MOwNiT lab1

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1 Treść zadania

Wykonać obliczenia (dla zmiennych typu float, double, long double) wg podanych poniżej wzorów dla 101 równoodległych wartości x z przedziału [0.99, 1.01]:

- $f(x) = x^8 - 8x^7 + 28x^6 - 56x^5 + 70x^4 - 56x^3 + 28x^2 - 8x + 1$
- $f(x) = (((((((x - 8)x + 28)x - 56)x + 70)x - 56)x + 28)x - 8)x + 1$
- $f(x) = (x - 1)^8$
- $f(x) = e^{(8ln(abs(x-1)))}, x \neq 1$

Porównać wyniki. Objaśnić różnice w wynikach.

2 Dane techniczne sprzętu

Obliczenia zostały wykonane na komputerze o następującej specyfikacji:

- Procesor: AMD Ryzen 7 5800U
- Pamięć RAM: 16 GB DDR4 3200 MHz (2×8GB)
- System operacyjny: Windows 11 Home x64

3 Wyniki obliczeń

Wszystkie obliczenia zostały przeprowadzone w jezyku C. Z bibliotek stdio.h oraz math.h z której zostały wykorzystane następujące funkcje:

- powf(), pow(), powl()
- expf(), exp(), expl()
- logf(), log(), logl()
- fabsf(), fabs(), fabsl()

Do sporządzenia wykresów wykorzystany był język R i biblioteka ggplot2.

3.1 Float

4 bajty:

