

Ms. 5100/20-21. Schludersbach-i ued'os'ek 1907

Lokoteg bor.
M. TUD. AKADEMIA
KÉZIRATI ÉS NÖVÉNYMÁSOLÓ
19. FEB. 17. SZ.

Ms 5100/20
24

Schwarzbach

M. Variometer

$$\begin{aligned}
 \frac{F}{2m\dot{h}\mu d} &= \left\{ 9 \frac{l}{a^4} \left(1 + \frac{5}{6} \frac{l^2}{a^2} + \frac{7}{16} \frac{l^4}{a^4} + \dots \right) + 12,5 \frac{l^3}{a^6} \left(1 + \frac{7}{4} \frac{l^2}{a^2} + \frac{6}{5} \frac{l^4}{a^4} + \dots \right) + \frac{2205}{128} \frac{l^5}{a^8} \left(1 + \frac{17}{4} \frac{l^2}{a^2} + \frac{607}{112} \frac{l^4}{a^4} + \dots \right) \right\} \sin 4\varphi \\
 &\quad \begin{matrix} 43,75 \\ \text{"} \\ 124,04 \end{matrix} \quad \begin{matrix} (=17,23 \\ \text{"} \\ \text{"} \end{matrix} \quad \begin{matrix} M \\ \text{"} \\ \text{"} \end{matrix} \quad \begin{matrix} 3 \\ \text{"} \\ \text{"} \end{matrix} \\
 + &\left\{ \frac{175}{4} \frac{l^3}{a^6} \left(1 + \frac{7}{4} \frac{l^2}{a^2} + \dots \right) + \frac{23827}{192} \frac{l^5}{a^8} \left(1 + \frac{17}{4} \frac{l^2}{a^2} + \dots \right) + \dots \right\} \sin 4\varphi \\
 &\quad \begin{matrix} 110,70 \\ \text{"} \\ \text{"} \end{matrix} \\
 + &\frac{14553}{128} \frac{l^5}{a^8} \left(1 + \frac{17}{4} \frac{l^2}{a^2} + \dots \right) \sin 6\varphi
 \end{aligned}$$

A mágnesek a keresztben beljebb vannak tolvá, úgy, hogy belső végeik távolsága a forgástengelytől 4,4 cm.

| Variometer a mágnespázi próbában; a kereszt magassága a padló felett 34 cm. | | | | | | | | Variometer ugyanott; I. mágnes hat. red. | | | | | | | |
|--|-----------|-------------------------|-------------------------|-----------|--------------------|----------------------|------------|---|-------------------------|-------------------------|-----------|--------------------|----------------------|------------|----------|
| Hely | Skálatav. | Fordulók | Redukált fordulók | Egyenfel. | Hitérés 250-tól | Hitérés skálatav. | Levegősid. | Skálatav. | Fordulók | Redukált fordulók | Egyenfel. | Hitérés 250-tól | Hitérés skálatav. | Levegősid. | Hely |
| I. | 111,5 cm. | 258,9 204,8 252,8 | 258,9 204,9 252,8 | 230,2 | -19,8 | -0,017758 | 61,6 sec. | 110,1 cm. | 149,2 304,4 166,5 | 150,3 304,2 167,2 | 231,7 | -18,3 | -0,016621 | 60,3 sec. | I. |
| I.-II. | 104,3 cm. | 167,5 248,1 180,0 | 168,3 248,1 180,4 | 226,4 | -23,6 | -0,022627 | 61,6 sec. | 99,6 cm. | 279,0 143,9 264,0 | 279,0 145,5 264,0 | 208,2 | -41,8 | -0,041964 | 61,2 sec. | I.-II. |
| II. | 108,2 cm. | 198,9 248,0 204,4 | 199,0 248,0 204,5 | 225,0 | -25,0 | -0,023105 | 62,0 sec. | 106,2 cm. | 265,7 187,0 256,7 | 265,7 187,3 256,7 | 224,0 | -26,0 | -0,024482 | 63,2 sec. | II. |
| II.-III. | 105,4 cm. | 321,7 158,6 303,2 | 321,3 159,5 303,0 | 235,4 | -14,6 | -0,013852 | 62,1 sec. | 106,2 cm. | 237,0 274,6 241,2 | 237,0 274,6 241,0 | 257,0 | +7,0 | +0,006591 | 62,1 sec. | II.-III. |
| III. | 102,5 cm. | 288,0 197,0 277,8 | 287,9 197,2 277,8 | 239,8 | -10,2 | -0,009958 | 61,4 sec. | 104,5 cm. | 295,5 193,0 284,1 | 295,4 193,2 284,0 | 241,2 | -8,8 | -0,008428 | 60,2 sec. | III. |
| III.-IV. | 103,1 cm. | 293,8 172,8 280,3 | 293,7 173,2 280,3 | 229,9 | -20,1 | -0,019496 | 61,2 sec. | 108,3 cm. | 143,1 264,8 157,0 | 144,5 264,8 157,8 | 208,2 | -41,8 | -0,038596 | 60,8 sec. | III.-IV. |
| IV. | 99,8 cm. | 185,0 256,3 193,0 | 185,4 256,3 193,2 | 222,9 | -27,1 | -0,027152 | 61,6 sec. | 102,6 cm. | 165,0 268,6 177,2 | 165,8 268,6 177,7 | 220,3 | -29,7 | -0,028947 | 62,6 sec. | IV. |
| IV.-I. | 112,6 cm. | 309,0 148,4 291,0 | 308,8 149,5 291,0 | 224,4 | -25,6 | -0,022735 | 61,8 sec. | 112,6 cm. | 232,8 258,9 235,5 | 232,8 258,9 235,5 | 246,5 | -3,5 | -0,003108 | 62,2 sec. | IV.-I. |

A kereszt és az I. mágnes kölcsönös helyzete és távolsága ugyanaz, mint előbb. -

Tullusten liivien iskelmien liivimiten.

Väriannetus määrittely

$$\frac{I+II}{2} = -0,01252 \quad \alpha = -0^{\circ} 43'$$

$$\frac{II+IV}{2} = -0,02672 \quad \alpha = 88^{\circ} 28'$$

$$\frac{III+III-IV}{2} = -0,04028 \quad \alpha = 42^{\circ} 42'$$

$$\frac{II-III+IV-I}{2} = +0,00174 \quad \alpha = 135^{\circ} 6'$$

0,01501 €

$$1) -0,01252 - k = -0,01251 C(A+A') + 0,99969 \cdot 2Ch$$

$$2) \frac{-0,267}{-0,02672} - k = +0,05350 C(A+A') + 0,99857 \cdot 2Ch$$

$$3) \frac{0,99678}{-0,04028} - k = +0,99678 C(A+A') + 0,00322 \cdot 2Ch$$

$$4) \frac{0,08020}{+0,00174} - k = -1,00000 C(A+A') + 0,00349 \cdot 2Ch$$

Väriannetus määrittely

$$\frac{I+III}{2} = -0,01386 \quad \alpha = -0^{\circ} 47'$$

$$\frac{II+IV}{2} = -0,02513 \quad \alpha = 88^{\circ} 34'$$

$$\frac{I-II+III-IV}{2} = -0,02107 \quad \alpha = 43^{\circ} 48'$$

$$\frac{II-III+IV-I}{2} = -0,01829 \quad \alpha = 135^{\circ} 57'$$

$$1) -0,01386 - k = -0,02774 CA + 0,99963 \cdot 2Ch$$

$$2) -0,02513 - k = +0,050012 CA - 0,99875 \cdot 2Ch$$

$$3) -0,02107 - k = +0,99926 CA + 0,03839 \cdot 2Ch$$

$$4) -0,01829 - k = -0,99923 CA - 0,03664 \cdot 2Ch$$

rovind keru verionehet mignad

$$\begin{aligned} (1,2) &+ 0,01420 = -0,07851 C(A+A') + 1,99826 zCh && 1,99678 \\ (2,4) &- 0,04202 = +1,99678 C(A+A') - 0,07671 zCh && 0,07851 \end{aligned}$$

$$2zCh = \frac{1,99678 \cdot 0,01420 - 0,07851 \cdot 0,04202}{1,99678 \cdot 1,99826 - 0,07851 \cdot 0,07671}$$

$$C(A+A') = -0,02080$$

0,0284
36
0,0652
126
162

$$\begin{aligned} (1,2) &+ 0,02776 = -1,02179 C(A+A') + 0,91949 zCh \\ (2,4) &- 0,02846 = +1,05350 C(A+A') - 1,00206 zCh \end{aligned}$$

zCh = 0,063

256
205
159
304
463

$$\begin{aligned} (1,2) &+ 0,01127 = -0,07785 CA + 1,99859 zCh && 1,99859 \\ (2,4) &- 0,00278 = 1,99859 CA - 0,07503 zCh && 0,07735 \end{aligned}$$

$$2zCh = \frac{1,99859 \cdot 0,01127 - 0,07735 \cdot 0,00278}{1,99859 \cdot 1,99859 - 0,07735 \cdot 0,07503}$$

75
56
131
575
0,02254
224
112
237
118

$$CA = -0,00118$$

$$zCh = 0,0056$$

$$CA' = 0,01962$$

56
292
348
1168
1120

$$\frac{2zCh}{CA'} = \frac{zCh}{A'} = \frac{56}{196} = 0,286 \quad \frac{h}{A'} = 0,143$$

Variációk mélyéről

$$A' = 9 \frac{m}{av} \left(1 + \frac{5}{6} \frac{a^2}{av} \right) + 12,15 \frac{a^2}{av^2} m$$

$$m = 17820 \quad h = 20$$

$$a = 200 \quad c = 17,1$$

(1,3) $+ 0,02907$
 ~~$+ 0,06033$~~ = $- 0,08244 C(A+d') + 1,99464 \cdot 2Ch$ 1,99491

