Solution of the problem 9.32

ORIGIN := 1 Magnetization curve of steel 1 51 2

$$BH1 := \begin{pmatrix} 0 & 0.1 & 0.2 & 0.3 & 0.4 & 0.5 & 0.6 & 0.7 & 0.8 & 0.9 & 1 & 1.1 \\ 0 & 0.13 & 0.25 & 0.35 & 0.5 & 0.65 & 0.8 & 0.95 & 1.15 & 1.5 & 2.0 & 3.0 \end{pmatrix}$$

$$BH2 := \begin{pmatrix} 1.15 & 1.2 & 1.25 & 1.3 & 1.35 & 1.4 & 1.45 & 1.5 & 1.55 & 1.6 & 1.7 & 1.76 \\ 3.7 & 4.65 & 6 & 7.2 & 9.2 & 12 & 15 & 23 & 33 & 49 & 90 & 120 \end{pmatrix}$$

$BH := \text{augment}(BH1, BH2)$ $B := \left(BH^T\right)^{\langle 1 \rangle}$ $H := \left(BH^T\right)^{\langle 2 \rangle}$ $m := \text{length}(B)$

BH =

	1	2	3	4	5	6	7	8	9	10
1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2	0	0.13	0.25	0.35	0.5	0.65	0.8	0.95	1.15	1.5

Approximation of the magnetization curve by analytical expression with the aid of the function linfit

$$F(x) := \begin{pmatrix} \sinh\left(0.63 \cdot x^3\right) \\ x^5 \\ x^9 \\ x^{15} \end{pmatrix}$$

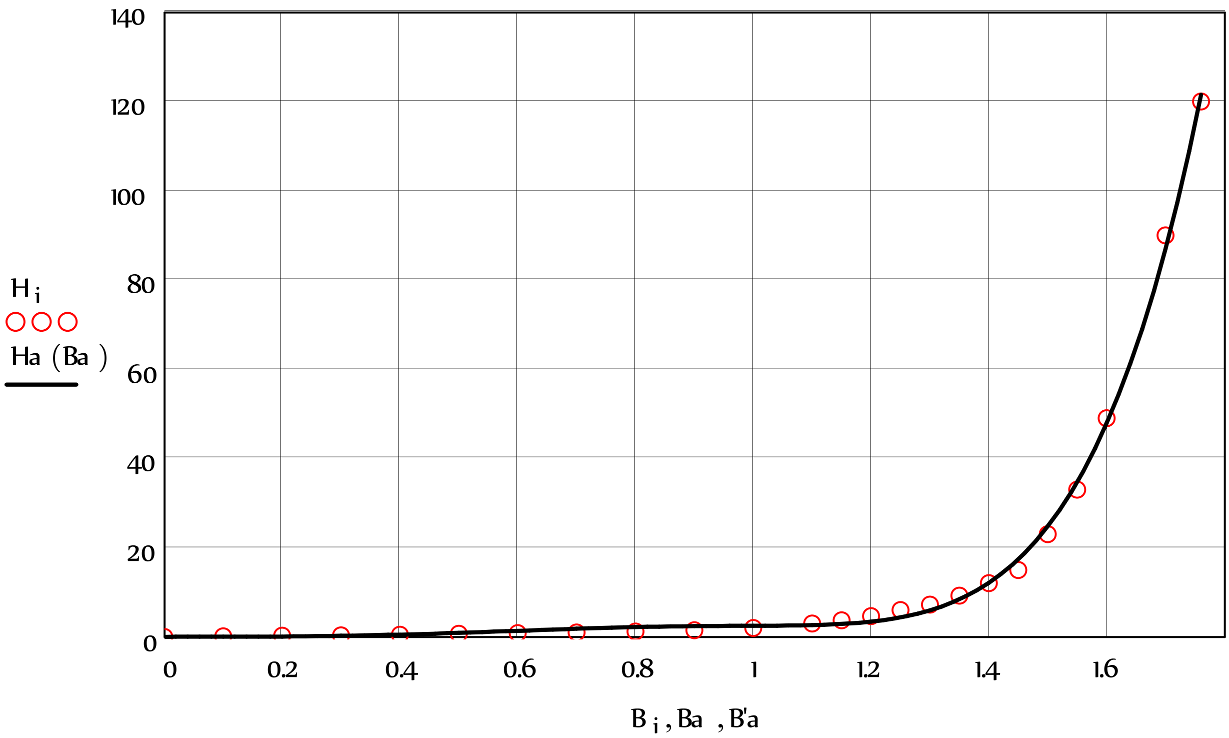
$K := \text{linfit}(B, H, F)$

$$K = \begin{pmatrix} 14.391 \\ -8.198 \\ 1.021 \\ -0.027 \end{pmatrix}$$

$i := 1 .. m$

$Ba := 0, 0.02 .. 1.76$

Verification of the approximation $\quad Ha(Ba) := F(Ba)\cdot K \qquad Ha(B_{11}) = 2.474$



