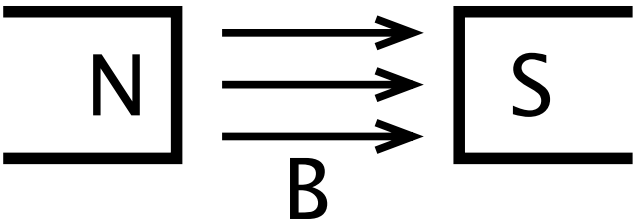
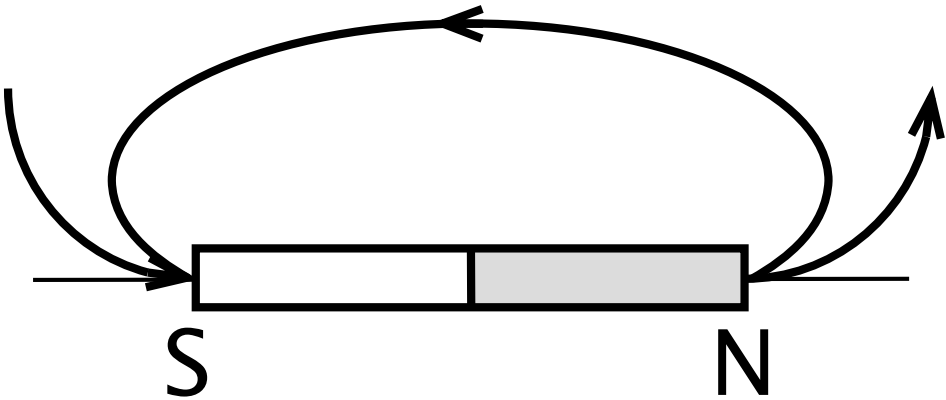
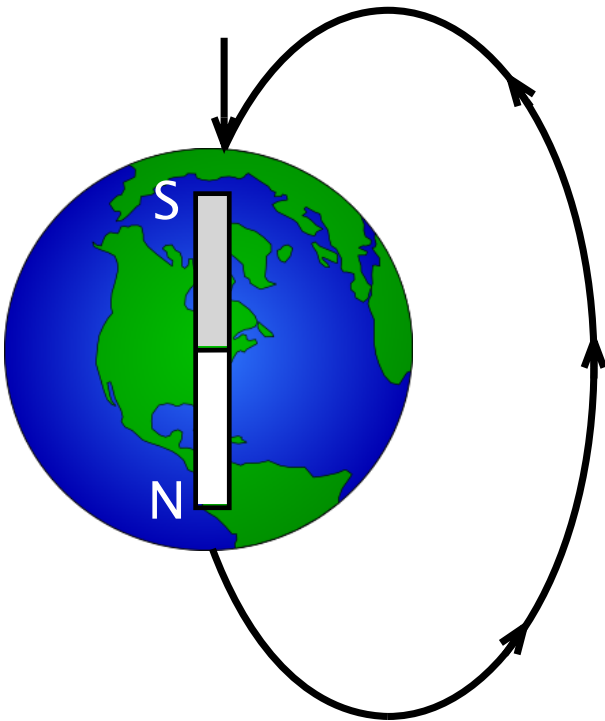
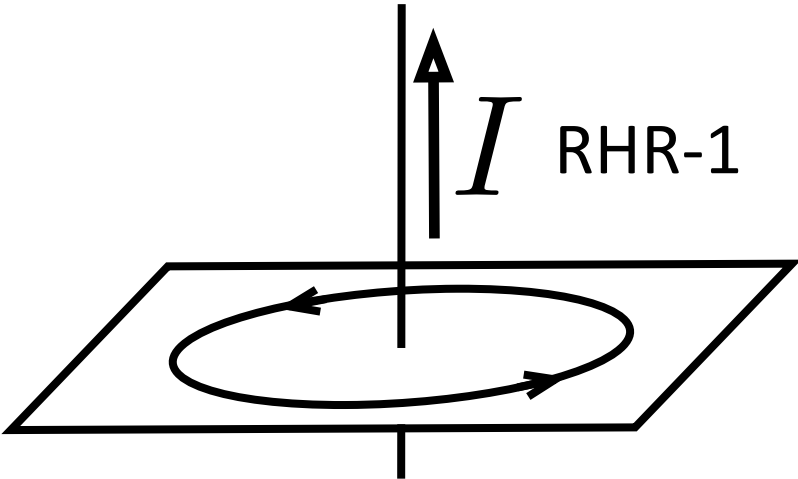