(2,4) $- 0,09744$
 ~~$- 0,06618$~~ = $+ 1,99491 C(A+d') - 0,05398 \cdot 2Ch$ 0,08244

$$2Ch = \frac{1,99491 \cdot \overset{0,02907}{\cancel{0,06033}} - 0,08244 \cdot \overset{0,09744}{\cancel{0,06618}}}{1,99491 \cdot 1,99464 - 0,08244 \cdot 0,05398}$$

így

$$2Ch = \frac{1,995 \cdot 0,0291}{1,995 \cdot 1,995 - 0,08244 \cdot 0,05398}$$

$$2Ch = 0,0126$$

$$C(A+d') = 0,0485$$

Mélyer nélkül

1) $+ 0,02568$
 ~~$+ 0,01663$~~ = $+ 0,00290 CA + 1,99973 \cdot 2Ch$ 1,99945

2) $- 0,00800$ = $+ 1,99945 CA + 0,03200 \cdot 2Ch$ 0,02900

$$2Ch = \frac{1,99945 \cdot \overset{0,02568}{\cancel{0,01663}} + 0,00290 \cdot \overset{0,00800}{\cancel{0,01105}}}{1,99945 \cdot 1,99973 - 0,00290 \cdot 0,03200}$$

$$2Ch = 0,0128$$

$$\begin{array}{r} 447 \overline{) 128} \\ 854 \\ \underline{2340} \\ 2135 \\ \underline{1050} \end{array}$$

$B = - 12,6 \cdot 10^{-6}$

$$CA = - 0,00380$$

$$\frac{2B}{A'} = - \frac{128}{447} =$$

$$A'C = - 0,0447$$

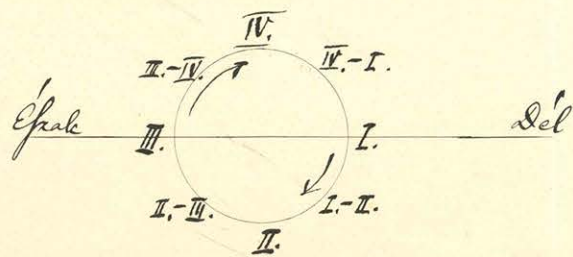
MAGYAR
TUDOMÁNYOS AKADÉMIA
KÖNYVTÁRA

Variometer a mágnespózi próbában;
a kereszt magassága a padló felett 34 cm.

Variometer ugyanott;
I. mágnes hatása.

| Hely | Skálataivol | Fordulók | Redukált fordulók | Egyenfel | Kitérés 250-tól | Kitérés / Skálataivol | Levegővidé | Skálataivol | Fordulók | Redukált fordulók | Egyenfel | Kitérés 250-tól | Kitérés / Skálataivol | Levegővidé |
|------------|-------------|-------------------------|-------------------------|----------|-----------------|-----------------------|------------|-------------|-------------------------|-------------------------|----------|-----------------|-----------------------|------------|
| I. | 114,2 cm. | 351,4 171,9 333,2 | 350,4 172,4 332,6 | 256,7 | +6,7 | +0,005867 | 94,7 sec. | 104,5 cm. | 168,7 336,8 185,0 | 169,3 336,1 185,3 | 256,9 | +6,9 | +0,006603 | 90,4 sec. |
| I. - II. | 102,0 cm. | 304,4 183,1 292,3 | 304,2 183,5 292,2 | 240,7 | -9,3 | -0,009118 | 94,0 sec. | 105,6 cm. | 257,4 136,0 245,6 | 257,4 137,8 245,6 | 194,5 | -55,5 | -0,052557 | 93,2 sec. |
| II. | 102,3 cm. | 325,0 151,9 307,5 | 324,5 153,1 307,3 | 234,3 | -15,7 | -0,015347 | 95,3 sec. | 108,3 cm. | 104,5 341,7 130,5 | 107,8 340,9 132,4 | 230,6 | -19,4 | -0,017913 | 100,2 sec. |
| II. - III. | 103,5 cm. | 209,7 294,0 218,2 | 209,8 293,9 218,2 | 254,1 | +4,1 | +0,003961 | 96,2 sec. | 103,5 cm. | 325,6 281,0 321,0 | 325,1 281,0 320,6 | 301,9 | +51,9 | +0,050145 | 95,7 sec. |
| III. | 104,6 cm. | 132,8 381,0 158,0 | 134,7 378,4 159,0 | 262,9 | +12,9 | +0,012333 | 94,7 sec. | 100,3 cm. | 341,1 192,4 326,8 | 340,3 192,6 326,2 | 262,5 | +12,5 | +0,012463 | 90,5 sec. |
| III. - IV. | 102,9 cm. | 204,5 279,3 212,0 | 204,6 279,3 212,0 | 243,9 | -6,1 | -0,005928 | 93,6 sec. | 104,6 cm. | 152,2 239,5 161,0 | 153,4 239,5 161,8 | 198,7 | -51,3 | -0,049044 | 92,4 sec. |
| IV. | 103,8 cm. | 247,2 190,0 268,5 | 247,2 190,3 268,5 | 231,5 | -18,5 | -0,017823 | 95,1 sec. | 103,0 cm. | 158,5 289,8 172,5 | 159,5 289,7 173,1 | 228,2 | -21,8 | -0,021165 | 99,4 sec. |
| IV. - I. | 109,3 cm. | 340,5 162,3 322,4 | 339,7 163,1 322,0 | 246,7 | -3,3 | -0,003019 | 95,9 sec. | 103,4 cm. | 331,2 262,0 324,3 | 330,6 262,0 323,3 | 294,6 | +44,6 | +0,043133 | 95,7 sec. |

A hely-jelek értelme:



A kereszt és az I. mágnes kölcsönös helyzete:



Variációs módszer

Függvény két érdekes elhatárolás

Variációs módszer nélkül

$$\frac{I+III}{2} = +0,00953 \quad \alpha = 0^\circ 33'$$

$$\frac{II+IV}{2} = -0,01954 \quad \alpha = 43^\circ 53'$$

$$\frac{I-II+III-IV}{2} = -0,05080 \quad \alpha = 87^\circ 5'$$

$$\frac{II-III+IV-I}{2} = +0,04664 \quad \alpha = 137^\circ 40'$$

$$\frac{F}{L} = c(A+A') \sin 2\alpha + 2CB \cos 2\alpha$$

$$A' = 9 \frac{m}{a^2} \left(1 + \frac{5}{6} \frac{h^2}{a^2}\right) + 12,5 \frac{L^2}{a^6} m$$

A, A', C mit adunk

a hól $m = 17820$
 $h = 20 \text{ c}$
 $a = 200 \text{ c}$
 $L = 17,5 \text{ c}$

- 1) $+0,00953 - \kappa = 0,01920 C(A+A') + 0,99982 \cdot 2CB$
- 2) $-0,05080 - \kappa = 0,99924 C(A+A') + 0,03897 \cdot 2CB$
- 3) $-0,01954 - \kappa = 0,10164 C(A+A') - 0,99482 \cdot 2CB$
- 4) $+0,04664 - \kappa = -0,99567 C(A+A') + 0,09295 \cdot 2CB$

~~(1,3) + 0,06033~~

$$\frac{I+III}{2} = +0,00910 \quad \alpha = 0^\circ 31'$$

$$\frac{II+IV}{2} = -0,01658 \quad \alpha = 44^\circ 3'$$

$$\frac{I-II+III-IV}{2} = -0,00753 \quad \alpha = 89^\circ 34'$$

$$\frac{II-III+IV-I}{2} = +0,00047 \quad \alpha = 135^\circ 2'$$

$$\frac{F}{L} = cA \sin 2\alpha + 2CA \cos 2\alpha$$

$$A = \frac{\partial^2 V}{\partial \gamma^2} - \frac{\partial^2 V}{\partial x^2}$$

$$b = \frac{\partial^2 V}{\partial x \partial \gamma} \quad C = \frac{CA}{L}$$

- 1) $+0,00910 - \kappa = 0,01803 CA + 0,99984 \cdot 2CB$
- 2) $-0,00753 - \kappa = 0,99945 CA + 0,03316 \cdot 2CB$
- 3) $-0,01658 - \kappa = 0,01513 CA - 0,99989 \cdot 2CB$
- 4) $+0,00047 - \kappa = -1,00000 CA + 0,00116 \cdot 2CB$

1
Közlekedés

Vasútvonal

MÁGYAR
TUDOMÁNYOS AKADÉMIA
KÖNYVTÁRA

| Hely | Skálataival | Fordulók | Fordulók redukálva | Redukált egyenlet | Kitérés 250-től | Kitérés Skálataival | Frög | Skálataival | Fa |
|----------|-------------|-------------------------|-------------------------|-------------------|-----------------|--------------------------------------|------|-------------|-----------------|
| I. | 102,3 cm. | 289,2 360,6 295,6 | 289,0 358,1 295,4 | 325,3 | + 75,3 | $\frac{75,3}{102,3} =$ +0,073607 | | 108,9 cm. | 24 38 28 |
| I.-II. | 110,0 cm. | 367,2 130,0 345,0 | 364,6 132,8 343,6 | 243,2 | - 6,8 | $\frac{-6,8}{110,0} =$ -0,006182 | | 115,7 cm. | 38 110 35 |
| II. | 117,6 cm. | 253,0 150,6 243,0 | 253,0 157,7 243,0 | 202,7 | - 47,3 | $\frac{-47,3}{117,6} =$ -0,040221 | | 118,7 cm. | 31 10 29 |
| II.-III. | 105,8 cm. | 218,0 400,5 236,0 | 218,1 394,7 236,0 | 310,8 | + 60,8 | $\frac{60,8}{105,8} =$ +0,057466 | | 100,0 cm. | 28 33 28 |
| III. | 103,4 cm. | — | — | 330,8 | + 80,8 | $\frac{80,8}{103,4} =$ +0,078143 | | 107,8 cm. | — |
| III.-IV. | 112,3 cm. | 338,0 181,7 323,2 | 336,9 182,2 322,6 | 255,8 | + 5,8 | $\frac{5,8}{112,3} =$ +0,005164 | | 111,1 cm. | 15 34 17 |
| IV. | 112,7 cm. | 131,0 308,2 149,4 | 133,7 307,9 151,0 | 225,4 | - 24,6 | $\frac{-24,6}{112,7} =$ -0,021827 | | 111,5 cm. | 14 29 15 |
| IV.-I. | 112,6 cm. | 265,6 392,0 278,1 | 265,6 387,7 278,1 | 330,0 | + 80,0 | $\frac{80,0}{112,6} =$ +0,071047 | | 113,7 cm. | 41 25 39 |

