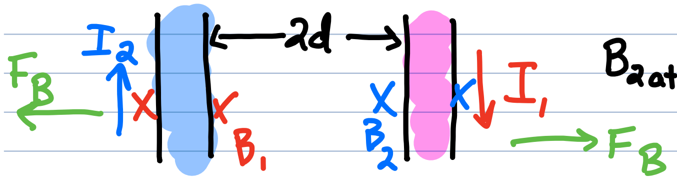


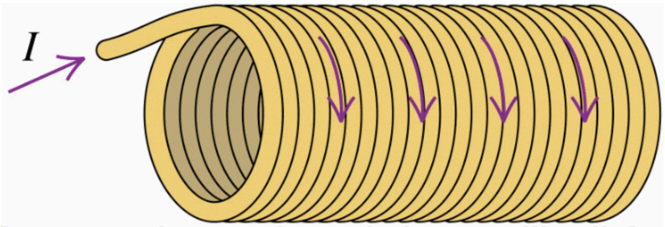
$$B_{2\text{ at wire }1} = \frac{\mu_0 I_2}{2\pi(2d)} \text{ into page}$$

$$B_{1\text{ at wire }2} = \frac{\mu_0 I_1}{2\pi(2d)} \text{ into page}$$

$$\vec{F}_B = I\vec{L}\times\vec{B} \rightarrow \vec{F}_{2on1} = I_1\vec{L}\times\vec{B}_2 = I_1 L B_2 \sin 90^\circ \hat{\imath} = I_1 L \frac{\mu_0 I_2}{2\pi 2d}\hat{\imath}$$

They repell! with an amplitude $\frac{4\pi\cdot10^{-7}}{2\pi}\frac{(10)(200)^2}{(2\cdot2)} = 0.02N$

compare to F_G : $mg = (\rho_{cu} L\pi r^2)g = (8.9\cdot10^3)(10)\pi(2\cdot10^{-2})^2 9.8 \sim 1000N$



If a current is sent through the metallic slinky, the coil will

[✓ a) contract to a shorter length.]
b) stretch to a longer length.
c) remain the same length.

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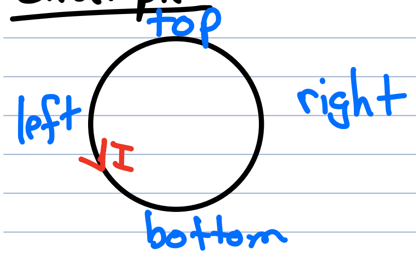
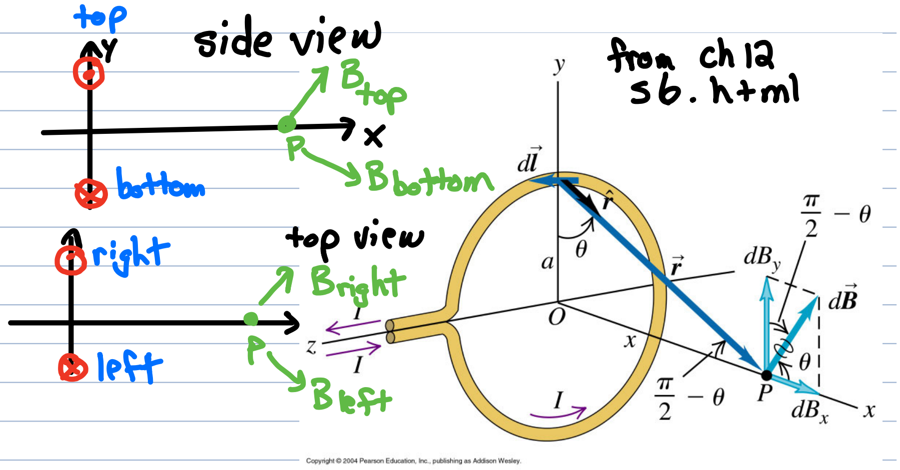
shrinks!