- Znak: 1 bit
- Mantysa: 23 bity
- Wykładnik: 8 bitów

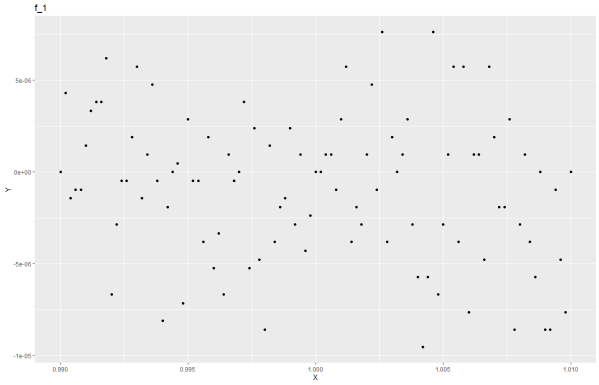
Dokładność: 6 - 7 cyfr znaczących

Tabela 1: Wyniki obliczeń dla float

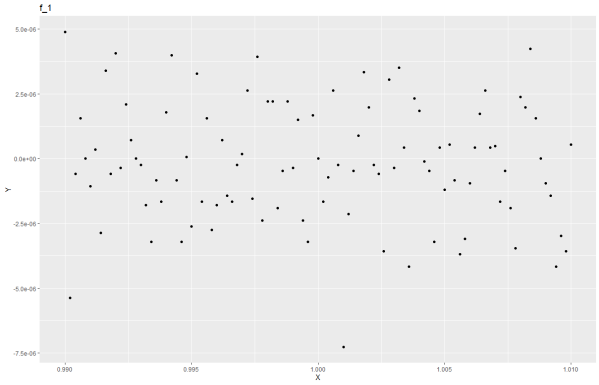
x	$f_1(x)$	$f_2(x)$	$f_3(x)$	$f_4(x)$
9.9019998E-01	4.2915344E-06	-5.3644180E-06	8.5077472E-17	8.5077604E-17
9.9040002E-01	-1.4305115E-06	-5.9604645E-07	7.2137978E-17	7.2138077E-17
9.9059999E-01	-9.5367432E-07	1.5497208E-06	6.0957421E-17	6.0957355E-17
9.9080002E-01	-9.5367432E-07	0.0000000E+00	5.1320856E-17	5.1320863E-17
9.9100000E-01	1.4305115E-06	-1.0728836E-06	4.3046850E-17	4.3046866E-17
9.9120003E-01	3.3378601E-06	3.5762787E-07	3.5962478E-17	3.5962475E-17
9.9140000E-01	3.8146973E-06	-2.8610229E-06	2.9921697E-17	2.9921723E-17
9.9160004E-01	3.8146973E-06	3.3974648E-06	2.4786725E-17	2.4786684E-17
9.9180001E-01	6.1988831E-06	-5.9604645E-07	2.0441205E-17	2.0441224E-17
9.9199998E-01	-6.6757202E-06	4.0531158E-06	1.6777488E-17	1.6777460E-17
9.9220002E-01	-2.8610229E-06	-3.5762787E-07	1.3700905E-17	1.3700888E-17
9.9239999E-01	-4.7683716E-07	2.0861626E-06	1.1130459E-17	1.1130460E-17
9.9260002E-01	-4.7683716E-07	7.1525574E-07	8.9917163E-18	8.9917080E-18
9.9280000E-01	1.9073486E-06	0.0000000E+00	7.2220626E-18	7.2220643E-18
9.9300003E-01	5.7220459E-06	-2.3841858E-07	5.7645998E-18	5.7645907E-18
9.9320000E-01	-1.4305115E-06	-1.7881393E-06	4.5716105E-18	4.5716097E-18
9.9339998E-01	9.5367432E-07	-3.2186508E-06	3.6005034E-18	3.6005009E-18
9.9360001E-01	4.7683716E-06	-8.3446503E-07	2.8147116E-18	2.8147149E-18
9.9379998E-01	-4.7683716E-07	-1.6689301E-06	2.1834448E-18	2.1834477E-18
9.9400002E-01	-8.1062317E-06	1.7881393E-06	1.6795765E-18	1.6795766E-18
9.9419999E-01	-1.9073486E-06	3.9935112E-06	1.2806463E-18	1.2806482E-18
9.9440002E-01	0.0000000E+00	-8.3446503E-07	9.6713937E-19	9.6713761E-19
9.9460000E-01	4.7683716E-07	-3.2186508E-06	7.2302177E-19	7.2302198E-19
9.9480003E-01	-7.1525574E-06	5.9604645E-08	5.3457162E-19	5.3457090E-19
9.9500000E-01	2.8610229E-06	-2.6226044E-06	3.9062201E-19	3.9062180E-19
9.9519998E-01	-4.7683716E-07	3.2782555E-06	2.8180296E-19	2.8180332E-19
9.9540001E-01	-4.7683716E-07	-1.6689301E-06	2.0047209E-19	2.0047212E-19
9.9559999E-01	-3.8146973E-06	1.5497208E-06	1.4048604E-19	1.4048593E-19
9.9580002E-01	1.9073486E-06	-2.7418137E-06	9.6823145E-20	9.6822977E-20
9.9599999E-01	-5.2452087E-06	-1.7881393E-06	6.5537061E-20	6.5536951E-20
9.9620003E-01	-3.3378601E-06	7.1525574E-07	4.3475624E-20	4.3475705E-20
9.9640000E-01	-6.6757202E-06	-1.4305115E-06	2.8211182E-20	2.8211189E-20
9.9660003E-01	9.5367432E-07	-1.6689301E-06	1.7856600E-20	1.7856624E-20
9.9680001E-01	-4.7683716E-07	-2.3841858E-07	1.0994967E-20	1.0994980E-20
9.9699998E-01	0.0000000E+00	1.7881393E-07	6.5613671E-21	6.5613715E-21
9.9720001E-01	3.8146973E-06	2.6226044E-06	3.7778881E-21	3.7778813E-21
9.9739999E-01	-5.2452087E-06	-1.5497208E-06	2.0883621E-21	2.0883588E-21
9.9760002E-01	2.3841858E-06	3.9339066E-06	1.1006835E-21	1.1006851E-21
9.9779999E-01	-4.7683716E-06	-2.3841858E-06	5.4877360E-22	5.4877310E-22
9.9800003E-01	-8.5830688E-06	2.2053719E-06	2.5597363E-22	2.5597345E-22
9.9820000E-01	1.4305115E-06	2.2053719E-06	1.1019993E-22	1.1019996E-22
9.9839997E-01	-3.8146973E-06	-1.9073486E-06	4.2955489E-23	4.2955530E-23
9.9860001E-01	-1.9073486E-06	-4.7683716E-07	1.4757376E-23	1.4757349E-23
9.9879998E-01	-1.4305115E-06	2.2053719E-06	4.3003990E-24	4.3004040E-24
9.9900001E-01	2.3841858E-06	-3.5762787E-07	9.9989700E-25	9.9989600E-25
9.9919999E-01	-2.8610229E-06	1.4901161E-06	1.6779500E-25	1.6779500E-25
9.9940002E-01	9.5367432E-07	-2.3841858E-06	1.6792000E-26	1.6792000E-26
9.9959999E-01	-4.2915344E-06	-3.2186508E-06	6.5500000E-28	6.5500000E-28
9.9980003E-01	-2.3841858E-06	1.6689301E-06	3.0000000E-30	3.0000000E-30
1.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	nan
1.0002000E+00	0.0000000E+00	-1.6689301E-06	3.0000000E-30	3.0000000E-30
1.0003999E+00	9.5367432E-07	-7.1525574E-07	6.5500000E-28	6.5500000E-28

