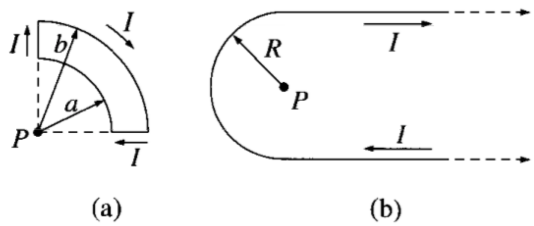
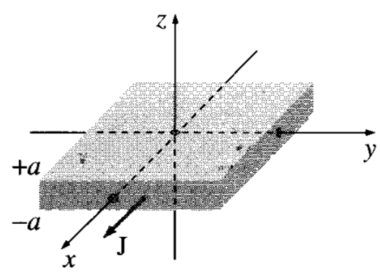
PHY 303: Classical Electrodynamics
MONSOON SEMESTER 2022
TUTORIAL 07

1. Using the Biot-Savart law, find out magnetic field at point P for each of the steady current configurations shown in figure below.



2. A thick slab extending from $z = -a$ to $z = +a$ and over the entire xy-plane, carries a uniform volume current $\mathbf{J} = J\,\hat{i}$; see the figure below. Find the magnetic field, as a function of z, both inside and outside the slab using (a) Biot-Savart law, and (b) Ampère's law.



3. Starting with the differential expression

$$d\mathbf{B} = \frac{\mu_0 I}{4\pi} d\mathbf{l}' \times \frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|^3}$$

for the magnetic induction at the point P with coordinates $\mathbf{r}$ produced by a current element $Id\mathbf{l}'$ at $\mathbf{r}'$, show explicitly that for a closed loop carrying a current I the magnetic induction at P is

$$\mathbf{B} = \frac{\mu_0 I}{4\pi} \boldsymbol{\nabla}\Omega,$$

where Ω is the solid angle subtended by the loop at the point P. This corresponds to a magnetic scalar potential, $\Phi_M = -\mu_0 I\Omega/4\pi$. The sign convention for the solid angle is that Ω is positive if the point P views the "inner" side of the surface spanning the loop, that is, if a unit normal $\mathbf{n}$ to the surface is defined by the direction of current flow via the right-hand rule, Ω is positive if $\mathbf{n}$ points *away* from the point P, and negative otherwise.

4. Consider a circular current carrying loop of radius a placed in the xy-plane with its center coinciding with the origin. Find out the solid angle subtended by the loop's area on a point lying on the z-axis, i.e., the point $(0, 0, z)$. Use the result obtained in the Problem 3 to calculate the magnetic induction $\mathbf{B}$ due to the loop at this point.