example





$$dB = \frac{\mu_0 I}{4\pi}\frac{d\vec{l}\times\hat{r}}{r^2} = \frac{\mu_0 I\, dl}{4\pi(x^2+a^2)}$$

$$dB_x = dB\cos\theta = dB\frac{a}{\sqrt{a^2+x^2}} \qquad \Sigma B_x \neq 0$$

$$dB_\perp = dB\sin\theta = dB\frac{x}{\sqrt{a^2+x^2}} \qquad \Sigma B_\perp = 0$$

$$B = B_x = \int dB_x = \frac{\mu_0 I}{4\pi}\int\frac{a\,dl}{(x^2+a^2)^{3/2}} = \frac{\mu_0 I a}{4\pi(x^2+a^2)^{3/2}}\overset{2\pi a}{\int dl}$$

→ B for a circular loop $\boxed{\frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}} \xrightarrow[x=0]{} \frac{\mu_0 I}{2a}$

Two loops have current flowing in the same direction. The loops

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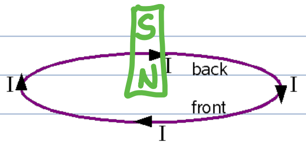
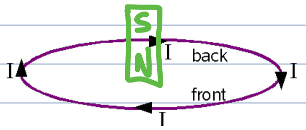
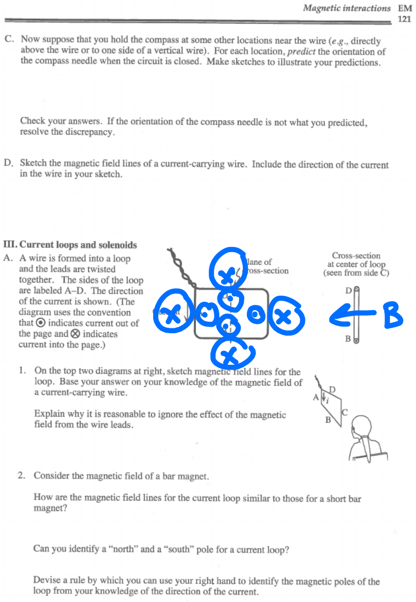
S2.html

a) repel.
[✓ b) attract]
c) do not interact.
d) exert torques on each other.
e) push each other sideways.





Please work on tutorials p. 121, 122, 123



C. Now suppose that you hold the compass at some other locations near the wire (*e.g.*, directly above the wire or to one side of a vertical wire). For each location, *predict* the orientation of the compass needle when the circuit is closed. Make sketches to illustrate your predictions.

Check your answers. If the orientation of the compass needle is not what you predicted, resolve the discrepancy.

D. Sketch the magnetic field lines of a current-carrying wire. Include the direction of the current in the wire in your sketch.

III. Current loops and solenoids

A. A wire is formed into a loop and the leads are twisted together. The sides of the loop are labeled A–D. The direction of the current is shown. (The diagram uses the convention that ⊙ indicates current out of the page and ⊗ indicates current into the page.)

1. On the top two diagrams at right, sketch magnetic field lines for the loop. Base your answer on your knowledge of the magnetic field of a current-carrying wire.

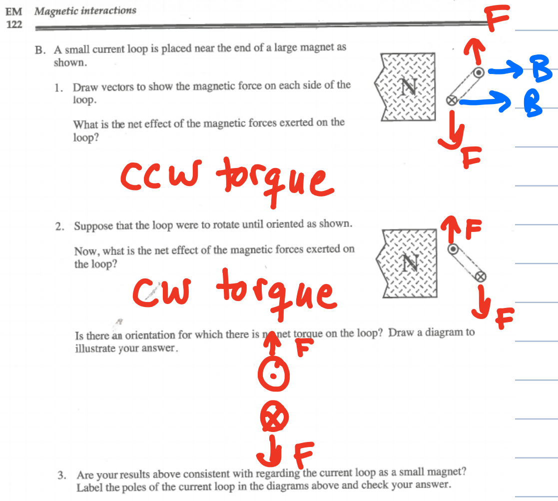
   Explain why it is reasonable to ignore the effect of the magnetic field from the wire leads.