1.0006000E+00	9.5367432E-07	2.6226044E-06	1.6792000E-26	1.6792000E-26
1.0008000E+00	-9.5367432E-07	-2.3841858E-07	1.6779500E-25	1.6779500E-25
1.0010000E+00	2.8610229E-06	-7.2717667E-06	1.0003740E-24	1.0003730E-24
1.0012000E+00	5.7220459E-06	-2.1457672E-06	4.2986910E-24	4.2986980E-24
1.0014000E+00	-3.8146973E-06	-4.7683716E-07	1.4757376E-23	1.4757349E-23
1.0016000E+00	-1.9073486E-06	8.9406967E-07	4.2955489E-23	4.2955530E-23
1.0017999E+00	-2.8610229E-06	3.3378601E-06	1.1017075E-22	1.1017095E-22
1.0020000E+00	9.5367432E-07	1.9669533E-06	2.5597363E-22	2.5597345E-22
1.0022000E+00	4.7683716E-06	-2.3841858E-07	5.4877360E-22	5.4877310E-22
1.0024000E+00	-9.5367432E-07	-5.9604645E-07	1.1009022E-21	1.1009034E-21
1.0026000E+00	7.6293945E-06	-3.5762787E-06	2.0879790E-21	2.0879763E-21
1.0028000E+00	-3.8146973E-06	3.0398369E-06	3.7778881E-21	3.7778813E-21
1.0030000E+00	1.9073486E-06	-3.5762787E-07	6.5613671E-21	6.5613715E-21
1.0032001E+00	0.0000000E+00	3.5166740E-06	1.0996605E-20	1.0996616E-20
1.0034000E+00	9.5367432E-07	4.1723251E-07	1.7856600E-20	1.7856624E-20
1.0036000E+00	2.8610229E-06	-4.1723251E-06	2.8211182E-20	2.8211189E-20
1.0038000E+00	-2.8610229E-06	2.3245811E-06	4.3481082E-20	4.3481014E-20
1.0039999E+00	-5.7220459E-06	1.8477440E-06	6.5529248E-20	6.5529203E-20
1.0042000E+00	-9.5367432E-06	-1.1920929E-07	9.6823145E-20	9.6822977E-20
1.0044000E+00	-5.7220459E-06	-4.7683716E-07	1.4048604E-19	1.4048593E-19
1.0046000E+00	7.6293945E-06	-3.2186508E-06	2.0049288E-19	2.0049277E-19
1.0048000E+00	-6.6757202E-06	4.1723251E-07	2.8177497E-19	2.8177538E-19
1.0050000E+00	-2.8610229E-06	-1.1920929E-06	3.9062201E-19	3.9062180E-19
1.0052000E+00	9.5367432E-07	5.3644180E-07	5.3462069E-19	5.3461986E-19
1.0053999E+00	5.7220459E-06	-8.3446503E-07	7.2295792E-19	7.2295854E-19
1.0056000E+00	-3.8146973E-06	-3.6954880E-06	9.6713937E-19	9.6713761E-19
1.0058000E+00	5.7220459E-06	-3.0994415E-06	1.2806463E-18	1.2806482E-18
1.0060000E+00	-7.6293945E-06	-9.5367432E-07	1.6797100E-18	1.6797111E-18
1.0062000E+00	9.5367432E-07	4.1723251E-07	2.1832768E-18	2.1832727E-18
1.0064000E+00	9.5367432E-07	1.7285347E-06	2.8147116E-18	2.8147149E-18
1.0066000E+00	-4.7683716E-06	2.6226044E-06	3.6005034E-18	3.6005009E-18
1.0067999E+00	5.7220459E-06	4.1723251E-07	4.5712896E-18	4.5712958E-18
1.0070000E+00	1.9073486E-06	4.7683716E-07	5.7645998E-18	5.7645907E-18
1.0072000E+00	-1.9073486E-06	-1.6689301E-06	7.2220626E-18	7.2220643E-18
1.0074000E+00	-1.9073486E-06	-4.7683716E-07	8.9922962E-18	8.9922912E-18
1.0075999E+00	2.8610229E-06	-1.9073486E-06	1.1129760E-17	1.1129780E-17
1.0078000E+00	-8.5830688E-06	-3.4570694E-06	1.3700905E-17	1.3700888E-17
1.0080000E+00	-2.8610229E-06	2.3841858E-06	1.6777488E-17	1.6777460E-17
1.0082000E+00	9.5367432E-07	1.9669533E-06	2.0442394E-17	2.0442396E-17
1.0084000E+00	-3.8146973E-06	4.2319298E-06	2.4786725E-17	2.4786684E-17
1.0086000E+00	-5.7220459E-06	1.5497208E-06	2.9921697E-17	2.9921723E-17
1.0088000E+00	0.0000000E+00	0.0000000E+00	3.5964427E-17	3.5964397E-17
1.0089999E+00	-8.5830688E-06	-9.5367432E-07	4.3044567E-17	4.3044567E-17
1.0092000E+00	-8.5830688E-06	-1.4305115E-06	5.1320856E-17	5.1320863E-17
1.0094000E+00	-9.5367432E-07	-4.1723251E-06	6.0957421E-17	6.0957355E-17
1.0096000E+00	-4.7683716E-06	-2.9802322E-06	7.2141558E-17	7.2141651E-17
1.0098000E+00	-7.6293945E-06	-3.5762787E-06	8.5073336E-17	8.5073389E-17
1.0100000E+00	0.0000000E+00	5.3644180E-07	9.9999234E-17	9.9999188E-17

