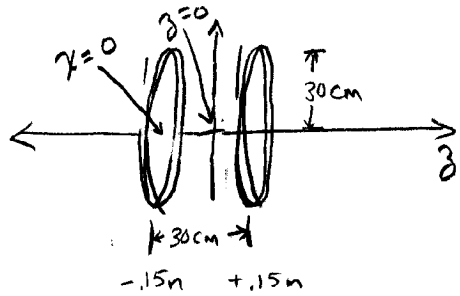
27-22 GIVEN: HELMHOLTZ COILS $R = 30\,cm$



SEPARATION = 30 cm

$I = 15\,A$ $N = 250\,T$

PLOT: B vs z $(-30cm \rightarrow +30cm)$

FIND: RANGE OVER WHICH B VARIES BY LESS THAN 20%

ONE COIL $$B = \frac{k_m N 2\pi R^2 I}{(x^2 + R^2)^{3/2}}$$

TWO COILS: $$B = \frac{k_m N 2\pi R^2 I}{(x^2 + R^2)^{3/2}} + \frac{k_m N 2\pi R^2 I}{((x-R)^2 + R^2)^{3/2}}$$

$$z = x - \frac{R}{2} \Rightarrow x = z + \frac{R}{2}$$

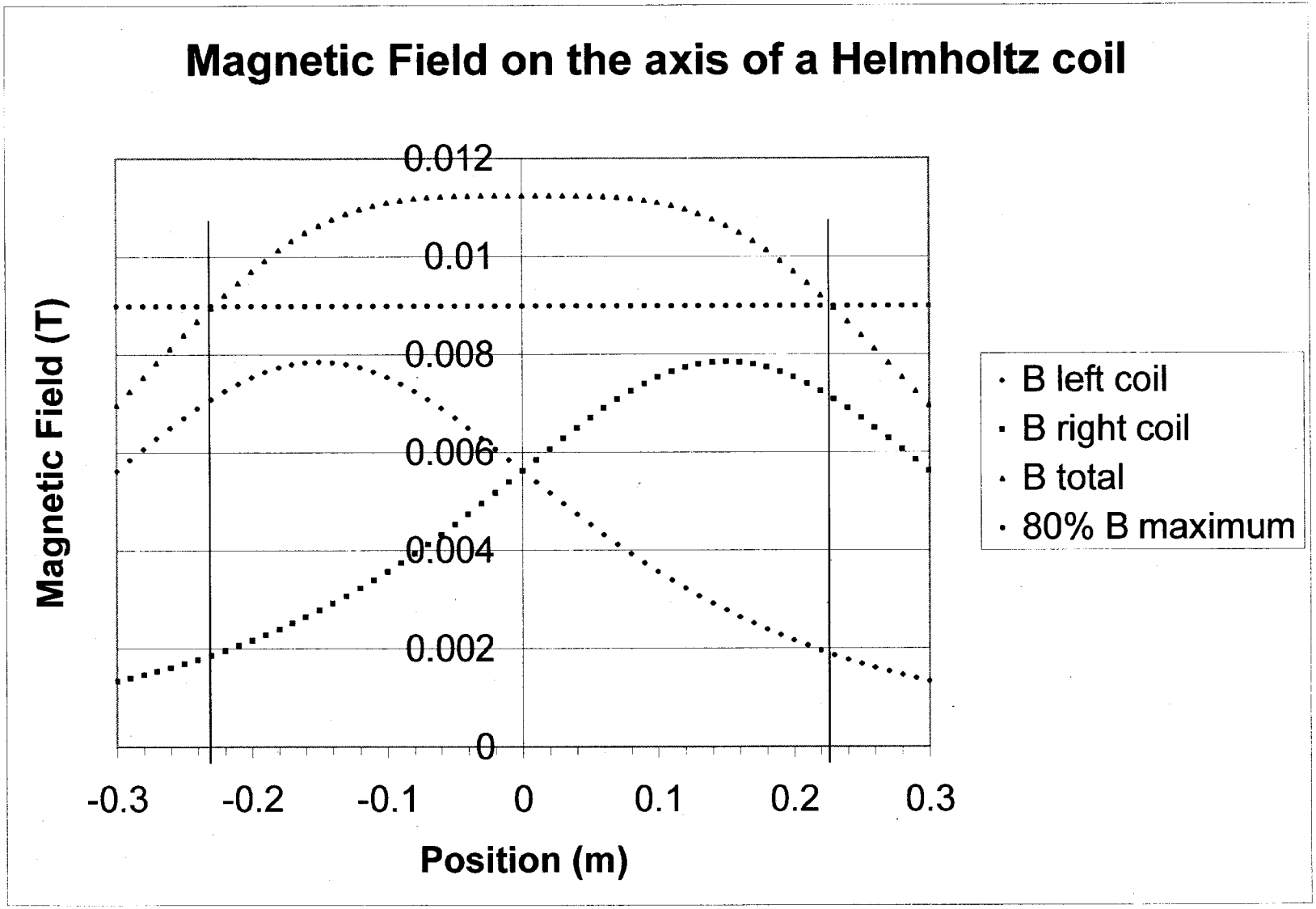
$$B = \frac{k_m N 2\pi R^2 I}{\left(\left(z+\frac{R}{2}\right)^2 + R^2\right)^{3/2}} + \frac{k_m N 2\pi R^2 I}{\left(\left(z+\frac{R}{2}-R\right)^2 + R^2\right)^{3/2}}$$

