Physics 4B Winter 2018 Test 3

Name: _____

Mar 9, 2018

Please show your work! Answer as many questions as you can, in any order. Books, notes, and internet connections are not allowed. Use any blank space to answer questions, but please make sure it is clear which question your answer refers to.
DO NOT OPEN TEST BOOKLET UNTIL TOLD TO DO SO.

$g = 9.8\ \text{ms}^{-2}$
$k = 8.99 \times 10^9\ \text{Nm}^2\text{C}^{-2} = \frac{1}{4\pi\epsilon_0}$
$\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2}$
$\mu_0 = 4\pi \times 10^{-7}\ \text{Tm/A}$
$e = 1.60 \times 10^{-19}\ \text{C}$
$m_e = 9.11 \times 10^{-31}\ \text{kg}$
$m_p = 1.67 \times 10^{-27}\ \text{kg}$
$c = \frac{1}{\sqrt{\epsilon_0\mu_0}} = 3.00 \times 10^8\ \text{m/s}$

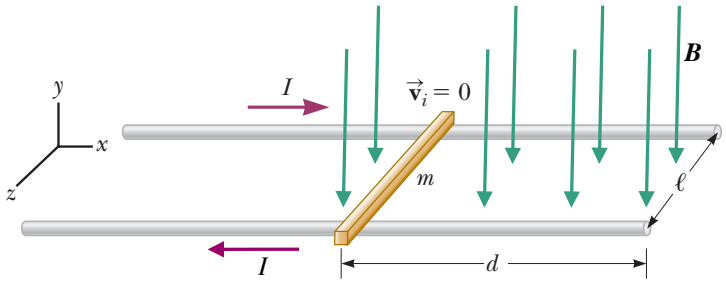
$\mathbf{B} = \frac{\mu_0 I a^2}{2(a^2+x^2)^{3/2}}$
$\mathbf{B} = \frac{\mu_0 I}{4\pi a}(\sin\theta_1 - \sin\theta_2)$

Trigonometric Identities

$\sin^2\theta + \cos^2\theta = 1$
$\sin(2\theta) = 2\sin(\theta)\cos(\theta)$
$\cos(2\theta) = \cos^2\theta - \sin^2\theta$
$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$
$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$
$\cos\alpha\cos\beta = \frac{1}{2}[\cos(\alpha-\beta) + \cos(\alpha+\beta)]$
$\sin\alpha\sin\beta = \frac{1}{2}[\cos(\alpha-\beta) - \cos(\alpha+\beta)]$
$\sin\alpha\cos\beta = \frac{1}{2}[\sin(\alpha+\beta) + \sin(\alpha-\beta)]$

$\sin\left(\theta + \frac{\pi}{2}\right) = \cos\theta$
$\cos\left(\theta + \frac{\pi}{2}\right) = -\sin\theta$
$\sec\theta := \frac{1}{\cos\theta}$
$\csc\theta := \frac{1}{\sin\theta}$
$\cot\theta := \frac{1}{\tan\theta}$

1. A metal rod of mass m carrying a current I glides on two horizontal rails a distance ℓ apart. A uniform magnetic field B is directed perpendicular to the rod and the rails in the $-y$ direction. If the coefficient of kinetic friction between the rod and rails is μ_k, and the rod starts from rest at the position shown, what is the speed of the rod as it leaves the rails after having traveled a distance d? [10 pts]



2. The figure shows a cross-sectional view of a very long, straight coaxial cable. The center conductor is surrounded by a rubber layer, an outer conductor, and another rubber layer. In a particular application, the current in the inner conductor is I_1 out of the page and the current in the outer conductor is $I_2 = 2I_1$ into the page.

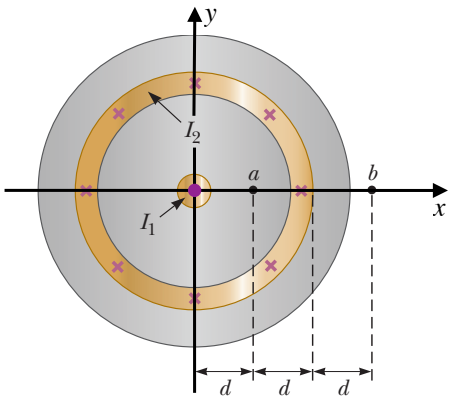
   In terms of I_1, d, and fundamental constant(s), determine the magnitude and direction of the magnetic field at

   (a) point a, located at $x = d$. [6 pts]

   (b) point b, located at $x = 3d$. [4 pts]

   (c) at a point $x = r$ inside the inner conductor, where $0 < r < R$, and R is the radius of the inner conductor. (Show your logic, do not simply write down the answer.) [5 pts]

   (d) Plot the y-component of the magnetic field versus positive values of x. You may assume the outer conductor begins at $x = 5d/3$ and ends at $x = 2d$. Label your axes with values where you can, in particular, label the maximum and minimum. [8 pts]



–Extra Workspace–

3. A loop of wire in the shape of a rectangle of width w and length L and a long, straight wire carrying a current I lies on a tabletop as shown.

   (a) Determine the magnetic flux through the loop due to the current I. [6 pts]

   (b) Suppose the loop is moving away from the wire (current I) with constant speed v, starting a distance from the wire $h = h_0$ at time $t = 0$. Determine the emf that is induced in the loop as a function of time. [6 pts]

   (c) What is the direction of the induced current in the rectangle? [1 pt]