PHYS 4330 ELECTRICITY & MAGNETISM II

HOMEWORK ASSIGNMENT 01

DUE DATE: February 11, 2020

Instructor: Dr. Daniel Erenso Name: ______________________

Mandatory problems: *Any two of the problems*

Student signature:_______________________________________

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P #	1	2	3	4	5	Score
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1. A copper rod of length, h, mass, m, and electric resistance, R, slides with negligible friction on metal rails that have negligible electric resistance (see Fig. 1). The rails are connected on the right with a wire of negligible electric resistance, and a magnetic compass is placed under this wire. There is a uniform magnetic field, $\vec{B}$, pointing out of the page that fills the entire region.

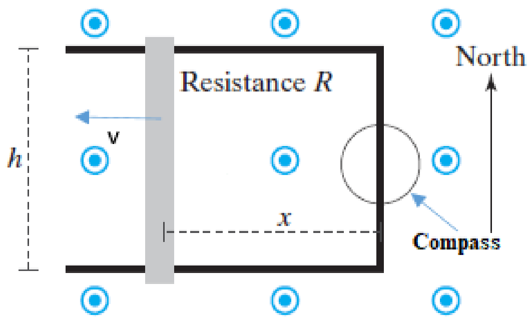

Figure 1: A rod sliding on u-shaped wire in a uniform magnetic field.

(a) If the bar moves to the left at a speed v, what is the magnitude and direction of the current in the circuit? Which direction would the compass deflect?

(b) What is the magnetic force on the bar?

(c) If the bar starts out with speed, v_0, at time, $t = 0$, and is left to slide, what is its speed at a later time, t.

(d) The initial kinetic energy of the bar was, of course,

$$KE_i = \frac{1}{2}mv_0.$$

Show that the energy delivered to the resistor is exactly equal to this initial kinetic energy.

2. A conducting circular loop of radius, b, is placed in a uniform magnetic field pointing along the z-direction, $\vec{B} = B_0\hat{z}$ and rotates with an angular velocity, ω, about a diameter which is perpendicular to $\vec{B}_0$ (i.e. $\vec{\omega} = -\omega\hat{x}$) (See Fig.2). Find the current in the loop, the retarding torque, and the average power which is required to maintain the rotation.

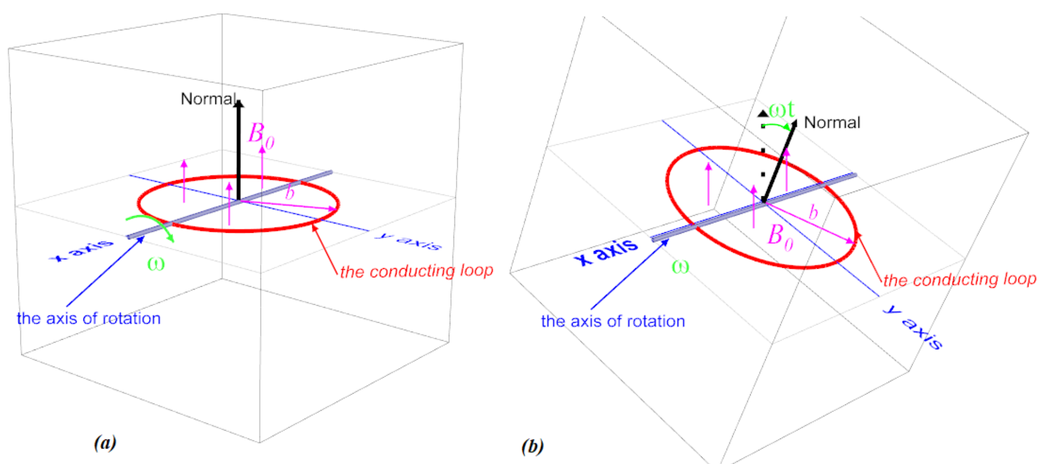

Figure 2: (a) The ring on the x-y plane at $t = 0$. (b) after it rotated about the x-axis at time, t. The angular displacement at this time is ωt from the z-axis.

3. A square loop is cut out of a thick sheet of aluminium. It is then placed so that the top portion is in a uniform magnetic field, $\vec{B}$, and is allowed to fall under gravity. The shaded region in the diagram (Fig.3) shows the magnetic field region which points out of the page (i.e. $\vec{B} = -B_0\hat{y}$). If the magnetic field is $1T$,

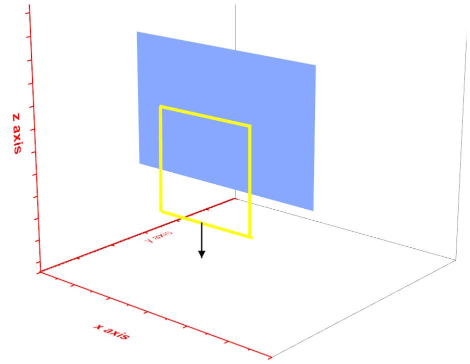

Figure 3: A square conducting loop falling in a uniform magnetic field.

(a) find the terminal velocity of the loop (in m/s).

(b) find the velocity of the loop as a function of time.

(c) how long does it take (in seconds) to reach, say 90% of the terminal speed? What would happen if you cut a tiny slit in the square loop, breaking the circuit?

4. Griffiths Problem 7.14 (*remember the demo I showed you in class*)

5. An alternating current $I = I_{\max}\cos(\omega t)$ flows down a long straight wire with negligible diameter and returns along a coaxial conducting tube of radius b as shown in Fig. 4

(a) In what direction does the induced electric field point. Give your answer using unit vectors in cylindrical coordinates (radial ($\pm\hat{s}$), circumferential ($\pm\hat{\varphi}$), or axial ($\pm\hat{z}$).