$$\frac{(I+III)}{2} = +0,0759$$

$$\frac{(I,II)+(III,IV)}{2} = -0,0005$$

$$\frac{(II,IV)}{2} = -0,0310$$

$$\frac{(II,III)+(IV,I)}{2} = +0,0643$$

$$\frac{F}{\sigma} = c A \sin \alpha + 2c B \cos \alpha$$

$$A = \frac{\partial^2 V}{\partial y^2} - \frac{\partial^2 V}{\partial x^2}$$

$$A = \frac{\partial^2 V}{\partial x \partial y}$$

$$C = \frac{cM}{\sigma}$$

$$+0,0747 -$$

$$- K$$

$$- 0,0380 -$$

$$+ 0,0645 -$$

| Kiteérés skálataival | függ. | Skálataiv. | Fordulólok | Fordulólok redukálva | Redukált lyempülye | Kitérés 250-től | Kiteérés skálataival | függ. |
|---------------------------------------|-------|------------|-------------------------|-------------------------|---------------------------|---------------------------|---|-------|
| $\frac{75,3}{1023} =$ $+0,073607$ | | 108,9cm. | 247,2 381,0 286,6 | 277,2 381,0 286,5 | 335,7 331,5 | +35,7 +81,5 | $\frac{81,5}{1089} = 0,007484$ $+0,078696$ | |
| $\frac{-6,8}{1100} =$ $-0,006182$ | | 115,7cm. | 381,0 116,5 356,0 | 377,8 119,9 354,3 | 242,9 | - 7,1 | $\frac{-7,1}{1157} =$ $-0,006136$ | |
| $\frac{-47,3}{1176} =$ $-0,040221$ | | 118,7cm. | 312,8 102,0 291,8 | 312,5 106,8 291,7 | 204,2 | - 45,8 | $\frac{-45,8}{1187} =$ $-0,038584$ | |
| $\frac{60,8}{1058} =$ $+0,057466$ | | 100,0cm. | 283,2 332,8 288,0 | 283,1 331,7 287,9 | 308,7 | + 58,7 | $\frac{58,7}{1000} =$ $+0,058700$ | |
| $\frac{80,8}{1034} =$ $+0,078143$ | | 107,8cm. | | | 330,5 | + 80,5 | $\frac{80,5}{1078} =$ $+0,074675$ | |
| $\frac{6,8}{1123} =$ $+0,005964$ | | 111,1cm. | 158,0 347,0 175,5 | 159,2 345,6 176,2 | 256,9 | + 6,9 | $\frac{6,9}{1111} =$ $+0,006211$ | |
| $\frac{-24,6}{1127} =$ $-0,021827$ | | 111,5cm. | 143,2 296,0 158,7 | 145,3 295,9 159,9 | 224,5 | + 25,5 | $\frac{-25,5}{1115} =$ $-0,022869$ | |
| $\frac{80}{1126} =$ $+0,071047$ | | 113,7cm. | 415,0 257,0 398,8 | 408,3 257,0 393,7 | 328,7 | + 78,7 | $\frac{78,7}{1137} =$ $+0,069217$ | |

$$\frac{F}{c} = c A \sin \alpha + 2c B \cos \alpha$$

$$A = \frac{\partial^2 V}{\partial y^2} - \frac{\partial^2 V}{\partial x^2}$$

$$A = \frac{\partial^2 V}{\partial x \partial y}$$

$$C = \frac{LM}{\sigma}$$

$$\frac{I+III}{2} = \frac{+0,0747}{+0,0767}$$

$$\frac{(I,II) + (III,IV)}{2} = 0,0000$$

$$\frac{II,IV}{2} = -0,0308$$

$$\frac{(II,III) + (IV,I)}{2} = +0,0645$$

Corrections a rád is kiadó
munkára által képzett 2° 06' mértékű

$$\alpha = 4^\circ 17'$$

$$\alpha = 4^\circ 29'$$

$$\alpha = 1^\circ 49'$$

$$\alpha = 45^\circ$$

$$\alpha = 42^\circ 32'$$

$$\alpha = 88^\circ 19'$$

$$\alpha = 85^\circ 46'$$

$$\alpha = 131^\circ 18'$$

$$\alpha = 138^\circ 42'$$

$$\alpha = 136^\circ 14'$$

$$+0,0747 - k = 0,0634 CA + 0,9980 \cdot 2CB \dots 1)$$

$$-k = 0,9963 CA + 0,0860 \cdot 2CB \dots 2)$$

$$-0,0380 - k = 0,1472 CA - 0,9891 \cdot 2CB \dots 3)$$

$$+0,0645 - k = -0,9991 CA + 0,0430 \cdot 2CB \dots 4)$$

1) 2) à 3) \rightarrow

$$CA = -0,02568 \quad 2CB = +0,05564$$

$$CB = +0,02782$$

Kétféleképpen számolva $\frac{1}{c} = -0,002428 = \frac{1}{c}$

$$CB = 0,02782 \text{ m} \quad \frac{1}{c} = -0,002428$$

$$B = -67,2 \cdot 10^{-6} \text{ m} \quad \frac{1}{c} = -0,002428$$

$$\frac{a-l}{r} = d$$

$$-2d\mu M \left\{ \frac{2(a-l)^2 + d^2 + (a-l)d}{((a-l)^2 + d^2)^{\frac{5}{2}}} - \frac{2(a+l)^2 - d^2 - (a+l)d}{((a+l)^2 + d^2)^{\frac{5}{2}}} \right\}$$

~~A~~

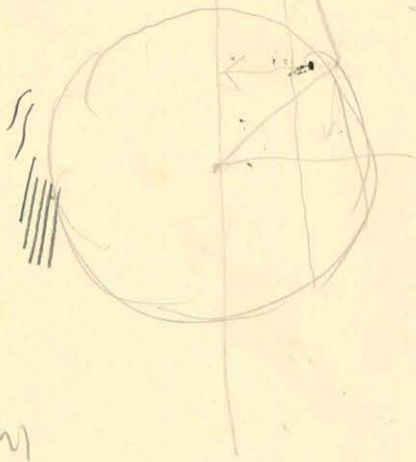
$$-2d\mu M \left\{ \frac{2(a-l)^2 + ad}{((a-l)^2 + d^2)^{\frac{5}{2}}} - \frac{2(a+l)^2 - ad}{((a+l)^2 + d^2)^{\frac{5}{2}}} \right\}$$

$$-2\mu M \delta l \left\{ \right.$$

$$-2\mu d M \delta l \left\{ \frac{-4(a-l) + a}{((a-l)^2 + d^2)^{\frac{5}{2}}} - \frac{2(a-l)^2 + ad}{((a-l)^2 + d^2)^{\frac{5}{2}}} (d - (a-l)) \right\}$$

$$- \frac{4(a+l) - a}{((a+l)^2 + d^2)^{\frac{5}{2}}} + \frac{2(a+l)^2 - ad}{((a+l)^2 + d^2)^{\frac{5}{2}}} (d + (a+l)) \left. \right\}$$

MAGYAR
TUDOMÁNYOS AKADEMIÁ
KÖNYVTÁRA



$$d = \frac{L}{\sqrt{2}}$$

$$\begin{aligned} & - \frac{2\rho d M \cos^2 \varepsilon}{r^3} - \frac{2\rho d M \cos \varepsilon \sin \varepsilon}{r^3} \\ & + \frac{2\rho d M \sin^2 \varepsilon}{r^3} - \frac{\rho d M \sin \varepsilon \cos \varepsilon}{r^3} \end{aligned}$$

$$\begin{aligned} & - \frac{2\rho d M \cos^2 \varepsilon'}{r'^3} + \frac{2\rho d M \cos \varepsilon' \sin \varepsilon'}{r'^3} \\ & + \frac{2\rho d M \sin^2 \varepsilon'}{r'^3} + \frac{\rho d M \sin \varepsilon' \cos \varepsilon'}{r'^3} \end{aligned}$$

$$- \frac{2\rho d M}{r^3} (2 \cos^2 \varepsilon - \sin^2 \varepsilon + 3 \sin \varepsilon \cos \varepsilon) \quad \sin \varepsilon = \frac{d}{r} \quad \cos \varepsilon = \frac{a-d}{r}$$

$$+ \frac{2\rho d M}{r'^3} (2 \cos^2 \varepsilon' - \sin^2 \varepsilon' - 3 \sin \varepsilon' \cos \varepsilon')$$

$$- 2\rho d M \left[\frac{2(a-d)^2 - d^2 + 3d(a-d)}{((a-d)^2 + d^2)^{\frac{5}{2}}} - \frac{2(a+d)^2 - d^2 - 3d(a+d)}{((a+d)^2 + d^2)^{\frac{5}{2}}} \right]$$

$$- 2\rho d M \left[\dots \right]$$

$$- 2\rho d M \left[\frac{-4(a-d) - 8d + 9a}{((a-d)^2 + d^2)^{\frac{5}{2}}} - 5 \frac{[2(a-d)^2 - d^2 + 3d(a-d)](2d-a)}{((a-d)^2 + d^2)^{\frac{7}{2}}} \right]$$

$$- \frac{4(a+d) - 8d - 9a}{((a+d)^2 + d^2)^{\frac{5}{2}}} + 5 \frac{[2(a+d)^2 - d^2 - 3d(a+d)](2d+a)}{((a+d)^2 + d^2)^{\frac{7}{2}}}$$

Handwritten calculations and numbers:
 $\lambda =$
 $a = 215$
 36
 18
 4242
 215
 84
 18
 215
 108

$$- \frac{287}{(197^2 + 18^2)^{\frac{5}{2}}} + 5 \frac{179 [2 \cdot 197^2 - 18^2 + 54 \cdot 197]}{(197^2 + 18^2)^{\frac{7}{2}}}$$

$$- \frac{143}{(233^2 + 18^2)^{\frac{5}{2}}} + 5 \frac{251 [2 \cdot 233^2 - 18^2 - 54 \cdot 233]}{(233^2 + 18^2)^{\frac{7}{2}}}$$

el adgn. a pozitív rész = $\frac{86,4010}{2}$

hatalm. $\frac{18}{215^4} = 84,2402$

$$\frac{F}{\text{cm. pd.}} = \left\{ \frac{3}{a^2} l + \frac{23}{2} \frac{l^3}{a^4} + \frac{87,2107375}{128} \frac{l^5}{a^6} + \frac{3,2109375}{a^6} \right\} \sin 2\varphi$$

MAGYAR
TUDOMÁNYOS AKADÉMIA
KÖNYVTÁRA

horiz. lines.

