Ch 12 Concept Q #3 The outermost loops on each end get attracted to their single neighboring loops. But every other loop is attracted to both the loop to its left and to its right. ⇒ answers A and C ok!

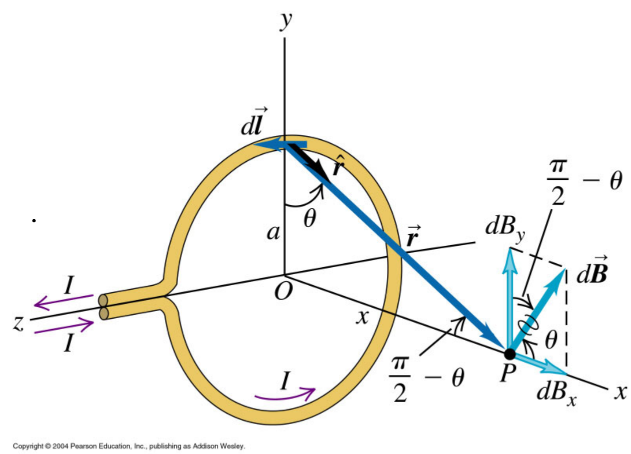
Magnetic field of a circular loop

$dB = \frac{\mu_0 I}{4\pi} \frac{|d\vec{l} \times \hat{r}|}{r^2}$

$= \frac{\mu_0 I \, dl}{4\pi (x^2+a^2)}$

$dB_x = dB \cos\theta = dB \frac{a}{\sqrt{x^2+a^2}}$

$dB_y = dB \sin\theta = dB \frac{x}{\sqrt{x^2+a^2}}$



$\Sigma B_y = 0$ by symmetry

$B_{tot} = B_{x\,tot} = \int dB_x = \frac{\mu_0 I}{4\pi} \int \frac{a \, dl}{(x^2+a^2)^{3/2}} = \frac{\mu_0 I}{4\pi} \frac{a}{(x^2+a^2)^{3/2}} \int dl$ → $L = 2\pi a$

$B = \frac{\mu_0 I a^2}{2(x^2+a^2)^{3/2}}$

at the center of a loop, $B = \frac{\mu_0 I}{2a}$ $(x=0)$ ~~For circuits students, just saying 0 good enough~~

Far, far away

$B \xrightarrow[x \gg a]{} \frac{\mu_0 I a^2}{2x^3}$ $\qquad B \xrightarrow[x \gg a]{} \frac{\mu_0 I a^2}{2x^3 \left(1+\frac{a^2}{x^2}\right)^{3/2}}$

Concept Q Ch 12/52.html

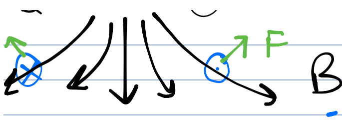
Approach #1 → imagine bar magnets created

⊗ [S/N] ⊙

⊗ [S/N] ⊙

Approach #2 → $I\vec{L} \times \vec{B}$ etc

⊗ ⊙



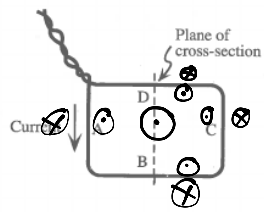
C. Now suppose that you hold the compass at some other locations near the wire (*e.g.*, directly above the wire or to one side of a vertical wire). For each location, *predict* the orientation of the compass needle when the circuit is closed. Make sketches to illustrate your predictions.

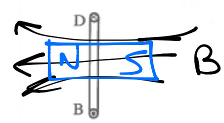
Check your answers. If the orientation of the compass needle is not what you predicted, resolve the discrepancy.

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.)

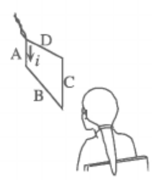




1. On the top two diagrams at right, sketch magnetic field lines for the loop. Base your answer on your knowledge of the magnetic field of a current-carrying wire.

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

   They cancel!



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?

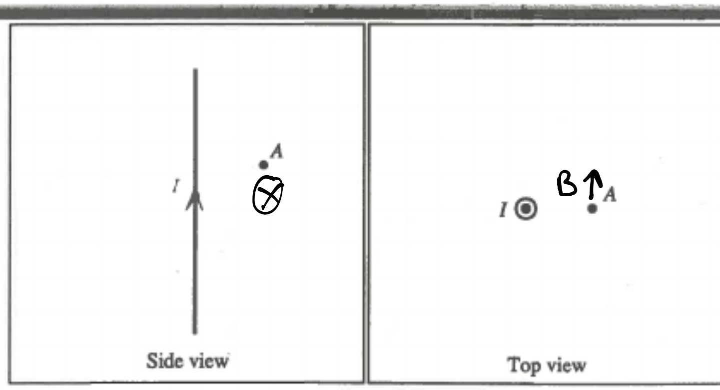
   Devise a rule by which you can use your right hand to identify the magnetic poles of the loop from your knowledge of the direction of the current.

