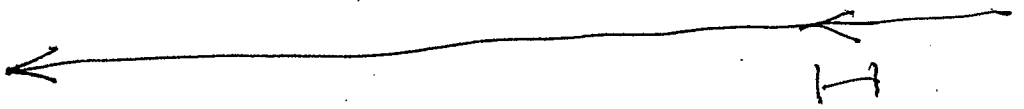
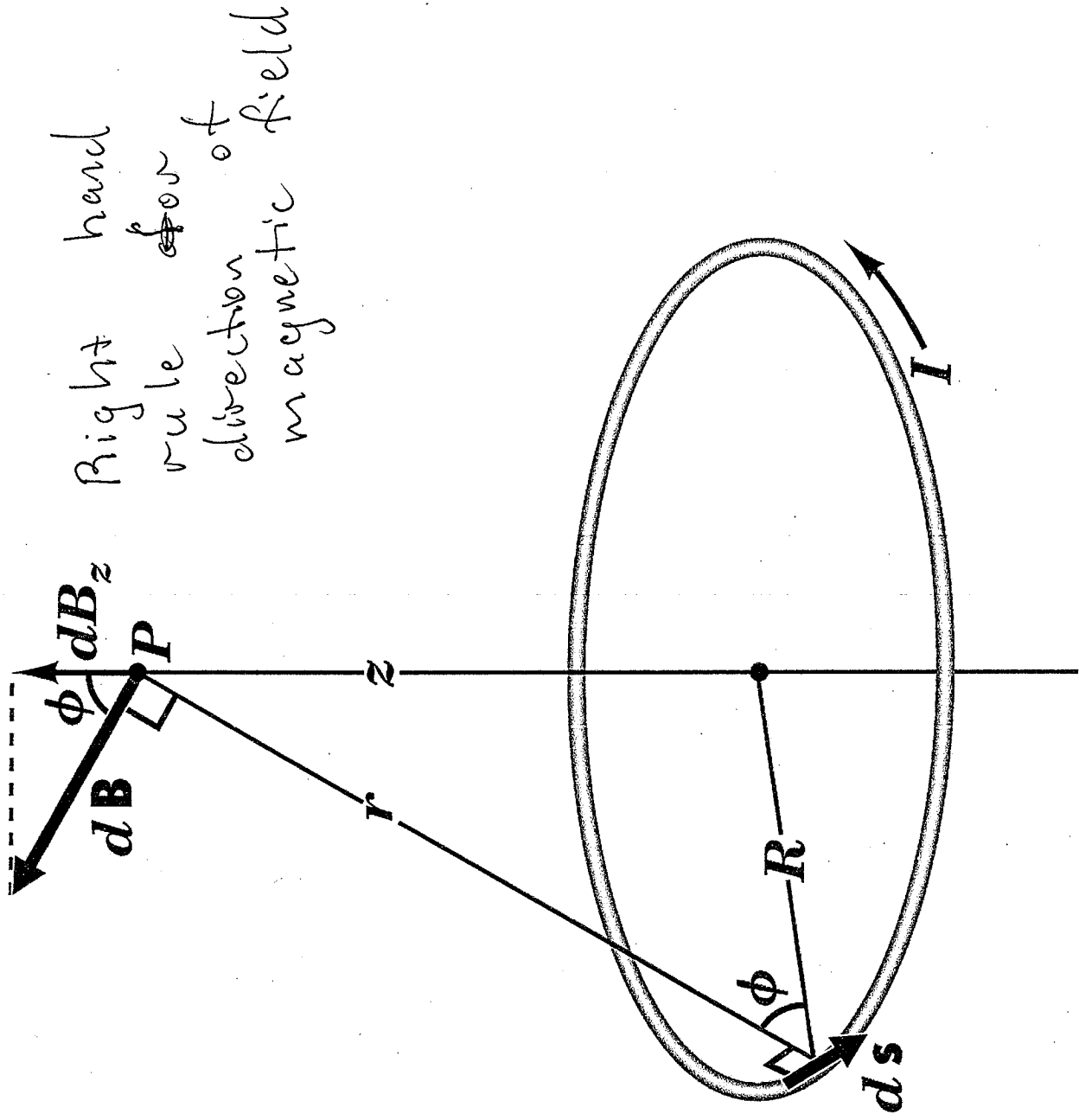


Lecture # 13
Magnetic Fields



The direction of magnetic field at points O and P are respectively

- (a) into paper & into paper
- (b) into paper & out of paper
- (c) out of paper & into paper
- (d) out of paper & out of paper



Right hand rule for direction of magnetic field

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What is the direction of field in solenoid?

Current in solenoid travels around many turns of a tight helical coil.

