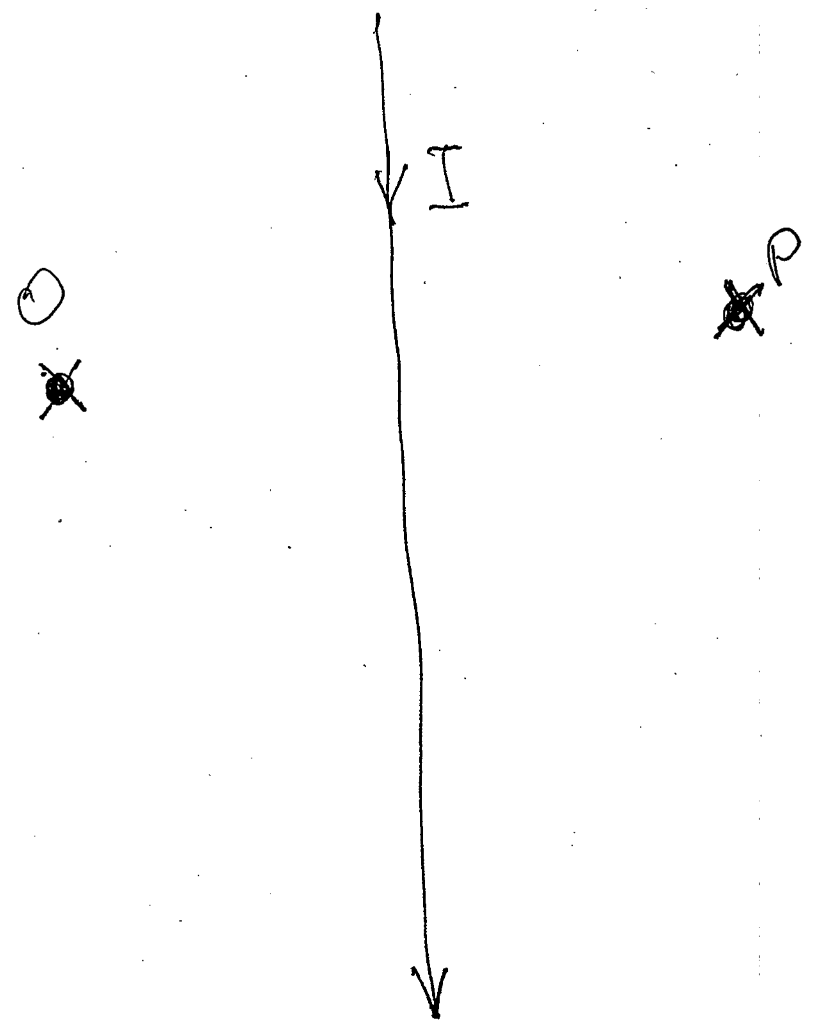
Lecture #13
Magnetic Fields



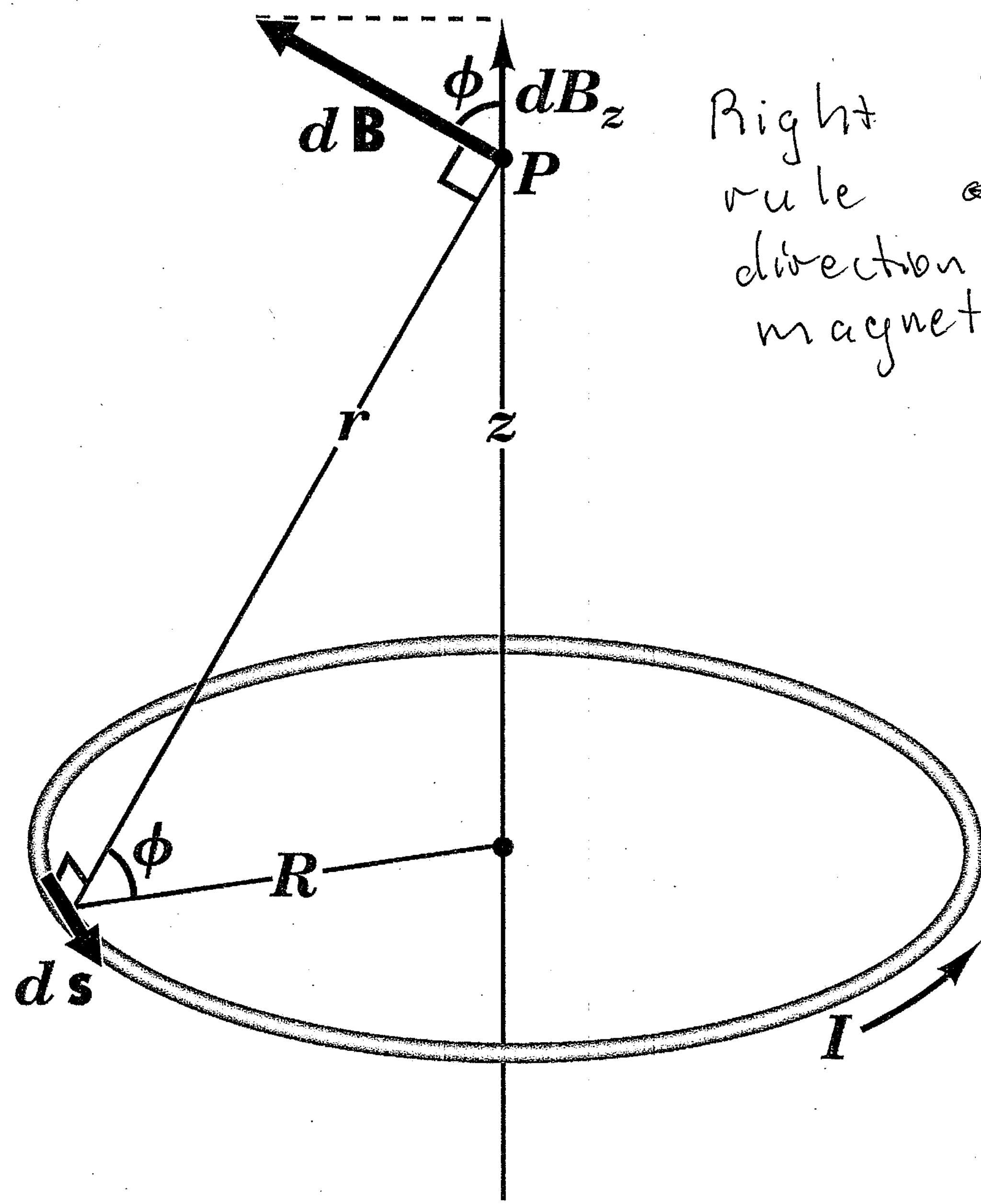
The direction of magnetic field at points O and P are respectively

(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

Figure 29-61 Physics for Engineers and Scientists 3/e

What is the direction of field in solenoid?

