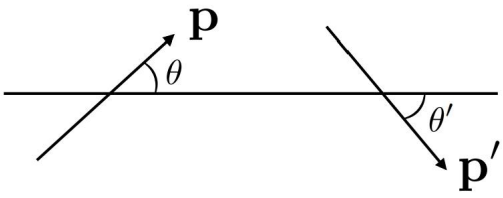
PH108 : Electricity & Magnetism : Problem Set 8

Only * problems are to be solved in the tut session

1. * Two co-planar dipoles are oriented as shown in the figure. Find equilibrium value of θ' if θ is fixed.



2. * Let I be the current carried by a wire bent into a planar loop. Place the origin of coordinates at an observation point P in the plane of the loop.

   (a) Show that the magnitude of the magnetic field at the point P is

   $$B(P) = \frac{\mu_0 I}{4\pi} \int_0^{2\pi} \frac{d\phi}{r(\phi)}$$

   where $r(\phi)$ is the distance from the origin of coordinates at P to the point on the loop located at an angle ϕ from the positive x -axis.

   (b) Show that the magnetic field at the center of a current-carrying wire bent into an ellipse with major and minor axes $2a$ and $2b$ is proportional to the integral of the form (with constant k),

   $$\int_0^{\pi/2} d\phi \sqrt{1 - k^2 \sin^2 \phi}$$

   What are the magnetic fields when $a = b$ and when $a \to \infty$ with b fixed?

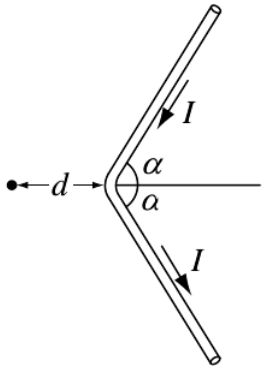
   (c) An infinitesimally thin wire is wound in the form of a planar coil which can be modeled using an effective surface current density $\mathbf{K} = K\hat{\boldsymbol{\phi}}$. Find the magnetic field at a point P on the symmetry axis of the coil. Express your answer in terms of the angle α subtended by the coil at P.

3. A circular loop of wire carries a current I_1. A long straight wire in the plane of the loop carries a current I_2. The loop subtends an angle 2θ at a point on the wire which is nearest to it. Show that the force between the wire and the loop has a magnitude $\mu_0 I_1 I_2 (\sec\theta - 1)$

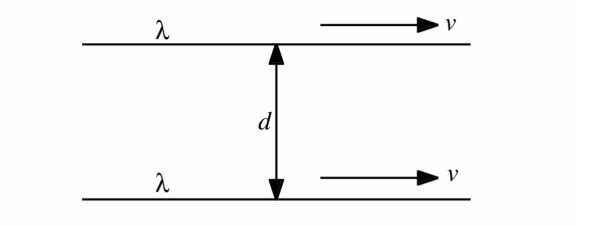
4. A long cylindrical conductor of radius R carries current through it, with current density $J = kr$. Find the expression for magnetic field B at a distance r ($r < R$).

5. Calculate the force between two closed circuits carrying steady currents.

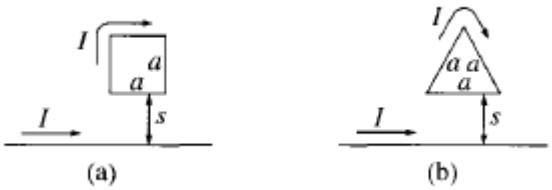
6. * Using Biot and Savart law, find $B(\mathbf{r})$ in the plane of the wire at a distance d from the bend along the axis of symmetry.



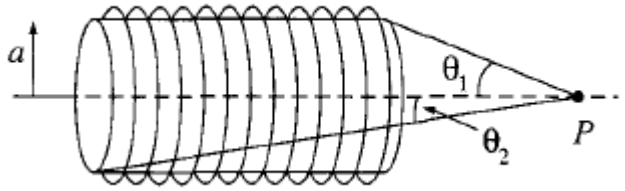
7. Suppose you have two infinite straight-line charges λ, a distance d apart, moving along at a constant v (see Figure below). How fast would v have to be in order for the magnetic attraction to balance the electrical repulsion?



8. (a) Find the force on a square loop placed as shown in Fig. (a), near an infinite straight wire. Both the loop and the wire carry a steady current I.
   (b) Find the force on the triangular loop in Fig. (b).



9. * Find the magnetic field at point P on the axis of a tightly wound solenoid (helical coil) consisting of n turn per unit length wrapped around a cylindrical tube of radius a and carrying current I. Express your answer in terms of θ_1 and θ_2. Consider the turns to be essentially circular. What is the field on the axis of an infinite solenoid (infinite in both direction)?



10. The current I flowing along the edges of one face of a cube(see Figure(a)) produces a magnetic field in the center of the cube of magnitude B_0. Consider another cube where the current I flows along a path shown in Figure (b). What magnetic field will now exist at the center of the cube?

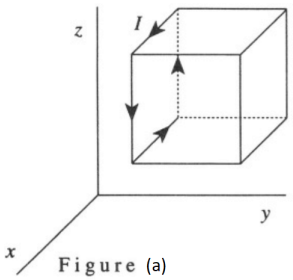


Figure (a)

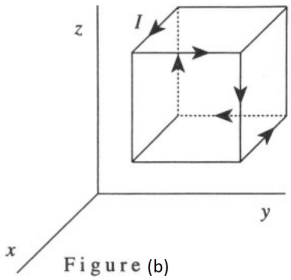


Figure (b)