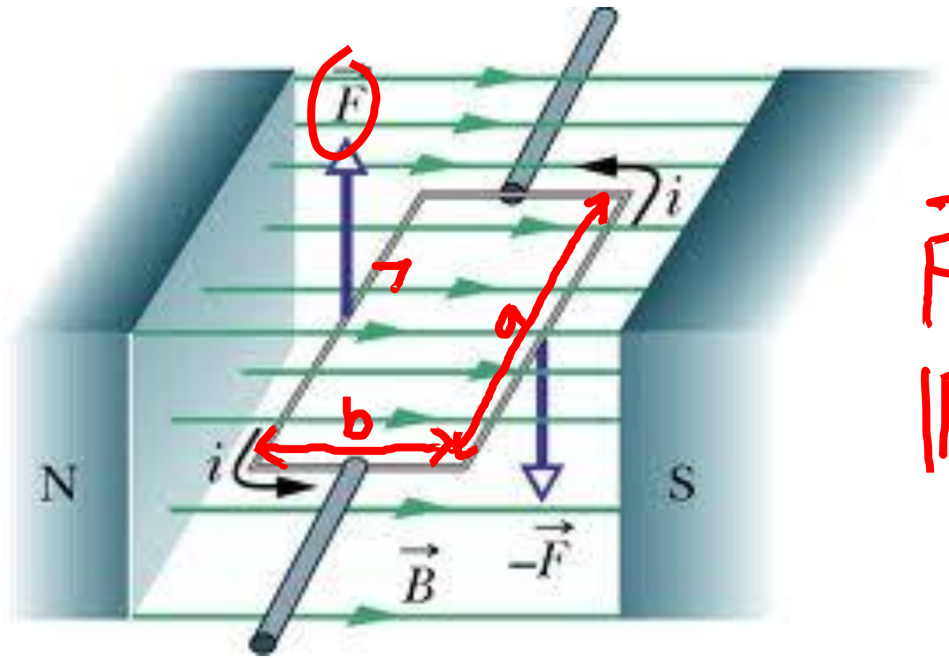
Current Loop in B field

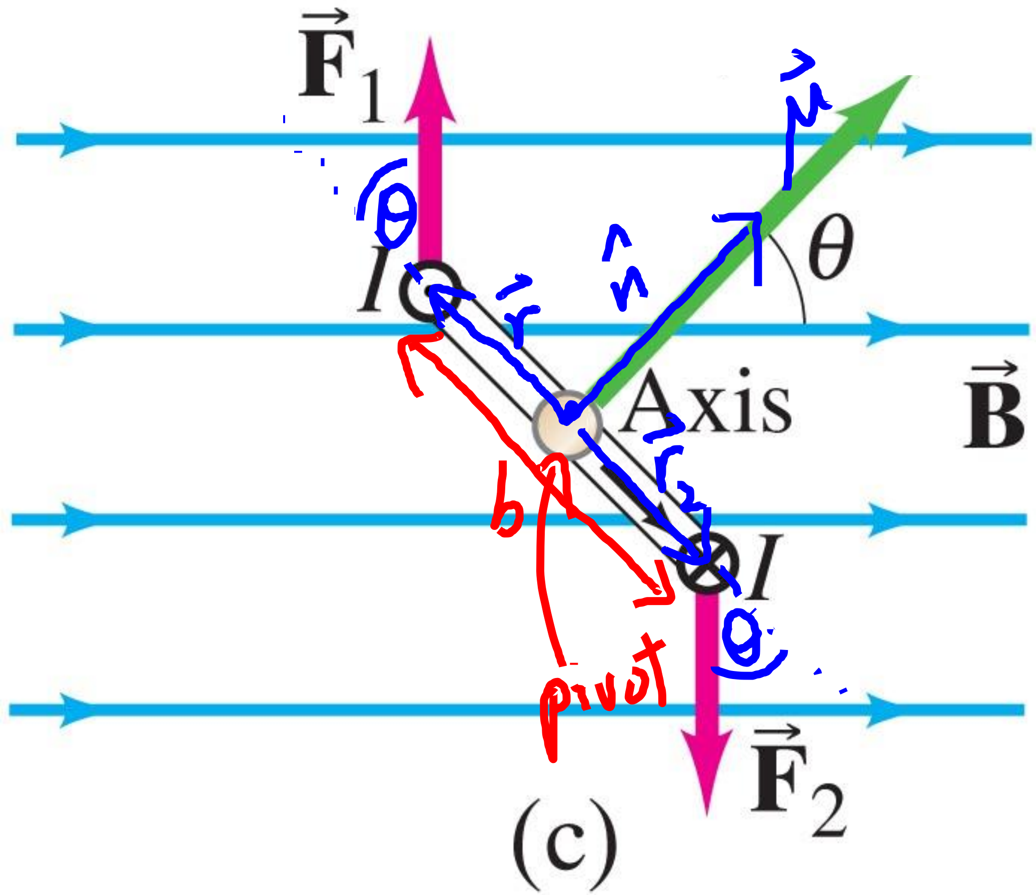


$$\vec{F} = I\, d\vec{l} \times \vec{B}$$

$$|F| = I\, dl\, B \sin\theta$$

$$= I a B$$

http://helios.augustana.edu/~dr/203/img/F28_20.jpg



$$|\tau_1| = |F_1||r|\sin\theta$$
$$= IaB\,\frac{b}{2}\sin\theta$$

$$|\tau_2| = |F_2||r_2|\sin\theta$$
$$= IaB\,\frac{b}{2}\sin\theta$$

$$\tau_{tot} = IaBb\sin\theta$$
$$= I\underbrace{(ab)}_{A}B\sin\theta$$
$$= IAB\sin\theta$$

$$\tau = \mu B\sin\theta$$

$$\vec{\tau} = \vec{\mu}\times\vec{B}$$

