

 **PHYSICS 132**

**Homework # 4 2nd. Semester 2015-16**

**NAME: STUDENT ID#:**

1. A coaxial cable consists of a 2.0-mm-diameter inner conductor and outer conductor with interior diameter 1.0 cm. A 100-mA current flows down the inner conductor. The thickness of the walls of the outer conductor is 0.5-mm. A200-mA current flows back along the outer conductor. Find the magnetic field strength (a) 0.50 mm, (b) 5.0 mm, (c) 1.2 cm, and (d) 2.0 cm from the cable axis.

$$R=1 mm=1×10^{-3} m$$

$$R\_{in}=0.5 cm=0.5×10^{-2} m$$

$$R\_{out}=0.55 cm=0.55×10^{-2} m$$

1. $r=0.50 mm=0.5 ×10^{-3} m$ (see figure1)

$$∮\_{}^{}\vec{B}.d\vec{s}=μ\_{°}I\_{enc}$$

$$∮\_{}^{}B.ds\cos(0)=μ\_{°}I\_{enc}$$

$B\left(2πr\right)=μ\_{°}I\_{enc}$…………………...…………………………………………….(1)

Note: I take the + in the outward direction

 The current density $\left(J\right)$ is constant (uniform current), thus

$I\_{enc}=JA\_{enc}$, where $A\_{enc}$: the area enclosed by Amperian loop

$$I\_{enc}=J\left(πr^{2}\right)$$

$$I\_{enc}=\frac{I\_{1}}{πR^{2}}\left(πr^{2}\right)$$

$I\_{enc}=\frac{r^{2}}{R^{2}}I\_{1}$ substituting this in (1)

$$B\left(2πr\right)=μ\_{°}\frac{r^{2}}{R^{2}}I\_{1}$$

$$B=\frac{μ\_{°}rI\_{1}}{2πR^{2}}=\frac{\left(4π×10^{-7}\right)\*\left(0.5×10^{-3}\right)\*\left(100×10^{-3}\right)}{2π\left(1×10^{-3}\right)^{2}}=1×10^{-5} T$$



Figure1

1. $r=5 mm=5 ×10^{-3} m$ (see Figure2)

Note here $r=R\_{in}$

$$∮\_{}^{}\vec{B}.d\vec{s}=μ\_{°}I\_{enc}$$

$$∮\_{}^{}B.ds\cos(0)=μ\_{°}I\_{enc}$$

$$B\left(2πr\right)=μ\_{°}I\_{enc}$$

$$B\left(2πr\right)=μ\_{°}I\_{1}$$

$$B=\frac{μ\_{°}I\_{1}}{2πr}=\frac{\left(4π×10^{-7}\right)\*\left(100×10^{-3}\right)}{2π\left(5×10^{-3}\right)}=0.4×10^{-5} T$$



Figure2

1. $r=1.2 cm=1.2 ×10^{-2} m$ (see Figure3)

$$∮\_{}^{}\vec{B}.d\vec{s}=μ\_{°}I\_{enc}$$

$$∮\_{}^{}B.ds\cos(180)=μ\_{°}\left(I\_{1}-I\_{2}\right)$$

Note here $I\_{enc}$ directed inward

$$-B\left(2πr\right)=μ\_{°}\left(I\_{1}-I\_{2}\right)$$

$$B\left(2πr\right)=μ\_{°}\left(I\_{2}-I\_{1}\right)$$

 $B=\frac{μ\_{°}\left(I\_{2}-I\_{1}\right)}{2πr}=\frac{\left(4π×10^{-7}\right)\*\left(200×10^{-3}-100×10^{-3}\right)}{2π\left(1.2×10^{-2}\right)}=0.167×10^{-5} T$

1. $r=2 cm=2 ×10^{-2} m$

Same as in ©

 $B=\frac{μ\_{°}I\_{1}}{2πr}=\frac{\left(4π×10^{-7}\right)\*\left(200×10^{-3}-100×10^{-3}\right)}{2π\left(2×10^{-2}\right)}=0.1×10^{-5} T$



Figure3

1. An electric motor contains a 300-turn circular coil 5 cm in diameter in a uniform magnetic field $\vec{B}=2\hat{i} T$. If a $100 A$ current passes through the coil, it rotates so that angle between the plan of the coil and the magnetic field is $30^{°}$.



1. What’s the magnitude of the coil’s dipole moment?

$$μ=NIA=NIπR^{2}=300\*100\*π\*\left(0.025^{2}\right)=58.9 A.m^{2}$$

1. What is the potential energy of the magnetic dipole?

$\vec{μ}$ perpendicular to the plan of the coil

Note that the angle between $\vec{μ}$ and $\vec{B}$: $θ=90-30=60$

$$U=-\vec{μ}.\vec{B}=-μB\cos(θ)=-58.9\*2\*\cos(60)=-58.9 J$$

1. What is the magnitude of the torque bone by the magnetic field on the coil?

$$τ=μB\sin(θ)=58.9\*2\*\sin(60)=102 N.m$$