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

Find B-field in solenoid

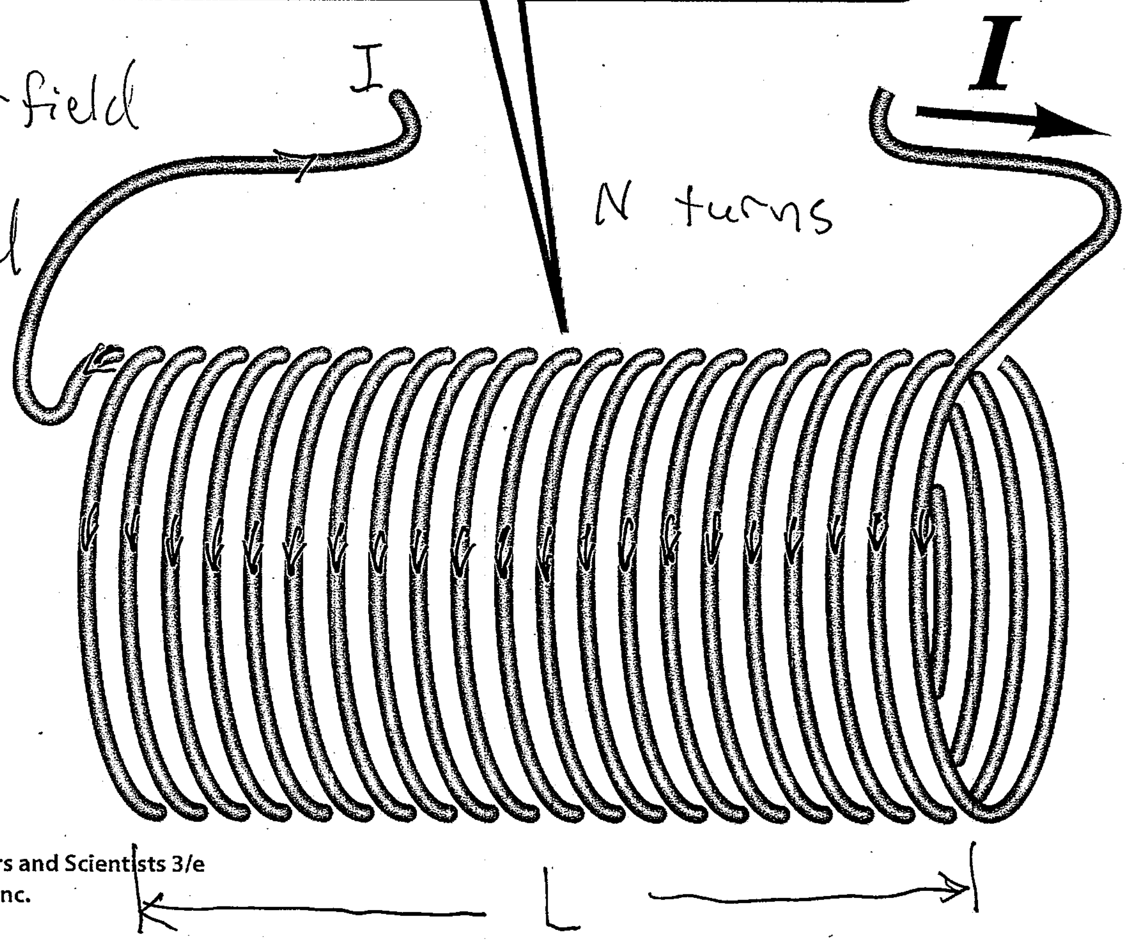


Figure 29-28 Physics for Engineers and Scientists 3/e

$\frac{N}{L} l = n$ # of turns in loop

Current I in wire

$N \equiv$ # turns of solenoid

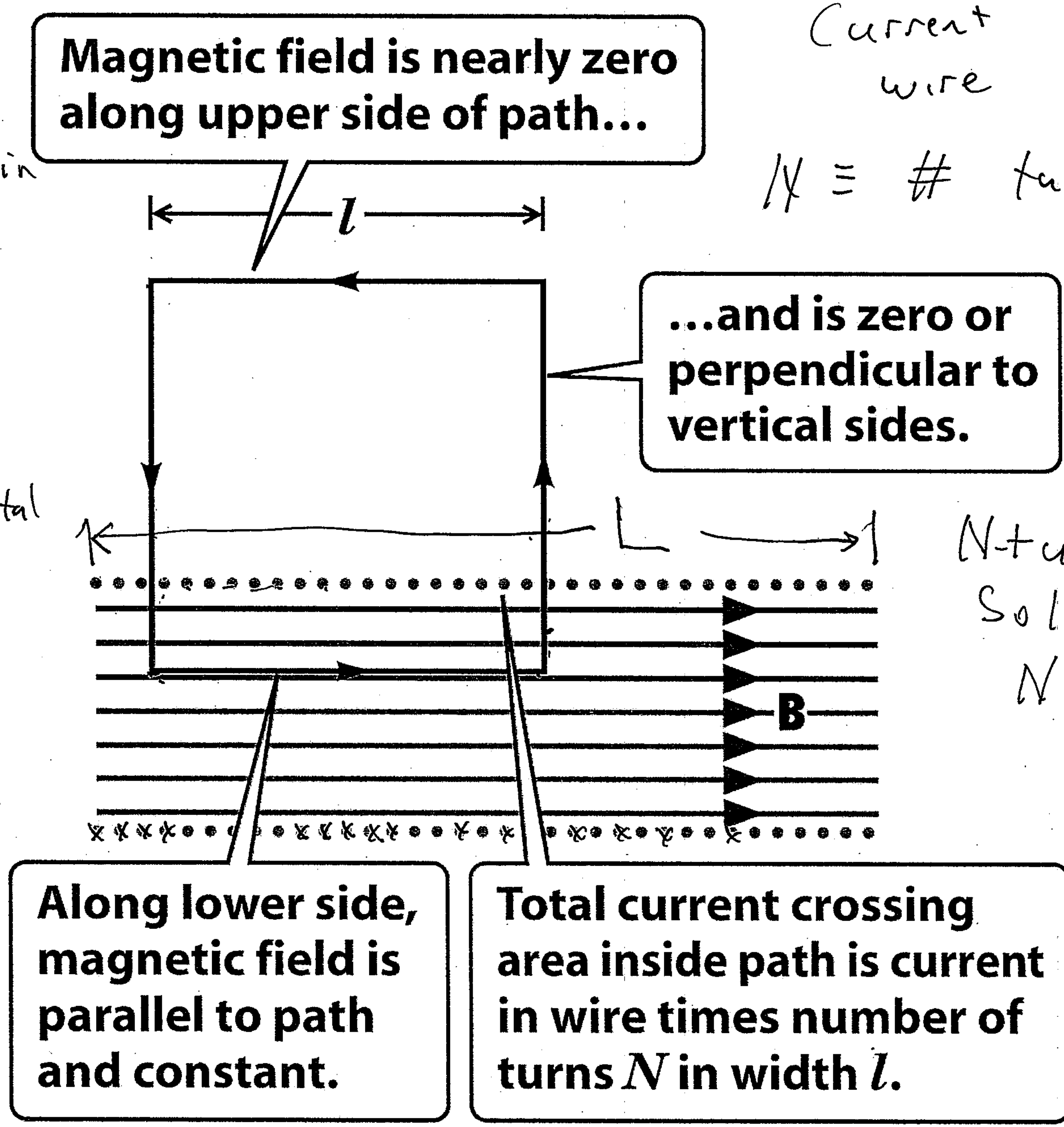


Figure 29-31 Physics for Engineers and Scientists 3/e

N turns of Solenoid

$N >> 1$

