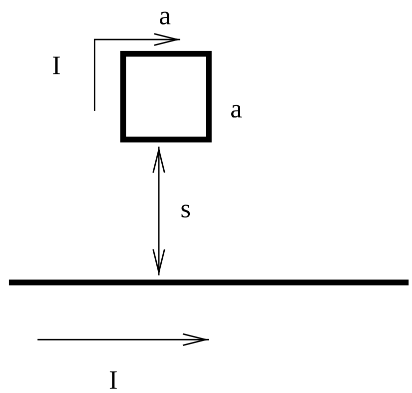
DEPARTMENT OF PHYSICS
INDIAN INSTITUTE OF TECHNOLOGY, MADRAS

PH1020 Physics II **Problem Set 5** **Feb 2019**

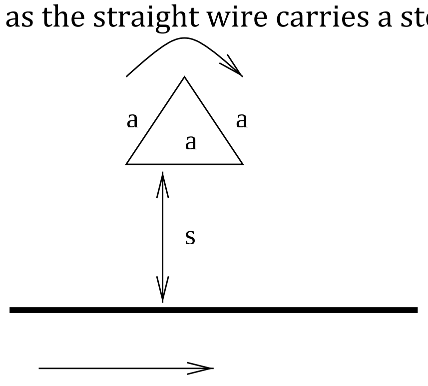
---

1. A current I flows in a square loop of dimension $\mathbf{L} \times \mathbf{L}$. Find the magnetic field a distance z from the center of the loop in a direction perpendicular to the plane of the loop.

2. Find the force on a square loop placed as shown in the figure below. Assume that the straight wire is infinite in extent. Further assume that both the square loop and the straight wire carries a steady current I,



3. Similar to the above problem, find the force on a triangular loop. Similar conditionsas elucidated for the above problem apply here too. Namely, the straight wire is infinite in extent and that both the triangular loop as well as the straight wire carries a steady current I.

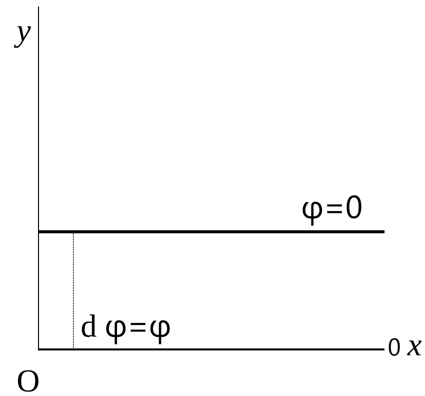


4. A long cylindrical conductor of radius R has a cylindrical hole of radius b ($b < R$). The axis of the hole is parallel to the axis of the conductor. The remaining portion of the conductor has a uniform volume current density $\mathbf{J}$ parallel to the axis. Show that the magnetic field in the hole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

5. 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 $\mathbf{B}$ at the center of the spiral.

6. 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.



7. **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 $d = a/2$.

8. (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.