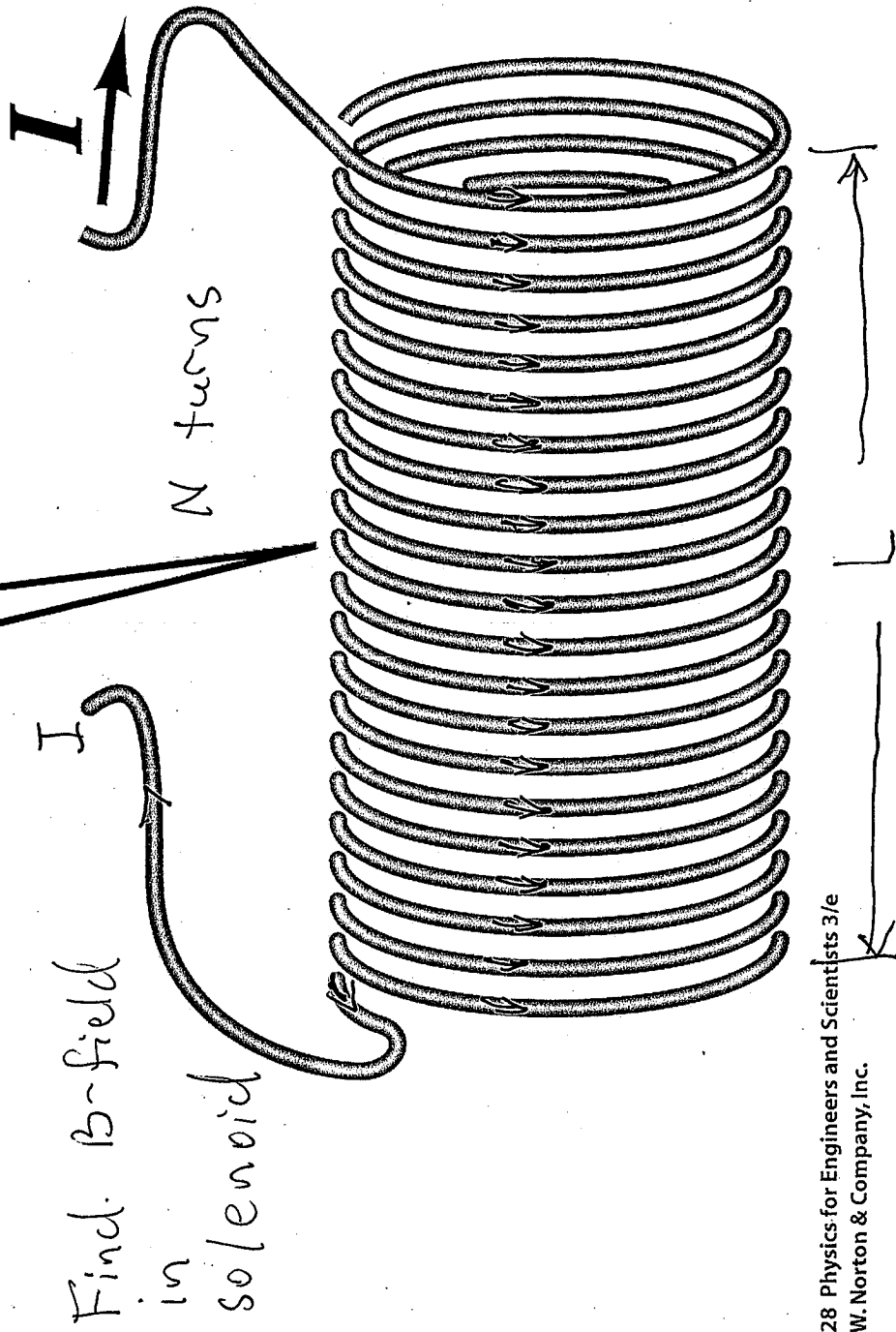


Figure 29-28 Physics for Engineers and Scientists 3/e
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$$\frac{N}{L} = \# \text{ of turns in loop}$$

Current I in wire
 $N \equiv \# \text{ turns of solenoid}$

Magnetic field is nearly zero along upper side of path...

...and is zero or perpendicular to vertical sides.

Along lower side, magnetic field is parallel to path and constant.

Total current crossing area inside path is current in wire times number of turns N in width l .

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{total}}$$

$$Bl + 0 + 0 + 0$$

$$Bl = \frac{N}{L} l \mu_0 I$$

$$B = \frac{\mu_0 N I}{L}$$

$$\eta = \frac{\# \text{ turns}}{\text{length}} = \mu_0 \eta I$$

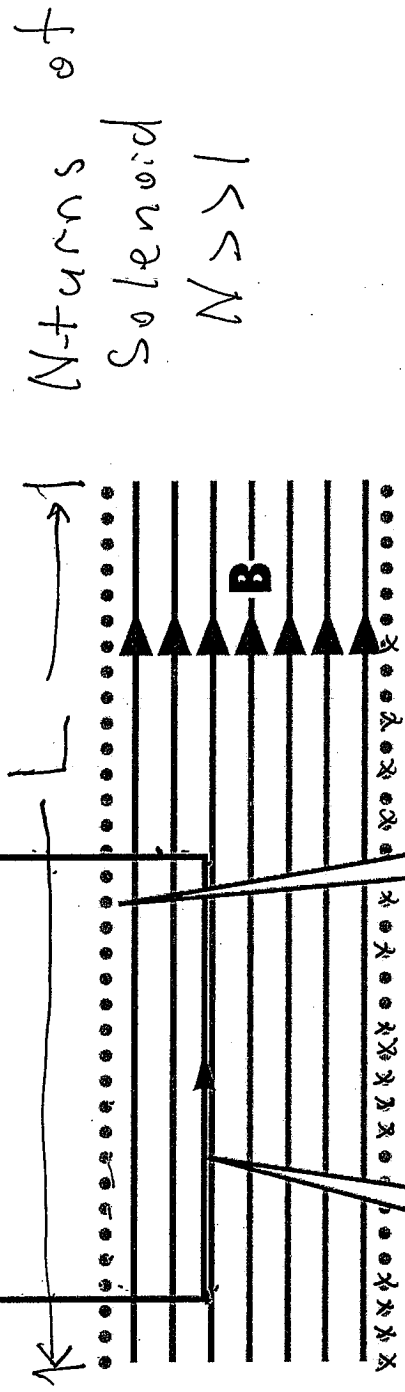


Figure 29-31 Physics for Engineers and Scientists 3/e
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Toroid (torus) donut