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

$Bl + 0 + 0 + 0$

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

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

$= \mu_0 n I$

$n = \frac{\# \text{turns}}{\text{length}}$

Toroid (torus) donut

N loops

Current I

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

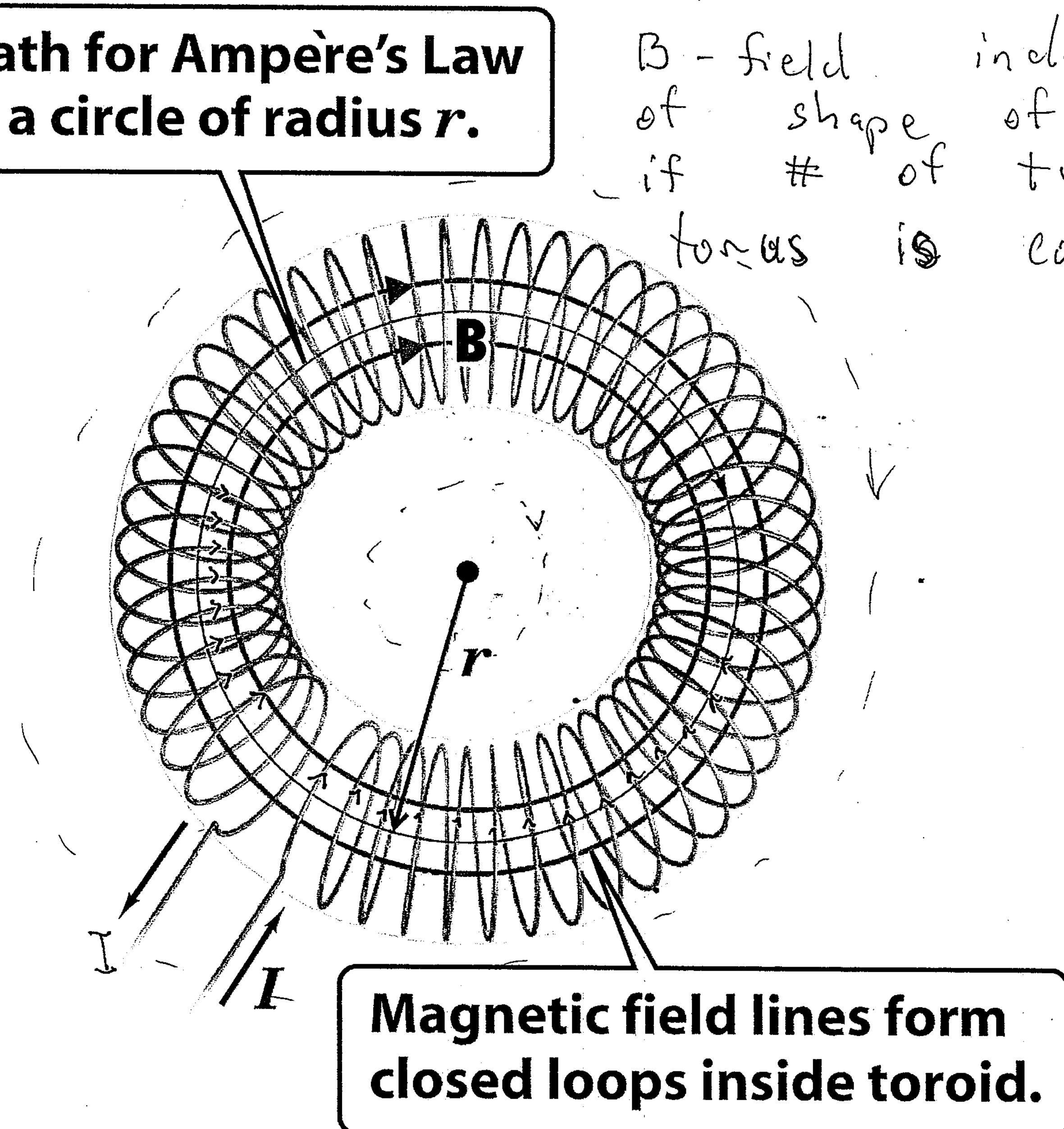


Figure 29-33 Physics for Engineers and Scientists 3/e

