Calculate the <u>force per unit length</u> exerted on the wire in the top-right corner by the field of the other three. Remember to give both the magnitude and direction of this force.

One approach is to find the magnetic forces on the top-right corner due to the other three corners and add these three forces by components.

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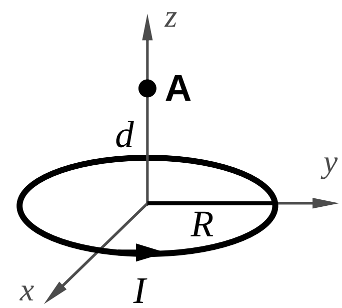
(b) Calculate the magnetic-field vector *B* at the center of the square (point A). The key is **<u>superposition</u>**, which works for **both** E and B fields.

A circular wire loop of radius R carries a current I circulating in the counterclockwise direction. The loop lies in the xy plane, and is centered on the origin. We are interested in the magnetic field at a point **A** located on the z axis a distance d above the xy plane.



(c) What is the magnetic field *B* at the point A?

(i) The only way to solve this is with the Biot-Savart law, in all its integral glory. We will have to integrate all the contributions $d\boldsymbol{B}$ to the field from each little current segment dI in the wire loop. As our first step, what is the *direction* of the total $\boldsymbol{B}$ field at point **A**?

(ii) From step (i), we realized that only *one component* will contribute to the final magnetic field. Good ... now write down an expression for this component of $d\boldsymbol{B}$, using the Biot-Savart law.

(iii) Finally, do the integral. To accomplish this, rewrite your integrand $d\boldsymbol{B}$ so that it depends on only one integration variable.