N loops
Current I

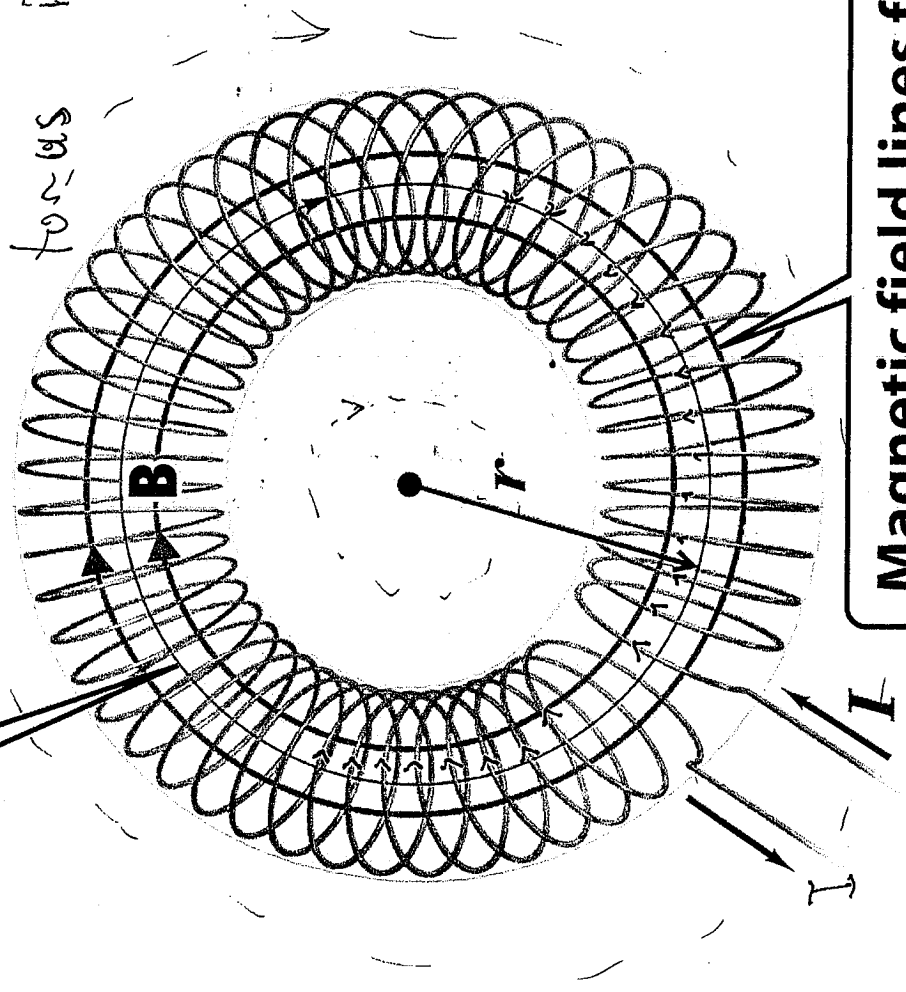
Path for Ampère's Law is a circle of radius r .

B -field independent of shape of toroid if # of turns around torus is constant

$$B \ell = \mu_0 I_{\text{total}}$$

$$B 2\pi r = \mu_0 I N$$

$$B = \frac{\mu_0 I N}{2\pi r}$$



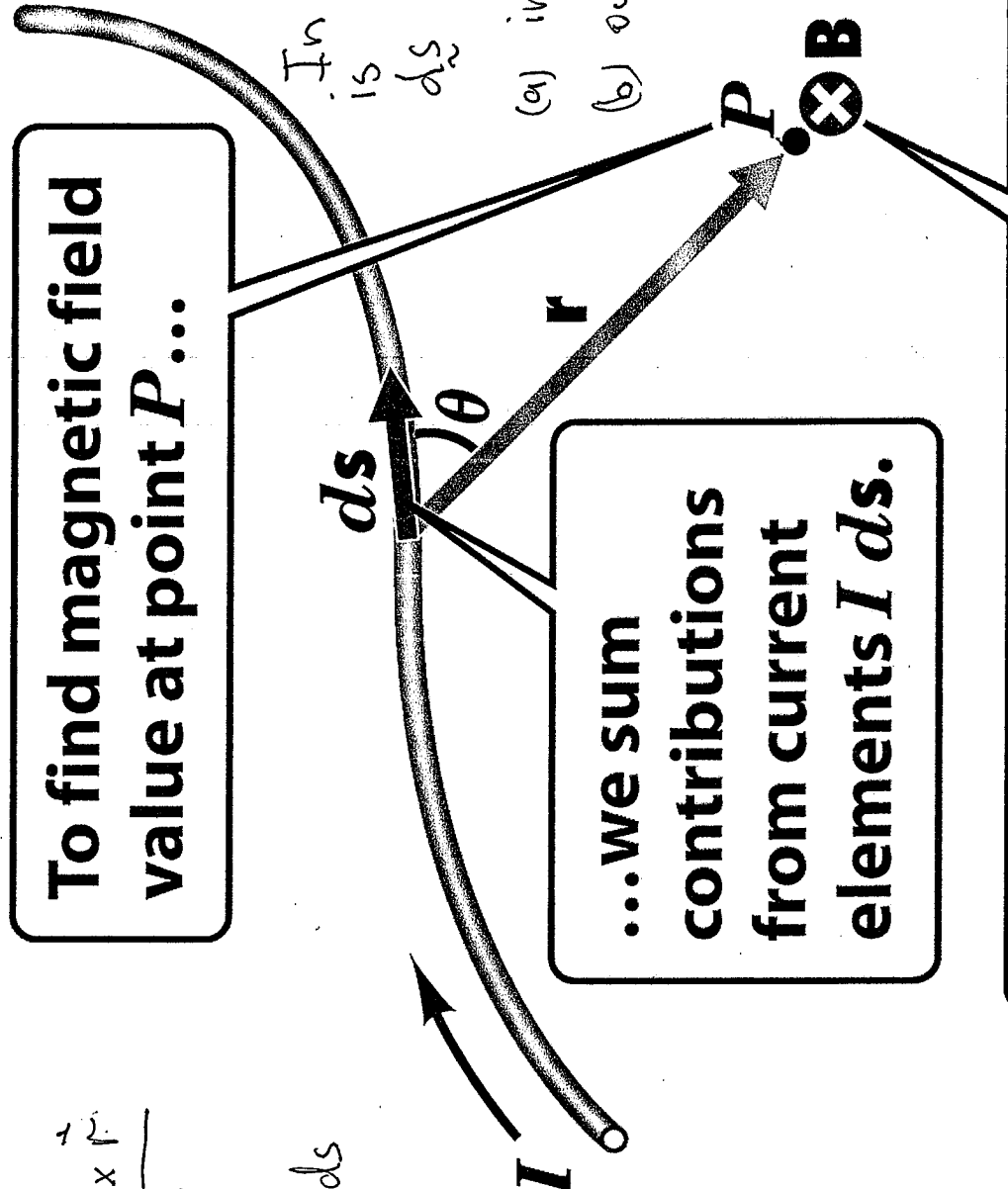
Magnetic field lines form closed loops inside toroid.