Initial data

$$Iw := \begin{pmatrix} 1500 \\ 2000 \end{pmatrix} \qquad l := \begin{pmatrix} 40 \\ 80 \\ 60 \\ 60 \\ 40 \\ 40 \end{pmatrix} \qquad S := \begin{pmatrix} 25\cdot 10^{-4} \\ 25\cdot 10^{-4} \\ 20\cdot 10^{-4} \\ 20\cdot 10^{-4} \\ 20\cdot 10^{-4} \\ 20\cdot 10^{-4} \end{pmatrix}$$

$$l\square := \begin{pmatrix} 0.005 \\ 0.01 \end{pmatrix}$$

$$F(x) := \left(K_1\cdot \sinh\left(0.63\cdot x^3\right) + K_2\cdot x^5 + K_3\cdot x^9 + K_4\cdot x^{15}\right)$$

Solution of the nonlinear equation system

$B1 := 0.5 \qquad B2 := 1. \qquad B3 := 0.3 \qquad B4 := 0.4 \qquad B5 := 1 \qquad B6 := 1$

Given

$$F(B1)\cdot l_1 + 8000\cdot B3\cdot l\square_1 + F(B3)\cdot l_3 + F(B5)\cdot l_5 = Iw_1 \qquad B4\cdot S_4 + B3\cdot S_3 = B1\cdot S_1$$

$$F(B1)\cdot l_1 + 8000\cdot B4\cdot l\square_2 + F(B4)\cdot l_4 + F(B6)\cdot l_6 = Iw_1 \qquad B2\cdot S_2 + B5\cdot S_5 = B3\cdot S_3$$

$$F(B2)\cdot l_2 + F(B6)\cdot l_6 - F(B5)\cdot l_5 = Iw_2 \qquad B6\cdot S_6 = B2\cdot S_2 + B4\cdot S_4$$

Answers: B in T, Φ in Wb, H in A/cm

$$\square\square := \mathrm{Find}(B1, B2, B3, B4, B5, B6)$$

$$□□ = \begin{pmatrix} 1.097 \\ 1.332 \\ 1.485 \\ -0.113 \\ -0.18 \\ 1.552 \end{pmatrix} \qquad H := \begin{pmatrix} F(□□_1) \\ F(□□_2) \\ F(□□_3) \\ F(□□_4) \\ F(□□_5) \\ F(□□_6) \end{pmatrix} \qquad H = \begin{pmatrix} 2.615 \\ 7.409 \\ 22.301 \\ -0.013 \\ -0.052 \\ 35.131 \end{pmatrix}$$

$$\Phi := \overrightarrow{(□□ \cdot S)} \qquad \Phi = \begin{pmatrix} 2.743 \times 10^{-3} \\ 3.33 \times 10^{-3} \\ 2.97 \times 10^{-3} \\ -2.269 \times 10^{-4} \\ -3.606 \times 10^{-4} \\ 3.103 \times 10^{-3} \end{pmatrix}$$

Solution of the problem 9.33

$ORIGIN := 1$

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$$BH1 := \begin{pmatrix} 0 & 0.3 & 0.6 & 0.7 & 0.8 & 0.9 & 1 & 1.1 & 1.2 & 1.25 \\ 0 & 0.4 & 0.81 & 1.1 & 1.3 & 1.52 & 1.82 & 2.13 & 2.43 & 2.58 \end{pmatrix}$$

$$BH2 := \begin{pmatrix} 1.3 & 1.35 & 1.4 & 1.45 & 1.5 & 1.55 & 1.6 & 1.65 & 1.7 \\ 2.75 & 2.95 & 3.2 & 3.5 & 3.9 & 4.5 & 5.2 & 6.32 & 8 \end{pmatrix}$$

$BH := augment(BH1, BH2)$ $\quad B := \left(BH^T\right)^{\langle 1 \rangle}$ $\quad H := \left(BH^T\right)^{\langle 2 \rangle}$ $\quad m := length(B)$

$m = 19$ Approximation of the magnetization curve by analytical expression with the aid of the function linfit

