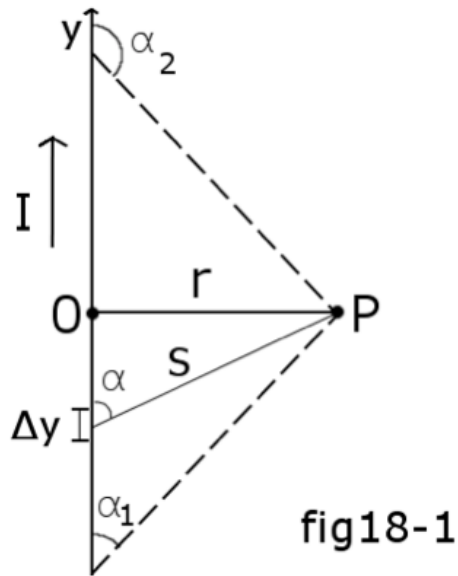


Lecture 19 Biot-Savart Law Application II

A long wire. Find B at P



Dir: $\hat{n}$ along $I\Delta\vec{l} \times \vec{r}$

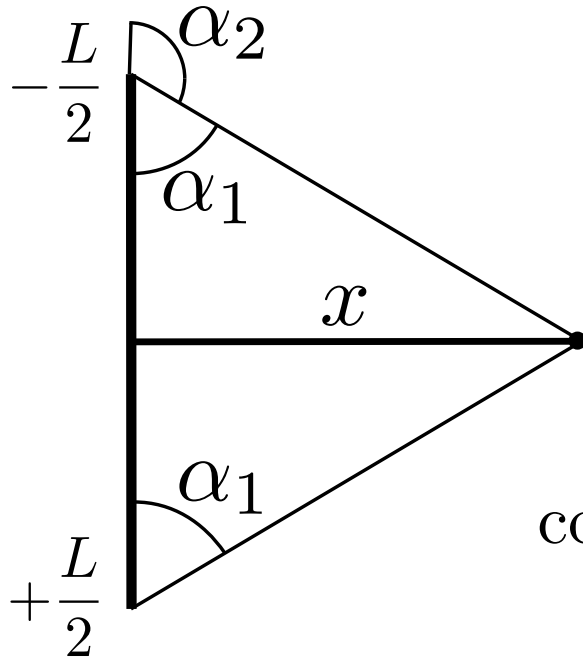
$$I\Delta\vec{l} \times \vec{r}: \otimes$$

$$\text{Mag: } \Delta B_P^{I\Delta y} : \Delta B = \frac{\mu_0}{4\pi} \cdot \frac{I\Delta y}{r^2} \sin \alpha$$

$$\text{Recall a math identity: } \frac{\Delta y}{r^2} = \frac{\Delta \alpha}{x}$$

$$\begin{aligned} B &= \frac{\mu_0 I}{4\pi} \int_{\alpha_1}^{\alpha_2} \frac{d\alpha}{x} \sin \alpha \\ &= \frac{\mu_0 I}{4\pi x} (-\cos \alpha) \Big|_{\alpha_1}^{\alpha_2} \\ &= \frac{\mu_0 I}{4\pi x} [\cos \alpha_1 - \cos \alpha_2] \end{aligned}$$

The textbook case – symmetric rod $y = -\frac{L}{2}$ to $+\frac{L}{2}$



$$\cos \alpha_1 - \cos \alpha_2 = 2 \cos \alpha_1 = \frac{2 \times \frac{L}{2}}{\sqrt{x^2 + \left(\frac{L}{2}\right)^2}}$$

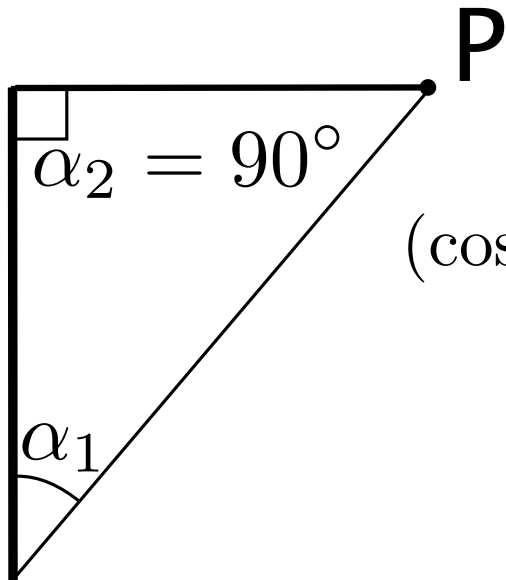
(see pg 721 in textbook last equation)

$$B = \frac{\mu_0 I}{4\pi x} \cdot \frac{L}{\sqrt{x^2 + \left(\frac{L}{2}\right)^2}}$$