Lecture 18

Magnetic field patterns and compass needle



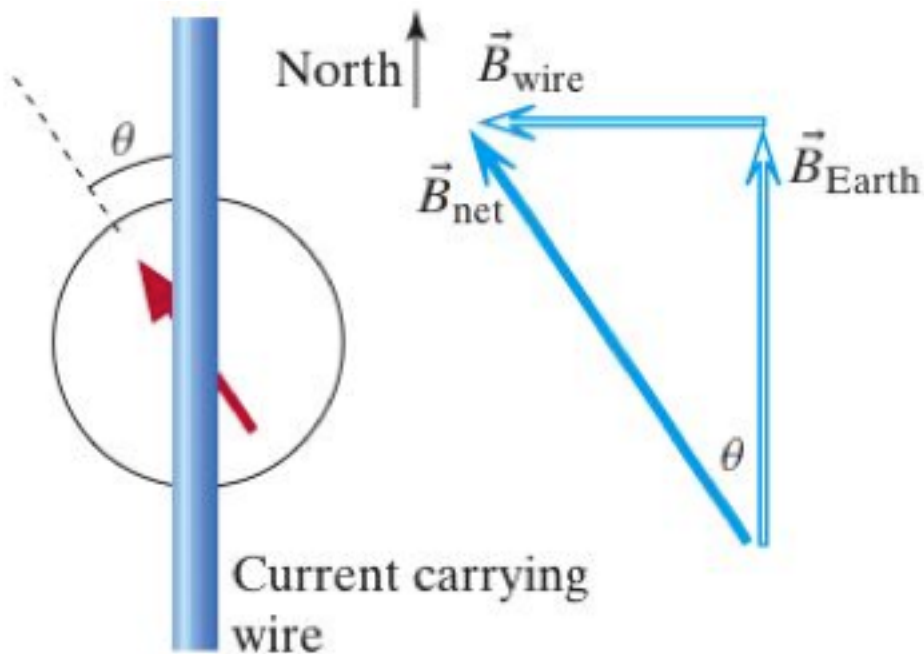
Demo:



Measurement of B_I



Figure 18.1 A compass needle points in the direction of the net magnetic field at its location.



$$\tan \theta = \frac{B_I}{B_{earth}}$$

Fig(clicker) 18-1

Given: $\mathbf{A} = \langle 2, 1, 0 \rangle$, $\mathbf{B} = \langle 1, 1, 0 \rangle$.

Vector product (or cross product): $\mathbf{C} = \mathbf{A} \times \mathbf{B} = AB \sin \alpha$

Determine $\mathbf{C}$ based on the 3x3 matrix method.

a. Find C and $\hat{\mathbf{C}}$

Choice	$C = \mathbf{C} $	$\hat{\mathbf{C}}$
1	1	$\hat{k}$
2	1	$\hat{j}$
3	3	$\hat{k}$
4	3	$\hat{j}$

b. Determine the sine factor

Choice	$\sin \alpha$
1	$\frac{1}{\sqrt{10}}$
2	$\frac{1}{\sqrt{5}}$

The Biot-Savart law and Biot-Savart application-I

Measurement of magnetic field by a compass needle

A long, current-carrying wire generates a magnetic field B_{wire} . A compass is placed beneath the wire.