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Biot Savart Law

$$d\vec{B} = \frac{\mu_0 I d\vec{s} \times \vec{r}}{4\pi r^3}$$

$$d\vec{I} = I ds$$



In which direction is B-field from ds at point P?

- (a) into paper
- (b) out of paper

To find magnetic field value at point P...

...we sum contributions from current elements $I ds$.

Magnetic field at P points in $ds \times r$ direction, here, into page.

Figure 29-37 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Magnetic Fields in a Loop

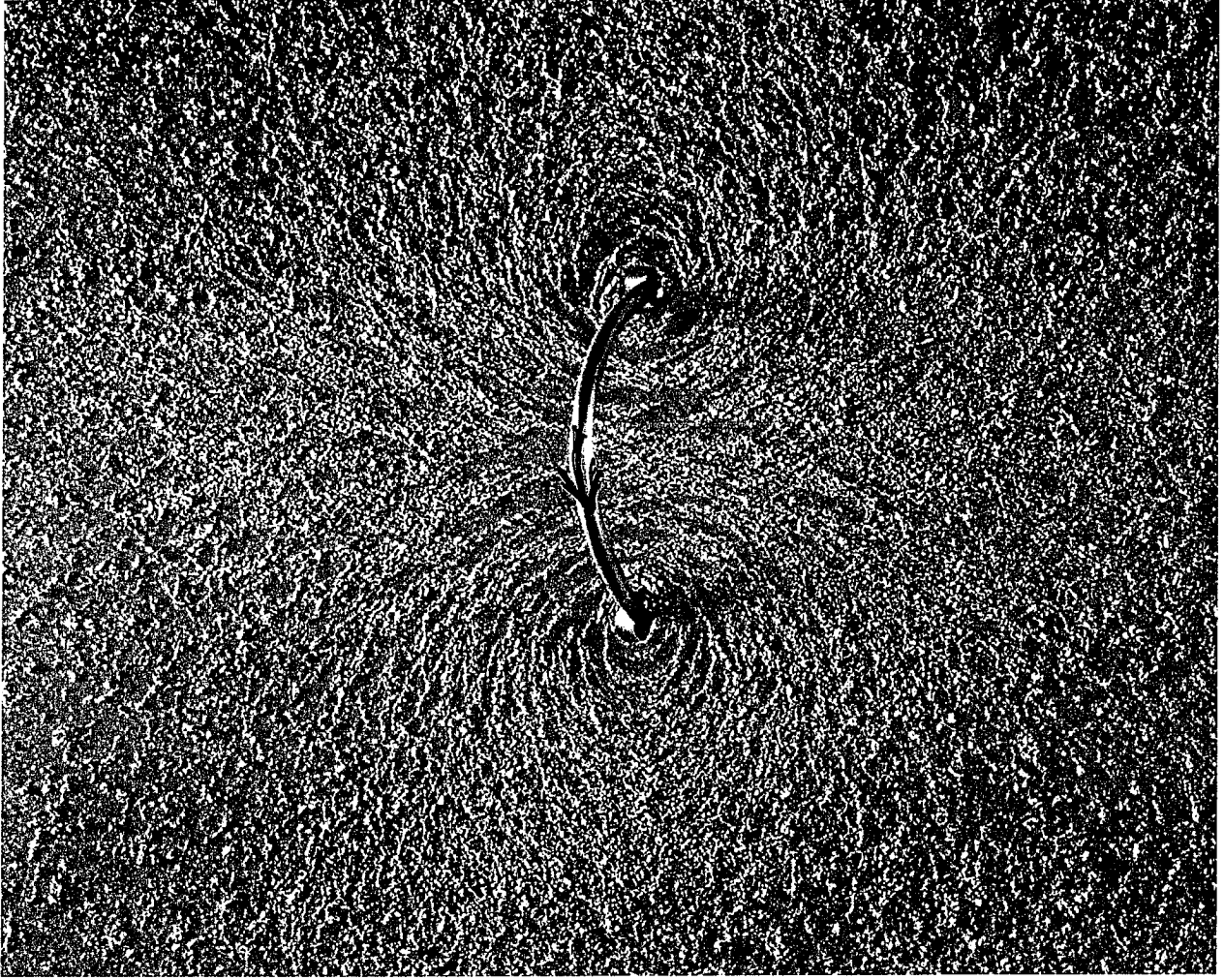


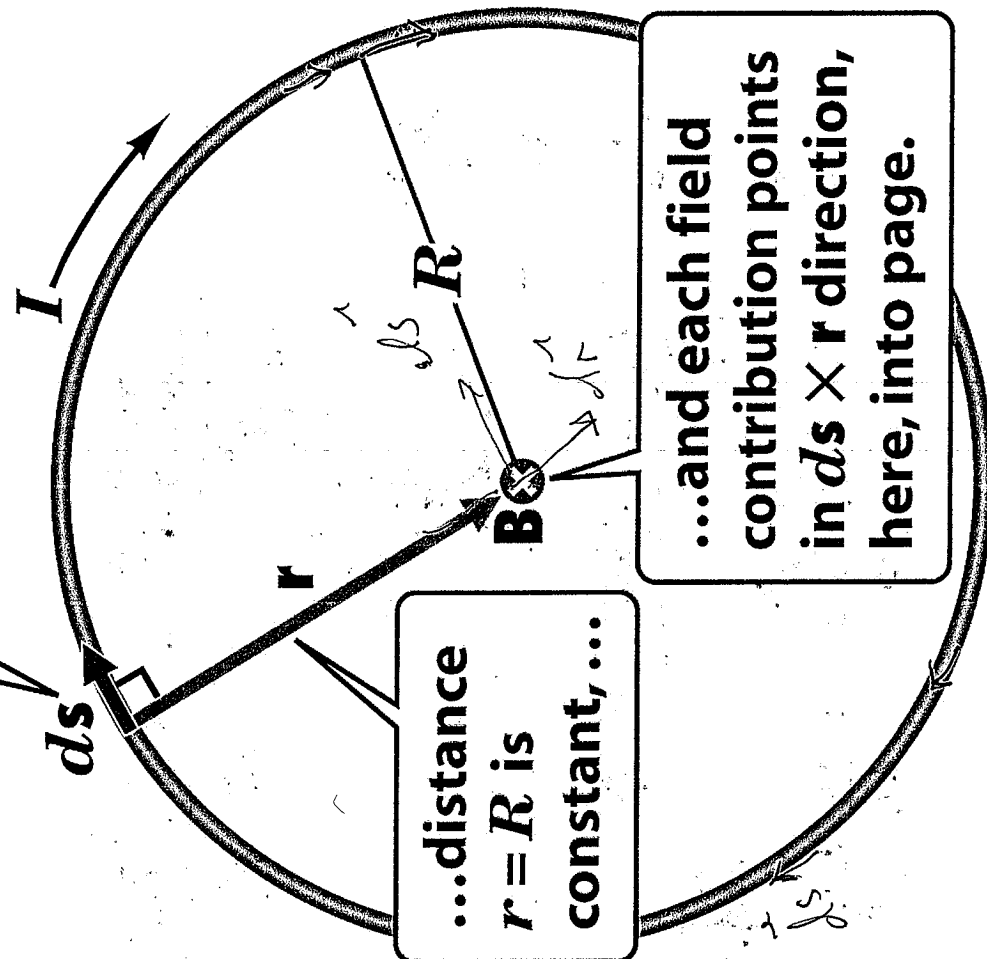
Figure 29-24 Physics for Engineers and Scientists 3/e
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In which direction is the magnetic field through the hoop
