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

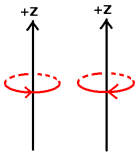
Answer each of the following questions completely, showing full details with correct SI units.

Time Start_____ Time finish_____ Pledged_____

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

Constants: $\mu_0 = 4\pi\times10^{-7}\ \frac{\text{Tm}}{\text{A}}$

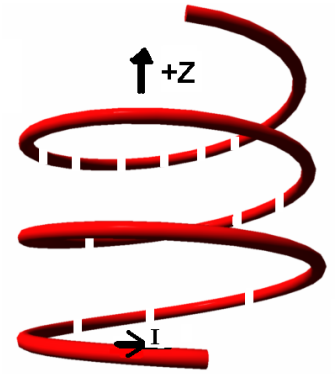
[1] A wire of radius a has a uniform current density J spread across its cross sectional area. The wire is directed along the z-axis and $\vec{J} = \left|\vec{J}\right|\hat{z}$. The wire carries a total current I so that the current density is given by $\left|\vec{J}\right| = \frac{I}{\pi a^2}$. Let the radial distance from the center of the wire be designated by the variable s.



(a) Which way is the magnetic field directed (circle the correct answer)?

(b) Calculate **(showing details)** the magnetic field outside the wire. Your answer involves I and s here.

(c) Calculate **(showing details)** the magnetic field inside the wire. Your answer involves I,a and s here.



[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.

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.**

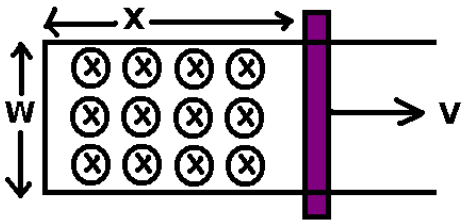
(b) Suppose the solenoid has a total of N turns. Assuming the magnetic field is uniform throughout the solenoid, calculate the total magnetic flux in the solenoid when this current is flowing. Your answer involves n, I and the interior volume of the solenoid.

(c) Calculate the inductance of the solenoid.

(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=5A, n=3000/m, A=0.5 m^2, h=0.2 m.

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



[3] A bar is traveling on a circuit which has a magnetic field through its interior B which is directed into the page as shown.

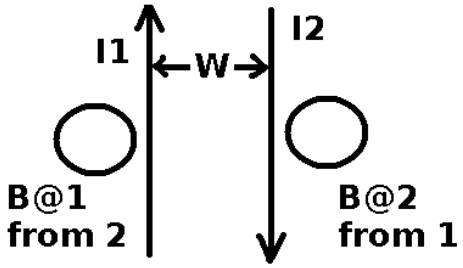
(a) Which direction is the induced current in the circuit flowing (circle the correct answer)?

(b) The bar is seen to move according to the equation: $x = x_0 + ct^3$. What is the magnitude of the induced emf in terms of B,w,c and t?

(c) If the circuit has a total resistance R, what is the current induced?

(d) Provide numerical answers **together with correct SI units** to (b) and (c) above for the case c=0.5 m/s^4, B=1 T, w=0.5 m, R=5Ω and t=3s.

(b) _____ (c)_____



[4] Two wires, each of length h (which you may assume to be very long, compared to w) carry currents I1 and I2 as shown.

(a) indicate the direction of the magnetic field at each wire (which comes from the current in the other wire). Show this in the circles.

(b) Indicate the direction of the force on each wire due to the interaction between the current in that wire and the magnetic field from the other wire with arrows. Show this on the diagram above.

(c) Calculate the magnitude of the total force on wire 2.

(d) Provide a numerical result **with correct SI units** for the case that I1=I2=1A, h=1 m, and W=0.5 m.