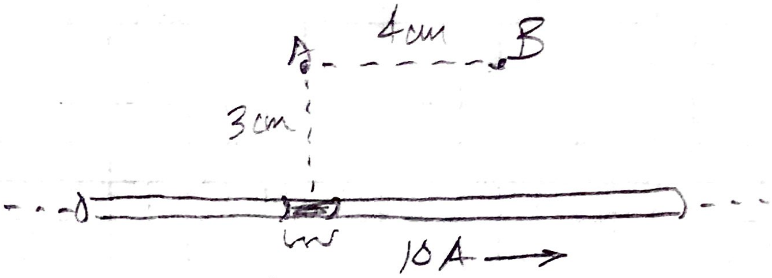
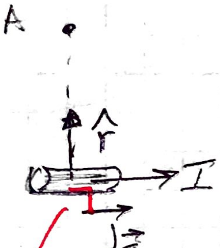
12.16



Entire wire carries current, but we're solving for magnetic field due only to this small part of it.

a)



unit vector
1

$\theta = 90°$

$d\vec{s} \times \hat{r} = (ds)(r)(\sin\theta)$

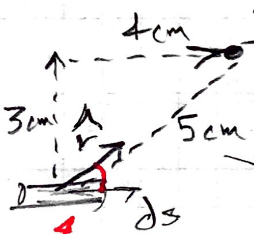
From Biot-Savart Law:

$$B = \int k_m \frac{I\, d\vec{s} \times \hat{r}}{r^2}$$

$$= \frac{(10^{-7} \frac{T m}{A})(10A)(0.5e{-3})(1)(\sin 90)}{(0.03m)^2}$$

$$= \boxed{5.56e{-7}\ T}$$

b)



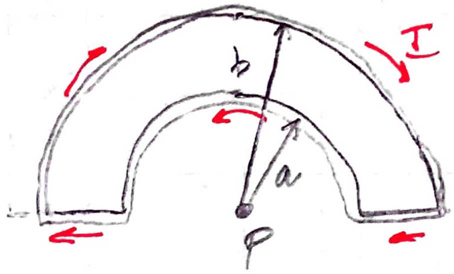
$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 36.9°$

$$B = \int \frac{k I\, d\vec{s} \times \hat{r}}{r^2}$$

$$= \frac{(10^{-7})(10A)(0.5e{-3})(1)\sin(36.9)}{(0.05m)^2}$$

$$B = \boxed{1.20e{-7}\ T}$$

12.18

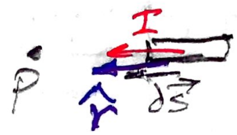


$$B = \int \frac{kI\, \vec{ds} \times \hat{r}}{r^2}$$

Find B at point P.

There are 4 segments of wire which have current in them — two straight & two parallel.

Lets do the easy ones first — the straight parts.

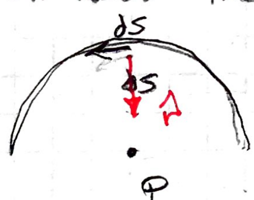


$\hat{r}$ points from $\vec{ds}$ toward P, & $\vec{ds}$ points in the same direction.

$$\vec{ds} \times \hat{r}$$
$$= (ds)(r)(\sin\theta)$$
$$= (ds)(r)(\sin 0)$$
$$= \boxed{0}$$

There is no magnetic field to a current-carrying wire at points that lie along the projected path of the wire.

What about the curved parts?



Inner curve:

$$B_a = \int \frac{kI\, \vec{ds} \times \hat{r}}{r^2}$$

unit vector

$$= \int \frac{kI(ds)(1)(\sin\theta)}{a^2}$$

90 because $\vec{ds}$ & $\hat{r}$ are always ⊥!