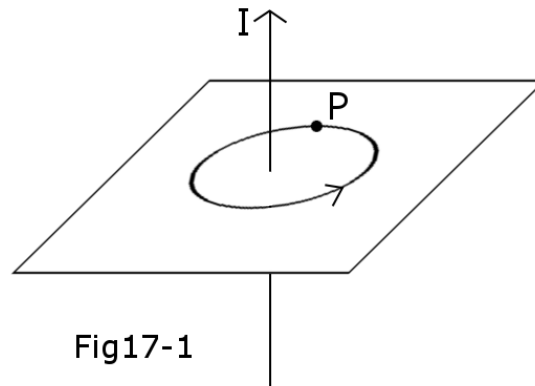
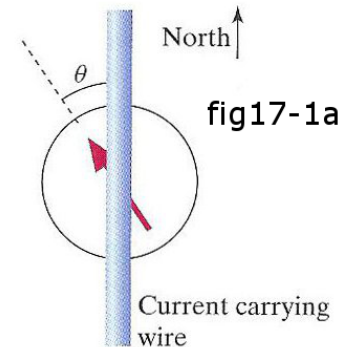


Fig17-1



The direction of B_{wire} , as determined by RHR, is shown in the left image. In the right image, the Earth's magnetic field points North, but B_{wire} deflects the compass needle through an angle θ . Determine the magnitude of the magnetic field at the compass:

Choice	B_{wire} at compass
1	$B_{earth} \sin \theta$
2	$B_{earth} \cos \theta$
3	$B_{earth} \tan \theta$
4	$B_{earth} \cot \theta$

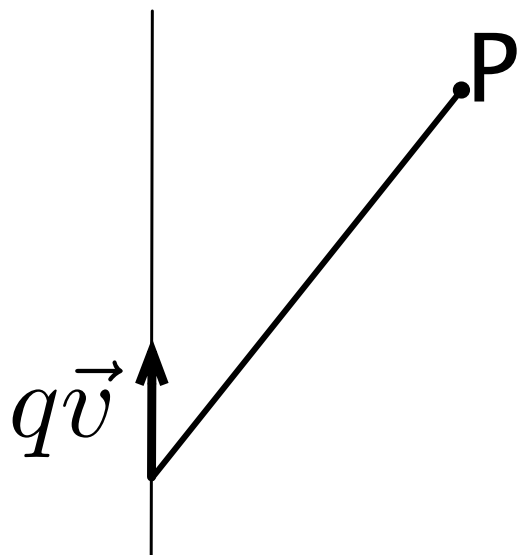
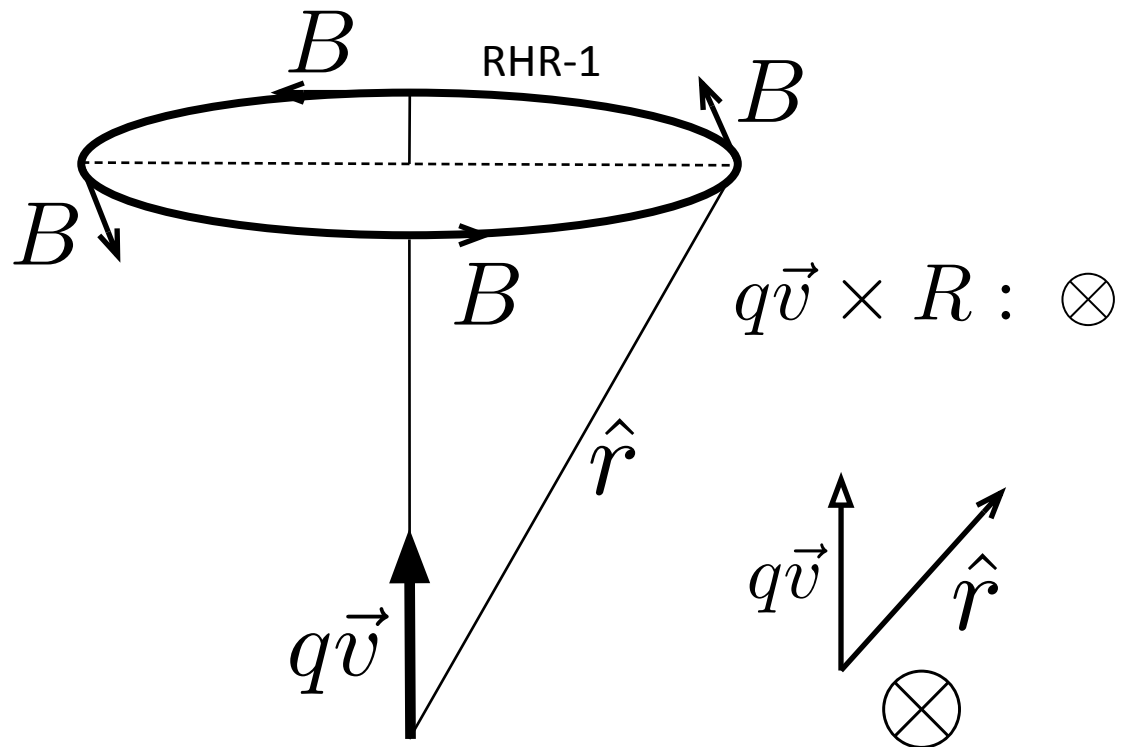
point source

