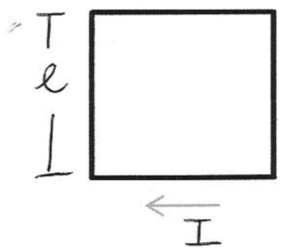
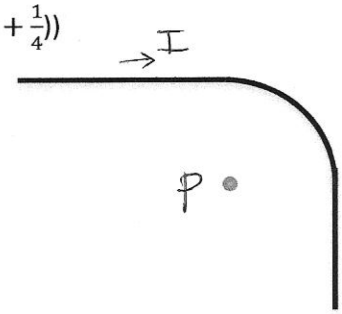
Homework Set 7 – Sources of the Magnetic Field

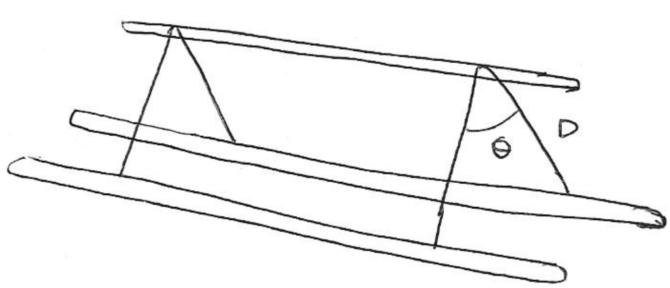
1. A square conducting loop has side a and carries clockwise current I as shown in the diagram. Calculate the magnitude and direction of the magnetic field at the center of the square. If the conductor is reshaped into a circle, what is the value of the magnetic field at the center? (Answers: for the square I get $B = \frac{2\sqrt{2}\mu_o I}{\pi l}$ into the page, for the circle $B = \frac{\mu_o I \pi}{4l}$)



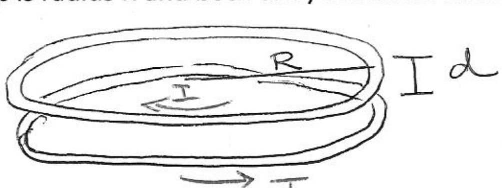
2. A long, straight wire carries a current I. A right-angle bend is made in the middle of the wire. The bend forms an arc of a circle of radius r as shown. Determine the magnetic field at point P, the center of the arc. (Answer $B = \frac{\mu_o I}{2r}(\frac{1}{\pi} + \frac{1}{4})$)



3. Two long parallel wires , each with a mass per unit length of λ are supported in a horizontal plane by strings of length D as shown in the diagram. When both wires carry the same current I, the wires repel each other so that the angle between the supporting strings is θ. Are the currents in the same or opposite directions? Find the magnitude of the current. *Answer* $I' = \sqrt{\frac{2\pi\lambda g a^2}{\mu_o \sqrt{D^2-a^2}}}$



4. Two circular loops are parallel, coaxial and almost in contact, with their centers a small distance d apart as shown. Each loop is radius R and both carry the same current, but in opposite directions as

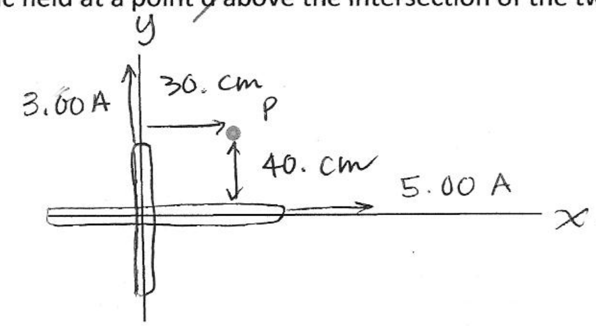


shown. Calculate the magnetic force exerted by the bottom loop on the top loop. If the upper loop has a mass m, calculate its acceleration. (Ans: $F_B = \frac{\mu_0 I^2 R}{d}$; $a = \frac{\mu_0 I^2 R - gd}{md}$)

5. Two long, straight wires cross each other perpendicularly as shown. The wires do not touch. Find the magnetic field magnitude and direction at the field point P which is in the same plane as the two wires. Find the magnetic field at a point ~~d~~ 30 cm above the intersection of the two wires. (a) $0.500\ \mu T$

(b) out of the page

(c) $3.89\ \mu T$ // to xy plane and @ 59° clockwise from the positive x direction

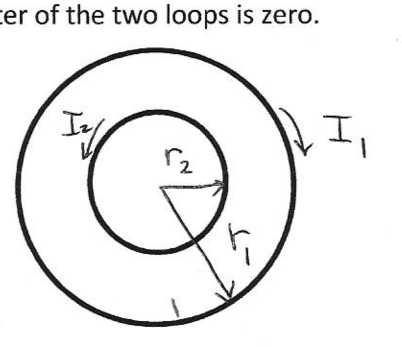


6. Two coplanar and concentric circular loops of wire carry currents of $I_1 = 5I$ and $I_2 = 3I$ in opposite directions ash shown. Let r_1 = R and r_2 = 3/4R, find the magnitude and direction of the magnetic field at the center of the two loop. If r_1 is fixed, but r_2 can vary, what is the value of r_2 so that the field at the center of the two loops is zero.

