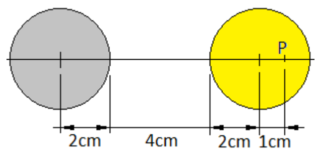
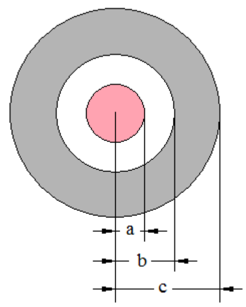
Physics II

Ampere's Law

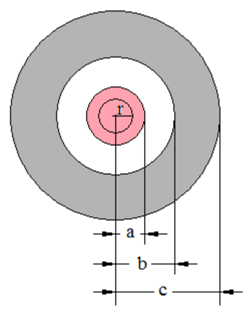
Problem 1.- Calculate the magnitude and direction of the magnetic field produced at point P due to the currents in two long parallel conductors with radius 2cm each and separated 4cm as shown in the figure. Assume that the currents are uniformly distributed in the conductors. The current of the left conductor is 150A towards us and the one on the right conductor is 150A away from us.



Problem 2.- Calculate the magnetic field in all space, produced by the long coaxial cable whose cross section is shown in the figure. The central conductor brings a current *I* towards us, and the external conductor takes it away from us. Assume that the currents are uniformly distributed over their conductors.



Solution: Case r<a



In this case, the direction of the magnetic field is anti-clockwise and we can calculate it with Ampere's law

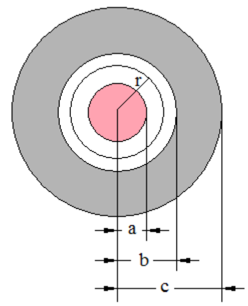
$$B2\pi r = \mu_o I_{enclosed},$$

Where we notice that the current is only the one inside a circle with radius r. Then

$I_{enclosed} = \dfrac{I}{\pi a^2}\pi r^2$, and substituting in the equation above we get:

$$B = \frac{\mu_o I r}{2\pi a^2}$$

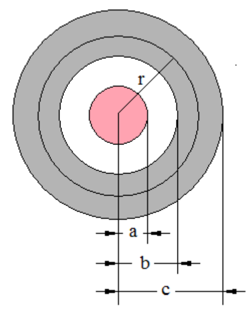
Case a<r<b



This time, the enclosed current is all of it (I). And replacing this in Ampere's law we get:

$$B 2\pi r = \mu_o I \rightarrow B = \frac{\mu_o I}{2\pi r}$$

Case b<r<c



When applying Ampere's law in this case we have two currents enclosed. One is I towards us and the other is in the space between r and b, which is in the opposite direction. To calculate this last current, we multiply the area between r and b by the current density in that conductor.

$$I_{enclosed} = I - \frac{I}{\pi c^2 - \pi b^2}\left(\pi r^2 - \pi b^2\right) = I \frac{c^2 - r^2}{c^2 - b^2}$$

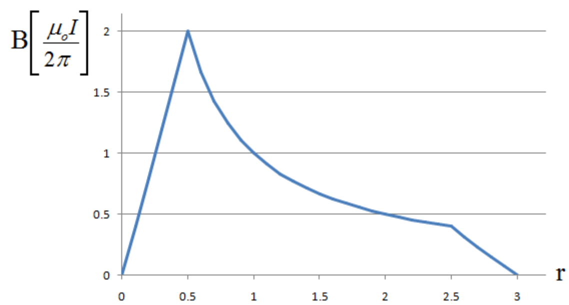
Replacing this equation in Ampere's law, we obtain:

$$B = \frac{\mu_o I}{2\pi r} \frac{c^2 - r^2}{c^2 - b^2}$$

Case c<r

Since the net current is zero, the field is zero as well in this case.

A graph for the case a=0.5, b=2.5 and c=3 looks like this:



$B\left[\frac{\mu_o I}{2\pi}\right]$
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
r