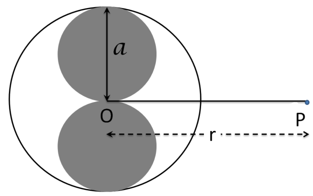
Problems 1, 2, 3 and 4 will be discussed during the tutorial hour.

1. An infinitely long solid conducting cylinder of radius a has two hollow cylindrical regions each of diameter a as shown by the shaded regions in the figure below. The conductor carries a current I flowing uniformly through the solid portion (unshaded region). Find the field at point P, a distance r from the center on the axis ($r > a$) as shown in the figure. What is the magnetic field at p when $r >> a$?



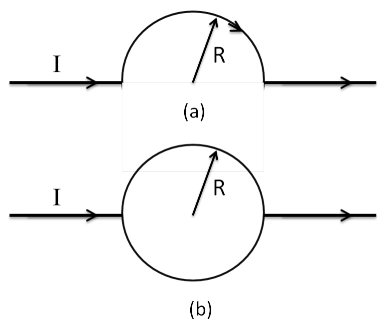
2. Consider two long coaxial solenoids each carrying current I, but in opposite direction as shown in Fig. 3. The inner solenoid of radius a has n_1 turns per unit length, and the outer one of radius $b(> a)$ has n_2. Find the magnetic field in each of the three regions:
   (a) inside the inner solenoid;
   (b) in between the two solenoids;
   (c) outside both the solenoids.

   Compare the results of the above situation with the following problem. A long cylindrical wire with inner radius $r = a$ and outer radius $r = b$ carries a uniform current I along the axis. Find the magnetic field
   (a) inside the hollow region ($r < a$);
   (b) inside the conducting region ($a < r < b$);
   (c) outside the conductor ($r > a$).

3. A spherical shell with radius R and uniform surface charge density σ spins with angular frequency ω around its diameter. Find the magnetic field at the center of the sphere using Biot-Savart law involving surface current distribution.

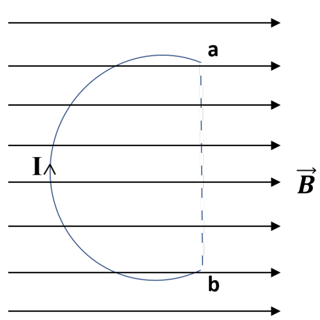
4. We have discussed in the lecture that the vector potential for a volume current density $\mathbf{J}$ is given by,
$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi}\int \frac{\mathbf{J}(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}\, d\tau'.$$
   Calculate $\nabla \times \mathbf{B}$ using the above expression assuming a steady current distribution.

5. A long wire, carrying a current I, is bent in such a way as to have a semicircular arc of radius R as shown in Fig. 2(a). Calculate the magnetic field at the center of the arc when $I = 10$ Amp and $R = 0.5$ cm. Then calculate the magnetic field at the center of the circular arc for the configuration shown in Fig. 2(b).



6. Consider a thick wire of finite length L having radius R ($R \ll L$) and carrying a current I flowing along z direction with uniform current density. Find the magnetic field near the middle of the wire both inside and just outside using Ampere's law with proper justification. Find out the corresponding curl of $\vec{B}$, both inside and just outside the wire. [You may use $(\nabla \times \vec{B})_z = \frac{1}{s}[\frac{\partial}{\partial s}(sB_\phi) - \frac{\partial B_s}{\partial \phi}]$, in cylindrical coordinates]

7. Find the net magnetic force on the bent wire carrying current I placed in a uniform magnetic field $\vec{B}$ as shown in the figure below. The straight path connecting the two points a and b (shown by dashed line) has a length L and is oriented perpendicular to $\vec{B}$.



8. Find the net force on the square loop of side length a near an infinite straight wire. One of the sides of the square loop is parallel to the infinite wire. Both the loop and the wire carry a steady current I.