12.17 解:

$$I = \frac{U}{R}$$

已知

待求

需求解

取长为 L，半径为 r，厚度 dr 的薄圆筒.

其电阻:

$$dR = \rho \cdot \frac{dr}{S} = \rho \frac{dr}{2\pi r L}$$

$$\therefore R = \int dR = \int_{r_1}^{r_2} \rho \frac{dr}{2\pi r L} = \frac{\rho}{2\pi L} \ln \frac{r_2}{r_1} = 3.3 \times 10^{10}\ \Omega$$

$$\therefore I = \frac{U}{R} = 1.8 \times 10^{-8}\ A$$

12.18. 解：

(1) 取半径为 r，~~垂~~厚度 dr 的球壳.

电阻 $dR = \rho \frac{dr}{S} = \frac{1}{\sigma} \cdot \frac{dr}{4\pi r^2}$

$\therefore R = \int dR = \frac{1}{4\pi\sigma}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\therefore I = \frac{U}{R} = \frac{4\pi U \sigma R_1 R_2}{R_2 - R_1}$

(2) $j = \frac{I}{4\pi r^2} = \frac{U\sigma R_1 R_2}{(R_2 - R_1) r^2}$

12.19. 解：同前面习题类似，

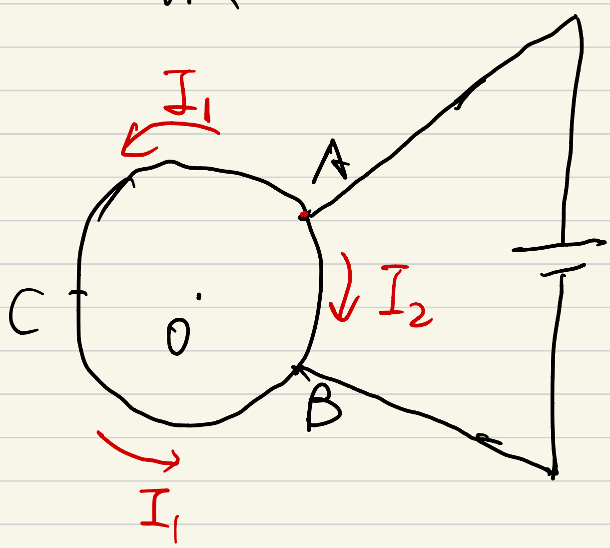
$$dR = \rho \cdot \frac{dr}{2\pi r^2}$$

$$\therefore R = \int dR = \int_a^{\infty} \rho \frac{dr}{2\pi r^2} = \frac{\rho}{2\pi a}$$

12.21 解：课堂PPT上讲过类似习题。

$$B = \frac{\mu_0 I}{4R}\left(1 - \frac{\sqrt{2}}{\pi}\right)$$

12.23 解：



电压：

$$\begin{cases} U = I_1 R_{ACB} = I_2 R_{AB} \\ R_{ACB} = \rho \frac{L_{ACB}}{S} \\ R_{AB} = \rho \frac{L_{AB}}{S} \end{cases}$$

$$\therefore I_1 L_{ACB} = I_2 L_{AB}$$

由毕奥-萨代尔定律，可得：

对于 $\overset{\frown}{ACB}$ 段，其在圆心处的磁感应强度

$$B_1 = \frac{\mu_0 I_1}{2R} \cdot \frac{l_{ACB}}{l_{ACB}+l_{AB}} \quad (方向：\otimes)$$