radius

$$= \frac{kI}{a^2}\int ds, \text{ where } \underbrace{ds = r\,d\theta}_{\text{Remember this?!}}$$

$$= \frac{kI}{a^2}\int_0^{\pi} r\,d\theta$$

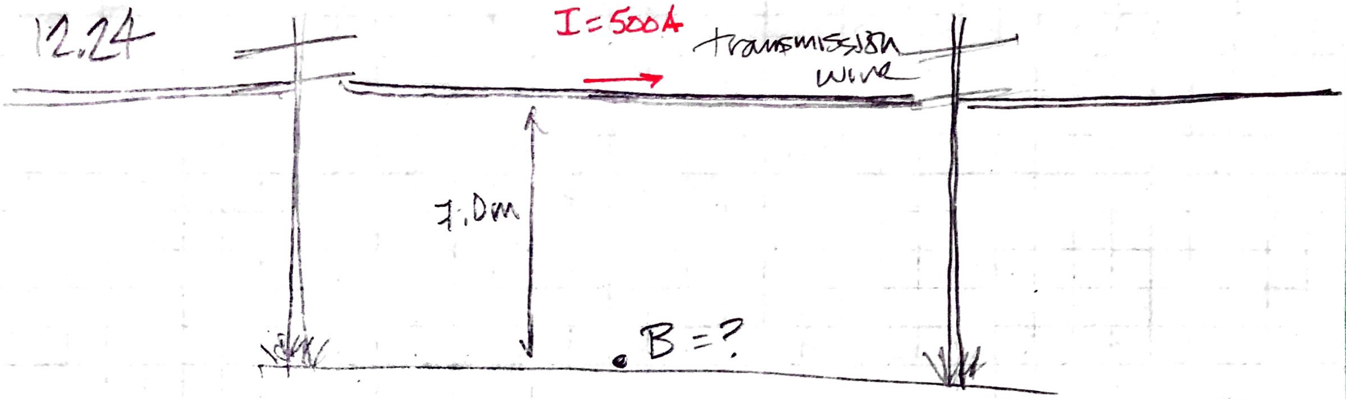
$$= \boxed{\frac{kI\pi}{a}}$$ out of page by RHR

Outer curve is the same, but w/ B into the page.

$$B_b = \boxed{\frac{kI\pi}{b}} \text{ into the page}$$

$$B_{net} = \boxed{kI\pi\left(\frac{1}{a} - \frac{1}{b}\right) \text{ out of the page}}$$

12.24



$$B = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi e\text{-}7)(500\,A)}{2\pi(7.0\,m)} = \boxed{1.43e\text{-}5\,T}$$

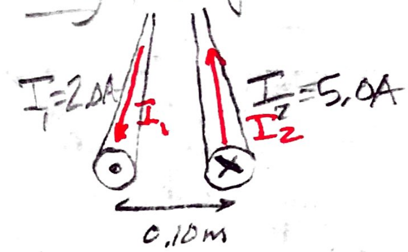
B earth at surface?

According to Wikipedia, B = 25e-6 to 65e-6 Teslas

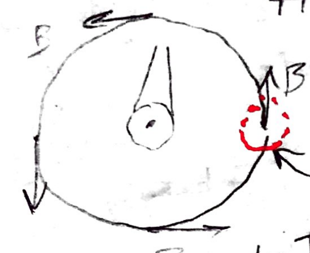
Our result is 14.3 e-6 T, so less than B earth but similar in magnitude!

$$\frac{14.3\,\mu T}{45\,\mu T\,(avg)} \times 100 = 32\% \text{ of Earth}$$

12.31 Two long, straight wires



a) If currents are in opposite directions...



$B_1 = \frac{\mu_0 I_1}{2\pi r}$ at this location

Force on second wire, then, is $F = I_2 l \times B$

$= I_2 l \times B_1$

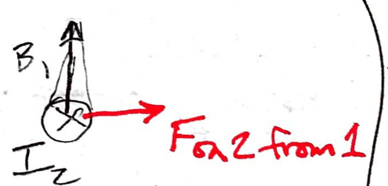
$F = I_2 l \times \frac{\mu_0 I_1}{2\pi r}$

$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$

$= \frac{(4\pi e\text{-}7)(2)(5)}{2\pi(0.10)}$

$\frac{F}{l} = \boxed{2.0e\text{-}5\ N}$

By the RHR, the force is away from the wire on the left.



By symmetry, the force on wire 1 from wire 2 is the same magnitude, but to the left.

b) If the currents flow in the same direction the forces are the same, but now the wires experience forces toward each other.