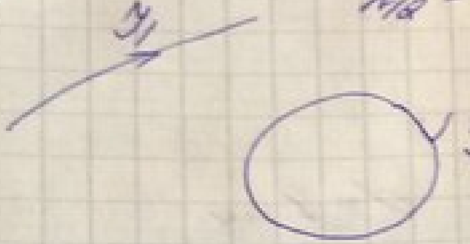
$\Phi = \int \vec{B}\, d\vec{S}$

$L_{12} = \frac{\Phi_2}{I_1} = L_{21}$



$L = \frac{\Phi}{I}$

№9.1

μ_1, μ_2

Дано: $\mu_1 = 400$

$\mu_2 = 100$

$R_2 = 10{,}8$

$R_1 = 4$

$h = 6$

$N = 400$

Решение: $L = \frac{\Phi}{I}$

$\oint \vec{H}\, d\vec{l} = H 2\pi r = NI \Rightarrow H = \frac{NI}{2\pi r}$

$B_{n1} = B_{n2}$ H и B ∥ границе раздела

$H_{\tau 1} = H_{\tau 2}$ ⇒ норм нет вообще

$B_1 = \mu_0 \mu_1 H$, $B_2 = \mu_0 \mu_2 H$

$\Phi = N \int \vec{B}\, d\vec{S} = N \int B\, dS = N \int \frac{h}{2} \int_{R_1}^{R_2} \frac{\mu_0 \mu_1 N I}{2\pi r}$

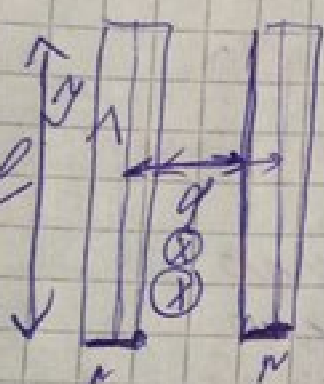
$dr + \frac{h}{2} \int \frac{\mu_0 \mu_2 N I}{2\pi r}\, dr = \frac{N^2 h \mu_0 I}{4\pi} \left(\mu_1 \ln \frac{R_2}{R_1} + \mu_2 \frac{R_2}{R_1} \right)$

$$L = \frac{\Phi}{I} = \frac{N^2 h \mu_0 (\mu_1 + \mu_2)}{4\pi} \ln\frac{R_2}{R_1} =$$

$\approx 0{,}5$ Гн

№ 9.2

Дано: $l = 1$, $a = 0{,}5$ мм, $d = 1$ см



$$L = \frac{\Phi}{I}$$

$$B_1 = \frac{\mu_0 I}{2\pi r}$$

$$B_2 = \frac{\mu_0 I}{2\pi (d-r)}$$

$$\Phi = \int B\,dS = \int (B_1 + B_2)\,dS =$$

$$= \frac{l \mu_0 I}{2\pi} \int_a^{d-a} \left(\frac{1}{r} + \frac{1}{d-r}\right) dr = \frac{\mu_0 I l}{2\pi} \Big(\ln r -$$

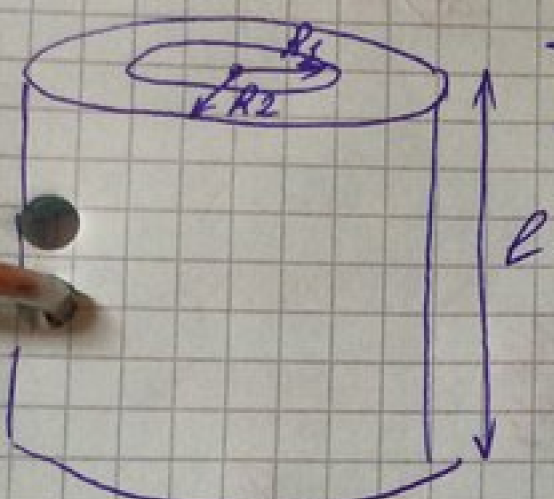
$$- \ln(d-r)\Big)\Big|_a^{d-a} = \frac{\mu_0 I l}{2\pi} \big(2\ln(d-a) - 2\ln a\big)$$