$$\vec{\mu} = IA\hat{n}$$

Figure 27.22c

Magnetic Fields Produced by Currents

- Right-hand Rule #2 – Thumb in direction of I. Fingers curl in direction of B.
- Principle of Superposition – Total field is the vector sum of the fields from all sources.

A wire carries an electric current straight upward. What is the direction of the magnetic field due to the current north of the wire?

1) north
2) east
3) west
4) south
5) upward

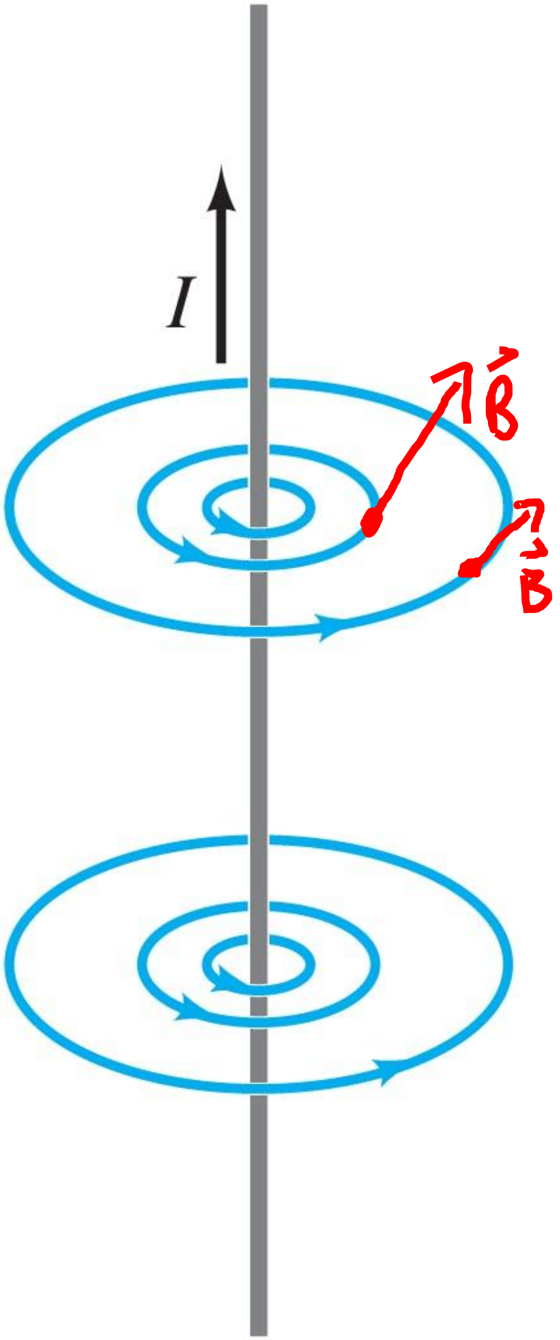
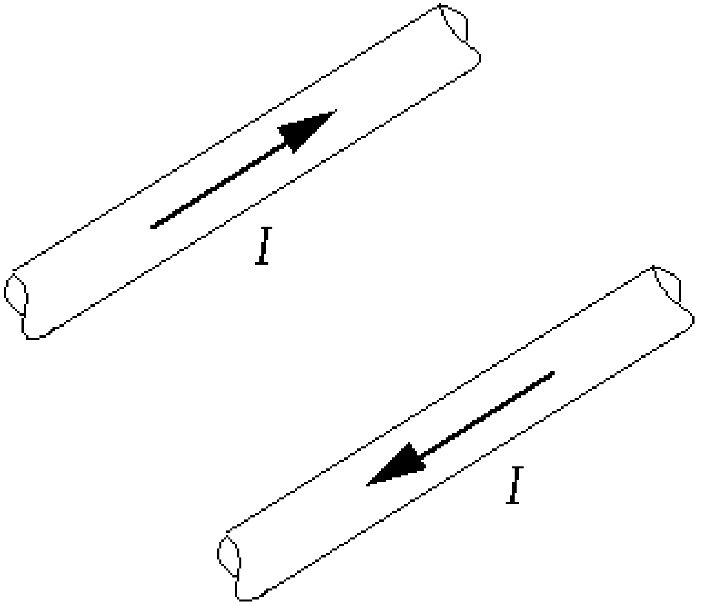


