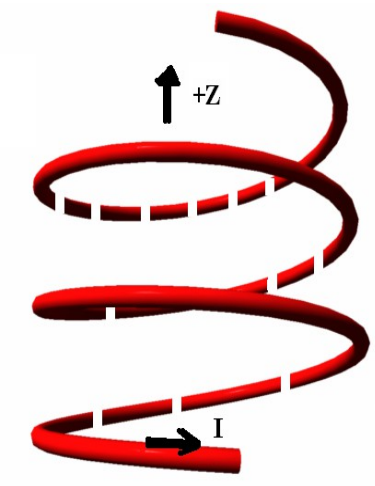
Instructions: You have a total of 50 minutes to complete this test.
Answer each of the following questions completely, showing full details with correct SI units.
Time Start_____ Time finish_____ Pledged_____
Do not discuss any aspect of this test with anyone until I return the test.

Constants: $\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$



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

In answering the following questions, you must show complete details leading up to your answer for full credit.
(a) Calculate the **vector magnetic** field inside the solenoid near the center**. You must show details, use words and sketches. Your answer involves n, I and a constant.**

(b) Assuming the magnetic field is uniform throughout the solenoid, calculate the total magnetic flux in the solenoid when this current is flowing. Your answer involves n, I and the interior volume of the solenoid.

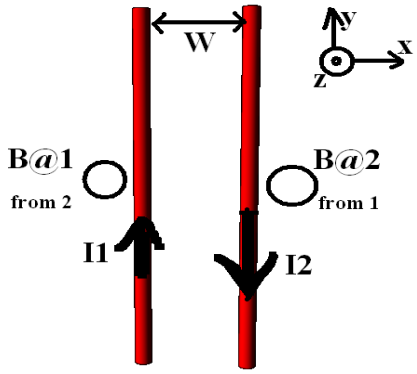
(c) Calculate the inductance of the solenoid in terms of n, A and h.

(d) Calculate the **total magnetostatic energy** of the solenoid. Here, express your answer in terms of a constant, B, A and h.

(e) Provide numerical answers for (a), (b), (c) and (d) **together with correct SI units** for the case I=10A, n=2000/m, A=0.5m^2, h=1 m.

(e:a)_____(e:b)_____ (e:c)_____(e:d)_____

[2] Two long wires each of length L are separated by a distance w carry currents I1 and I2 in the directions shown. Note that x and y are in the plane of the wire while z comes out of the page.



(a) In the circles provided, show the direction of the magnetic fields, B@1 from 2 and B@2 from 1.

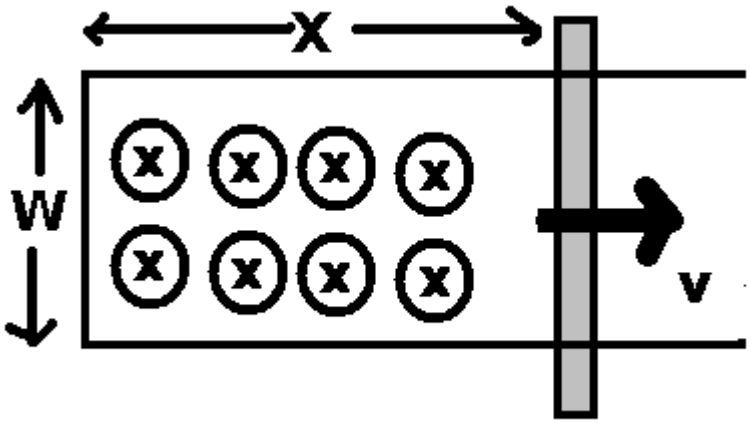
(b) Sketch, and label, force on wire 1 (F1) and the force on wire 2 (F2) on the diagram.

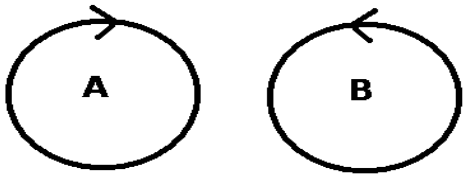
(c) Showing complete details, calculate the magnitude of the magnetic field at wire 2 (due to the current in wire 1). Your answer is in terms of I1, and W.

(d) Calculate the magnitude of the force per unit length on wire 2 in terms of I1, I2, W and a constant.

(e) Suppose I1=1 A, I2=2 A, and W=1m. Provide a numerical result (with the correct unit vector direction, and correct SI units) for the force per unit length on wire 2.

[3]Consider the following situation: a conducting rail is moving with an instantaneous position given by $x = x_0 + \frac{1}{2}at^2$ (x_0 and a are constants and the rail is moving in the +x direction). In the area enclosed by the rail system, a uniform magnetic field (B) is directed into the negative z direction: $\vec{B} = -|\vec{B}|\hat{z}$. 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 **magnitude** of 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.

[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) and why (in words). Be very clear in your answer to this question.

[d] Suppose $a = 2\ m/s^2$, $w = 0.5\ m$, $x_0 = 100m$, $t = 2s$, and $B = 1\ T$. Provide numerical answers to [a] and [b] **together with correct SI units.**

[d:a] _____ **[d:b]** _____

[4] A circuit consists of an inductor (L=2x10^{-5} H) and a capacitor (C=8x10^{-5} f) in series.
[a] Calculate the resonance frequency (f) of this circuit.

f=_____
[b] Another circuit consists of an inductor (L=2x10^{-5} h) , a capacitor (C=8x10^{-5} f) and a resistor (R=5 Ω) in series. If the circuit is operated at f=1000 Hz, calculate the impedance of this circuit.

Z=_____
[c] A transformer consists of a primary coil with 10 turns and a secondary coil with 50 turns. If an input voltage of 10 V (RMS) AC is applied to the primary side, what is the secondary voltage?

[d] A transformer consists of a primary coil with 100 turns and a secondary coil with 50 turns. If an input voltage of 10 V (RMS) DC is applied to the primary side, what is the secondary voltage?