fields

$$q \quad \vec{E} = \frac{kq}{r^2} \hat{r}$$

$$qv \quad \vec{B} = \left(\frac{\mu_0}{4\pi} \right) \frac{q\vec{v} \times \hat{r}}{r^2}$$

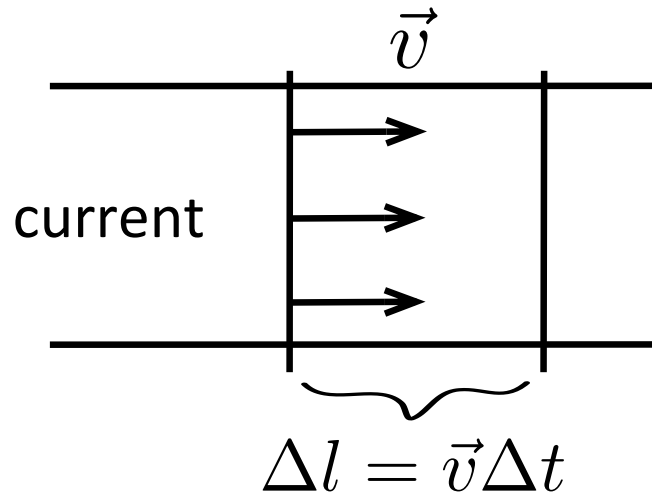
$$qa \quad \text{Radiative Fields} \rightarrow \vec{E}_{rad}, \vec{B}_{rad}$$



	source	Magnetic field
Biot-Savart Law	$I \Delta l$	$\Delta \vec{B} = \left(\frac{\mu_0}{4\pi} \right) \frac{I \Delta \vec{l} \times \hat{r}}{r^2}$

Drift Velocity

over time interval Δt



$$\Delta N q \vec{v} = \Delta N q \frac{\Delta l}{\Delta t} = \left(\frac{\Delta N q}{\Delta t} \right) \Delta l = I \Delta l$$

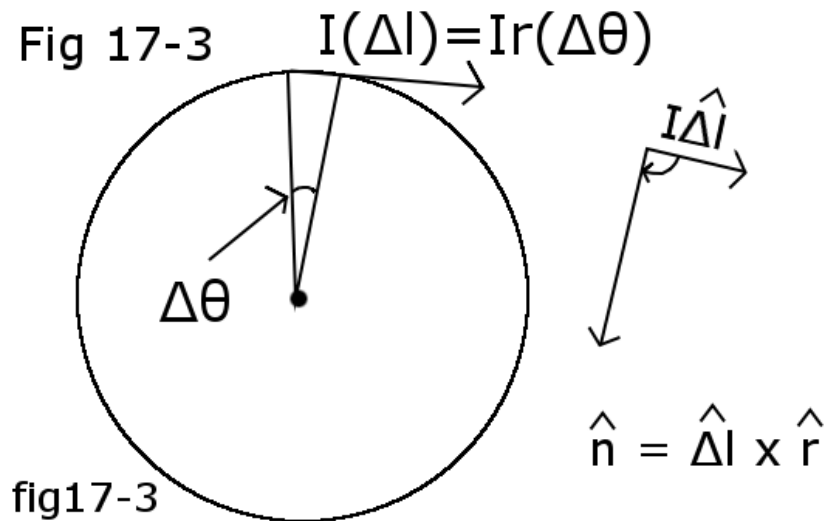
$$\frac{\mu_0}{4\pi} = 1 \times 10^{-7} \text{ SI units}$$

From Biot-Savart Law: $\frac{\mu_0}{4\pi}$ in units of $\frac{\text{Tesla } m^2}{\text{Amp m}} = \frac{\text{Tm}}{\text{A}}$.

