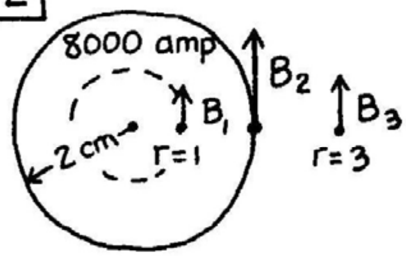
$\boxed{6.1}$ $B = \dfrac{2I}{cr} = \dfrac{2 \times 6 \times 10^{10}}{3 \times 10^{10} \times 5} = 0.8$ gauss

Force per cm $= IB/c = 6 \times 10^{10} \times 0.8/3 \times 10^{10} = 1.6$ dyne/cm

$\boxed{6.2}$



8000 amp $= 24 \times 10^{12}$ esu/sec

current inside $r=1$ is 6×10^{12} esu/sec

$$B_1 = \frac{2I}{rc} = \frac{2 \times 6 \times 10^{12}}{3 \times 10^{10} \times 1} = 400 \text{ gauss}$$

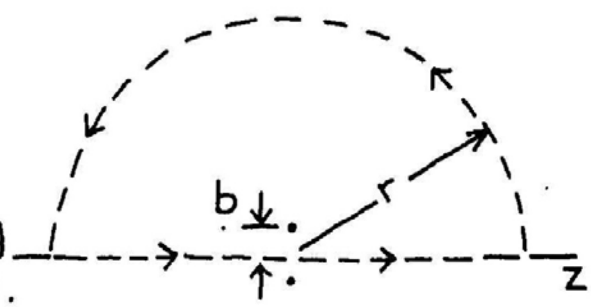
$$B_2 = \frac{2 \times 24 \times 10^{12}}{3 \times 10^{10} \times 2} = 800 \text{ gauss}$$

$$B_3 = \frac{2 \times 24 \times 10^{12}}{3 \times 10^{10} \times 3} = 533 \text{ gauss}$$

$\boxed{6.3}$ $B_z = \dfrac{2\pi b^2 I}{c(b^2+z^2)^{3/2}}$ $\quad \displaystyle\int_{-\infty}^{\infty} B_z\,dz = \frac{2\pi b^2 I}{c}\int_{-\infty}^{\infty}\frac{dz}{(b^2+z^2)^{3/2}}$

$$= \frac{2\pi b^2 I}{c}\left[\frac{z}{b^2(b^2+z^2)^{1/2}}\right]_{-\infty}^{\infty} = \frac{2\pi b^2 I}{c}\cdot\frac{2}{b^2} = \frac{4\pi I}{c}$$

To see why the return path can be ignored in the limit $z \to \infty$, consider the finite path out to $z = r$, returning by way of the large semicircle.



On the axis $B_z \sim \frac{1}{z^3}$, for $z \gg b$ and we may infer that, going out in any direction from the ring, $|B| \sim \frac{1}{r^3}$ as $r \to \infty$. Since the length of the semicircle is proportional to r, the integral $\int \underset{\sim}{B} \cdot d\underset{\sim}{s}$ over the semicircle must vanish at least as fast as $1/r^2$ as $r \to \infty$. [In fact, it vanishes just that fast.]

6.4

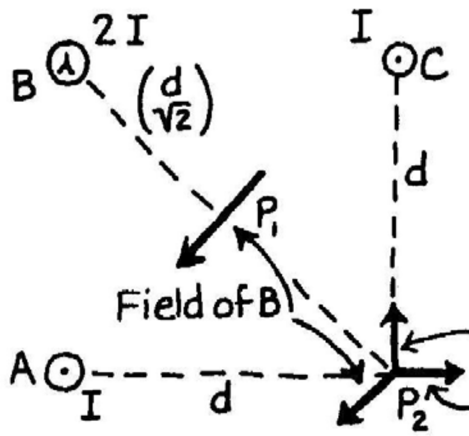
$$B = \underbrace{\frac{1}{2}\left(\frac{2I}{rc}\right) + \frac{1}{2}\left(\frac{2I}{rc}\right)}_{\text{Each straight section contributes half the field of an infinite wire}} + \underbrace{\frac{1}{2}\left(\frac{2\pi I}{rc}\right)}_{\text{Half the field of a complete ring}}$$

Each straight section contributes half the field of an infinite wire

Half the field of a complete ring

$$B = (2+\pi)\frac{I}{rc} = 5.1416\,\frac{I}{rc}$$

6.5



At P_1 the field of wires A and C cancel. Field of wire B at P_1 is $\dfrac{2 \times 2I}{c\left(\frac{d}{\sqrt{2}}\right)} = \dfrac{4\sqrt{2}\,I}{cd}$

Field of B at P_2 $= \dfrac{2\sqrt{2}\,I}{cd}$

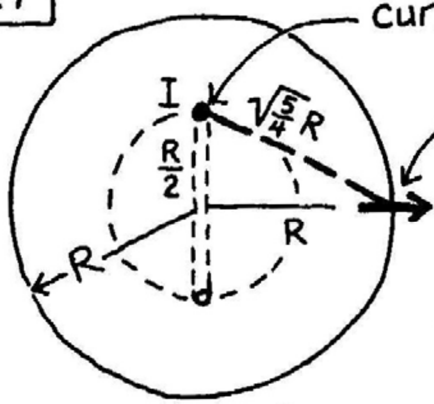
Field of A $= \dfrac{2I}{cd}$

Field of C

The vector sum of the 3 fields at P_2 is zero.

