Instructions: You have a total of 50 minutes to complete this test.

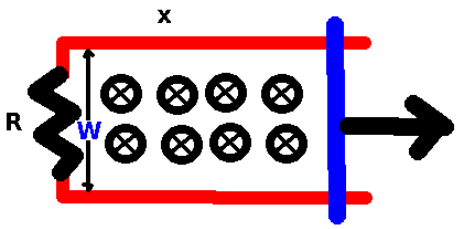
Answer each of the following questions completely, showing full details with correct SI units.

Time Start_____ Time finish_____ Pledged_____

Do not discuss any aspect of this test with anyone until I return the test.

Constants:

$$\mu_0 = 4\pi x 10^{-7}\frac{Tm}{A}; \mu \equiv 1x10^{-6}$$

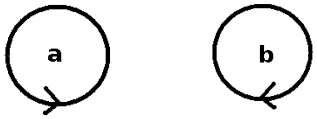


[1] Consider the following situation: conducting rail is moving with an instantaneous position given by $x = x_0 - pt^3$ (x_0 and p are constants). In the area enclosed by the rail system, **a uniform magnetic field (B) is directed into the -z direction.** The rail system has a total resistance (at the end only) given by R and this value is assumed to be constant throughout this problem.

(a) At an instant in time, calculate the magnetic flux through the enclosed region of the system. You may assume the normal to the area of the enclosed region points into the +z direction which is out of the page.

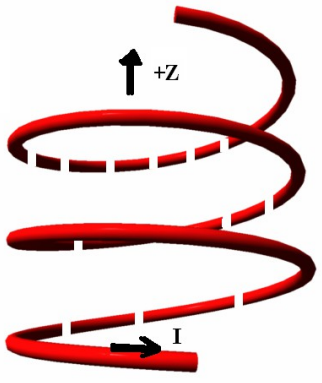
(b) Find the **magnitude** of the induced emf in the system at any time t.

(c) Which direction will the induced current flow: (a or b). (circle the correct answer).



(d) Suppose R=1 Ω, p=4 m/s^3 , w=0.5 m, x_0=100m, t=2s, and B=1 T. Provide numerical answers to (a) and (b) together with correct SI units.

[2] An ideal solenoid has a total length h and the interior cross sectional area is A with windings as shown to the right. A current I is injected into the solenoid at the top and exits at the bottom as shown. Note that in the image to the right, dashed portions are behind while solid portions are in front.



[a] Circle the correct direction for the magnetic field inside the solenoid.

$$+\hat{z} \qquad -\hat{z}$$

In answering the following questions, you must show complete details leading up to your answer for full credit.

[b] Calculate the magnitude of the magnetic field inside the solenoid near the center**. You must show details, use words, include assumptions and sketches. Your answer involves n, I and a constant.**

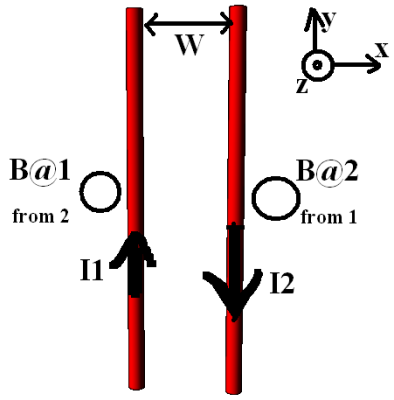
[c] Suppose the solenoid has a total of N turns. Assuming the magnetic field is uniform throughout the solenoid, calculate the inductance of the solenoid. Your answer involves n, and the interior volume of the solenoid.

[d] Calculate the magnetostatic energy density of the solenoid. Here, express your answer in terms of a constant and B.

[e] Provide numerical answers for (b), (c), and (d) **together with correct SI units** for the case I=2A, n=1000/m, A=1 m^2, h=10 m.

[e:b] _____ **[e:c]** _____ **[e:d]** _____

[3] Two long wires (each with the same length h) carry currents I1 and I2 in the directions shown. In the coordinate system indicated, **z is out of the paper**. You may assume the wires are long enough so that they may be treated as ideal. **Note that a dot represents a vector coming out of the page while a cross is a vector pointing into the page.**



[a] In the circles provided, show the direction that the magnetic fields point for B at 1 from 2 and B at 2 from 1. Use these symbols: ⊙ if the field is in the +z direction and ⊗ for the field directed into the -z direction.

[b] Showing **complete details**, calculate the magnitude of the magnetic field B@1 from 2.

[c] Determine the direction of the force on wire 1 due to wire 2. (circle the correct answer).

$$+\hat{x} \quad -\hat{x} \quad +\hat{y} \quad -\hat{y} \quad +\hat{z} \quad -\hat{z}$$

[d] Determine the direction of the force on wire 2 due to wire 1. (circle the correct answer).

$$+\hat{x} \quad -\hat{x} \quad +\hat{y} \quad -\hat{y} \quad +\hat{z} \quad -\hat{z}$$

[e] Calculate the **magnitude of the force** on wire 1 due to wire 2.

[f] Suppose that I1=2A, I2=2A, w=2 m and h=2.0 m. Provide numerical answers for [b] and [e] **together with correct SI units**.

[d:b] _____ **[d:e]** _____

[4] In answering the following questions, be sure to include proper SI units.

[a] Suppose a circuit consists of an inductor (L=5μH), and a capacitor (C=5μf) in a **series configuration**. Calculate the resonance frequency (f_0) of this circuit.

f_0 =_____

[b] Calculate the impedance (Z) of the RLC series circuit with L=5μH, C=5μf and R=10Ω when operated at a frequency of **f=1x10⁶ Hz**. Be sure to provide correct SI units here.

Z=_____

[c] A transformer consists of two coils with N_p=10 turns on the primary side and N_s=30 turns on the secondary side. You may assume perfect flux coupling here. If a DC voltage of 10 V is input on the primary side of the transformer, what is the output voltage?

[d] If an AC voltage of 30 V (RMS) is input on the primary side of the transformer, what is the (RMS) output voltage?