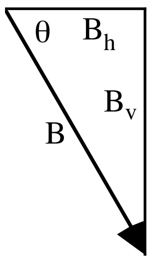
Name:_______________________________________

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. An electron is traveling northward at $3.20\text{x}10^6$m/s near Chico where the magnetic field of Earth is northward and has a magnitude of 52.0μT at 62° below the horizontal. (a)Find the horizontal component of the field and (b)the vertical component of the field. (c)Find the magnitude and direction of the force exerted on the electron by the horizontal component of the field and (d)the vertical component of the field.



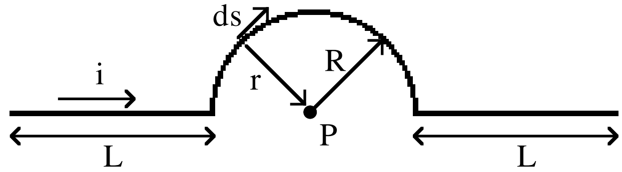
(a)Taking the vector components, $B_h = B\cos\theta = 52.0\cos 62° = \underline{\underline{24.4\mu T}}$

(b) and $B_v = B\sin\theta = 52.0\sin 62° = \underline{\underline{45.9\mu T}}$.

(c)The force on a moving charge is, $\vec{F} = q\vec{v}\times\vec{B}$ since the velocity is in the same direction as this component of the field, the force due to this component is <u>zero</u>.

(d)Again, the force on a moving charge is, $\vec{F} = q\vec{v}\times\vec{B}$. The right hand rule indicates that the force will be toward the <u>east</u>. Since the velocity and the field are perpendicular, the magnitude of the force is, $F = evB = (1.60\text{x}10^{-19})(3.20\text{x}10^{6})(45.9\text{x}10^{-6}) = \underline{\underline{2.35\text{x}10^{-17}\,N}}$.

2. The section of wire shown carries a current i. Find the magnetic field at the point P caused by (a)the segment of length L on the left, (b)the segment of length L on the right, (c)the semicircular arc of radius R and (d)the entire section of wire.



The key idea for this problem is the Biot-Savart Rule,

$$\vec{B} = \frac{\mu_o}{4\pi}\int \frac{I d\vec{s} \times \hat{r}}{r^2}.$$

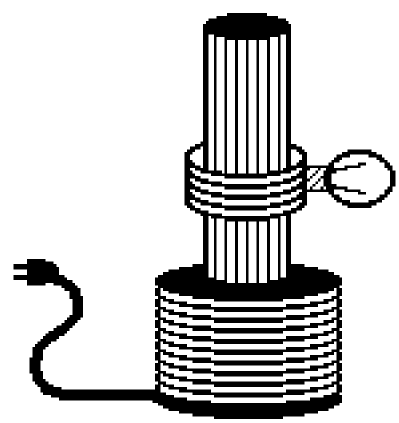
(a)Along this segment $d\vec{s}$ is parallel with $\hat{r}$, therefor the B-field at P due to this segment is zero.
(b)Along this segment $d\vec{s}$ is anti-parallel with $\hat{r}$, therefor the B-field at P due to this segment is also zero.
(c)Along the arc $d\vec{s}$ is perpendicular to $\hat{r}$, so the field points into the page at P. The magnitude of the field can be found because $|d\vec{s} \times \hat{r}| = (ds)(1)\sin 90° = ds$. Since the current and radius are constant, the Biot-Savart Rule yields,

$$B = \frac{\mu_o}{4\pi}\int \frac{ids}{R^2} = \frac{\mu_o i}{4\pi R^2}\int ds = \frac{\mu_o i}{4\pi R^2}\cdot \pi R = \underline{\underline{\frac{\mu_o i}{4R}}}$$

(d)The total field is just the sum of the fields from each of the segments,

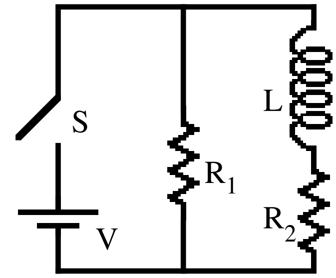
$$B = 0 + 0 + \frac{\mu_o i}{4R} = \underline{\underline{\frac{\mu_o i}{4R}}}$$

3. In the lab, you studied the behavior of a coil of wire wrapped around an iron core. The coil was connected to the wall current (110V at 60Hz). When the current was turned on in the coil, a small light bulb with its own smaller coil, also went on. Explain why the bulb lights.



This is an example of Faraday's Law. The current in the coil creates a magnetic field in the iron core. Since the current is changing this magnetic field is changing. The changing magnetic field through the smaller coil induces a voltage according to Faraday's Law. This voltage creates the current that lights the bulb.

4. Find the voltage across each resistor and the inductor (a)just after the switch S is closed and (b)after the switch S is closed for a very long time. Explain your reasoning.



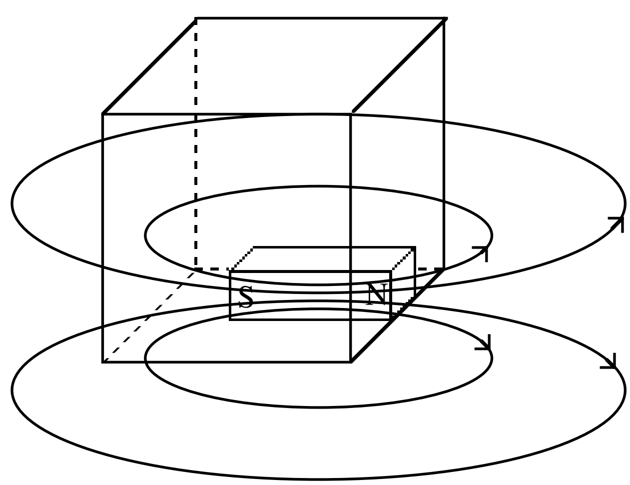
	just after	long after
R_1	V	V
R_2	0	V
L	V	0

When the switch is closed the voltage across both legs of the circuit must equal the battery voltage by the loop theorem. At all times then the voltage on R_1 must equal V and the voltage on L and R_2 must sum to V.

(a)The voltage across the inductor will be large because the current is changing rapidly just as the switch closes. The voltage across the inductor will be V leaving no voltage across R_2.

(b)Long after the switch has been closed, the current has reached equilibrium and is no longer changing. Therefor, the voltage on L will be zero and the voltage on the R_2 must be V.

5. A bar magnet rests with its north pole against the bottom right side of a cubical hat box that is 25.0cm on a side. The pole faces have an area of 1.00cm^2 and the field at the poles is 200mT. (a)Sketch the field of the magnet. Find (b)the net magnetic flux that leaves the right hand side of the magnet and (c)the net magnetic flux over the entire surface of the hat box.



(b)Using the definition of magnetic flux,

$$\Phi_B \equiv \int \vec{B} \bullet d\vec{A}.$$

Assuming that the field over the pole face of the magnet is constant and perpendicular to the face,

$$\Phi_B \equiv \int \vec{B} \bullet d\vec{A} = BA = (0.200)(1.00\text{x}10^{-4}) = \underline{\underline{2.00\text{x}10^{-5}\,\text{T}\cdot\text{m}^2}}.$$

(c)Treating the hat box as a Gaussian surface and applying Gauss's Law for Magnetism,

$$\oint \vec{B} \bullet d\vec{A} = 0 \Rightarrow \underline{\underline{\Phi = 0}}.$$