(Let $\hat{k}$ out of the page $\odot \hat{k}$)

(a) $\vec{B}_{net} = \frac{\mu_0 I}{2R} \hat{k}$

(b) $R_2 = \frac{3}{5} R$



7. An infinitely long, thick cylindrical shell of inner radius a and outer radius b carries a current I uniformly distributed across a cross section of the shell. Find the magnetic field everywhere, that is for the cases: r < a, a < r < b, and r > b. (Ans $r < a$ $B = 0$; $a < r < b$ $B = \frac{\mu_0 I}{2\pi r}\left(\frac{r^2 - a^2}{R^2 - a^2}\right)$

$r > b$

$B = \frac{\mu_0 I}{2\pi r}$

8. A long, straight wires carries a current I_1 as shown. A rectangular coil with two sides parallel to the straight wires has sides of L and 2L and the near side is a distance L/2 from the wire. The coil carries a current of I_2. Find the force on each segment of the coil and the net force on the coil.

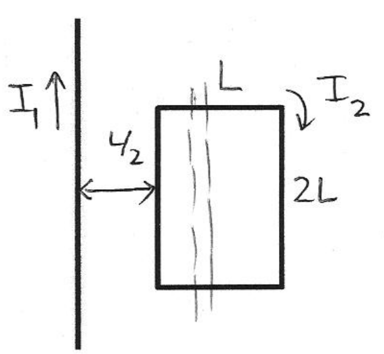
Left: $(-\hat{i})$ $\hat{j}$ $\hat{i}$

$\vec{F}_l = -\frac{2\mu_0 I_1 I_2}{\pi} \hat{i}$

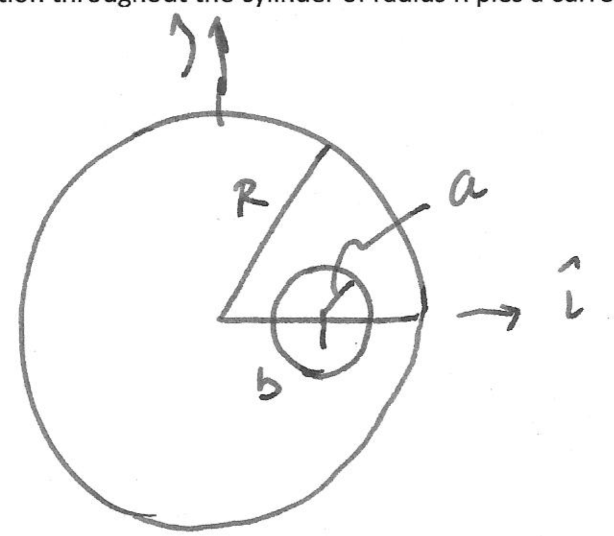
Right: $\vec{F}_R = \frac{2\mu_0 I_1 I_2}{3\pi} \hat{i}$

Top: $\vec{F}_T = \frac{\mu_0 I_1 I_2}{2\pi} \ln 3 \hat{j}$

Bottom: Sum $|\vec{F}_T|$ but $-\hat{j}$



9. A very long, straight conductor with a circular cross section of radius R carries a current I. Inside the conductor, there is a cylindrical hole of radius a whose axis is parallel to the axis of the conductor a distance b from it. Let the z axis be the axis of the conductor and the the axis of the hole be at x = b. Find the magnetic field B at the point (a) on the x axis at x = 2R and (b) on the y axis at y = 2R. Hint: consider a uniform current distribution throughout the cylinder of radius R ples a current in the opposite direction in the hole.



(a) $$B_y = \frac{\mu_0 I}{2\pi(R^2-a^2)}\left[\frac{R}{2} - \frac{a^2}{2R-b}\right]$$

(b) $$B_x = \frac{\mu_0 I}{\pi(R^2-a^2)}\left[\frac{a^2 R}{4R^2+b^2} - \frac{R}{4}\right]$$

$$B_y = \frac{\mu_0 I a^2 b}{2\pi(R^2-a^2)(4R^2+b^2)}$$