$\frac{\mu_0}{2} = 2\pi k_m$ $$B = \frac{k_m N 2\pi R^2 I}{\left(\left(z+\frac{R}{2}\right)^2 + R^2\right)^{3/2}} + \frac{k_m N 2\pi R^2 I}{\left(\left(z-\frac{R}{2}\right)^2 + R^2\right)^{3/2}}$$

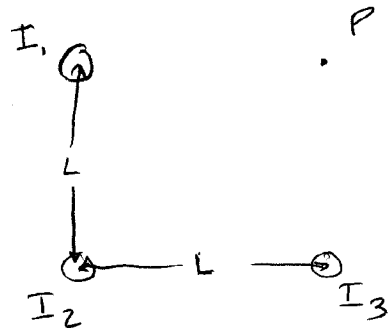
$$B = \frac{\left(10^{-7}\frac{N}{A^2}\right)(250)(2\pi)(.3m)^2(15A)}{\left((z+.15m)^2 + (.3m)^2\right)^{3/2}} + \frac{\left(10^{-7}\frac{N}{A^2}\right)(250)(2\pi)(.3m)^2(15A)}{\left((z-.15m)^2 + (.3m)^2\right)^{3/2}}$$

$$= \frac{2.12\times10^{-4}\ T\text{-}m^3}{\left((z+.15m)^2 + .09m^2\right)^{3/2}} + \frac{2.12\times10^{-4}\ T\text{-}m^3}{\left((z-.15m)^2 + .09m^2\right)^{3/2}}$$

3-0235 — 50 SHEETS — 5 SQUARES
3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET


Magnetic Field on the axis of a Helmholtz coil
0.012
0.01
0.008
0.006
0.004
0.002
0
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
Magnetic Field (T)
Position (m)
B left coil
B right coil
B total
80% B maximum

27-38 GIVEN :



(a) ALL CURRENTS INTO PAGE

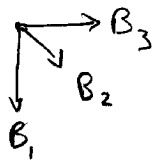
(b) I_1, I_3 ⊗ I_2 ⊙

(c) I_1, I_2 ⊗ I_3 ⊙

FIND : B IN EACH CASE

$$\boxed{|\vec{B}_1| = \frac{\mu_0 I}{2\pi L} = |\vec{B}_3|} \qquad \boxed{|\vec{B}_2| = \frac{\mu_0 I}{2\pi\sqrt{2L^2}} = \frac{\mu_0 I}{2\sqrt{2}\pi L}}$$

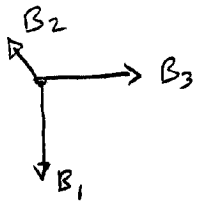
(a)



$$B = B_1\cos 45 + B_2 + B_3\cos 45$$
$$= (2)\frac{\mu_0 I}{2\pi L}\left(\frac{\sqrt{2}}{2}\right) + \frac{\mu_0 I}{2\sqrt{2}\pi L}$$
$$= \frac{\mu_0 I\, 2}{2\sqrt{2}\pi L} + \frac{\mu_0 I}{2\sqrt{2}\pi L} = \boxed{\frac{3\mu_0 I}{2\sqrt{2}\pi L}}$$

45° BELOW HORIZ

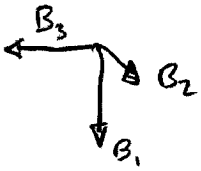
(b)



$$B = B_1\cos 45 - B_2 + B_3\cos 45$$
$$= \frac{\mu_0 I\, 2}{2\sqrt{2}\pi L} - \frac{\mu_0 I}{2\sqrt{2}\pi L} = \boxed{\frac{\mu_0 I}{2\sqrt{2}\pi L}}$$

45° BELOW HORIZ.

(c)



$$B_x = -B_3 + B_2\cos 45$$
$$= \frac{-\mu_0 I}{2\pi L}\frac{2}{2} + \frac{\mu_0 I}{2\sqrt{2}\pi L}\frac{\sqrt{2}}{2} = \boxed{\frac{-\mu_0 I}{4\pi L}}$$

$$B_y = -B_1 - B_2\cos 45$$
$$= \frac{-\mu_0 I}{2\pi L}\frac{2}{2} - \frac{\mu_0 I}{2\sqrt{2}\pi L}\frac{\sqrt{2}}{2} = \boxed{\frac{-3\mu_0 I}{4\pi L}}$$

$$|B| = \sqrt{B_x^2 + B_y^2} = \frac{\mu_0 I}{4\pi L}\sqrt{(-1)^2 + (-3)^2}$$
$$= \frac{\mu_0 I\sqrt{10}}{4\pi L}$$

$$\theta = \tan^{-1}\left(\frac{B_y}{B_x}\right) = \tan^{-1}\left(\frac{-3}{-1}\right)$$
$$\theta = 251.6^\circ \quad (71.6^\circ \text{ BELOW } -x \text{ AXIS})$$

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