1782
1535
3317

$$\frac{I + III}{2} = +0,00910$$

00587
1273
0,01820

$$\frac{II + IV}{2} = -0,01658$$

$$\frac{I + III}{2} + \frac{II + IV}{2} = -0,00748$$

-0,00912
593
0,01505

$$\frac{I, IV + III, IV}{2} = -0,00753$$

$$\frac{I, II + III, IV}{2} + \frac{III + IV}{2} = -0,00706$$

00596
362
0,00894

$$\frac{II, III + IV, I}{2} = +0,00047$$

horiz. lines

1246
660
1906

$$\frac{I + III}{2} = +0,00953$$

$$\frac{I + III}{2} + \frac{II + IV}{2} = -0,01001$$

1791
2117
3908

$$\frac{II + IV}{2} = -0,01954$$

$$\frac{I, II + III, IV}{2} + \frac{III + IV}{2} = 0,00416$$

5256
4904
10160

$$\frac{I, II + III, IV}{2} = -0,05080$$

515
4313
3528

$$\frac{III + IV, I}{2} = +0,04664$$

horiz. lines

1776
955
2771

$$\frac{I + III}{2} = -0,01386$$

$$\frac{I + III}{2} + \frac{II + IV}{2} = -0,03899$$

2210
2715
5025

$$\frac{II + IV}{2} = -0,02513$$

$$\frac{I, II + III, IV}{2} + \frac{III + IV, I}{2} = -0,03936$$

2263
1950
4213

$$\frac{I, II + III, IV}{2} = -0,02107$$

1385
2278
3663

$$\frac{III + IV, I}{2} = -0,01829$$

1662
842
2504

$$\frac{I + III}{2} = -0,01252$$

$$\frac{I + III}{2} + \frac{II + IV}{2} = -0,02923$$

2448
2899
5347

$$\frac{II + IV}{2} = -0,02671$$

$$\frac{I, II + III, IV}{2} + \frac{III + IV, I}{2} = 0,02854$$

4196
3060
8056

$$\frac{I, II + III, IV}{2} = -0,04028$$

0,01954
40,1745
4,00209

1° 7'

2° 55'

659
217
348

$$\frac{III + IV, I}{2} = +0,00174$$

5080
3491
1589

2° 40'

26

-24

57
26

4664
3491
1173

2 40

1 7

1 7

-27

1 33

2° 55'

2° 40'

-15

MHC



M-ben érkező függőleges erő,
 és benne ráadásul két újabb egyenlő méretű és irányú függőleges erő.
 F függőleges.

$$\frac{F}{2mp} = \left\{ \frac{1.3}{2.4} (2l)^2 \frac{a^2}{(a^2+l^2)^{3/2}} + \frac{1}{2^2} \frac{1.7}{2.8} \frac{4}{1} (2l)^4 \frac{a^4}{(a^2+l^2)^{5/2}} + \frac{1}{2^4} \frac{1.11}{2.12} \frac{6.5}{1.2} (2l)^6 \frac{a^6}{(a^2+l^2)^{7/2}} + \dots \right\} \sin 2\varphi$$

$$+ \left\{ \frac{1}{2} \frac{1.7}{2.8} (2l)^4 \frac{a^4}{(a^2+l^2)^{5/2}} + \frac{1}{2^3} \frac{1.11}{2.12} (2l)^6 \frac{a^6}{(a^2+l^2)^{7/2}} + \dots \right\} \sin 4\varphi$$

$$+ \left\{ \frac{3}{2^4} \frac{1.11}{2.12} (2l)^6 \frac{a^6}{(a^2+l^2)^{7/2}} + \dots \right\} \sin 6\varphi$$

$$+ \dots$$

$$\frac{F}{2mp} = \left\{ \frac{1.3}{2.4} \frac{1}{a^3} (2l)^2 - \frac{1.3}{2.4} (2l)^2 \frac{1}{a^3} \frac{5l^2}{2a^2} + \frac{1}{2^2} \frac{1.7}{2.8} \frac{4}{1} (2l)^4 \frac{1}{a^5} + \frac{1.3}{2.4} (2l)^2 \frac{1}{a^3} \frac{5.7}{1.2} \frac{l^4}{2a^4} \right.$$

$$\left. - \frac{1}{2^2} \frac{1.7}{2.8} \frac{4}{1} (2l)^4 \frac{1}{a^5} \frac{9l^2}{2a^2} + \frac{1}{2^4} \frac{1.11}{2.12} \frac{6.5}{1.2} (2l)^6 \frac{1}{a^7} + \dots \right\} \sin 2\varphi$$

$$+ \left\{ \frac{1}{2} \frac{1.7}{2.8} (2l)^4 \frac{1}{a^5} - \frac{1}{2} \frac{1.7}{2.8} (2l)^4 \frac{1}{a^5} \frac{9l^2}{2a^2} + \frac{1}{2^3} \frac{1.11}{2.12} (2l)^6 \frac{1}{a^7} + \dots \right\} \sin 4\varphi$$

$$+ \left\{ \frac{3}{2^4} \frac{1.11}{2.12} (2l)^6 \frac{1}{a^7} + \dots \right\} \sin 6\varphi$$

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$$\frac{1.3}{2.4} 2^2 = A_1 = +\frac{3}{2}$$

$$-\frac{1.3}{2.4} 2^2 \frac{5}{2} + \frac{1}{2^2} \frac{1.7}{2.8} \frac{4}{1} \cdot 2^4 = B_1 = +\frac{5}{8}$$

$$+\frac{1.3}{2.4} 2^2 \frac{5.7}{1.2 \cdot 2^2} - \frac{1}{2^2} \frac{1.7}{2.8} \frac{4}{1} \cdot 2^4 \frac{9}{2} + \frac{1}{2^4} \frac{1.11}{2.12} \frac{6.5}{1.2} 2^6 = C_1 = +\frac{945}{2204} = \frac{105}{256}$$

$$+\frac{1}{2} \frac{1.7}{2.8} 2^4 = B_2 = \frac{105}{48} = \frac{35}{16} \quad \left| \quad -\frac{1}{2} \frac{1.7}{2.8} (2l)^4 \frac{9}{2} + \frac{1}{2^3} \frac{1.11}{2.12} 2^6 = C_2 = \frac{9261}{1152} = \frac{1087}{384}$$

$$\frac{3}{2^4} \frac{1.11}{2.12} 2^6 = C_3 = \frac{2079}{268} = \frac{693}{256}$$

$$\frac{F}{2mpd} = \left\{ \frac{A}{a^3} l^2 + \frac{B}{a^5} l^4 + \frac{C}{a^7} l^6 + \dots \right\} \sin 2\varphi +$$

$$+ \left\{ \frac{B'}{a^5} l^4 + \frac{C'}{a^7} l^6 + \dots \right\} \sin 4\varphi$$

$$+ \left\{ \frac{C''}{a^7} l^6 + \dots \right\} \sin 6\varphi$$

+ - - - -

A továbbiakban vizsgáljuk $\frac{\partial F}{\partial l}$ szerinti

$$\frac{F}{2mpd} = \left\{ 2 \frac{A}{a^3} l + 4 \frac{B}{a^5} l^3 + 6 \frac{C}{a^7} l^5 + \dots \right\} \sin 2\varphi$$

$$+ \left\{ 4 \frac{B'}{a^5} l^3 + 6 \frac{C'}{a^7} l^5 + \dots \right\} \sin 4\varphi$$

$$+ \left\{ 6 \frac{C''}{a^7} l^5 + \dots \right\} \sin 6\varphi$$

Az első tagok vizsgálata az $\frac{1}{a^3}$ tagok vizsgálatahoz hasonlóan

$\frac{1}{a^3}$ tagok vizsgálata $\frac{1}{(a-\frac{h}{2})^3} - \frac{1}{(a+\frac{h}{2})^3} = 3 \frac{h}{a} + \frac{5}{2} \frac{h^3}{a^3} + \frac{21}{16} \frac{h^5}{a^5}$

$\frac{1}{a^5}$ tagok vizsgálata $\frac{1}{(a-\frac{h}{2})^5} - \frac{1}{(a+\frac{h}{2})^5} = 5 \frac{h}{a} + \frac{35}{4} \frac{h^3}{a^3} + 6 \frac{h^5}{a^5}$

$\frac{1}{a^7}$ tagok vizsgálata $\frac{1}{(a-\frac{h}{2})^7} - \frac{1}{(a+\frac{h}{2})^7} = 7 \frac{h}{a} + \frac{119}{4} \frac{h^3}{a^3} + \frac{607}{16} \frac{h^5}{a^5}$

$$\frac{F}{2mpd} = \left\{ 6 \frac{A l}{a^4} \left(1 + \frac{5}{6} \frac{h^2}{a^2} + \frac{7}{16} \frac{h^4}{a^4} \right) + 20 \frac{B l^3}{a^6} \left(1 + \frac{7}{4} \frac{h^2}{a^2} + \frac{6}{5} \frac{h^4}{a^4} \right) + 42 \frac{C l^5}{a^8} \left(1 + \frac{17}{4} \frac{h^2}{a^2} + \frac{607}{112} \frac{h^4}{a^4} \right) \right\} \sin 2\varphi$$

$$+ \left\{ 20 \frac{B' l^3}{a^6} \left(1 + \frac{7}{4} \frac{h^2}{a^2} + \frac{6}{5} \frac{h^4}{a^4} \right) + 42 \frac{C' l^5}{a^8} \left(1 + \frac{17}{4} \frac{h^2}{a^2} + \frac{607}{112} \frac{h^4}{a^4} \right) \right\} \sin 4\varphi$$

$$+ 42 \frac{C'' l^5}{a^8} \left(1 + \frac{17}{4} \frac{h^2}{a^2} + \frac{607}{112} \frac{h^4}{a^4} \right) \sin 6\varphi$$