6.7

current ring



$R = 6 \times 10^8$ cm

$$B = \frac{I \times 2\pi (R/2)}{c\left(\sqrt{\frac{5}{4}}R\right)^2} \cdot \frac{(R/2)}{\left(\sqrt{\frac{5}{4}}R\right)}$$

$$= \frac{1.1\,I}{cR} = 0.5 \text{ gauss}$$

$$I = \frac{0.5}{1.1}cR = \frac{0.5}{1.1}\,3 \times 10^{10} \times 6 \times 10^8 \text{ esu/sec}$$

$$= 9 \times 10^{18} \text{ esu/sec} = 3 \times 10^9 \text{ amp}$$

6.9 Evidently the magnetic field of the current in the wire was .2 gauss at a distance of roughly 2 cm. The current must have been about 2 amperes.

6.10 For 10^7 watts at 5×10^4 volts, $I = 200$ amp.

Field in teslas at 1 meter $= \dfrac{\mu_0 I}{2\pi r}$ ← amp, ← meters

$$= \frac{4\pi \times 10^{-7}}{2\pi} \times \frac{200}{1} = 4 \times 10^{-5}\,T = .4 \text{ gauss}$$

Other wire causes equal field : $B = 8 \times 10^{-5}\,T = 0.8$ gauss

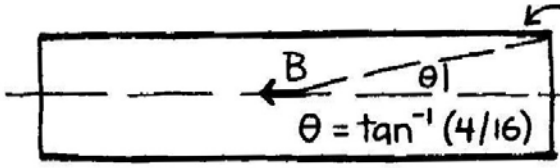
6.11 Average diameter of turn $= 8 + 2 \times 0.163 = 8.3$ cm

Total length of wire $= \pi \times 8.33 \times 8 \times 32 = 67$ meters

Resistance $= 0.67$ ohm $\quad I = 50/.67 = 75$ amps

Power $= 50 \times 75 = 3750$ watts

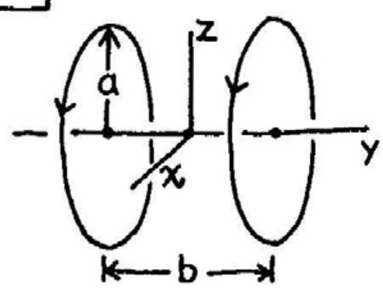
8×75 amp turns/cm

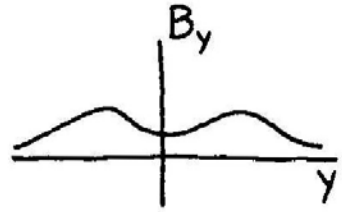


Field in infinitely long coil would be $.4\pi \times 600$ or 754 gauss.

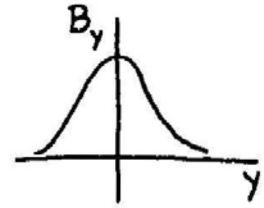
$B = 754 \times \cos(\tan^{-1} \frac{1}{4}) = 731$ gauss

6.13





coils far apart



coils close together

$$B_y \propto \frac{b/2 - y}{\left[a^2 + (b/2 - y)^2\right]^{3/2}} + \frac{b/2 + y}{\left[a^2 + (b/2 + y)^2\right]^{3/2}}$$ Differentiate

twice and set $\frac{d^2 B_y}{dy^2} = 0$ at $y = 0$. This gives: $b = a$

Note that $\frac{d^3 B_y}{dy^3} = 0$ at $y = 0$ just from symmetry.

With $b = a$ we have $B_y = B_y(0) + \text{constant} \times y^4 + \cdots$
Two coils thus arranged are called Helmholtz coils.

6.16 If the hole were filled with a copper rod carrying a current of 300 amperes, complete symmetry would be restored and the field at P would surely be zero. So the actual field at P must be the negative of the field of the rod just described. Its magnitude in gauss is $(2/10)I/r$ with $I = 300$ amperes and $r = 2$ cm, or 30 gauss, and it points to the left. A more remarkable fact, not too hard to prove: The field is 30 gauss pointing to the left not only at P but <u>everywhere within the cylindrical hole</u>!