DEPARTMENT OF PHYSICS
INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

PH1020 Physics II **Problem Set 7** **2.3.2014**

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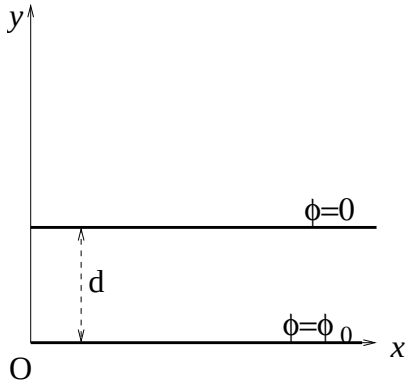
1. A long cylindrical conductor of radius R has a cylindrical hole of radius b ($b < R$). The axis of the hole is parallel to the axis of the conductor. The remaining portion of the conductor has a uniform volume current density **J** parallel to the axis. Show that the magnetic field in the hole is uniform.

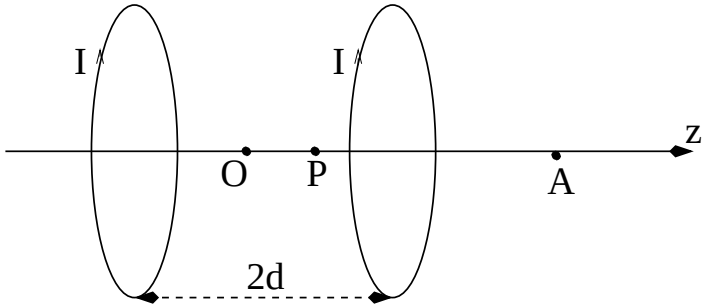
2. A thin isolated wire is bent in the form of a planar spiral consisting of a large number N of closely packed circular turns through which a steady current I flows. The inner radius of the spiral is a and the outer radius is b. Find the magnetic field **B** at the center of the spiral.

3. Two parallel conducting plates are at a distance d apart and have a potential difference ϕ_0 between them as shown in the figure. A uniform magnetic field $\mathbf{B} = B\hat{e}_z$ is also present in the region between the plates. Particles of charge q and mass m are released from rest at the point O. Find the equation of the trajectory of the particles and sketch this trajectory in the xy-plane.

4. **Understanding Helmholtz coils:** Two identical circular coils each having N turns and radius a are placed parallel to each other with a common axis. Their centres are separated by a distance $2d$, as shown in the figure. The width of each coil is negligible compared to a and d. Let O be the point midway between the centres of the two coils.

   (a) As seen by an observer at A, the same current I flows through both coils in the clockwise sense. Find the magnetic induction **B** at a point P at a distance z from O.





   (b) If the field is found to be uniform *correct to second order* in z, show that we must have $d = a/2$.

5. (a) Consider the infinite yz-plane. If a steady current of uniform surface current density $K_0\,\hat{e}_z$ flows in this plane, find **B** at a point with coordinates (x, y, z). Sketch the magnetic field lines.

   (b) Now suppose the infinite plane given by $x = L$ **also** carries the same uniform surface current density as the plane $x = 0$. Find **B** in the different regions corresponding to (i) $x < 0$, (ii) $0 < x < L$, (iii) $x > L$. Sketch the field lines.