+ - - - -



mek
a rind ugiin pu erulu pua

Paksi:
 $\frac{dA}{dx} = 0 +$
 impa
 Frigimometur = $\frac{dA}{dt}$

$$\frac{A}{2m\mu} = - \left\{ \frac{1 \cdot 3}{2 \cdot 4} (2l)^2 \frac{a^2}{(a^2+l^2)^2} + \frac{1}{2^2} \frac{1 \cdot 7}{2 \cdot 8} \cdot \frac{4}{1} (2l)^4 \frac{a^4}{(a^2+l^2)^4} + \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} \cdot \frac{6 \cdot 5}{1 \cdot 2} (2l)^6 \frac{a^6}{(a^2+l^2)^6} + \dots \right\} \sin 2\varphi$$

$$- 2 \left\{ \frac{1}{2^2} \frac{1 \cdot 7}{2 \cdot 8} (2l)^4 \frac{a^4}{(a^2+l^2)^4} + \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} \cdot \frac{6}{1} (2l)^6 \frac{a^6}{(a^2+l^2)^6} + \frac{1}{2^6} \frac{1 \cdot 15}{2 \cdot 16} \cdot \frac{8 \cdot 7}{1 \cdot 2} (2l)^8 \frac{a^8}{(a^2+l^2)^8} + \dots \right\} \sin 4\varphi$$

$$- 3 \left\{ \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} (2l)^6 \frac{a^6}{(a^2+l^2)^6} + \frac{1}{2^6} \frac{1 \cdot 15}{2 \cdot 16} \cdot \frac{8}{1} (2l)^8 \frac{a^8}{(a^2+l^2)^8} + \frac{1}{2^8} \frac{1 \cdot 19}{2 \cdot 20} \cdot \frac{10 \cdot 9}{1 \cdot 2} (2l)^{10} \frac{a^{10}}{(a^2+l^2)^{10}} + \dots \right\} \sin 6\varphi$$

ivind
 Nis kugus a rind erulu ugiin lamma polusur larvala d teluk monometur

mek. Frigimometur = $-\frac{\partial A}{\partial l} l = F$ thid

$$\frac{F}{2m \cdot \mu d} = \left\{ \frac{1 \cdot 3}{2 \cdot 4} \left(4 \cdot 2l \frac{a^2}{(a^2+l^2)^2} - 2(2l)^3 \frac{a^2}{(a^2+l^2)^3} \right) + \frac{1}{2^2} \frac{1 \cdot 7}{2 \cdot 8} \frac{4}{1} \left(16 \cdot 4l^3 \frac{a^4}{(a^2+l^2)^4} - 4(2l)^5 \frac{a^4}{(a^2+l^2)^5} \right) \right.$$

$$+ \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} \cdot \frac{6 \cdot 5}{1 \cdot 2} \left(2 \cdot 6 \cdot 6l^5 \frac{a^6}{(a^2+l^2)^6} - 6(2l)^7 \frac{a^6}{(a^2+l^2)^7} \right) + \dots \left. \right\} \sin 2\varphi$$

$$+ 2 \left\{ \frac{1}{2^2} \frac{1 \cdot 7}{2 \cdot 8} \left(2 \cdot 4 \cdot 4l^3 \frac{a^4}{(a^2+l^2)^4} - 4(2l)^5 \frac{a^4}{(a^2+l^2)^5} \right) + \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} \cdot \frac{6}{1} \left(2 \cdot 6 \cdot 6l^5 \frac{a^6}{(a^2+l^2)^6} - 6(2l)^7 \frac{a^6}{(a^2+l^2)^7} \right) + \dots \right\} \sin 4\varphi$$

$$+ 3 \left\{ \frac{1}{2^4} \frac{1 \cdot 11}{2 \cdot 12} \left(2 \cdot 6 \cdot 6l^5 \frac{a^6}{(a^2+l^2)^6} - 6(2l)^7 \frac{a^6}{(a^2+l^2)^7} \right) + \dots \right\} \sin 6\varphi$$

Mu

$$\frac{a^2}{(a^2+c^2)^{\frac{5}{2}}} = \frac{1}{a^3} \left(\frac{1}{\left(1+\frac{c^2}{a^2}\right)^{\frac{5}{2}}} \right) = \frac{1}{a^3} \left(1 - \frac{5}{2} \frac{c^2}{a^2} + \frac{5 \cdot 7}{1 \cdot 2 \cdot 2^2} \frac{c^4}{a^4} - \frac{5 \cdot 7 \cdot 9}{1 \cdot 2 \cdot 3 \cdot 2^3} \frac{c^6}{a^6} \right)$$

$$\frac{a^4}{(a^2+c^2)^{\frac{7}{2}}} = \frac{1}{a^5} \left(\frac{1}{\left(1+\frac{c^2}{a^2}\right)^{\frac{7}{2}}} \right) = \frac{1}{a^5} \left(1 - \frac{7}{2} \frac{c^2}{a^2} + \frac{7 \cdot 9}{1 \cdot 2 \cdot 2^2} \frac{c^4}{a^4} - \dots \right)$$

$$\left(\frac{a^6}{(a^2+c^2)^{\frac{9}{2}}} \right) = \frac{1}{a^7} \left(\frac{1}{\left(1+\frac{c^2}{a^2}\right)^{\frac{9}{2}}} \right) = \frac{1}{a^7} \left(1 - \frac{9}{2} \frac{c^2}{a^2} \right)$$

111. $\sin^2 \varphi$ 的展开式

$$\frac{1}{(1+x)^n} = 1 - nx + \frac{n(n-1)}{1 \cdot 2} x^2 - \frac{n(n-1)(n-2)}{1 \cdot 2 \cdot 3} x^3 + \dots$$

$$\frac{a^2}{(a^2+l^2)^2} = \frac{1}{a^2} \frac{1}{(1+\frac{l^2}{a^2})^2} = \frac{1}{a^2} \left(1 - 2\frac{l^2}{a^2} + \frac{2 \cdot 3}{1 \cdot 2} \frac{l^4}{a^4} - \frac{2 \cdot 3 \cdot 4}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{a^2}{(a^2+l^2)^3} = \frac{1}{a^4} \left(1 - 3\frac{l^2}{a^2} + \frac{3 \cdot 4}{1 \cdot 2} \frac{l^4}{a^4} - \frac{3 \cdot 4 \cdot 5}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{a^4}{(a^2+l^2)^4} = \frac{1}{a^4} \left(1 - 4\frac{l^2}{a^2} + \frac{4 \cdot 5}{1 \cdot 2} \frac{l^4}{a^4} - \frac{4 \cdot 5 \cdot 6}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{a^4}{(a^2+l^2)^5} = \frac{1}{a^6} \left(1 - 5\frac{l^2}{a^2} + \frac{5 \cdot 6}{1 \cdot 2} \frac{l^4}{a^4} - \frac{5 \cdot 6 \cdot 7}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{a^6}{(a^2+l^2)^6} = \frac{1}{a^6} \left(1 - 6\frac{l^2}{a^2} + \frac{6 \cdot 7}{1 \cdot 2} \frac{l^4}{a^4} - \frac{6 \cdot 7 \cdot 8}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{a^6}{(a^2+l^2)^7} = \frac{1}{a^8} \left(1 - 7\frac{l^2}{a^2} + \frac{7 \cdot 8}{1 \cdot 2} \frac{l^4}{a^4} - \frac{7 \cdot 8 \cdot 9}{1 \cdot 2 \cdot 3} \frac{l^6}{a^6} + \dots \right)$$

$$\frac{F}{\sin^2 \varphi} = \left\{ \frac{1 \cdot 3}{2 \cdot 4} \cdot 4 \cdot 2l \cdot \frac{1}{a^2} + \left(-\frac{1 \cdot 3}{2 \cdot 4} \cdot 2 \cdot (2l)^3 \cdot \frac{1}{a^4} + \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 16 \cdot 4l^3 \cdot \frac{1}{a^4} \right) \sin 2\varphi \right.$$

$$\left. + 2 \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 2^4 \cdot 4l^3 \cdot \frac{1}{a^4} \sin 4\varphi \right.$$

$$\left(+ \frac{1 \cdot 3}{2 \cdot 4} \cdot 4 \cdot 2l \cdot \frac{2 \cdot 3}{1 \cdot 2} \frac{l^4}{a^6} + \frac{1 \cdot 3}{2 \cdot 4} \cdot 2 \cdot (2l)^3 \cdot \frac{l^2}{a^6} - \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 16 \cdot 4l^3 \cdot 4 \frac{l^2}{a^6} - \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 4 \cdot 2l \cdot \frac{l^5}{a^6} + \right.$$

$$\left. + \frac{1}{2^4} \cdot \frac{1 \cdot 3 \cdot 5 \cdot 7}{2 \cdot 4 \cdot 6} \cdot \frac{6 \cdot 5}{1 \cdot 2} \cdot 2^6 \cdot 6l^5 \cdot \frac{1}{a^6} \right) \sin 2\varphi$$

$$\left(-2 \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 2^4 \cdot 4l^3 \cdot 4 \frac{l^2}{a^6} - 2 \cdot \frac{1}{2^2} \cdot \frac{1 \cdot 3 \cdot 5}{2 \cdot 4} \cdot 4 \cdot (2l)^5 \cdot \frac{1}{a^6} + 2 \frac{1}{2^4} \cdot \frac{1 \cdot 3 \cdot 5 \cdot 7}{2 \cdot 4 \cdot 6} \cdot 2^6 \cdot 6l^5 \cdot \frac{1}{a^6} \right) \sin 4\varphi$$