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

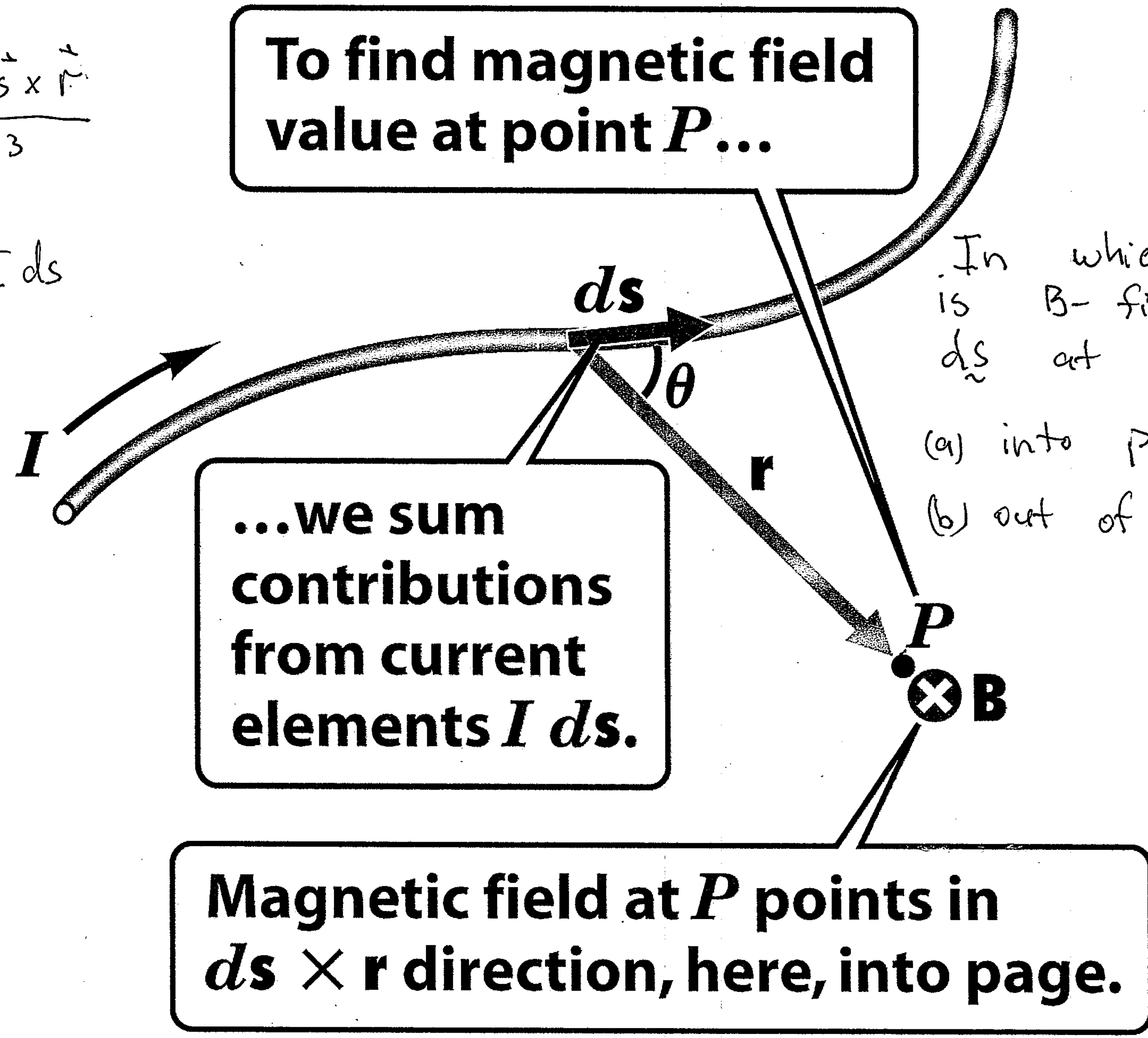
$B 2\pi r = \mu_0 I N$

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

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

Figure 29-37 Physics for Engineers and Scientists 3/e

Magnetic Fields in a Loop

In which direction is the magnetic field through the hoop

III (a) upward (b) downward

II Outside the hoop?