Long wire case: $x \ll \frac{L}{2}$

$$B = \frac{\mu_0 I}{4\pi x} \cdot \frac{L}{\left(\frac{L}{2}\right)} = \frac{\mu_0 I}{2\pi x}$$

Semi-long case:



$$(\cos \alpha_1 - \cos \alpha_2) \rightarrow (\cos 0^\circ - \cos 90^\circ) = 1$$

$$B = \frac{\mu_0 I}{4\pi x}$$

3 RHRs

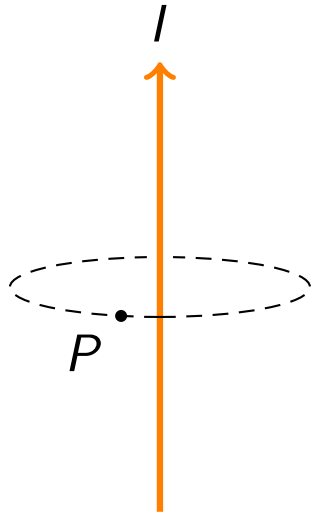
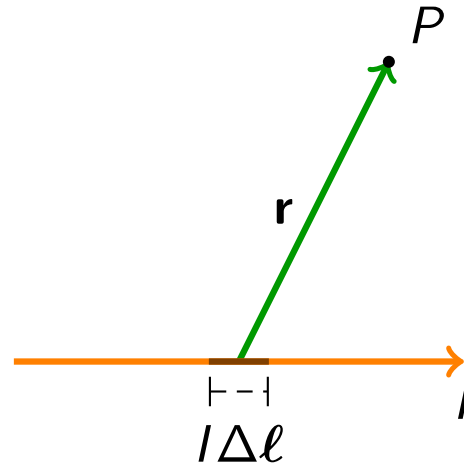
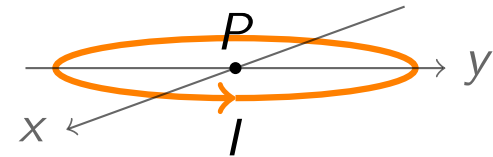
Dir of $\vec{B}$ due to a long wire

Dir of $\vec{B}$ in $I\Delta\vec{l} \times \hat{r}$

Dir of $\vec{B}$ along the symmetry axis of a current loop

Fig(clicker) 17-4

Lec17-4 The 3 Right Hand Rules



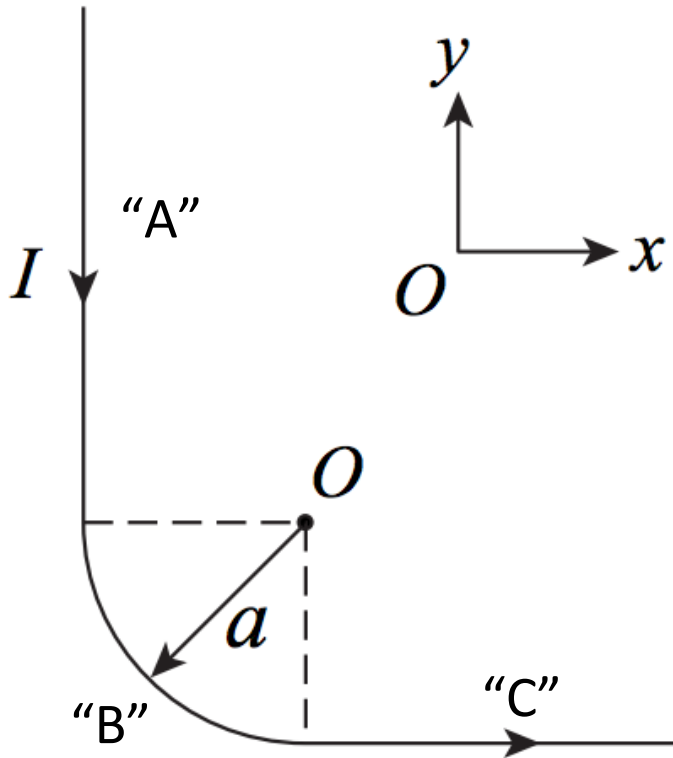
Choice	B at P (RHR1)	B at P (RHR2)	B at P (RHR3)
1	CW	Out	Up
2	CCW	Out	Up
3	CCW	Out	Down
4	CCW	Into	Up

CW = clockwise, CCW = counter-clockwise

View from top

Comments on Ch18-02 003-004

Curved wire segment



Superposition Principal

$$\vec{B}_O = \vec{B}_O^A + \vec{B}_O^B + \vec{B}_O^C$$

Check direction of B contributed by each segment is in the same direction, so vectors are reduced to simple addition.