$$+ 3 \frac{1}{2^4} \cdot \frac{1 \cdot 3 \cdot 5 \cdot 7}{2 \cdot 4 \cdot 6} \cdot \left(2^6 \cdot 6l^5 \cdot \frac{1}{a^6} \right) \sin 6\varphi$$

$$\frac{1}{a^3} \frac{(a + \frac{h}{2a})^3 - (a - \frac{h}{2a})^3}{(1 - \frac{h^2}{4a^2})^3} = \frac{3a^2h + \frac{1}{4}h^3}{a^3} \cdot (1 - \frac{h^2}{4a^2})^{-3} = \frac{3h}{a} + \frac{9}{4} \frac{h^3}{a^3} + \frac{9}{8} \frac{h^5}{a^5} + \frac{1}{4} \frac{h^7}{a^7} + \frac{3}{16} \frac{h^9}{a^9}$$

$$\frac{1}{a^5} \frac{(a + \frac{h}{2a})^5 - (a - \frac{h}{2a})^5}{(1 - \frac{h^2}{4a^2})^5} = \frac{5a^4h + \frac{5}{2}a^2h^3 + \frac{1}{16}h^5}{a^5} \cdot (1 - \frac{h^2}{4a^2})^{-5} =$$

$$\frac{1}{a^7} \frac{(a + \frac{h}{2a})^7 - (a - \frac{h}{2a})^7}{(1 - \frac{h^2}{4a^2})^7} = \frac{7a^6h + \frac{35}{2}a^4h^3 + \frac{21}{16}h^5 + \frac{1}{64}h^7}{a^7} \cdot (1 - \frac{h^2}{4a^2})^{-7}$$

$$a^3 + 3a^2 \cdot \frac{h}{2a} + \frac{3 \cdot 2 \cdot 1}{1 \cdot 2} a \frac{h^2}{4a^2} + \frac{3 \cdot 2 \cdot 1}{1 \cdot 2 \cdot 3} \frac{h^3}{8a^3}$$

$$a^5 + 5a^4 \frac{h}{2} + \frac{5 \cdot 4}{1 \cdot 2} a^3 \frac{h^2}{4} + \frac{5 \cdot 4 \cdot 3}{1 \cdot 2 \cdot 3} a^2 \frac{h^3}{8} + \frac{5 \cdot 4 \cdot 3 \cdot 2}{1 \cdot 2 \cdot 3 \cdot 4} a \frac{h^4}{16} + \frac{5 \cdot 4 \cdot 3 \cdot 2 \cdot 1}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \frac{h^5}{32}$$

$$a^7 + 7a^6 \frac{h}{2} + \frac{7 \cdot 6}{1 \cdot 2} a^5 \frac{h^2}{4} + \frac{7 \cdot 6 \cdot 5}{1 \cdot 2 \cdot 3} a^4 \frac{h^3}{8} + \frac{7 \cdot 6 \cdot 5 \cdot 4}{1 \cdot 2 \cdot 3 \cdot 4} a^3 \frac{h^4}{16} + \frac{7 \cdot 6 \cdot 5 \cdot 4 \cdot 3}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \frac{h^5}{32}$$

$$+ \frac{7 \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6} \frac{h^6}{64} + \frac{7 \cdot \dots}{1 \cdot \dots \cdot 7} \frac{h^7}{128}$$

$$\frac{1}{(1 - \frac{h^2}{4a^2})^2} = 1 + \frac{3h^2}{4a^2} + \frac{3 \cdot 5}{1 \cdot 2} \frac{1}{16} \frac{h^4}{a^4} + \frac{3 \cdot 4 \cdot 5}{1 \cdot 2 \cdot 3} \frac{1}{256} \frac{h^6}{a^6} + \dots$$

$$\frac{1}{(1 - \frac{h^2}{4a^2})^5} = 1 + \frac{5h^2}{4a^2} + \frac{5 \cdot 6}{1 \cdot 2} \frac{1}{16} \frac{h^4}{a^4} + \frac{5 \cdot 6 \cdot 7}{1 \cdot 2 \cdot 3} \frac{1}{256} \frac{h^6}{a^6} + \dots$$

$$\frac{1}{(1 - \frac{h^2}{4a^2})^8} = 1 + \frac{7h^2}{4a^2} + \frac{7 \cdot 8}{1 \cdot 2} \frac{1}{16} \frac{h^4}{a^4} + \frac{7 \cdot 8 \cdot 9}{1 \cdot 2 \cdot 3} \frac{1}{256} \frac{h^6}{a^6} + \dots$$

$$21^5 \cdot 5a^2h + \frac{9}{4}h^3 + \frac{9 \cdot 4}{1 \cdot 2} \frac{1}{16} \frac{h^5}{a^2}$$

$$5 \frac{h}{a} + \frac{25}{4} \frac{h^3}{a^3} + \frac{25 \cdot 6}{1 \cdot 2} \frac{1}{16} \frac{h^5}{a^5}$$

$$+ \frac{5}{2} \frac{h^2}{a^2} + \frac{5 \cdot 5 \cdot 6}{1 \cdot 2 \cdot 3} \frac{1}{76} + \frac{5 \cdot 5 \cdot 5}{4} \frac{h^5}{2a^5} + \frac{1}{16} \frac{h^5}{a^5}$$

$$\frac{75}{16} + \frac{20}{16} + \frac{1}{16}$$

$$\frac{49}{4} \frac{h^2}{a^2} + \frac{49 \cdot 8}{1 \cdot 2} \frac{1}{16} \frac{h^4}{a^4}$$

$$+ \frac{35}{2} \frac{h^2}{a^2} + \frac{25 \cdot 7}{2} \frac{h^5}{4a^5}$$

$$+ \frac{21}{16} \frac{h^5}{a^5}$$

87
20
46
14

196
490
21
687
16

49
70
117
4

35
140
35
49

64
49
576
2136
4921
3647
16

8
112

Ms. 51007A

Schwerbach

1907

Barycentrum
Länge



$$\frac{2mx^2 dx}{(x^2+c^2)^2} = 2m \left\{ -\frac{x}{\sqrt{x^2+c^2}} + \int \frac{dx}{\sqrt{x^2+c^2}} \right\}$$

$$= 2m \left\{ -\frac{x}{\sqrt{x^2+c^2}} + \log(x + \sqrt{x^2+c^2}) \right\}$$

$$2\pi m \frac{c^2}{(a-x)^2+c^2}$$

$$2\pi m c \frac{2(a-x)}{((a-x)^2+c^2)^2} x dx$$

~~2/mc~~

$a-x = \xi$

$d\xi = -dx$

$$-\frac{2\xi d\xi (a-\xi)}{(c^2+\xi^2)^2}$$

$$\int_{a+\infty}^{a-a} -4\pi m c \frac{\xi(a-\xi) d\xi}{(c^2+\xi^2)^2} = -4\pi m c \left[a \left(\frac{\xi d\xi}{c^2+\xi^2} - \frac{\xi^2 d\xi}{(c^2+\xi^2)^2} \right) \right]$$

$$= -4\pi m c \left\{ -\frac{a}{2(c^2+\xi^2)} + \frac{\xi}{2(c^2+\xi^2)} - \frac{1}{2} \frac{1}{c} \arctan \frac{\xi}{c} \right\}$$

~~2/m~~
= 2π/m

$$\int \frac{\partial^2 U}{\partial x \partial y} x dx dy = \int \frac{\partial^2 x dx dy}{\partial x} = 2\pi/m$$

$$\iint g dx dy = 2\pi/m$$

$\int u dx = m - \int v dx$

$\int x y - \int g dx$

$\int g dx - \int g dx$

Miller Mein System

$\frac{21}{1}$

$$(1+x)^n = 1 + \binom{n}{1}x + \binom{n}{2}x^2 + \binom{n}{3}x^3 + \dots$$

85
7
105

$k = \dots$

$$\binom{n}{k} = \frac{n(n-1)\dots(n-k+1)}{1 \cdot 2 \cdot 3 \dots k}$$

$\frac{3 \cdot 5}{2 \cdot 2}$
112

$n_1 = \dots$

$$\binom{n}{k} = \frac{n}{k} \binom{n-1}{k-1}$$

$$n_1 = n$$

$$h = +\frac{1}{2}$$

$$n_1 = \frac{1}{2}$$

$$n_2 = \frac{n(n-1)}{1 \cdot 2}$$

$$n_2 = \frac{\frac{1}{2} \cdot \frac{1}{2}}{1 \cdot 2} = -\frac{1}{8}$$

$\frac{24}{16}$
 $\frac{144}{384}$

$$n_3 = \frac{n(n-1)(n-2)}{1 \cdot 2 \cdot 3}$$

$$n_3 = \frac{\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{3}{2}}{1 \cdot 2 \cdot 3} = \frac{3}{48}$$

$\frac{24}{15}$
105

$$n_4 = \frac{n(n-1)(n-2)(n-3)}{1 \cdot 2 \cdot 3 \cdot 4}$$

$$h = -\frac{1}{2} =$$

$$n_1 = -\frac{1}{2}$$

$$n = -\frac{3}{2}$$

$\frac{3 \cdot 5 \cdot 7}{2 \cdot 2 \cdot 2}$
1123

68
45
~~575~~
63
945

$$n_2 = +\frac{3}{8}$$

$$n_3 = -\frac{\frac{1}{2} \cdot \frac{3}{2} \cdot \frac{5}{2}}{1 \cdot 2 \cdot 3} = -\frac{15}{48}$$

$$n_1 = -\frac{3}{2}$$

$$n_2 = +\frac{15}{8}$$

$\frac{3 \cdot 5 \cdot 7 \cdot 9}{1 \cdot 2 \cdot 3 \cdot 4}$

$\frac{11}{10}$

$$n_4 = +\frac{\frac{1}{2} \cdot \frac{3}{2} \cdot \frac{5}{2} \cdot \frac{7}{2}}{1 \cdot 2 \cdot 3 \cdot 4} = +\frac{105}{384}$$

etc.