2. Consider the magnetic field of a bar magnet.

   How are the magnetic field lines for the current loop similar to those for a short bar magnet?

   Can you identify a "north" and a "south" pole for a current loop?

   Devise a rule by which you can use your right hand to identify the magnetic poles of the loop from your knowledge of the direction of the current.



B. A small current loop is placed near the end of a large magnet as shown.

1. Draw vectors to show the magnetic force on each side of the loop.

   What is the net effect of the magnetic forces exerted on the loop?

   ccw torque

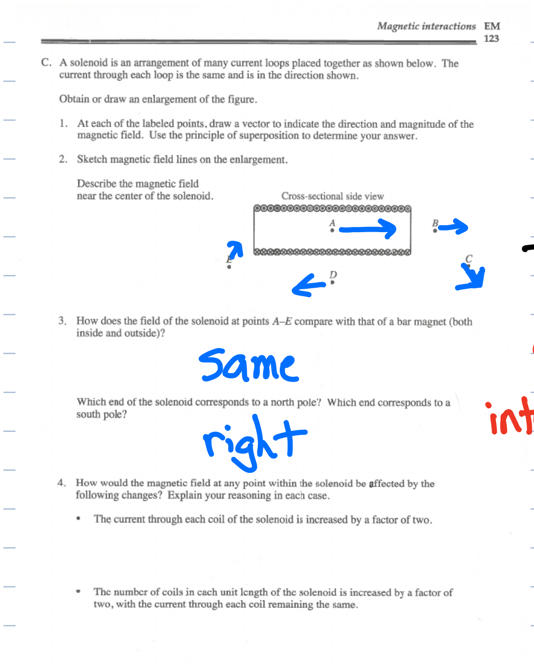
2. Suppose that the loop were to rotate until oriented as shown.

   Now, what is the net effect of the magnetic forces exerted on the loop?

   cw torque

   Is there an orientation for which there is no net torque on the loop? Draw a diagram to illustrate your answer.

3. Are your results above consistent with regarding the current loop as a small magnet? Label the poles of the current loop in the diagrams above and check your answer.



C. A solenoid is an arrangement of many current loops placed together as shown below. The current through each loop is the same and is in the direction shown.

Obtain or draw an enlargement of the figure.

1. At each of the labeled points, draw a vector to indicate the direction and magnitude of the magnetic field. Use the principle of superposition to determine your answer.

2. Sketch magnetic field lines on the enlargement.

   Describe the magnetic field near the center of the solenoid.

Cross-sectional side view

3. How does the field of the solenoid at points *A–E* compare with that of a bar magnet (both inside and outside)?

   same

   Which end of the solenoid corresponds to a north pole? Which end corresponds to a south pole?

   right

4. How would the magnetic field at any point within the solenoid be affected by the following changes? Explain your reasoning in each case.

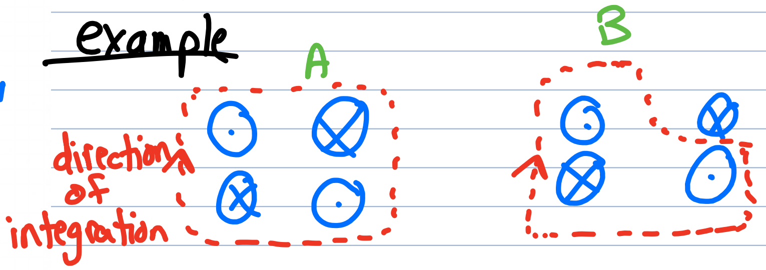
   - The current through each coil of the solenoid is increased by a factor of two.

   - The number of coils in each unit length of the solenoid is increased by a factor of two, with the current through each coil remaining the same.

Ampere's Law

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enclosed}$$

example



4 long parallel conductors, each carrying 2A.

A) $I_{enclosed} = 0$

B) $I_{enclosed} = -I + I - I = -2A$

$\rightarrow \oint \vec{B}\cdot d\vec{l} = \mu_0(-2A)$