(a) upward (b) downward

Outside the hoop?

(a) upward (b) downward

For field at center of circular current loop, r is always perpendicular to ds ,...



...and each field contribution points in $ds \times r$ direction, here, into page.

...distance $r = R$ is constant,...

$$\vec{B} = \frac{\mu_0}{4\pi} \int \frac{I \vec{ds} \times \vec{r}}{r^3}$$

$$= \hat{z} \frac{\mu_0 I}{4\pi R^2} \int ds$$

$$\vec{B} = \hat{z} \frac{\mu_0 I}{4\pi R^2} \int ds$$

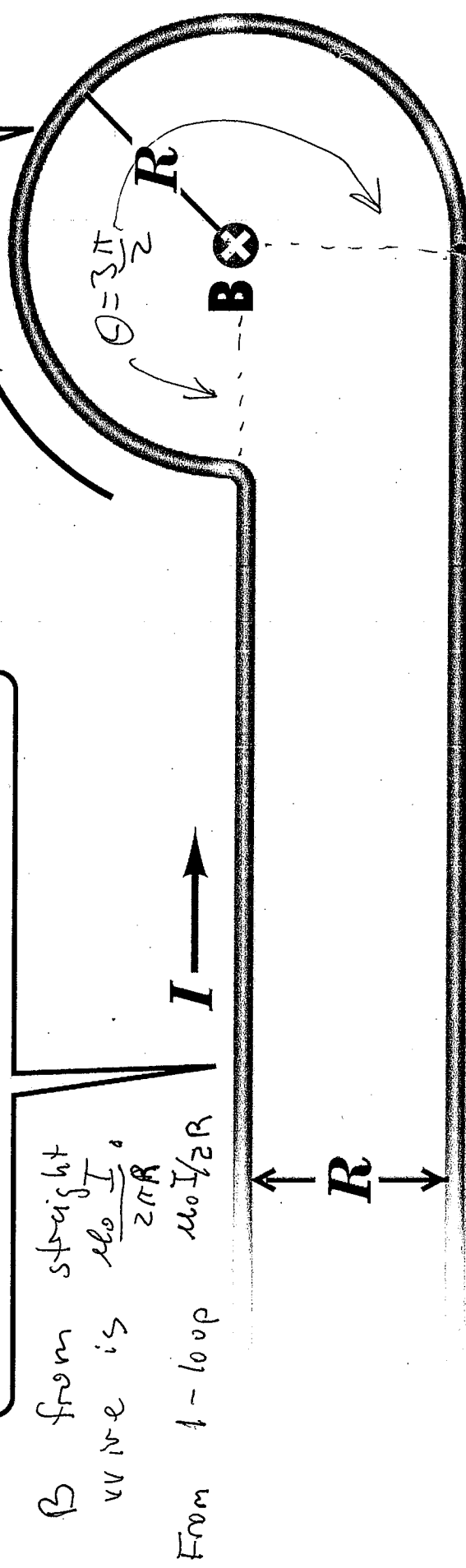
$$= \hat{z} \frac{\mu_0 I}{4\pi R^2} 2\pi R$$

$$\vec{B} = \hat{z} \frac{\mu_0 I}{2R}$$

Figure 29-38 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Current in this straight segment flows directly toward center of curvature.