$$n_3 = +\frac{105}{48}$$

$$n_4 = +\frac{945}{384}$$

$\frac{945}{10395}$

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$$n_5 = -\frac{10395}{3840}$$

$$\sum_{i=0}^{\infty} r_0^i = 900 \quad N = 700 \quad r^2 = 1600$$

$$\frac{1}{r^2} = \frac{1}{1600} = \frac{1}{27000} - \frac{3}{2} \frac{700}{900 \cdot 27000} + \frac{15}{8} \frac{700}{900} \frac{700}{900} \frac{1}{27000}$$

$$= \frac{1}{27000} \left(1 - \frac{21}{18} + \frac{15}{8} \cdot \frac{49}{81} \cdot \frac{1}{900} \right)$$

$$\begin{array}{r} 490 \\ 245 \\ \hline 735 \end{array} \quad \begin{array}{r} 7000 \\ 17600 \\ \hline 58200 \end{array}$$

$$- \frac{3}{18}$$

$$\frac{1}{(1+x)^{\frac{1}{2}}} \quad \frac{\partial}{\partial x} = -\frac{1}{2} \left(\frac{1}{} \right)^{\frac{1}{2}} \quad \frac{\partial^2}{\partial x^2} = +\frac{3}{4} \left(\frac{1}{} \right)^{\frac{3}{2}} \quad \frac{\partial^3}{\partial x^3} = -\frac{15}{8} \left(\frac{1}{} \right)^{\frac{5}{2}}$$

$$\frac{1}{(1+x)^{\frac{1}{2}}} = 1 - \frac{1}{2}x + \frac{3}{8}x^2 - \frac{15}{48}x^3 + \dots$$

$$\frac{1}{(1+x)^{\frac{3}{2}}} \quad \frac{\partial}{\partial x} = -\frac{3}{2} \left(\frac{1}{} \right)^{\frac{3}{2}} \quad \frac{\partial^2}{\partial x^2} = +\frac{15}{4} \left(\frac{1}{} \right)^{\frac{5}{2}} \quad \frac{\partial^3}{\partial x^3} = -\frac{105}{8} \left(\frac{1}{} \right)^{\frac{7}{2}}$$

$$\frac{1}{(1+x)^{\frac{3}{2}}} = 1 - \frac{3}{2}x + \frac{15}{8}x^2 - \frac{105}{48}x^3 + \dots$$

$$1 - \frac{1}{10}$$

$$\frac{1}{(1+x)^{\frac{3}{2}}} = 1 - 0,15 + 0,01875 - 0,0021875$$

$$\begin{array}{r} 1,01875 \\ -0,1521875 \\ \hline 0,8665625 \\ \hline 86678 \end{array}$$

$$0,124179$$

$$0,062090$$

$$0,937910 - 1$$

$$\begin{array}{r} 48 \mid 0,105 \\ 0,15 \\ 90 \\ 420 \\ 288 \\ \hline 360 \\ 236 \\ \hline 240 \end{array}$$

$$0,0021875$$

$$2 \int \frac{(a-x)}{(a-x)^2 + c^2}$$

$$= 2 \int \frac{1}{(a-x)^2 + c^2} + 4 \int \frac{(a-x)}{((a-x)^2 + c^2)^2}$$

$$= 2 \int \frac{c^2 dx}{((a-x)^2 + c^2)^2} + 2 \int \frac{(a-x)^2 dx}{((a-x)^2 + c^2)^2}$$

$$a-x = \xi$$

$$-dx = d\xi$$

$$2 \int \left\{ \frac{c^2(a-\xi) d\xi}{(\xi^2 + c^2)^2} + \frac{\xi^2(a-\xi) d\xi}{(\xi^2 + c^2)^2} \right\}$$

$$2 \int \left\{ \frac{ac^2 d\xi}{(\xi^2 + c^2)^2} - \frac{c^2 \xi d\xi}{(\xi^2 + c^2)^2} - \frac{a \xi^2 d\xi}{(\xi^2 + c^2)^2} + \frac{\xi^3 d\xi}{(\xi^2 + c^2)^2} \right\}$$

$$2 \int \frac{ac^2}{c} \frac{1}{c} = \frac{c^2}{2} \frac{1}{c}$$

$$2 \int \left\{ \frac{ac^2 x}{2c^2(\xi^2 + c^2)} + \frac{ac^2}{2c^2} \frac{1}{c} \operatorname{arctg} \frac{x}{c} + \frac{c^2}{2(\xi^2 + c^2)} + \frac{a \xi}{2(\xi^2 + c^2)} - \frac{a}{2c} \operatorname{arctg} \frac{x}{c} \right. \\ \left. + \frac{a^2}{2(\xi^2 + c^2)} + \frac{1}{2} \log(\xi^2 + c^2) \right\}$$

$$2 \int \left\{ \frac{c^2}{\xi^2 + c^2} + \frac{a \xi}{\xi^2 + c^2} + \frac{1}{2} \log(\xi^2 + c^2) \right\}$$

Handwritten numbers and scribbles at the top of the page, including '12/154', '8', '261', '48', '282', '290', '8101', '9601', '69', '8902', '231', '1024', '77', '3', '693', '4096', '1024', '14336', '14336', '57344', '64512', '15015', '2000', '45045', '229376', '36465', '196608', '46189', '262144', '225225', '180180', '2027025', '1146880', '917504', '1032192', '315', '2048'.

$$\frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} = \frac{15}{48} = \frac{5}{16}$$

$$\frac{7}{8} = \frac{105}{384} = \frac{35}{128}$$

$$\frac{9}{10} = \frac{945}{3840} = \frac{63}{256}$$

$$\frac{11}{12} = \frac{10395}{46080} = \frac{231}{1024}$$

$$\frac{13}{14} = \frac{135135}{645120} = \frac{3003}{14336}$$

$$\frac{15}{16} = \frac{2027025}{10321920} = \frac{45045}{229376}$$

$$\frac{17}{18} = \frac{34459425}{185794560} = \frac{765765}{4128768} = \frac{36465}{196608}$$

$$\frac{19}{20} = \frac{654729075}{3901685760} = \frac{46189}{262144}$$

$$\frac{21}{22} = \frac{13745110575}{87749606400} = \frac{969969}{5767168}$$

$$\frac{23}{24} = \frac{316137543225}{1961990553600} = \frac{7436429}{46137344}$$

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315
2048

3,692671
1,821514
4,118496
1,405346
1,301030

13,339057
1,537819
1,801238
2,099125
~~63776~~
0,702113 - 2

0,50262

3

9
121,22.

0,954243
2,083574
0,870669 - 2

1,07424

0,031101

0,015551
2,083574

2,099125

17,25

3450

245

$$\int \frac{\sigma b h 4 \rho^2 L^2 dl}{(\rho^2 + c^2 + L^2)^{\frac{5}{2}}}$$

$$\int \frac{\sigma b h 16 \rho^4 L^4 dl}{(\rho^2 + c^2 + L^2)^{\frac{7}{2}}}$$

$$4 \sigma b h \rho^2 \int \frac{L^2 dl}{(\rho^2 + c^2 + L^2)^{\frac{5}{2}}} = 4 \sigma b h \rho^2 \frac{L^3}{3(\rho^2 + c^2)(\rho^2 + c^2 + L^2)^{\frac{3}{2}}}$$

$$16 \sigma b h \rho^4 \int \frac{L^4 dl}{(\rho^2 + c^2 + L^2)^{\frac{7}{2}}} = 16 \sigma b h \rho^4 \left(\frac{2L^7}{35(\rho^2 + c^2)} + \frac{L^5}{5(\rho^2 + c^2)} \right) \frac{1}{(\rho^2 + c^2 + L^2)^{\frac{7}{2}}}$$

$$c = 0$$

$$4 \sigma b h \rho^2 \int \frac{L^2 dl}{(\rho^2 + L^2)^{\frac{5}{2}}} = \frac{4}{3} \sigma b h \frac{L^3}{(\rho^2 + L^2)^{\frac{3}{2}}}$$

$$16 \sigma b h \rho^4 \int \frac{L^4 dl}{(\rho^2 + L^2)^{\frac{7}{2}}} = \frac{32}{35} \sigma b h \frac{L^7}{(\rho^2 + L^2)^{\frac{7}{2}}} + \frac{16}{5} \rho^2 \frac{L^5}{(\rho^2 + L^2)^{\frac{7}{2}}}$$

$$\frac{1}{(\rho^2 + L^2)^{\frac{3}{2}}} = \frac{1}{\rho^3} \frac{1}{\left(1 + \frac{L^2}{\rho^2}\right)^{\frac{3}{2}}}$$

$$\frac{1}{(\rho^2 + L^2)^{\frac{7}{2}}} = \frac{1}{\rho^7} \frac{1}{\left(1 + \frac{L^2}{\rho^2}\right)^{\frac{7}{2}}}$$

| | | |
|-------|-------------------|------|
| +1,45 | -1,35 | 2,70 |
| +1,35 | -1,00 | 2,35 |
| +0,90 | -0,90 | 1,80 |
| +1,00 | -0,75 | 1,75 |
| <hr/> | | |
| 4,70 | - 3,30 | |
| | 1,00 | |

| | |
|-----------------|-------------------|
| +8,75 | -8,75 |
| +8,45 | -8,00 |
| +9,05 | - 9,05 |
| | -8,75 |
| <hr/> | |
| +8,30 | +8,25 |
| <hr/> | |
| 24,55 | 22,85 |
| 2,70 | 4,00 |
| 8,64 | 8,46 |
| <hr/> | |
| 8,05 | 8,55 |

| | |
|-------|-------|
| 17,50 | +0,40 |
| 16,45 | -0,65 |
| 17,80 | +0,70 |
| 16,65 | -0,45 |
| <hr/> | |
| 68,40 | |
| 17,10 | |