$\alpha_2 = 90^\circ$, so "A" is a semi-long segment

Lec18-2 Magnetic field due a current ring

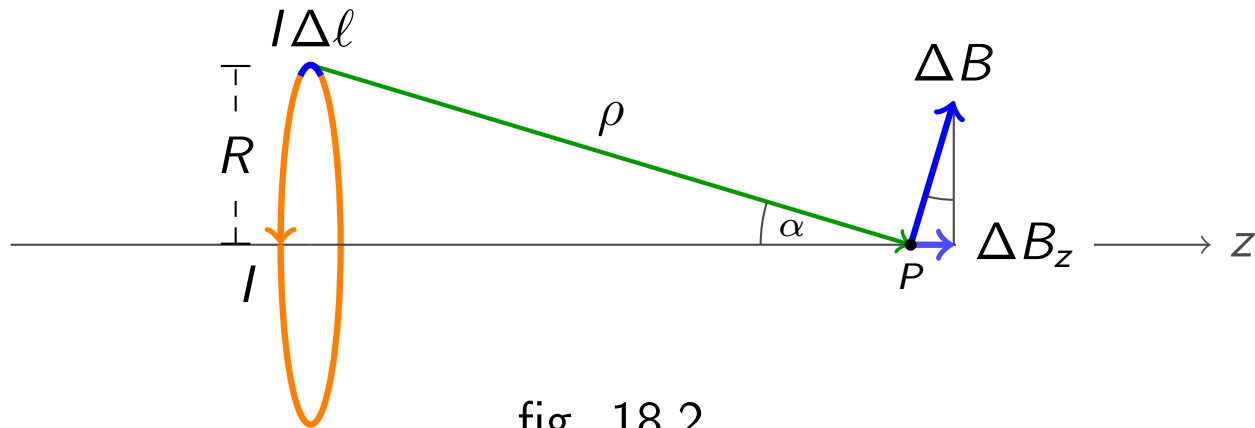


fig. 18.2

$$\Delta B = \frac{\mu_0}{4\pi} \frac{I\Delta\ell \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi} \frac{I\Delta\ell}{\rho^2}$$

Fig18-2 shows the vector ΔB for the top current segment $I\Delta\ell$; ΔB has both a perpendicular component and a z -component. By cylindrical symmetry, the ring produces only the z -component.

$$B_z = B \sin \alpha = \frac{\mu_0}{4\pi} \frac{I2\pi R}{\rho^2} \sin \alpha \quad (1)$$

If the loop is represented by a dipole moment, for large z :

$$B_z \rightarrow \frac{\mu_0}{4\pi} \frac{2\mu_{loop}}{z^3} \quad (2)$$

Determine μ_{loop} . Hint: for large z : $\rho \rightarrow z$. $\sin \alpha = R/\rho$

Choice	μ_{loop}
1	$I\pi R^2$
2	$I2\pi R^2$
3	$I4\pi R^2$

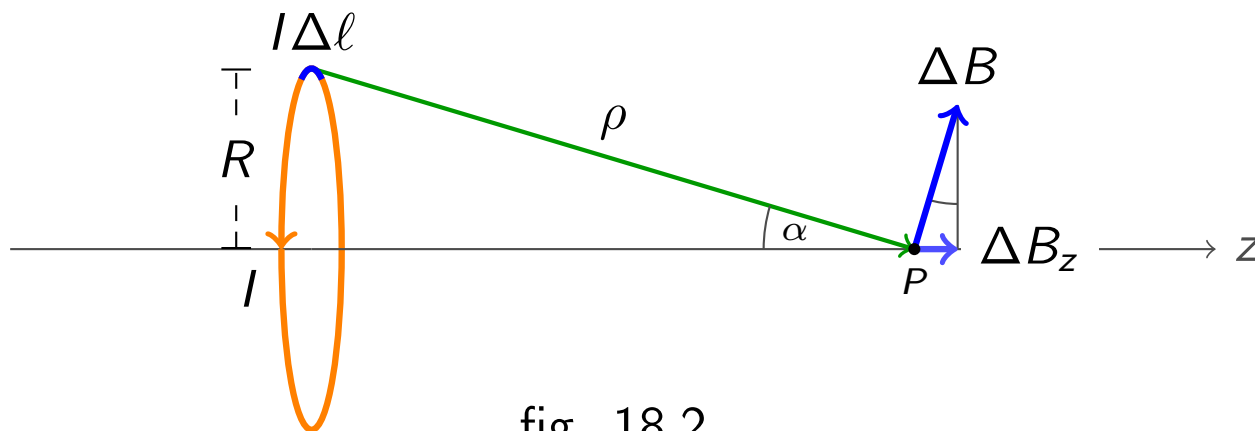


fig. 18.2