Arc is 3/4 of full circle.



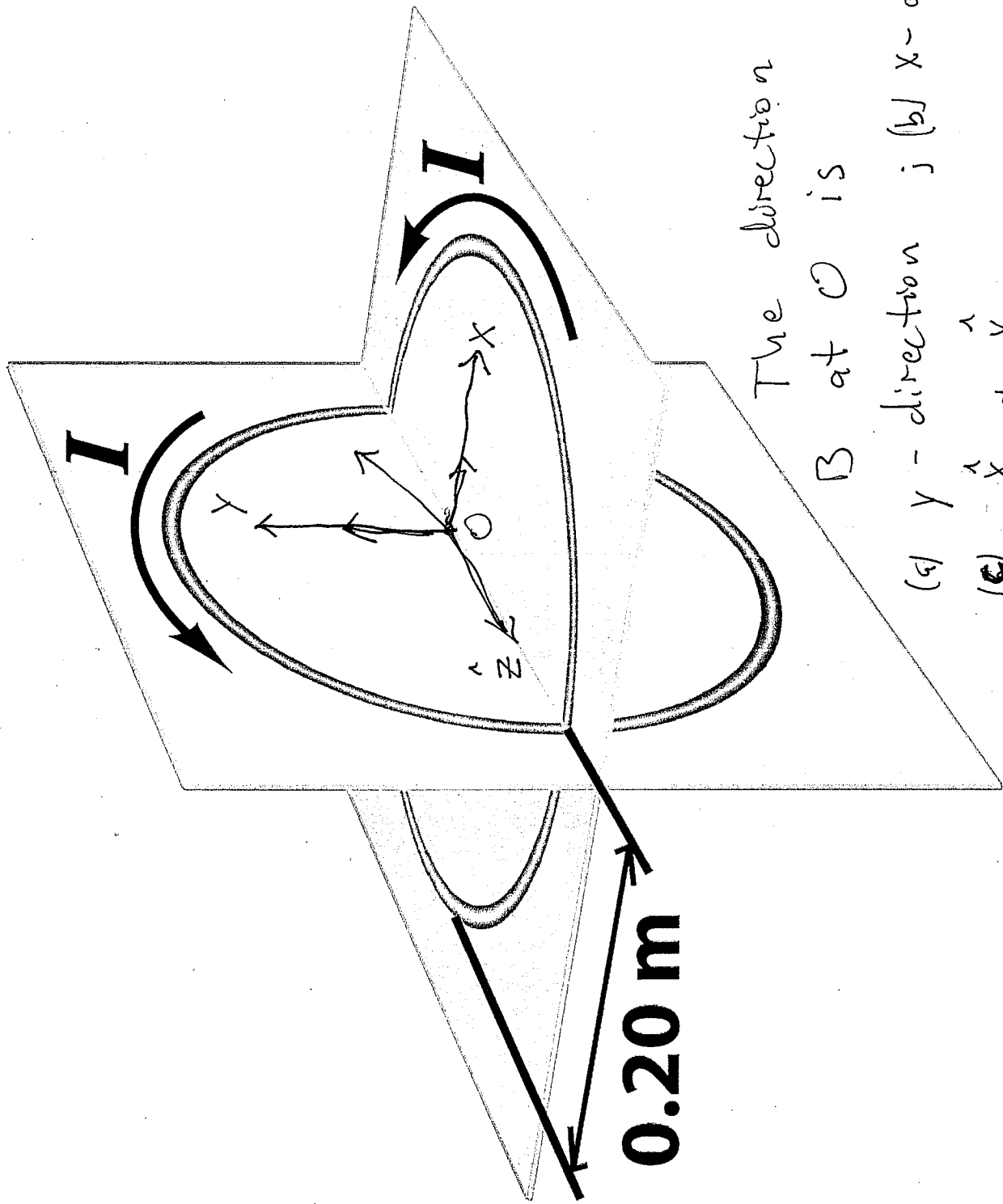
This straight segment is perpendicular distance R from center of curvature.

B from straight wire is $\frac{\mu_0 I}{2\pi R}$
 From 1-loop $\frac{\mu_0 I}{2R}$

What is B at indicated point

- (1) $\mu_0 \frac{I}{R} \left[\frac{1}{2\pi} + \frac{1}{2} \right]$
- (2) $\mu_0 \frac{I}{R} \left[\frac{1}{4\pi} + \frac{1}{4} \right]$
- (3) $\mu_0 \frac{I}{R} \left[\frac{1}{4\pi} + \frac{3}{8} \right]$

Figure 29-40 Physics for Engineers and Scientists 3/e
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The direction of B at O is

