Name: _____ Student ID5_____ Session: T ___

PHYS 3033 - Electricity and Magnetism I

Quiz 8

Time allowed: 15 minutes

3 Nov 2015

A steady current *I* flows down a long cylindrical wire of radius *a* (Fig. 1). Find the magnetic field, both inside and outside the wire, if

(a) The current is uniformly distributed over the outside surface of the wire.

(b) The current distributed in such a way that *J* is proportional to *s*, the distance from the axis.

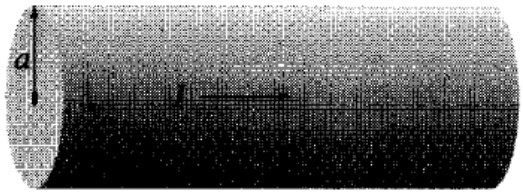

Fig. 1

Solution

(a) $\oint \mathbf{B}\cdot d\mathbf{l} = B2\pi s = \mu_0 I_{enc} \Rightarrow \mathbf{B} = \begin{cases} 0, & for\ s < a \\ \dfrac{\mu_0 I}{2\pi s}\hat{\boldsymbol{\phi}}, & for\ s > a \end{cases}.$

(b) $J = ks\,; I = \int_0^a J da = \int_0^a ks(2\pi s)ds = \dfrac{2\pi k a^3}{3} \Rightarrow k = \dfrac{3I}{2\pi a^3}.$

$I_{enc} = \int_0^s J da = \int_0^s k\bar{s}(2\pi\bar{s})d\bar{s} = I = \dfrac{2\pi k s^3}{3} = I\dfrac{s^3}{a^3}$, for $s < a$; $I_{enc} = I$, for $s > a$.

So

$$\mathbf{B} = \begin{cases} \dfrac{\mu_0 I s^2}{2\pi a^3}\hat{\boldsymbol{\phi}}, & for\ s < a \\ \dfrac{\mu_0 I}{2\pi s}\hat{\boldsymbol{\phi}}, & for\ s > a \end{cases}.$$