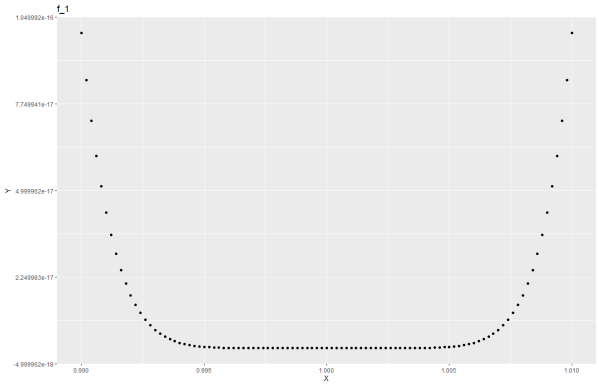
3.1.1 Wykresy



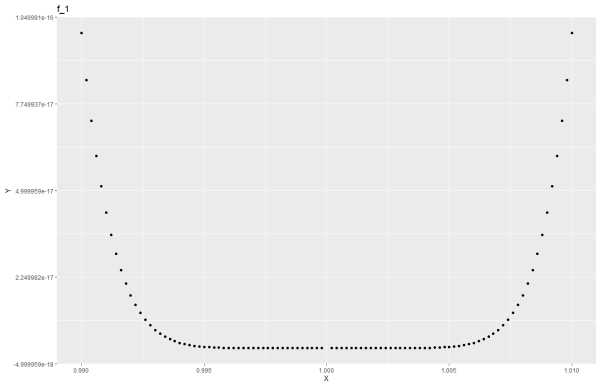
(a) Pierwszy wzór funkcji



(b) Drugi wzór funkcji



(c) Trzeci wzór funkcji



(d) Czwarty wzór funkcji

Rysunek 1: Wykresy dla typu float

3.2 Double

8 bajtów:

- Znak: 1 bit
- Mantysa: 52 bity
- Wykładnik: 11 bitów

Dokładność: 15 - 16 cyfr znaczących

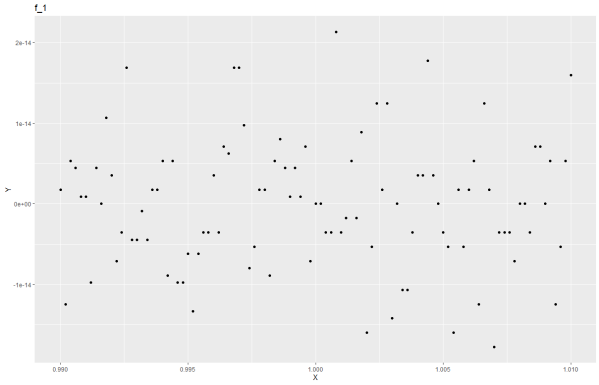
Tabela 2: Wyniki obliczeń dla double

x	$f_1(x)$	$f_2(x)$	$f_3(x)$	$f_4(x)$
9.9020000000E-01	-1.2434497876E-14	-5.3290705182E-15	8.5076302258E-17	8.5076302258E-17
9.9040000000E-01	5.3290705182E-15	5.5511151231E-16	7.2138957898E-17	7.2138957898E-17
9.9060000000E-01	4.4408920985E-15	3.2196467714E-15	6.0956893854E-17	6.0956893854E-17
9.9080000000E-01	8.8817841970E-16	9.3258734069E-15	5.1321887314E-17	5.1321887314E-17
9.9100000000E-01	8.8817841970E-16	5.5511151231E-15	4.3046721000E-17	4.3046721000E-17
9.9120000000E-01	-9.7699626167E-15	4.1078251911E-15	3.5963452481E-17	3.5963452481E-17
9.9140000000E-01	4.4408920985E-15	-8.6597395921E-15	2.9921792711E-17	2.9921792711E-17
9.9160000000E-01	0.0000000000E+00	4.2188474936E-15	2.4787589111E-17	2.4787589111E-17
9.9180000000E-01	1.0658141036E-14	-4.6629367034E-15	2.0441408587E-17	2.0441408587E-17
9.9200000000E-01	3.5527136788E-15	-6.6613381478E-16	1.6777216000E-17	1.6777216000E-17