(a) upward (b) downward

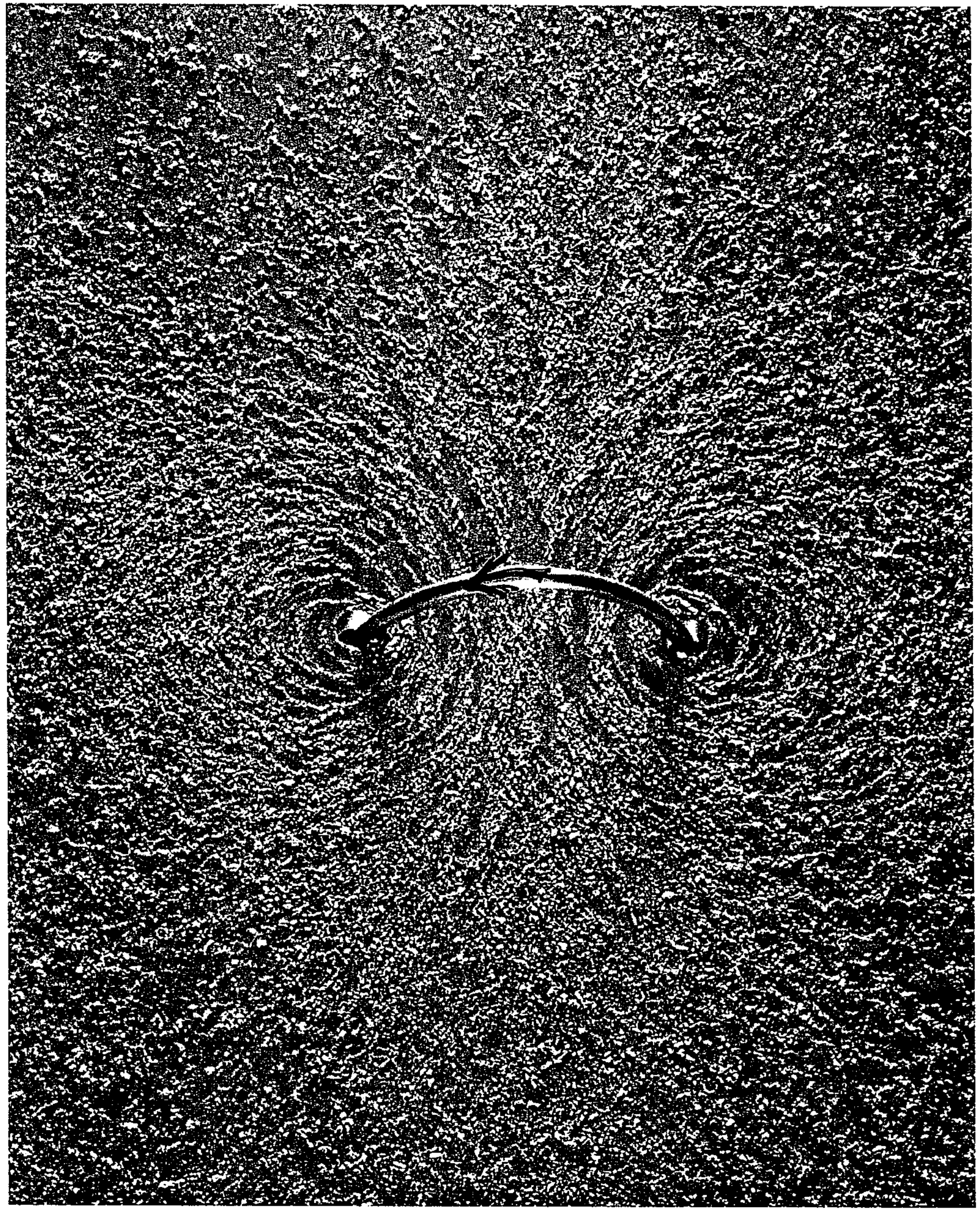


Figure 29-24 Physics for Engineers and Scientists 3/e

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

$$= -\hat{z} \frac{\mu_0}{4\pi} \frac{I\, ds}{r^2}$$