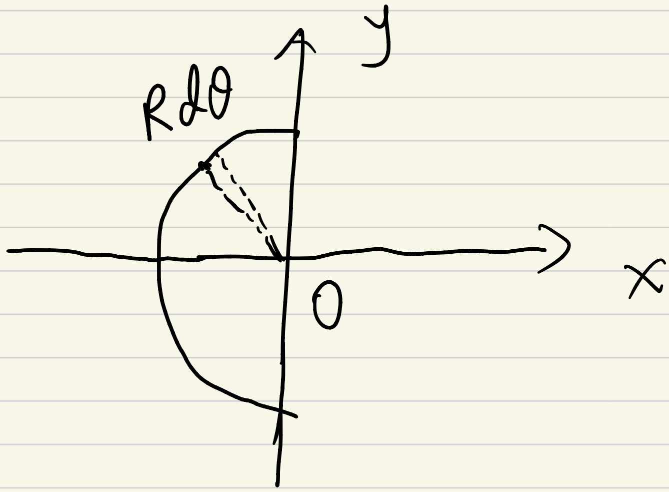
对于 $\overset{\frown}{AB}$ 段，— — — — —

$$B_2 = \frac{\mu_0 I_2}{2R} \frac{l_{AB}}{l_{ACB}+l_{AB}} \quad (方向 \odot)$$

∴ 总磁感应强度：

$$B = B_1 - B_2 = 0$$

12.25 解：[注：圆柱面是空心，只表面有电流]



取一根宽为 $dl = R d\theta$ 的无限长直导线

其电流 $dI = \frac{I}{\pi R} \cdot dl = \frac{I}{\pi} d\theta$

∴ 其在轴线上任意点

$$dB = \frac{\mu_0}{2\pi R} dI = \frac{\mu_0 I}{2\pi^2 R} d\theta$$

考虑 x 轴方向上，相互抵消.

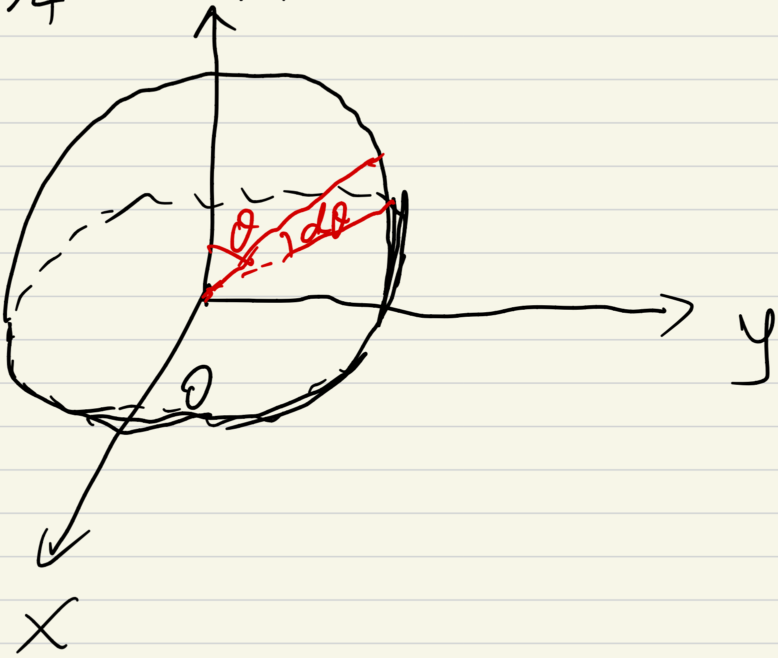
那么，该半圆环在 O 点

$$dB_y = dB \cos\theta.$$

$$B_y = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} dB \cos\theta = \frac{\mu_0 I}{\pi^2 R},$$ 沿 y 轴正方向

12.26 解：在 $\frac{1}{4}$ 圆周上单位长度内的线圈匝数

$$n = \frac{N}{2\pi R/4} = \frac{2N}{\pi R}$$



在半球面取一个宽 $Rd\theta$ 的圆环.

$$dI = I\underbrace{\frac{2N}{\pi R}R\,d\theta} = \frac{2NI}{\pi}d\theta.$$

该圆环电流半径 $r = R\sin\theta$，圆心到球心的距离 $z = R\cos\theta$.

∴其对轴线上任意点

$$dB = \frac{\mu_0 r^2}{2(r^2+z^2)^{3/2}}dI = \frac{\mu_0 N I \sin^2\theta}{\pi R}d\theta$$

∴总磁场：$B = \int dB = \int_0^{\frac{\pi}{2}} \cdots d\theta = \frac{\mu_0 N I}{4R}$

12、28 解：根据课堂上的习题，可求得：

$$\Phi = \int d\Phi = \frac{\mu_0 I}{2\pi} c - \frac{\mu_0 I a c}{2\pi b} \ln \frac{a+b}{a}$$