$$= \frac{\mu_0 I l}{\pi} \ln\frac{d-a}{a}$$

$$L = \frac{\mu_0 l}{\pi} \ln\frac{d}{a} =$$

№9.3

Дано: $l = 1$ м; $R_1 = 0{,}5$ мм, $R_2 = 1$ см



Найти: L

Решение: $L = \frac{\Phi}{I}$

$$H(r) = \frac{I}{2\pi r}$$

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

$$\Phi = \int_S B\,dS =$$

$$= \frac{\mu_0 I}{2\pi}\int_S \frac{dS}{r} = \frac{\mu_0 I}{2\pi}\int_0^l dz \int_{R_1}^{R_2} \frac{1}{r}\,dr$$

$$= \frac{\mu_0 I}{2\pi}\ln\frac{R_2}{R_1}$$

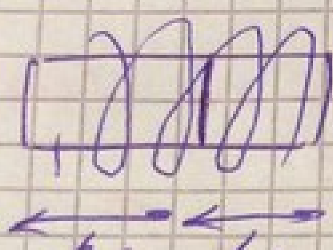
$$L = \frac{\Phi}{I} = \frac{\mu_0}{2\pi}\ln\frac{R_2}{R_1}$$

№9.1 (?)

Дано: L_1, L_1, L_2

Найти: 1) L - ?

2) N - ?



Решение

$\frac{L_2}{L_1} = \left(\frac{N_2}{N_1}\right)^2$ $\qquad \frac{\Phi_2}{\Phi_1} = \frac{N_2}{N_1}$

1) $L = \frac{\Phi}{I}$ $\qquad L_1 = \frac{\Phi_1}{I}$ $\qquad L_2 = \frac{\Phi_2}{I}$

$\cancel{I = \frac{\Phi_1}{L_1} = \Phi_2}$

$\Phi = \Phi_1 + \Phi_2$

$IL = IL_1 + IL_2$

$L = L_1 + L_2$

2) $\frac{\Phi_1}{\Phi_2} = \frac{N_1}{N_2} = \sqrt{\frac{L_1}{L_2}}$ $\qquad N_2 = \sqrt{\frac{L_2}{L_1}} N_1$

$N = N_1 + N_2 = N_1\left(1 + \sqrt{\frac{L_2}{L_1}}\right)$

?

№95

Дано: $N = 500$

$R_2 = 10{,}8$ см

$R_1 = 4$ см

$h = 6$ см

$\mu = 100$

Найти: L_{12}

Решение: $L_{12} = \dfrac{\Phi_2}{I_1}$

I в проводе I_1. Найдем Φ_2:

$$\Phi_2 = N\int_S B\,dS = \frac{N I \mu \mu_0}{2\pi} \int_0^h dz \int_{R_1}^{R_2} \frac{dr}{r} =$$

$$H \cdot 2\pi r = I \Rightarrow H(r) = \frac{I}{2\pi r}$$

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

$$= \frac{N h \mu_0 \mu I}{2\pi} \ln\frac{R_2}{R_1}$$

$$L_{12} = \frac{\Phi_2}{I_1} = \frac{N h \mu_0 \mu}{2\pi} \ln\frac{R_2}{R_1}$$

№9.6

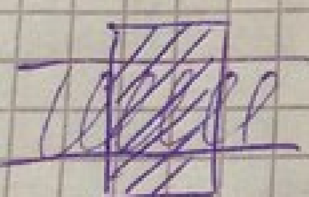
Дано: $n = 10^3$ витков/ед. длины

$S = 10\,м^2$

$N = 20$ витков

Найти: L_{12}

Решение:



I по соленоиду течет ток $I_1 \Rightarrow L_{12} = \frac{\Phi_2}{I_1}$

$\Phi_2 = N\int_S B\,dS = N \cdot \mu_1 \mu_0 n I S$

$B = \mu_1 \mu_0 H$

$\boxed{B = \mu_0 \mu n I}$

$\cancel{\oint H dl} = I$

l

$\cancel{H}$

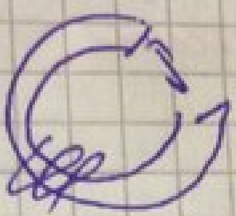
L — длина соленоида

№9.77

Дано: $R_2,\ R_1,\ h,\ \Delta = 1$ мм

$\mu,\ N$

Найти: L



Решение $L = \dfrac{\Phi}{I}$

$$\Phi = N\int_S B\,dS =$$

$$H = \frac{B(r)}{\mu_0\mu} \qquad H_з = \frac{B(r)}{\mu_0\mu} \; -$$

$$IN = \frac{B(r)}{\mu_0\mu}(2\pi r - d) + \frac{B(r)}{\mu_0}d$$

$$B(r) = \frac{\mu_0\mu I N}{2\pi r + (\mu-1)d}$$

$$= N\frac{\mu_0\mu I N}{2\pi r + (\mu-1)d} \qquad N^2\mu_0\mu I\int_0^h dz\int_{R_1}^{R_2}$$

$$\frac{1}{2\pi r + (\mu-1)\Delta} = \frac{N^2\mu_0\mu I}{2\pi}\cdot h\cdot \ln\left(\frac{R_2+(\mu-1)\Delta}{R_1+(\mu-1)\Delta}\right)$$

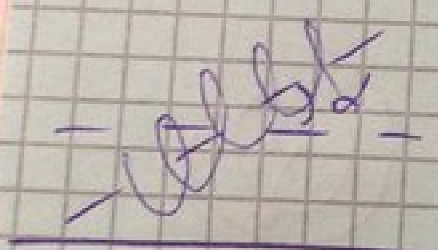
№9.8

Дано: ∞ солен с n на ед длины

S, N

Найти: L_{12}, если между осями α

$$L_{12} = \frac{\Phi_2}{I_1}$$



∃ по соленоиду течет I_1.

$B = \mu_0 n I_1$ (7.9)

$\Phi_2 = N \int_S \vec{B} d\vec{S} = \mu_0 n N I_1 S \cos\alpha$

$L_{12} = \mu_0 n N S \cos\alpha$ //

№9.9 (не уверена)

Дано: $l, N, S, d \ll l, \mu \gg 1$

Найти: L

Решение: $\Phi = N \int_S B dS =$

$= \left\{ B = \mu_0 \frac{N}{l-d} I \right\}$

$= \frac{\mu_0 N^2 I S}{l-d}$

№9.10

Дано: $l = 20$ см, $R = 6$

$r = 3$ мм

$I = 100$ A

$\mu = 1000$

Найти: $W_м$

Решение:

$$W_м = \frac{LI^2}{2}$$

$$L = \frac{\mu\mu_0 l}{2\pi}\ln\left(\frac{R}{r}\right) \quad (\text{из } 9.3)$$

$$W = \frac{\mu\mu_0 l I^2 \ln\left(\frac{R}{r}\right)}{4\pi}$$

№9.11

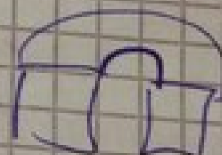
Дано: $I = 10$ А

$R_2 = 5.4$ мм

$R_1 = 2$ мм

h, μ, N

Найти: W_m



$$W_m = \frac{L I^2}{2}$$

$L = \frac{\Phi}{I}$ → в катушке

$$\Phi = \oint_S B\,dS = \mu_1\mu_0 \int_S H\,dS = \checkmark$$

$$= \mu_1\mu_0 \frac{IN^2}{2\pi} \int dS/r =$$

$$= \mu_1\mu_0 \frac{IN^2}{2\pi} \int_0^h dz \int_{R_1}^{R_2} \frac{dr}{r} =$$

$$= \mu_0\mu_1 \frac{Ih}{2\pi} \ln\frac{R_2}{R_1} N^2$$

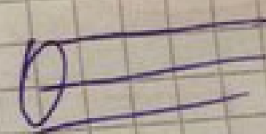
$$L = \frac{\mu_1\mu_0 I h N^2}{2\pi} \ln\frac{R_2}{R_1}$$

$$W_m = \frac{\mu_1\mu_0 I^2 h}{4\pi} \ln\frac{R_2}{R_1} N^2$$

$$L = \frac{\mu \mu_0 N^2 h}{2\pi} \ln \frac{R_2}{R_1}$$

$$W = \frac{\mu \mu_0 N^2 h I^2}{4\pi} \ln \frac{R_2}{R_1}$$

№ 9.12



Дано: n_0, S_1, S_2

$S_1 \ll S_2$

Найти: $\frac{W_c}{W_{пл}}$

Решение:

1) $W_c = \frac{L I^2}{2}$ $\quad L = \mu_0 n_0^2 S_2$

$$W_c = \frac{\mu_0 n_0^2 S_2 I^2}{2}$$

$$W = \frac{L I^2}{2} = \frac{1}{2} I \Phi$$

2) $W = \frac{1}{2} \vec{B} \vec{H}$

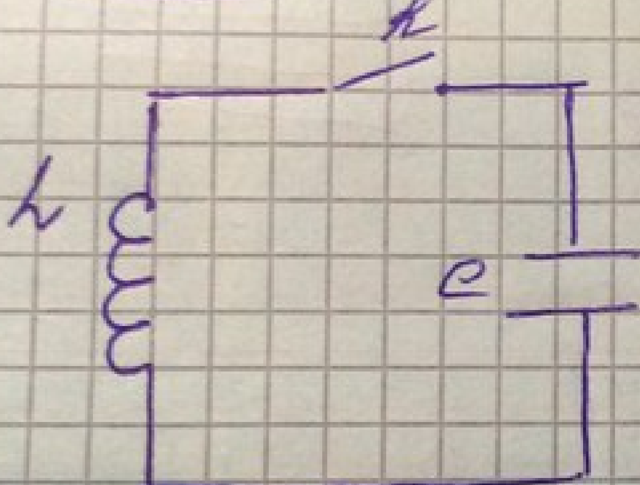
$$B_{пл} = \frac{\mu_0 I}{2\pi r} \qquad \Phi = \int_S B\,dS = \frac{\mu_0 I}{2\pi} \ln \frac{R_2}{R_1}$$

$$W_c = \frac{1}{2} I \Phi = \frac{1}{2} I \frac{\mu_0 I}{2\pi} \ln \frac{R_2}{R_1}$$

$$W_{пр} = \frac{1}{4\pi}\mu_0 I^2 \ln\frac{R_2}{R_1} = \frac{1}{8\pi}\mu_0 I^2 \ln\frac{S_2}{S_1}$$

$$\frac{W_c}{W_{пр}} = \frac{n_0^2 S_1}{\ln\frac{S_2}{S_1}} 4\pi$$

№9.13



Дано:

C, U_0, L

Найти: I_{max}

Решение

$$W_L = \frac{CU_0^2}{2}$$

$$I_{max}: \quad W = \frac{LI_{max}^2}{2} = \frac{CU_0^2}{2}$$

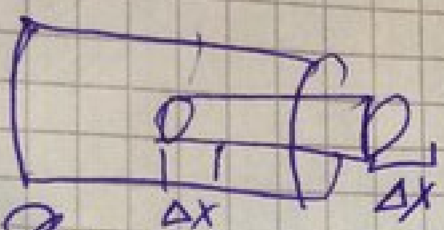
$$I_{max} = U_0\sqrt{\frac{C}{L}}$$

№9.14 (не уверена)

<u>Дано:</u>

I_1, I_2, n

$F = ?$



<u>Решение</u>

Сместим внутр соленоид на Δx.

$\delta A = F\Delta x$

$\delta A = I\Delta\Phi$

$F = \frac{I\Delta\Phi n_1}{\Delta x}$ $F = \frac{I_1 n_1 \Delta\Phi}{\Delta x}$

$\Delta\Phi = \Phi_2 - \Phi_1 = \cancel{B_2 S - B_1 S}$. $\cancel{\Delta\Phi =}$

$= N_2 B_2 S - N_1 B_1 S$ $\Delta N = \Delta x \cdot n$

$N_2 = N_1 = \Delta N = n\Delta x$

$\Delta\Phi = \frac{\mu_0 n_2 I_2 \pi r^2 \cdot \Delta x}{\Phi_2}$

№ 9.15

<u>Дано:</u> h_0, β

<u>Найти:</u> h

<u>Решение:</u> $h = h_0 + h_1$

$$\frac{h_0}{h_1} = \frac{\cancel{\mu_0} n_1^2 S \cancel{\ell_1}}{\cancel{\mu_0 \ell} n_2^2 S_1} = \beta \Rightarrow h_1 = \frac{h_0}{\beta}$$