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

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

$$\boxed{\vec{B} = -\hat{z} \frac{\mu_0 I}{2r}}$$

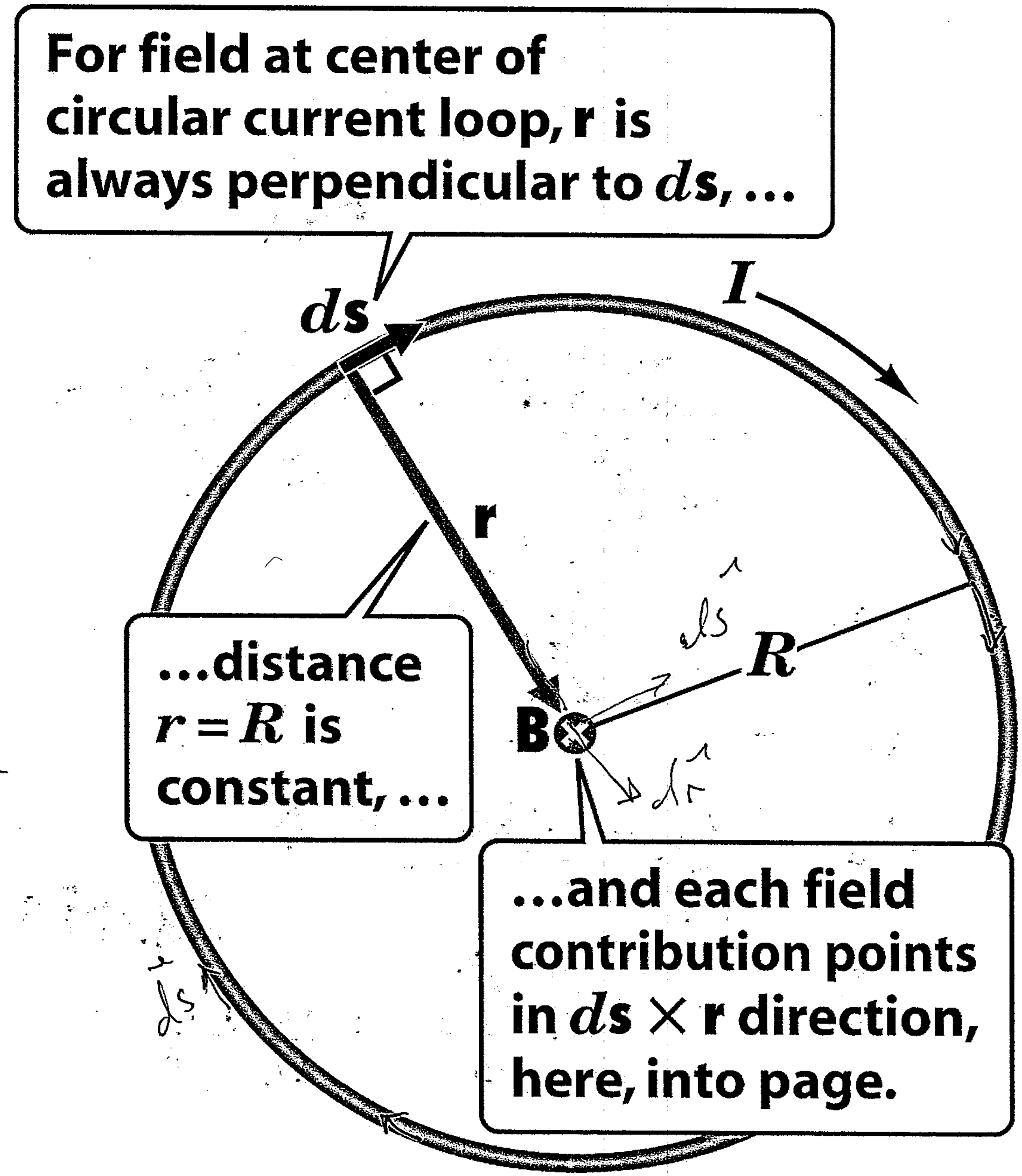
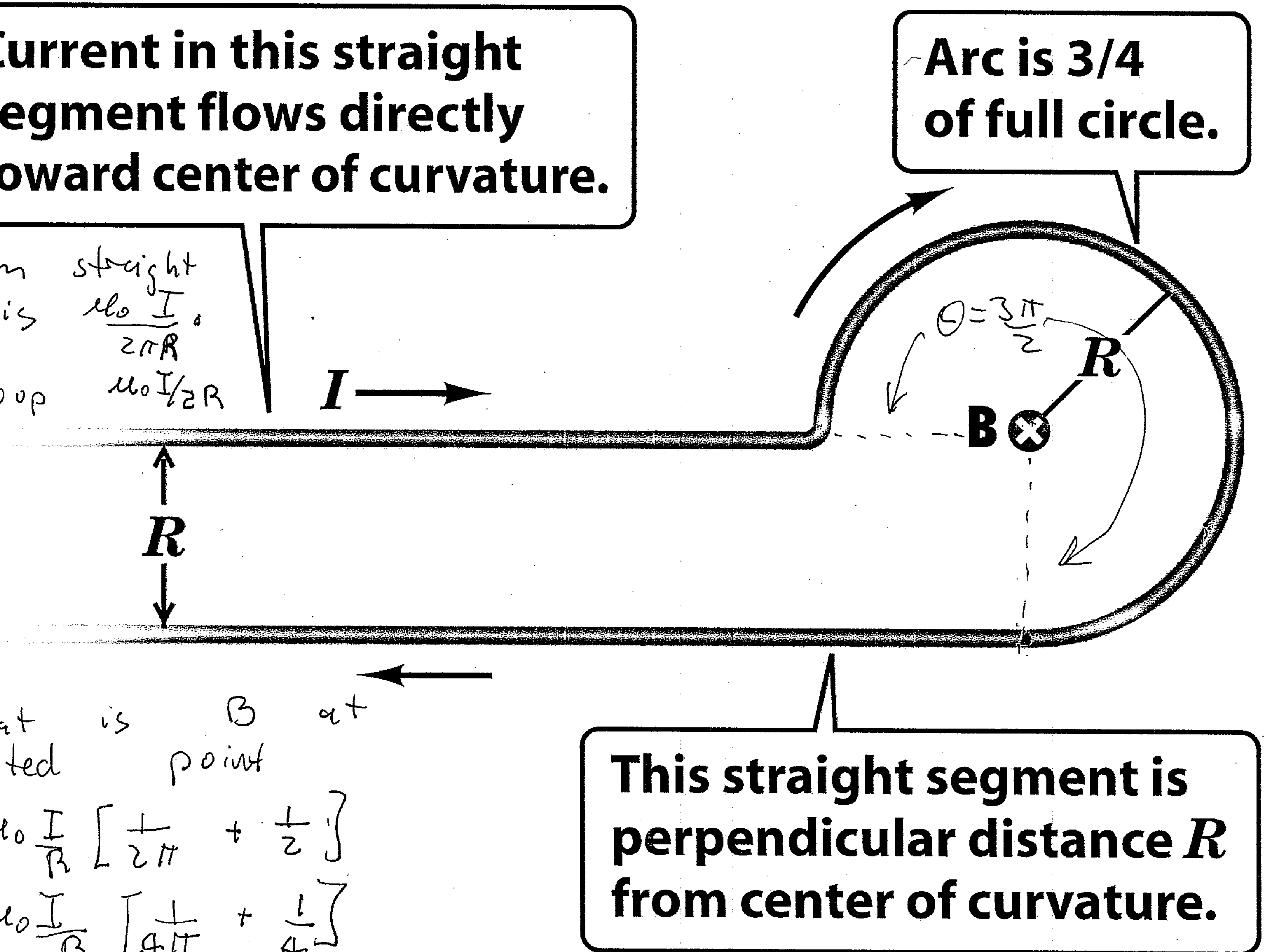