From Coulomb's Law: $k = \frac{1}{4\pi\epsilon_0}$ in units of $\frac{Nm^2}{C^2}$.

Cross product in Biot-Savart Law

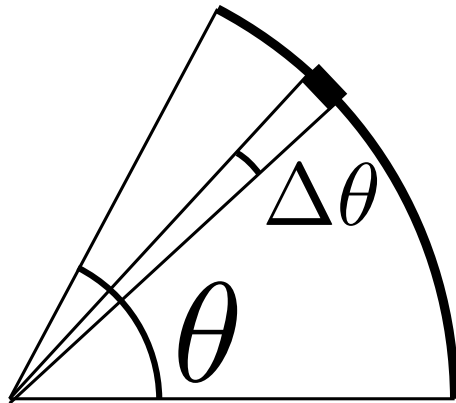
Analyze the magnetic field at the center of a current-carrying circular arc, given that the current flows in a clockwise direction.



$$\Delta B = \frac{\mu_0}{4\pi} \frac{I \Delta \ell \times \hat{r}}{r^2} = \frac{\mu_0}{4\pi} \frac{I \Delta \theta}{r} \sin \alpha \hat{n}, \quad \hat{n} = \Delta \hat{\ell} \times \hat{r}, \quad \text{and} \quad \Delta \ell = r \Delta \theta$$

Choice	$\sin \alpha$	$\hat{n}$
1	< 1	Into
2	< 1	Out
3	1	Into
4	1	Out

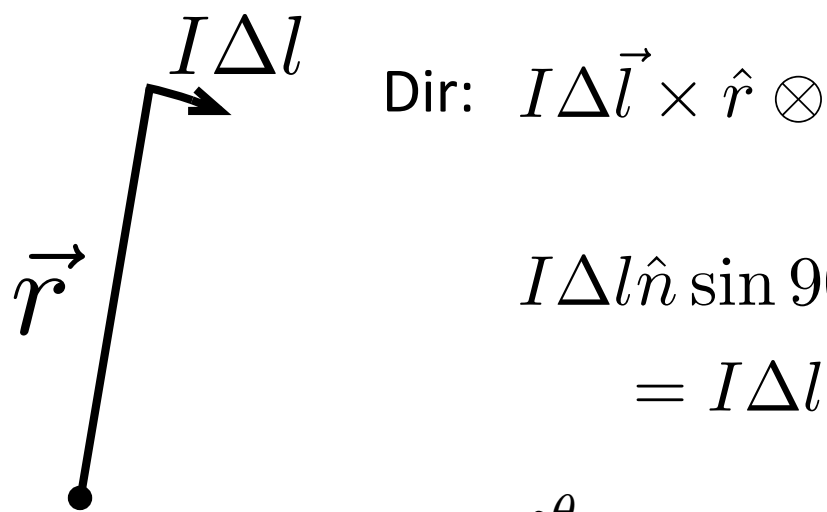
Circular Arc



Given: I, R, θ

Find: B at O

$$\Delta \vec{B} = \left(\frac{\mu_0}{4\pi} \right) \frac{I \Delta \vec{l} \times \hat{r}}{r^2}$$



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

$$I \Delta l \hat{n} \sin 90^\circ = I \Delta l \otimes$$

$$\Delta B = \frac{\mu_0}{4\pi} \frac{I \Delta l}{r^2}$$

$$B_\theta = \int_0^\theta \Delta B = \frac{\mu_0}{4\pi} \frac{I r \Delta \theta|_0^\theta}{r^2} = \frac{\mu_0}{4\pi} \frac{I \theta}{r}$$

$$\text{loop } \theta = 2\pi \qquad B_{loop} = \frac{\mu_0 I}{2r}$$