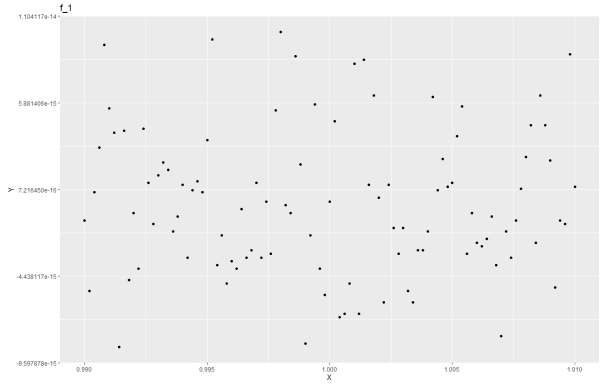
9.9220000000E-01	-7.1054273576E-15	-3.9968028887E-15	1.3701143707E-17	1.3701143707E-17
9.9240000000E-01	-3.5527136788E-15	4.3298697960E-15	1.1130347875E-17	1.1130347875E-17
9.9260000000E-01	1.6875389974E-14	1.1102230246E-15	8.9919474020E-18	8.9919474020E-18
9.9280000000E-01	-4.4408920985E-15	-1.3322676296E-15	7.2220413631E-18	7.2220413631E-18
9.9300000000E-01	-4.4408920985E-15	1.5543122345E-15	5.7648010000E-18	5.7648010000E-18
9.9320000000E-01	-8.8817841970E-16	2.3314683517E-15	4.5716323965E-18	4.5716323965E-18
9.9340000000E-01	-4.4408920985E-15	1.8873791419E-15	3.6004060627E-18	3.6004060627E-18
9.9360000000E-01	1.7763568394E-15	-1.7763568394E-15	2.8147497671E-18	2.8147497671E-18
9.9380000000E-01	1.7763568394E-15	-8.8817841970E-16	2.1834010558E-18	2.1834010558E-18
9.9400000000E-01	5.3290705182E-15	9.9920072216E-16	1.6796160000E-18	1.6796160000E-18
9.9420000000E-01	-8.8817841970E-15	-3.3306690739E-15	1.2806308172E-18	1.2806308172E-18
9.9440000000E-01	5.3290705182E-15	6.6613381478E-16	9.6717311574E-19	9.6717311574E-19
9.9460000000E-01	-9.7699626167E-15	1.2212453271E-15	7.2301961339E-19	7.2301961339E-19
9.9480000000E-01	-9.7699626167E-15	5.5511151231E-16	5.3459728532E-19	5.3459728532E-19
9.9500000000E-01	-6.2172489379E-15	3.6637359813E-15	3.9062500000E-19	3.9062500000E-19
9.9520000000E-01	-1.3322676296E-14	9.6589403142E-15	2.8179280429E-19	2.8179280429E-19
9.9540000000E-01	-6.2172489379E-15	-3.7747582837E-15	2.0047612232E-19	2.0047612232E-19
9.9560000000E-01	-3.5527136788E-15	-1.9984014443E-15	1.4048223625E-19	1.4048223625E-19
9.9580000000E-01	-3.5527136788E-15	-4.8849813084E-15	9.6826519964E-20	9.6826519964E-20
9.9600000000E-01	3.5527136788E-15	-3.5527136788E-15	6.5536000000E-20	6.5536000000E-20
9.9620000000E-01	-3.5527136788E-15	-3.9968028887E-15	4.3477921385E-20	4.3477921385E-20
9.9640000000E-01	7.1054273576E-15	-4.4408920985E-16	2.8211099075E-20	2.8211099075E-20
9.9660000000E-01	6.2172489379E-15	-3.3306690739E-15	1.7857939049E-20	1.7857939049E-20
9.9680000000E-01	1.6875389974E-14	-2.8865798640E-15	1.0995116278E-20	1.0995116278E-20
9.9700000000E-01	1.6875389974E-14	1.1102230246E-15	6.5610000000E-21	6.5610000000E-21
9.9720000000E-01	9.7699626167E-15	-3.3306690739E-15	3.7780199830E-21	3.7780199830E-21
9.9740000000E-01	-7.9936057773E-15	0.0000000000E+00	2.0882706460E-21	2.0882706460E-21
9.9760000000E-01	-5.3290705182E-15	-3.1086244690E-15	1.1007531420E-21	1.1007531420E-21
9.9780000000E-01	1.7763568394E-15	5.4400928207E-15	5.4875873500E-22	5.4875873500E-22
9.9800000000E-01	1.7763568394E-15	1.0103029524E-14	2.5600000000E-22	2.5600000000E-22
9.9820000000E-01	-8.8817841970E-15	-2.2204460493E-16	1.1019960600E-22	1.1019960600E-22
9.9840000000E-01	5.3290705182E-15	-6.6613381478E-16	4.2949673000E-23	4.2949673000E-23
9.9860000000E-01	7.9936057773E-15	8.6597395921E-15	1.4757891000E-23	1.4757891000E-23
9.9880000000E-01	4.4408920985E-15	2.2204460493E-15	4.2998170000E-24	4.2998170000E-24
9.9900000000E-01	8.8817841970E-16	-8.4376949872E-15	1.0000000000E-24	1.0000000000E-24
9.9920000000E-01	4.4408920985E-15	-1.9984014443E-15	1.6777200000E-25	1.6777200000E-25
9.9940000000E-01	8.8817841970E-16	5.7731597281E-15	1.6796000000E-26	1.6796000000E-26
9.9960000000E-01	7.1054273576E-15	-3.9968028887E-15	6.5500000000E-28	6.5500000000E-28
9.9980000000E-01	-7.1054273576E-15	-5.5511151231E-15	3.0000000000E-30	3.0000000000E-30
1.0000000000E+00	0.0000000000E+00	0.0000000000E+00	0.0000000000E+00	nan
1.0002000000E+00	0.0000000000E+00	4.7739590059E-15	3.0000000000E-30	3.0000000000E-30
1.0004000000E+00	-3.5527136788E-15	-6.8833827527E-15	6.5500000000E-28	6.5500000000E-28
1.0006000000E+00	-3.5527136788E-15	-6.6613381478E-15	1.6796000000E-26	1.6796000000E-26
1.0008000000E+00	2.1316282073E-14	-4.8849813084E-15	1.6777200000E-25	1.6777200000E-25
1.0010000000E+00	-3.5527136788E-15	8.2156503822E-15	1.0000000000E-24	1.0000000000E-24
1.0012000000E+00	-1.7763568394E-15	-6.6613381478E-15	4.2998170000E-24	4.2998170000E-24
1.0014000000E+00	5.3290705182E-15	8.4376949872E-15	1.4757891000E-23	1.4757891000E-23
1.0016000000E+00	-1.7763568394E-15	9.9920072216E-16	4.2949673000E-23	4.2949673000E-23
1.0018000000E+00	8.8817841970E-15	6.3282712404E-15	1.1019960600E-22	1.1019960600E-22
1.0020000000E+00	-1.5987211555E-14	2.2204460493E-16	2.5600000000E-22	2.5600000000E-22
1.0022000000E+00	-5.3290705182E-15	-5.9952043330E-15	5.4875873500E-22	5.4875873500E-22
1.0024000000E+00	1.2434497876E-14	9.9920072216E-16	1.1007531420E-21	1.1007531420E-21
1.0026000000E+00	1.7763568394E-15	-1.5543122345E-15	2.0882706460E-21	2.0882706460E-21
1.0028000000E+00	1.2434497876E-14	-3.1086244690E-15	3.7780199830E-21	3.7780199830E-21
1.0030000000E+00	-1.4210854715E-14	-1.5543122345E-15	6.5610000000E-21	6.5610000000E-21
1.0032000000E+00	0.0000000000E+00	-5.3290705182E-15	1.0995116278E-20	1.0995116278E-20