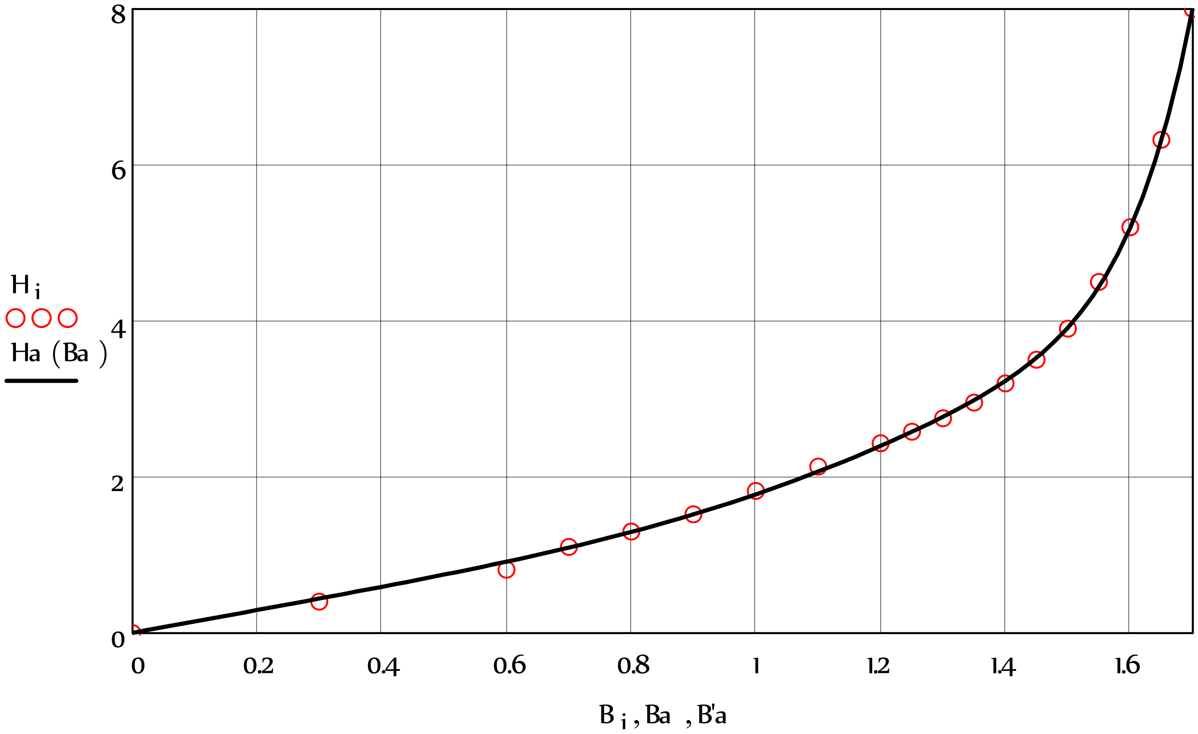
$$M(x) := \begin{pmatrix} \sinh(0.63 \cdot x) \\ x^5 \\ x^9 \\ x^{15} \end{pmatrix} \qquad K := linfit(B, H, M) \qquad K = \begin{pmatrix} 2.307 \\ 0.262 \\ -0.039 \\ 2.088 \times 10^{-3} \end{pmatrix}$$

$i := 1 .. m$

Verificationof the approximation

$Ba := 0, 0.02 .. 1.7$ $\quad Ha(Ba) := M(Ba) \cdot K$

$Ha(B_{10}) = 2.577$



Initial data

$$lw := \begin{pmatrix} 2000 \\ 3000 \end{pmatrix} \qquad l := \begin{pmatrix} 25 \\ 50 \\ 40 \\ 45 \end{pmatrix} \qquad l□ := \begin{pmatrix} 0.1 \\ 0.08 \end{pmatrix} \qquad S := \begin{pmatrix} 25 \cdot 10^{-4} \\ 20 \cdot 10^{-4} \\ 18 \cdot 10^{-4} \\ 18 \cdot 10^{-4} \end{pmatrix}$$

$$F(x) := \left(K_1 \cdot \sinh(0.63 \cdot x) + K_2 \cdot x^5 + K_3 \cdot x^9 + K_4 \cdot x^{15}\right)$$

Solution of the nonlinear equation system

$B1 := 1 \qquad B2 := 1 \qquad B3 := 0 \qquad B4 := 0 \qquad Um := 1000$

Given $\qquad B4 \cdot S_4 + B3 \cdot S_3 = B1 \cdot S_1 + B2 \cdot S_2$

$F(B3) \cdot l_3 + 8000 \cdot B3 \cdot l□_1 = Um \qquad F(B1) \cdot l_1 + Um = lw_1$

$F(B4) \cdot l_4 + 8000 \cdot B4 \cdot l□_2 = Um \qquad F(B2) \cdot l_2 + Um = lw_2$

□□ := Find (B1 ,B2 ,B3 ,B4 ,Um)

Answers: B in T, Φ in Wb, H in A/cm

$$□□ = \begin{pmatrix} 1.115 \\ 1.855 \\ 1.784 \\ 1.827 \\ 1.947 \times 10^3 \end{pmatrix}$$

$$B := \begin{pmatrix} \square\square_1 \\ \square\square_2 \\ \square\square_3 \\ \square\square_4 \end{pmatrix} \qquad B = \begin{pmatrix} 1.115 \\ 1.855 \\ 1.784 \\ 1.827 \end{pmatrix} \qquad Um := \square\square_5 \qquad Um = 1.947 \times 10^{3}$$

$$H := F(B) \qquad H = \begin{pmatrix} 2.115 \\ 21.058 \\ 13.006 \\ 17.289 \end{pmatrix} \qquad \Phi := \overrightarrow{(B \cdot S)} \qquad \Phi = \begin{pmatrix} 2.788 \times 10^{-3} \\ 3.711 \times 10^{-3} \\ 3.21 \times 10^{-3} \\ 3.288 \times 10^{-3} \end{pmatrix}$$