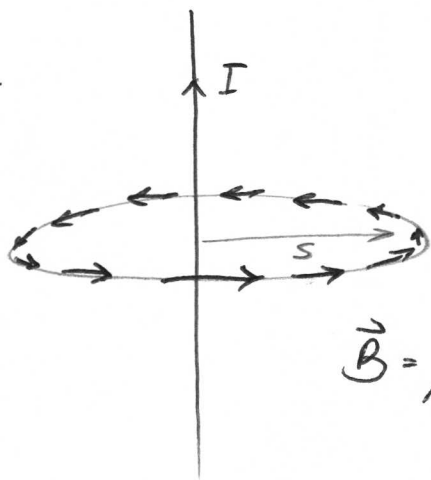


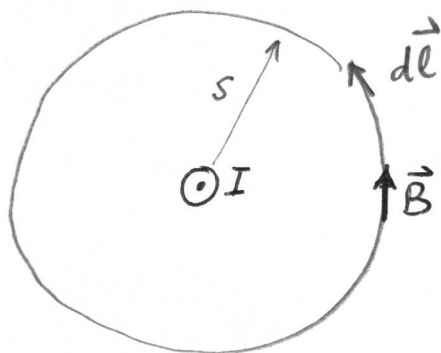
Last time



$$\vec{B} = \frac{\mu_0 I}{2\pi s} \hat{\phi}$$

derived the long way.

## THE AMPERE'S LAW SHORT CUT



On the circle, notice that

$$d\vec{l} \parallel \vec{B}$$

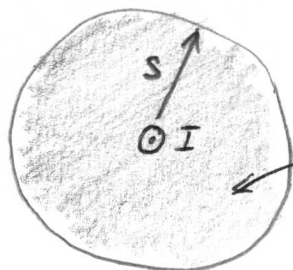
and  $|\vec{B}|$  is constant.

Consider the closed loop integration

$$\oint \vec{B} \cdot d\vec{l} = 2\pi s B$$

and recall the diff. eqn that governs magnetostatics

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$



LHS & RHS  
Integrate over the area enclosed  
by the circle

$$\int \vec{\nabla} \times \vec{B} \cdot d\vec{a} = \int \mu_0 \vec{J} \cdot d\vec{a}$$

Apply Stokes's thm.

②

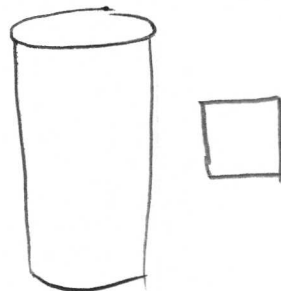
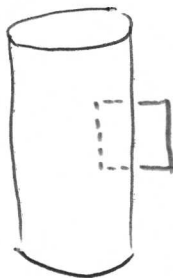
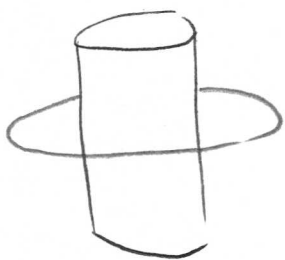
$$\oint_{\text{around loop}} \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enclosed by loop}}$$

Ampere's Law

By combining Ampere's Law with symmetry arguments, you can solve a handful of magnetostatics problems without resorting to Biot Savart law.

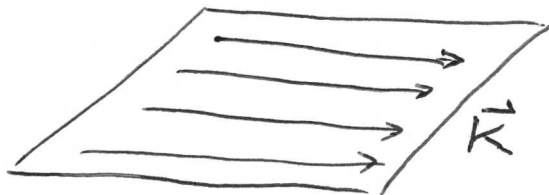
Hint for pop quiz solenoid geometry

- $B \rightarrow 0$  far away from solenoid
- Consider several different Ampere loops



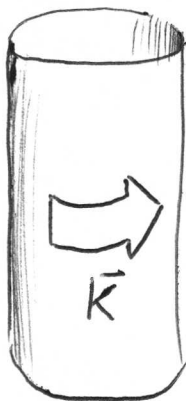
Choose one of the three cases below. Use symmetry arguments and Ampere's Law to find  $\vec{B}$  everywhere. ~~without~~

I



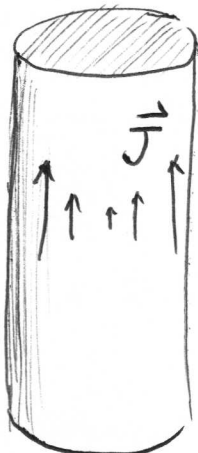
Infinite sheet of current

II



Infinitely long solenoid

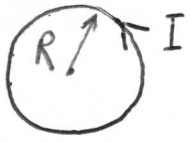
III



$$\vec{J} = ks^2 \hat{z} \quad \text{when } s < R$$

Infinitely long wire.  
Finite radius.

# LOOPS OF CURRENT

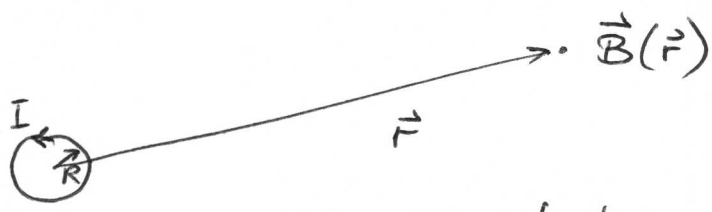


The simplest finite-sized magnetostatic object

(You can't have any isolated "dot" of current that stays in ~~one~~ one place, since current is a flow of charge. ~~A~~ A loop of current is the closest we can get).

Current loops are the building block for understanding magnetic materials: Electrons travel in circles around the nucleus and spin about their own axes.

If  $R$  is very small (like it is for an atom) then most of space is considered "far field",  $|\vec{r}| \gg R$ .



Our task: Calculate  $\vec{B}(\vec{r})$  in the far-field.