Figure 28.1

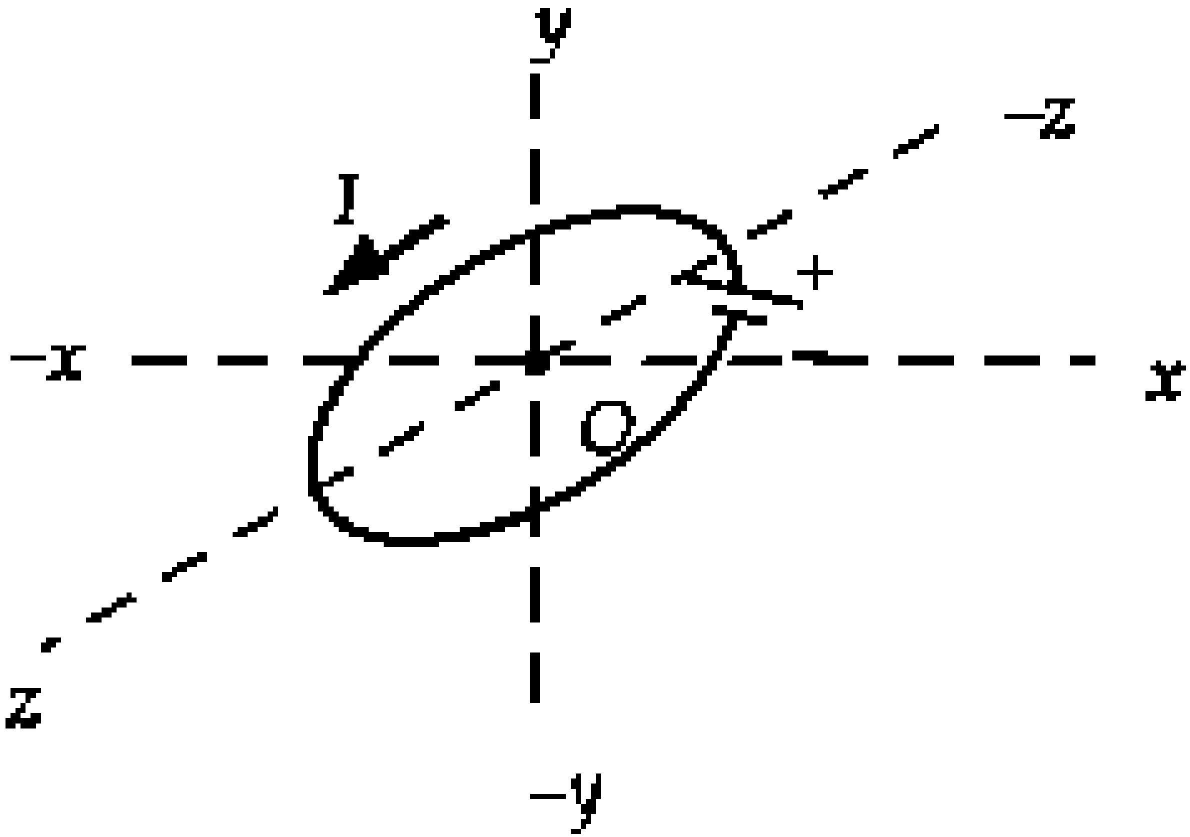
Two wires lying in the plane of this page carry equal currents in opposite directions, as shown. At a point midway between the wires, the magnetic field is



1) zero.
2) into the page.
3) out of the page.
4) toward the top or bottom of the page.
5) toward one of the two wires.