Pretest: Magnetic interactions

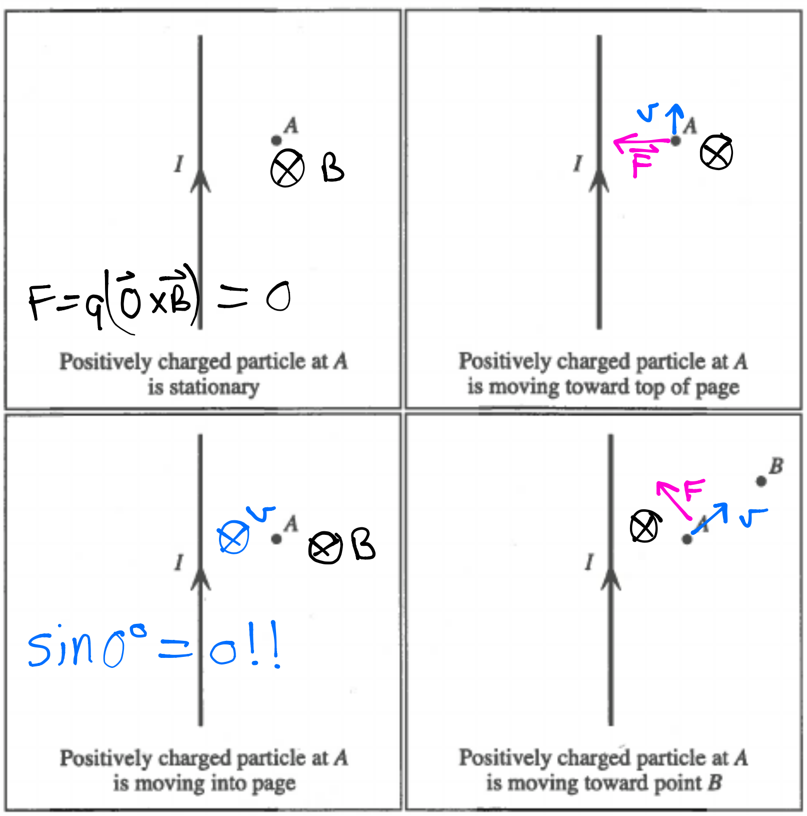
Name ______________

1. The diagrams at right show a long, straight wire through which there is a current I. (Both a side view and a top view of the wire are shown.)

   Indicate the direction of the magnetic field at point A on both views of the wire.



2. A positively charged particle is located near a current-carrying wire. Determine the direction of the magnetic force on the particle if it is moving as described in each of the four diagrams below. If the magnetic force on the particle has zero magnitude, indicate that explicitly.

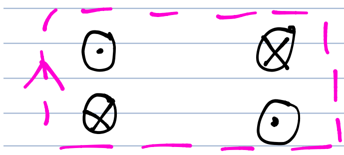


Ampere's Law

Magnetic equivalent to Gauss' Law $\oint \vec{B} \cdot \vec{dl} = \mu_0 I_{enclosed}$

→ many time a shortcut to otherwise-nasty calculus

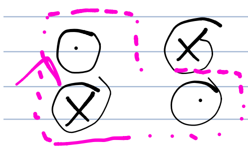
example



4 long parallel wires, each carrying 2 A

$I_{enclosed} = 0 \rightarrow \oint \vec{B} \cdot \vec{dl} = 0$

example



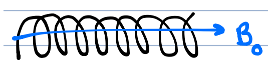
$I_{enclosed} = -I + I - I = -I = -2A$

$\rightarrow \oint \vec{B} \cdot \vec{dl} = \mu_0(-2A) = -2.5 \cdot 10^{-6}$ T·m

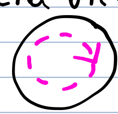
example

A long solenoid has n=100 turns per centimeter and carries current I. An electro moves within the solenoid, along a circular path of R=2.30 cm and with speed v=1.4e7 m/s. What is I?

side view



end view



cut view (cross-section)