71

0,7/17/

25

186,25 184,45

186,05 184,80

185,55

185,65

185,55

185,75

185,56

185,25

185,10

184,90

184,85

184,70

184,80

184,65

| | | |
|-------|---|--------------|
| 29,85 |) | 29,85 |
| 7,46 | | 7,46 |
| <hr/> | | |
| | | 8 |

17,50 - 2,80 = 14,70

16,45 - 2,35 = 14,10

17,80 - 1,80 = 16,00

16,65 - 1,75 = 14,90

$$\frac{3.172318.66,3}{87,2} \text{ €} = \underline{14,92}$$

$$\begin{cases} n_6 - n_1 = 0,28A \\ n_0 - n_2 = 0,14A \\ n_0 - n_3 = -0,14B \end{cases}$$

1,940516

460

$10^{2,24}$

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$n_5 - n_4 = 0,18 \left(\frac{P}{A} \right) + 0,28 \frac{24}{227} \text{ cal.}$

| | |
|--------------|--|
| 1,173769 | |
| 5,821548 | |
| <hr/> | |
| 6,995317 | |
| 7,534965 | |
| <hr/> | |
| 0,460352 - 1 | |

| | |
|----------|--|
| 1,821514 | |
| 0,477121 | |
| 5,226330 | |
| <hr/> | |
| 7,534965 | |

$n_1 - n_0 = 0,28B$

$n_1 - n_0 = 0,866A - 0,14B$

$n_3 - n_0 = +0,866 \cdot 0,14A - 0,14B$

$n_0 - n_1 = 0,28B$

$n_1 - n_2 = -0,121A - 0,14B$

$n_0 - n_3 = +0,121A - 0,14B$

| | |
|---------|--|
| 3464 | |
| 866 | |
| <hr/> | |
| 9,12124 | |
| 9,24248 | |

$n_2 - n_3 = +0,242A$

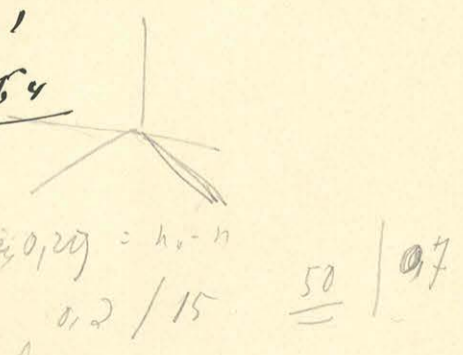
$n_1 + n_3 - 2n_1 = 0,56B$

$A = 0,11 \quad n_2 - n_3$

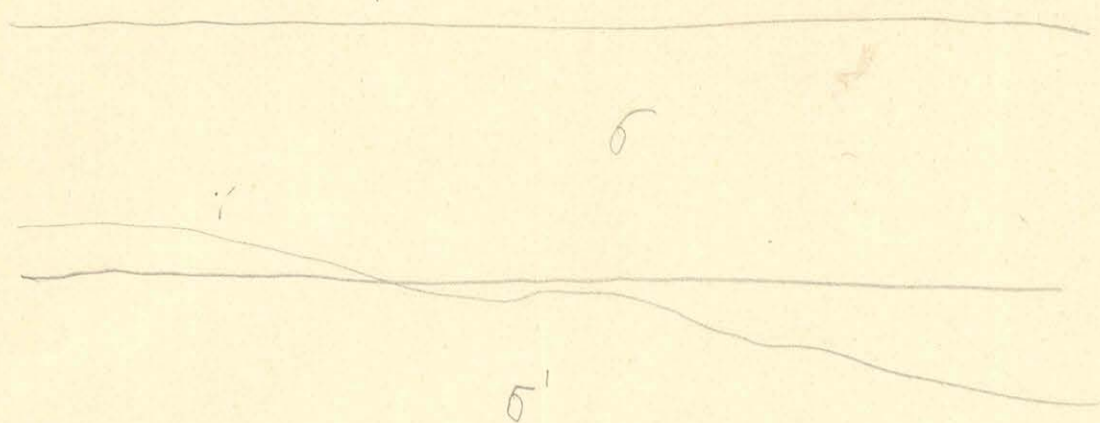
$A = 4,13(n_2 - n_3)$

$n_3 + n_2 - 2n_1 = -0,56B$

$1,1786(2n_1 - n_2 - n_3) = 1,786B$



Schmittner 1907



$$\begin{aligned}
 V &= \int \frac{\xi (\sigma - \sigma') d\xi d\eta}{\sqrt{(\xi - x)^2 + (\eta - y)^2 + (c + \frac{\xi}{2})^2}} \\
 &= f(\sigma - \sigma') \int \frac{\xi d\xi d\eta}{\sqrt{(\xi - x)^2 + (\eta - y)^2 + c^2 + c\xi + \frac{\xi^2}{4}}} \\
 &= k(\sigma + \sigma') \int \frac{\xi d\xi d\eta}{\sqrt{(\xi - x)^2 + (\eta - y)^2 + c^2}} - f(\sigma - \sigma') c \int \frac{\xi^2 d\xi d\eta}{[(\xi - x)^2 + (\eta - y)^2 + c^2]^{\frac{3}{2}}} \\
 &\quad - \frac{1}{4} k(\sigma - \sigma') \int \frac{\xi^3 d\xi d\eta}{[(\xi - x)^2 + (\eta - y)^2 + c^2]^{\frac{3}{2}}}
 \end{aligned}$$

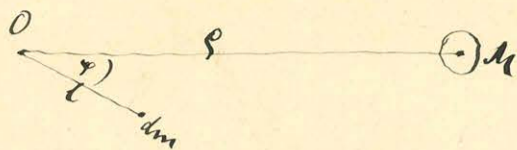
$$k(\sigma - \sigma') \frac{3}{2} \int \frac{\xi(a - x^2) - (b - y)^2}{\sqrt{\dots}}$$

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276480
 46080
 737280
 51
 30
 15
 24
 12
 6
 3
 6144
 1024
 16384

Schulterverband 1907

Barycentrisches Moment a projektion
 F prismenmechanisch leitend.



$$\begin{aligned}
 F = - \frac{M dm}{\sqrt{\rho^2 + l^2}} & \left[2 \sin \varphi \left\{ \frac{1}{2} \cdot \frac{1}{1} k + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} \cdot \frac{3}{1} k^3 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10} \cdot \frac{5 \cdot 4}{1 \cdot 2} k^5 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14} \cdot \frac{7 \cdot 6 \cdot 5}{1 \cdot 2 \cdot 3} k^7 + \dots \right\} \right. \\
 & + 4 \sin^2 \varphi \left\{ \frac{1 \cdot 3}{2 \cdot 4} k^2 + \frac{1 \cdot 3 \cdot 5 \cdot 7}{2 \cdot 4 \cdot 6 \cdot 8} \cdot \frac{4}{1} k^4 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12} \cdot \frac{6 \cdot 5}{1 \cdot 2} k^6 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16} \cdot \frac{8 \cdot 7 \cdot 6}{1 \cdot 2 \cdot 3} k^8 + \dots \right\} \\
 & + 6 \sin^3 \varphi \left\{ \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6} k^3 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10} \cdot \frac{5}{1} k^5 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12} \cdot \frac{7 \cdot 6}{1 \cdot 2} k^7 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14} \cdot \frac{9 \cdot 8 \cdot 7}{1 \cdot 2 \cdot 3} k^9 + \dots \right\} \\
 & + 8 \sin^4 \varphi \left\{ \frac{1 \cdot 3 \cdot 5 \cdot 7}{2 \cdot 4 \cdot 6 \cdot 8} k^4 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12} \cdot \frac{6}{1} k^6 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14} \cdot \frac{8 \cdot 7}{1 \cdot 2} k^8 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16} \cdot \frac{10 \cdot 9 \cdot 8}{1 \cdot 2 \cdot 3} k^{10} + \dots \right\} \\
 & + 10 \sin^5 \varphi \left\{ \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10} k^5 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14} \cdot \frac{7}{1} k^7 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16} \cdot \frac{9 \cdot 8}{1 \cdot 2} k^9 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15 \cdot 17}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16 \cdot 18} \cdot \frac{11 \cdot 10 \cdot 9}{1 \cdot 2 \cdot 3} k^{11} + \dots \right\} \\
 & + 12 \sin^6 \varphi \left\{ \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12} k^6 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16} \cdot \frac{8}{1} k^8 + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15 \cdot 17 \cdot 19}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16 \cdot 18 \cdot 20} \cdot \frac{10 \cdot 9}{1 \cdot 2} k^{10} + \frac{1 \cdot 3 \cdot 5 \cdot 7 \cdot 9 \cdot 11 \cdot 13 \cdot 15 \cdot 17 \cdot 19 \cdot 21}{2 \cdot 4 \cdot 6 \cdot 8 \cdot 10 \cdot 12 \cdot 14 \cdot 16 \cdot 18 \cdot 20 \cdot 22} \cdot \frac{12 \cdot 11 \cdot 10}{1 \cdot 2 \cdot 3} k^{12} + \dots \right\} \\
 & + \dots \left. \right]
 \end{aligned}$$

$$k = \frac{2 \rho l}{\rho^2 + l^2}$$

$$\begin{aligned}
 F = - \frac{M dm}{\sqrt{\rho^2 + l^2}} & \left\{ \frac{1}{2} \sin \varphi \left\{ k + \frac{15}{32} k^3 + \frac{945}{3072} k^5 + \frac{945 \cdot 945}{612 \cdot 8768} k^7 + \dots \right\} \right. \\
 & + \frac{3}{8} \sin^2 \varphi \left\{ k^2 + \frac{210}{768} k^4 + \frac{10395}{18432} k^6 + \frac{105105}{229372} k^8 + \dots \right\} \\
 & + \frac{15}{64} \sin^3 \varphi \left\{ k^3 + \frac{21}{128} k^5 + \frac{3003}{20480} k^7 \right. \\
 & \left. \left. \dots \right\} \right.
 \end{aligned}$$