(a) y -direction ; (b) x -direction

(c) $\hat{x} \frac{1}{\sqrt{2}} + \hat{y} \frac{1}{\sqrt{2}}$

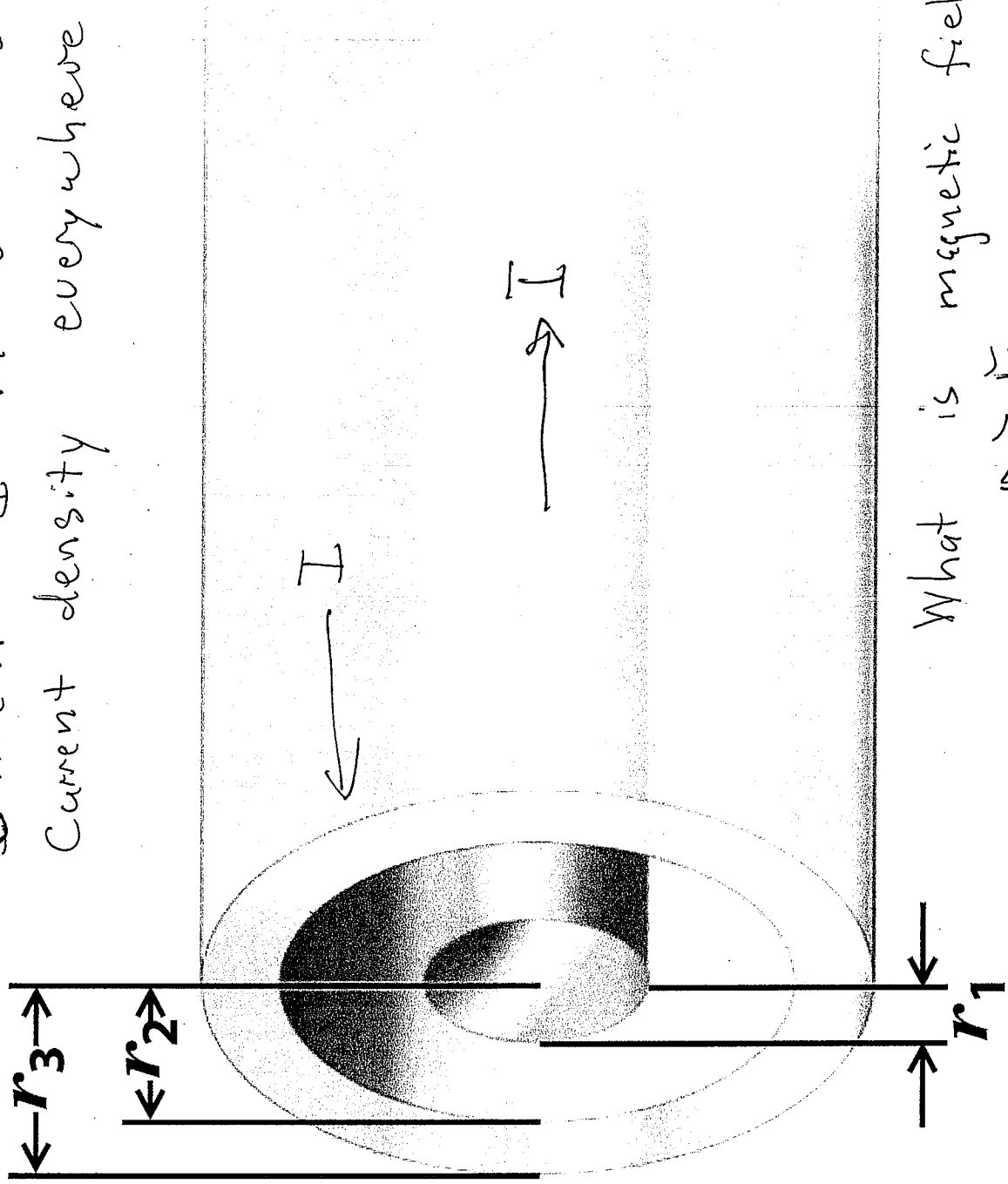
(d) $-\hat{x} \frac{1}{\sqrt{2}} + \hat{y} \frac{1}{\sqrt{2}}$

Figure 29-48 Physics for Engineers and Scientists 3/e
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Current I in center rod