(b) Assuming that the field goes to zero as $s \to \infty$, find $\vec{E}(s,t)$.

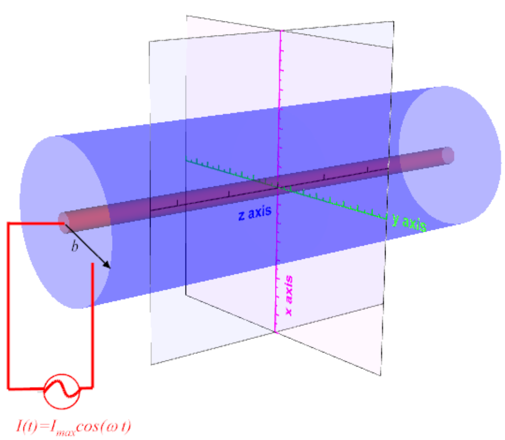

Figure 4: An ac current flows down a long wire (red) and returns along a coaxial conducting tube (blue).

6. *Problem 1 with a twist*: A copper bar of length h and electric resistance R slides with negligible friction on metal rails that have negligible electric resistance (see Fig.5). The rails are connected on the right with a wire of negligible electric resistance, and a magnetic compass is placed under this wire. The compass needle deflects to the right of north, as shown on the diagram. Throughout this region there is a uniform magnetic field $\vec{B}$

pointing out of the page, produced by large coils that are not shown. This magnetic field is increasing with time, and the magnitude is, $B = B_0 + \alpha t$, where B_0 and α are constants, and t is the time in seconds. You slide the copper bar to the right and at time, $t = 0$, you release the bar when it is a distance x from the right end of the apparatus. At that instant the bar is moving to the right with a speed v.

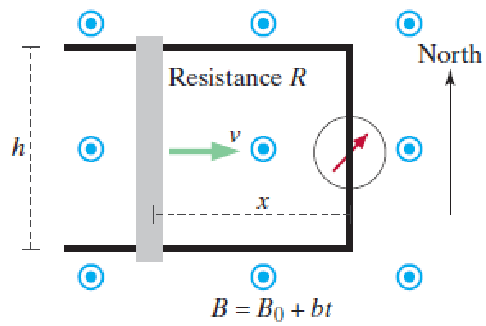

Figure 5: A rod sliding on u-shaped wire in a time varying magnetic field. The magntic field is increasing at a rate, $\frac{dB}{dt} = \alpha$

(a) Calculate the magnitude of the initial current I in this circuit.

(b) Calculate the magnitude of the net force on the bar just after you release it.

7. *Similar to Example 7.9*: A line charge is glued onto the rim of a wheel of radius, b, which is then suspended horizontally, as shown in the figure below, so that it is free to rotate (the spokes are made of some nonconducting material) (see Fig. 6). In the central region, out to radius a, there is a magnetic field pointing along the positive z-axis ($\vec{B} = B_0\hat{z}$). This magnetic field begins to increase at a rate of

$$\frac{dB}{dt} = \alpha.$$

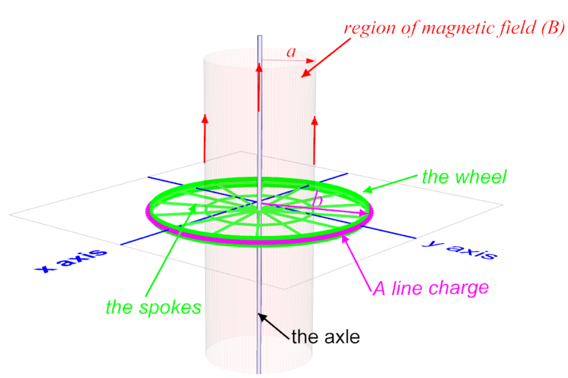

Figure 6: A circular (radius b) line charge (pink) glued to none conducting wheel (on the x-y plane) connected by a none conducting spokes (green) is free to rotate about an axle. A uniform magnetic field along the z-direction confined to a region with radius, a (red) is increasing at a rate, $\frac{dB}{dt} = \alpha$, where α is a constant.

(a) Explain qualitatively and quantitatively what is going to happen?

(b) Show that the angular momentum imparted to the wheel does not depend on the value of α.

8. In Fig . 7 there is a solenoidal coil with radius, b. A thin conducting ring of radius, a, (i.e. $a < b$) is sitting under the solenoid. The solenoid is connected to a switched-off power supply. You suddenly turned the switch on.

(a) If the ring has a resistance, R, what would be the magnitude and direction of the induced current in the ring? Both the axial and radial components of the magnetic field of the solenoid can be approximated to be a constant.

(b) Find the approximate magnitude and the direction of the magnetic force on the ring.

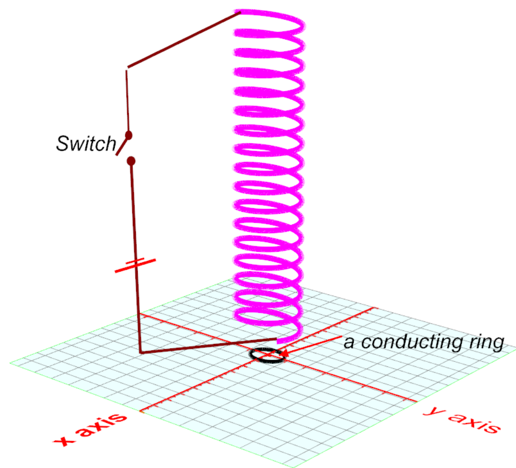

Figure 7: A solenoidal, a ring sitting at the bottom of the solenoid. The two ends of the solenoid are connected to a power suply with a switch.