1.0034000000E+00	-1.0658141036E-14	-5.9952043330E-15	1.7857939049E-20	1.7857939049E-20
1.0036000000E+00	-1.0658141036E-14	-2.8865798640E-15	2.8211099075E-20	2.8211099075E-20
1.0038000000E+00	-3.5527136788E-15	-2.8865798640E-15	4.3477921385E-20	4.3477921385E-20
1.0040000000E+00	3.5527136788E-15	-1.7763568394E-15	6.5536000000E-20	6.5536000000E-20
1.0042000000E+00	3.5527136788E-15	6.2172489379E-15	9.6826519964E-20	9.6826519964E-20
1.0044000000E+00	1.7763568394E-14	6.6613381478E-16	1.4048223625E-19	1.4048223625E-19
1.0046000000E+00	3.5527136788E-15	2.5535129566E-15	2.0047612232E-19	2.0047612232E-19
1.0048000000E+00	0.0000000000E+00	8.8817841970E-16	2.8179280429E-19	2.8179280429E-19
1.0050000000E+00	-3.5527136788E-15	1.1102230246E-15	3.9062500000E-19	3.9062500000E-19
1.0052000000E+00	-5.3290705182E-15	3.8857805862E-15	5.3459728532E-19	5.3459728532E-19
1.0054000000E+00	-1.5987211555E-14	5.6621374256E-15	7.2301961339E-19	7.2301961339E-19
1.0056000000E+00	1.7763568394E-15	-3.1086244690E-15	9.6717311574E-19	9.6717311574E-19
1.0058000000E+00	-5.3290705182E-15	-6.6613381478E-16	1.2806308172E-18	1.2806308172E-18
1.0060000000E+00	1.7763568394E-15	-2.4424906542E-15	1.6796160000E-18	1.6796160000E-18
1.0062000000E+00	5.3290705182E-15	-2.6645352591E-15	2.1834010558E-18	2.1834010558E-18
1.0064000000E+00	-1.2434497876E-14	-2.2204460493E-15	2.8147497671E-18	2.8147497671E-18
1.0066000000E+00	1.2434497876E-14	-8.8817841970E-16	3.6004060627E-18	3.6004060627E-18
1.0068000000E+00	1.7763568394E-15	-3.7747582837E-15	4.5716323965E-18	4.5716323965E-18
1.0070000000E+00	-1.7763568394E-14	-7.9936057773E-15	5.7648010000E-18	5.7648010000E-18
1.0072000000E+00	-3.5527136788E-15	-1.7763568394E-15	7.2220413631E-18	7.2220413631E-18
1.0074000000E+00	-3.5527136788E-15	-3.3306690739E-15	8.9919474020E-18	8.9919474020E-18
1.0076000000E+00	-3.5527136788E-15	-1.1102230246E-15	1.1130347875E-17	1.1130347875E-17
1.0078000000E+00	-7.1054273576E-15	7.7715611724E-16	1.3701143707E-17	1.3701143707E-17
1.0080000000E+00	0.0000000000E+00	2.6645352591E-15	1.6777216000E-17	1.6777216000E-17
1.0082000000E+00	0.0000000000E+00	4.5519144010E-15	2.0441408587E-17	2.0441408587E-17
1.0084000000E+00	-3.5527136788E-15	-2.4424906542E-15	2.4787589111E-17	2.4787589111E-17
1.0086000000E+00	7.1054273576E-15	6.3282712404E-15	2.9921792711E-17	2.9921792711E-17
1.0088000000E+00	7.1054273576E-15	4.5519144010E-15	3.5963452481E-17	3.5963452481E-17
1.0090000000E+00	0.0000000000E+00	2.4424906542E-15	4.3046721000E-17	4.3046721000E-17
1.0092000000E+00	5.3290705182E-15	-5.1070259133E-15	5.1321887314E-17	5.1321887314E-17
1.0094000000E+00	-1.2434497876E-14	-1.1102230246E-15	6.0956893854E-17	6.0956893854E-17
1.0096000000E+00	-5.3290705182E-15	-1.3322676296E-15	7.2138957898E-17	7.2138957898E-17
1.0098000000E+00	5.3290705182E-15	8.7707618945E-15	8.5076302258E-17	8.5076302258E-17
1.0100000000E+00	1.5987211555E-14	8.8817841970E-16	1.0000000000E-16	1.0000000000E-16