Current $-I$ in outer shell

Current density everywhere uniform



What is magnetic field for

$r > r_3$

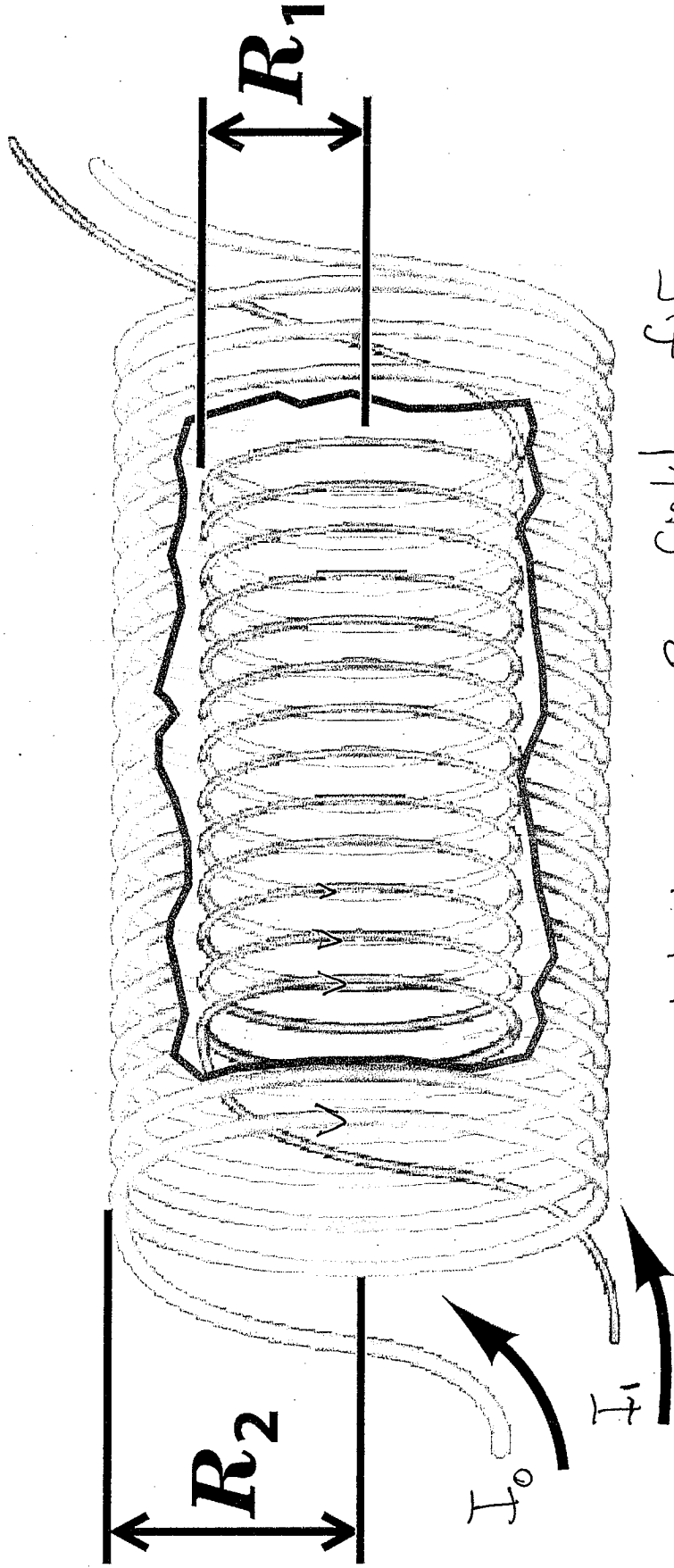
(a) 0, (b) $= \frac{\mu_0 I}{2\pi r}$

(c) $\frac{\mu_0 I}{2\pi(r-r_3)}$

(28)

Figure 29-50 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

$$\frac{N_1}{L_1} = \frac{N_2}{L_2}$$



What is B-field for

$$r < R_1 ?$$

$$R_1 < r < R_2$$

$$r > R_2$$

Figure 29-66 Physics for Engineers and Scientists 3/e
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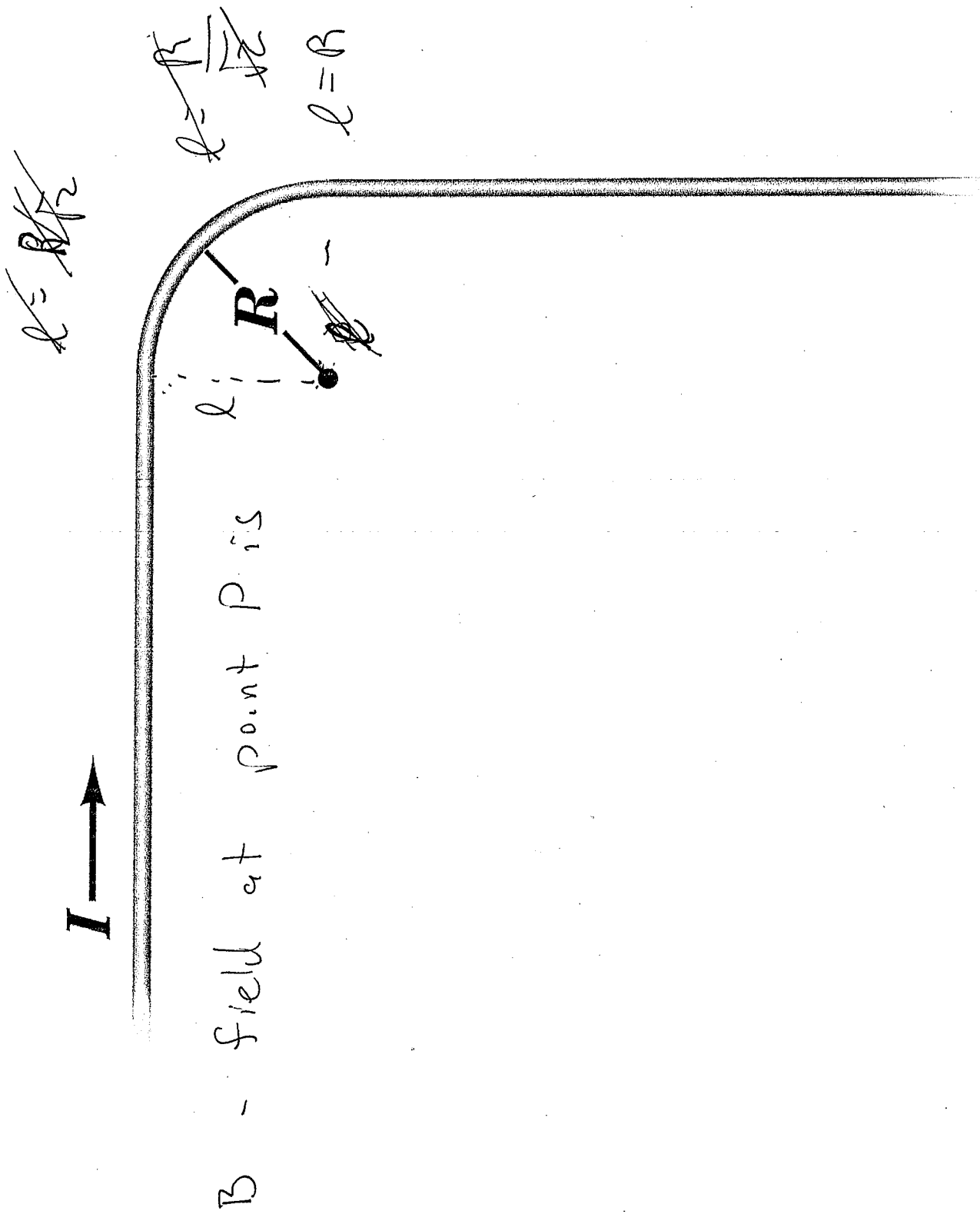


Figure 29-59 Physics for Engineers and Scientists 3/e
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