The sketch shows a circular coil in the *xz* plane carrying a current *I*. The direction of the magnetic field at point *O* is

1) $+x$
2) $-x$
3) $+y$
4) $-y$
5) $-z$



B produced by a current segment – The Biot-Savart Law

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

$$\mu_0 = 4\pi \times 10^{-7}\,\frac{Tm}{A}$$

$$= \text{"permeability of free space"}$$

Calculating B from Currents

- Break up current into small segments of length dl.
- Find direction of **dB** produced by **dl** at your point of interest using $\mathbf{d}\vec{\mathbf{l}} \times \hat{\mathbf{r}}$.
- Calculate magnitude of dB at point of interest using $\frac{\mu_0}{4\pi}\frac{Idl}{r^2}$.
- Add up (integrate) all of the contributions from all of the small segments.

$d\vec{B} \parallel d\vec{\ell} \times \hat{r}$

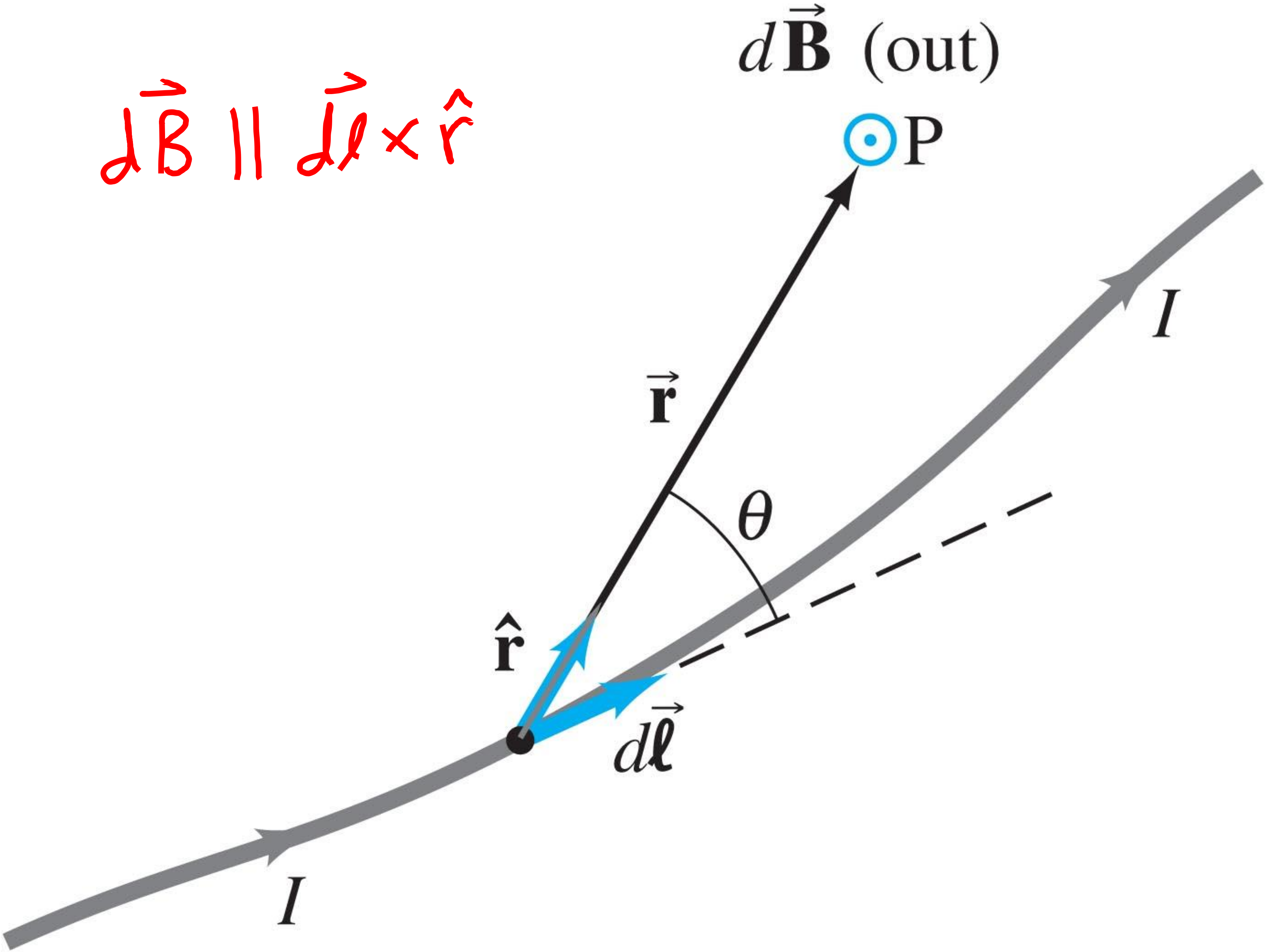
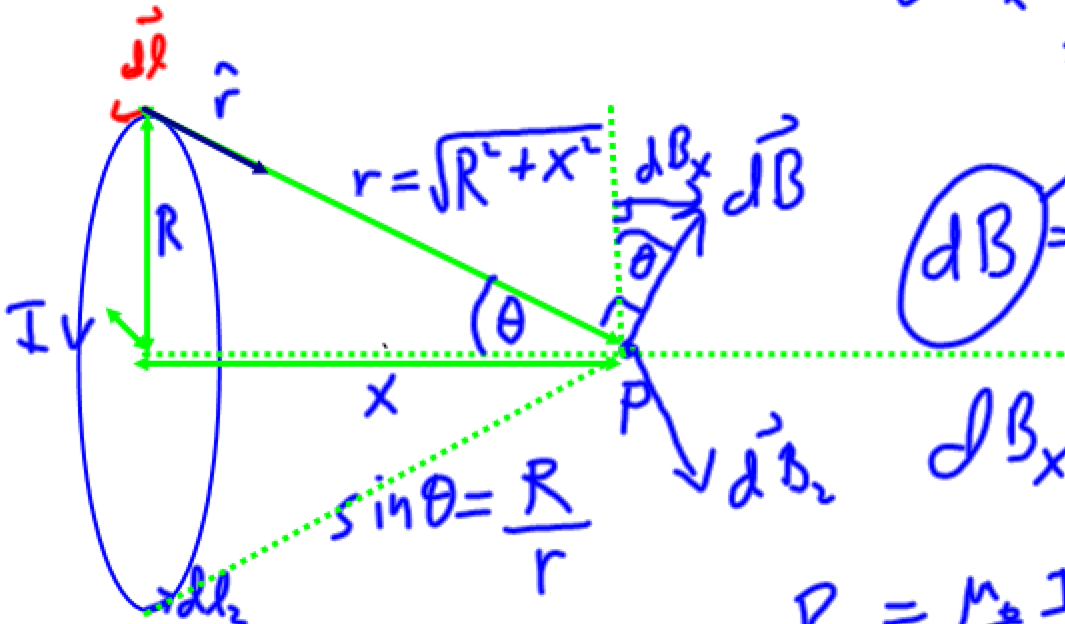


Figure 28.18



$$\mu = IA$$
$$= I\pi R^2$$

$$dB_x = dB\sin\theta$$
$$= dB\,\frac{R}{r}$$

$$dB = \frac{\mu_0}{4\pi}\,\frac{I\,dl}{r^2}$$

$$dB_x = \frac{\mu_0}{4\pi}\,\frac{IR\,dl}{r^3}$$

$$B_x = \frac{\mu_0}{4\pi}\,\frac{IR}{r^3}\underbrace{\int dl}_{2\pi R}$$

$$= \frac{\mu_0}{4\pi}\,\frac{2I\pi R^2}{r^3}$$

$$B_x = \frac{\mu_0}{4\pi}\,\frac{2\mu}{r^3}$$

Magnetic field produced by a current loop

- Along x axis:

$$\vec{\mathbf{B}} = \frac{\mu_0}{4\pi} \frac{2\mu}{\left(x^2 + R^2\right)^{3/2}} \hat{\mathbf{i}}$$

$$\approx \frac{\mu_0}{4\pi} \frac{2\mu}{x^3} \hat{\mathbf{i}} \quad \text{for } x >> R \text{ (or } x << -R\text{)}$$