Figure 29-38 Physics for Engineers and Scientists 3/e

B from straight wire is $\frac{\mu_0 I}{2\pi R}$.

From 1-loop $\mu_0 I/2R$



What is B at indicated point

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

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

Figure 29-40 Physics for Engineers and Scientists 3/e

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

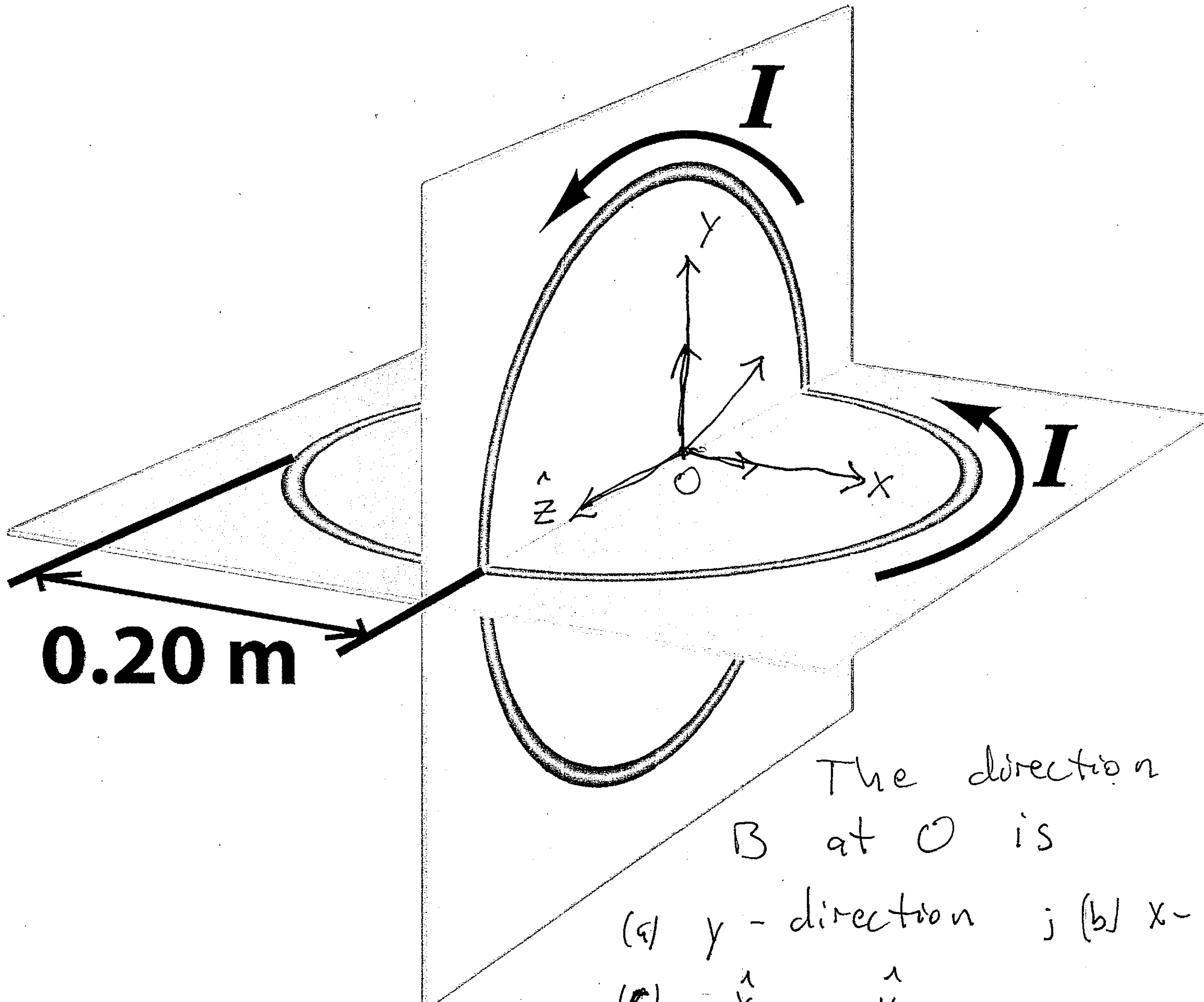


Figure 29-48 Physics for Engineers and Scientists 3/e

The direction of B at O is

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

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

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

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Current I in center rod

Current $-I$ in outer shell

Current density everywhere uniform

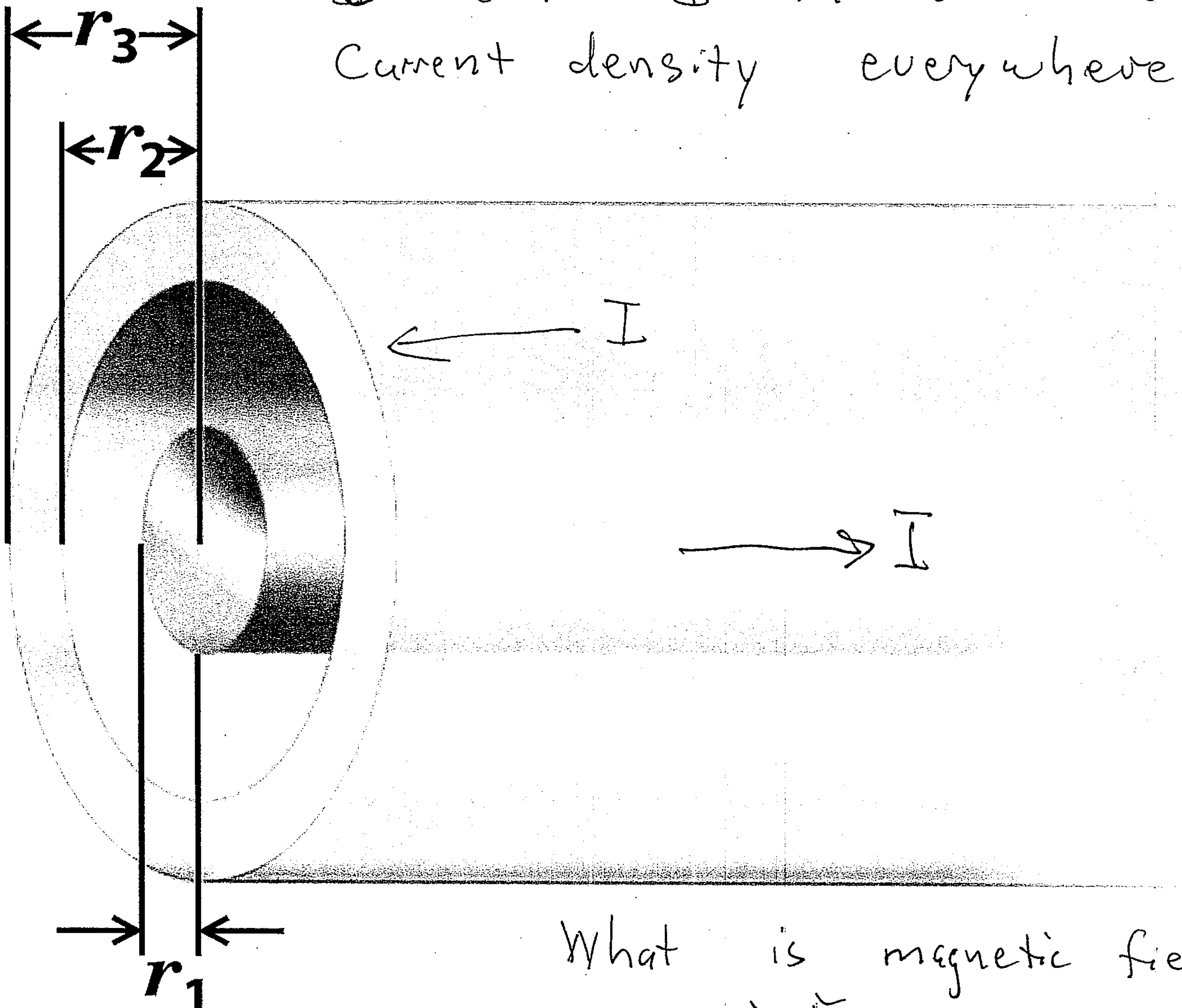

Figure 29-50 Physics for Engineers and Scientists 3/e

What is magnetic field for $r > r_3$

(a) 0 , (b) $= \frac{\mu_0 I}{2\pi r}$ (c) $\frac{\mu_0 I}{2\pi (r - r_3)}$

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

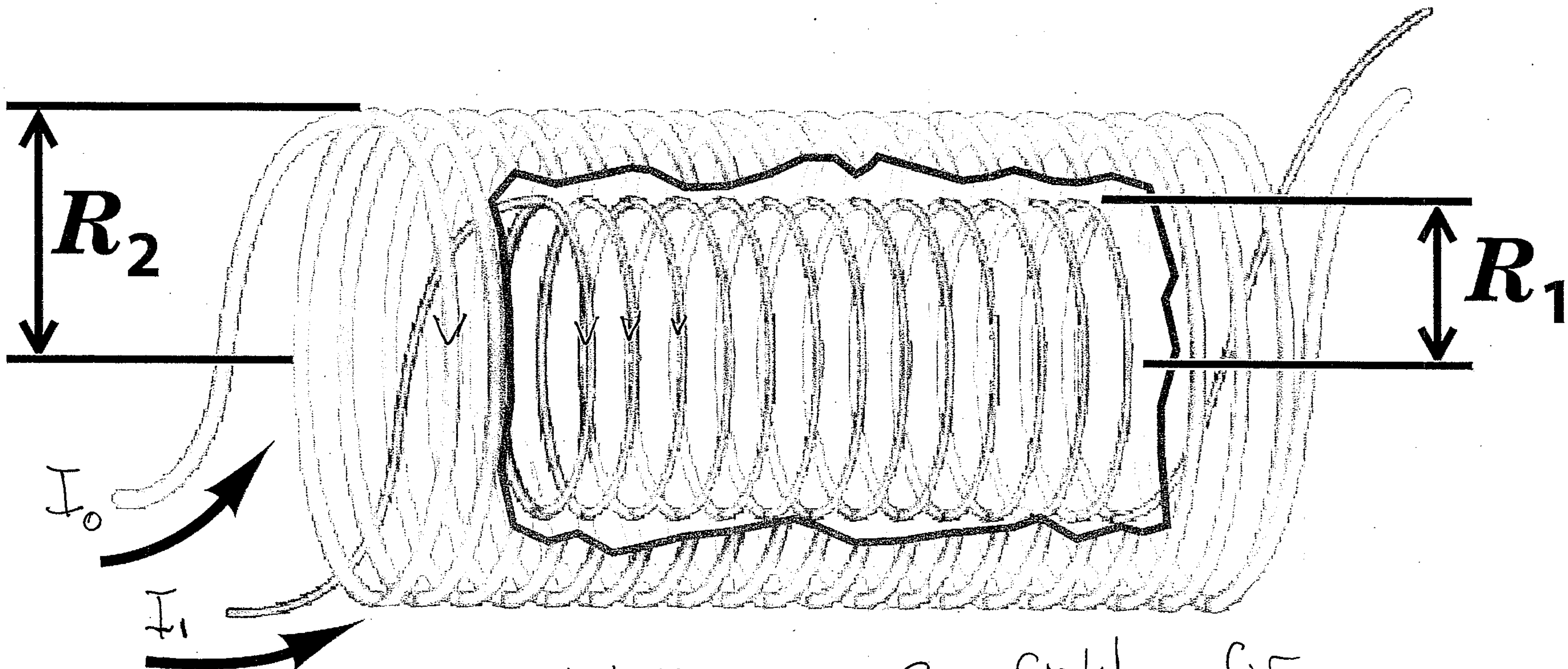

Figure 29-66 Physics for Engineers and Scientists 3/e

What is B-field for

$r < R_1$?

$R_1 < r < R_2$

$r > R_2$

B - field at point P is

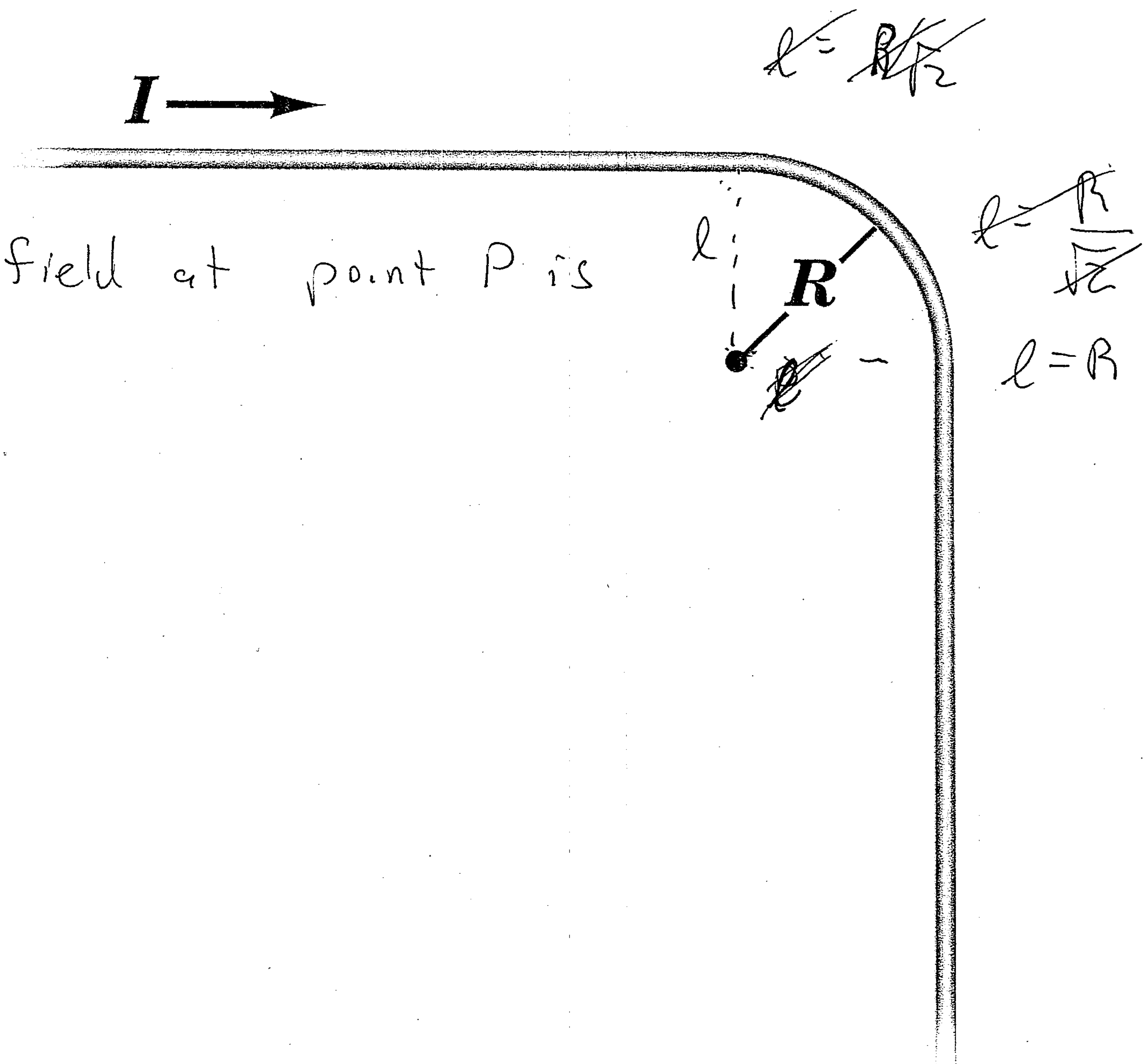

Figure 29-59 Physics for Engineers and Scientists 3/e