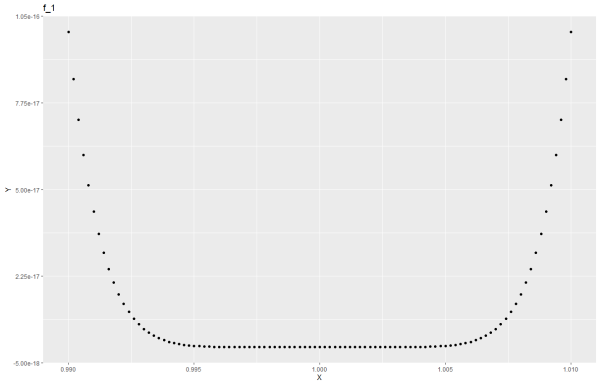
3.2.1 Wykresy



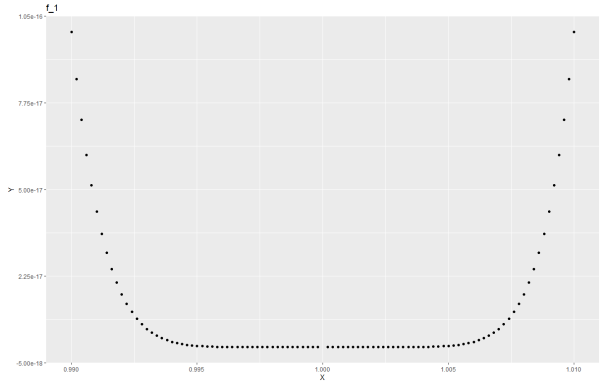
(a) Pierwszy wzór funkcji



(b) Drugi wzór funkcji



(c) Trzeci wzór funkcji



(d) Czwarty wzór funkcji

Rysunek 2: Wykresy dla typu double

3.3 Long double

16 bajtów:

- Znak: 1 bit
- Mantysa: 64 bity

Dokładność: 19 - 20 cyfr znaczących

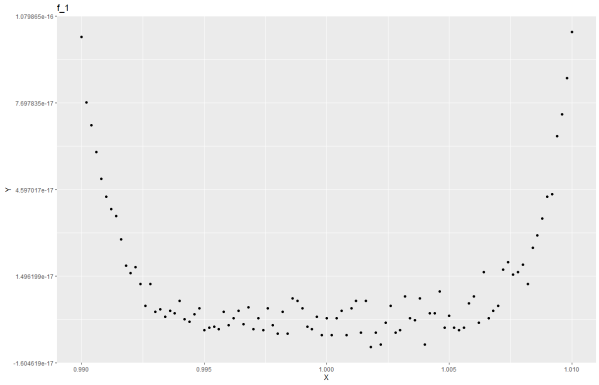
Tabela 3: Wyniki obliczeń dla long double

x	$f_1(x)$	$f_2(x)$	$f_3(x)$	$f_4(x)$
9.9020000000E-01	7.7195194681E-17	8.3104096521E-17	8.5076300000E-17	8.5076300000E-17
9.9040000000E-01	6.8955258170E-17	7.3237856751E-17	7.2139000000E-17	7.2139000000E-17
9.9060000000E-01	5.9414279052E-17	6.0877951985E-17	6.0956900000E-17	6.0956900000E-17
9.9080000000E-01	4.9873299934E-17	5.1499603193E-17	5.1321900000E-17	5.1321900000E-17
9.9100000000E-01	4.3368086899E-17	4.4777549724E-17	4.3046700000E-17	4.3046700000E-17
9.9120000000E-01	3.9031278209E-17	3.7133924408E-17	3.5963500000E-17	3.5963500000E-17
9.9140000000E-01	3.6429192996E-17	2.8460307028E-17	2.9921800000E-17	2.9921800000E-17
9.9160000000E-01	2.8189256485E-17	2.4177708446E-17	2.4787600000E-17	2.4787600000E-17
9.9180000000E-01	1.8648277367E-17	1.8160386389E-17	2.0441400000E-17	2.0441400000E-17
9.9200000000E-01	1.6046192153E-17	1.6154612370E-17	1.6777200000E-17	1.6777200000E-17
9.9220000000E-01	1.8214596498E-17	1.5070410198E-17	1.3701100000E-17	1.3701100000E-17

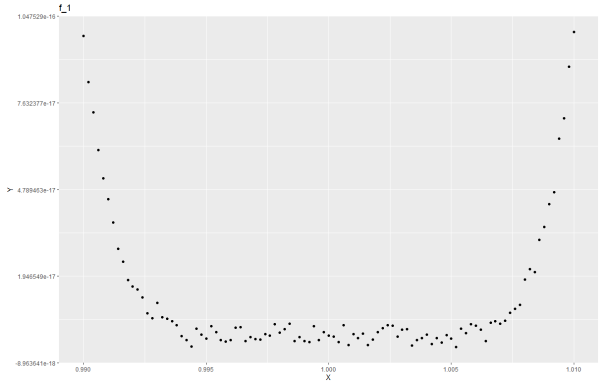
9.9240000000E-01	1.2143064332E-17	1.2468324984E-17	1.1130300000E-17	1.1130300000E-17
9.9260000000E-01	4.3368086899E-18	7.3183646643E-18	8.9919500000E-18	8.9919500000E-18
9.9280000000E-01	1.2143064332E-17	5.6920614055E-18	7.2220400000E-18	7.2220400000E-18
9.9300000000E-01	2.1684043450E-18	1.0733601508E-17	5.7648000000E-18	5.7648000000E-18
9.9320000000E-01	3.0357660830E-18	6.0715321659E-18	4.5716300000E-18	4.5716300000E-18
9.9340000000E-01	4.3368086899E-19	5.4752209711E-18	3.6004100000E-18	3.6004100000E-18
9.9360000000E-01	2.6020852140E-18	4.7162794503E-18	2.8147500000E-18	2.8147500000E-18
9.9380000000E-01	1.7347234760E-18	3.4152368433E-18	2.1834000000E-18	2.1834000000E-18
9.9400000000E-01	6.0715321659E-18	-1.0842021725E-19	1.6796200000E-18	1.6796200000E-18
9.9420000000E-01	-4.3368086899E-19	-1.5178830415E-18	1.2806300000E-18	1.2806300000E-18
9.9440000000E-01	-1.3010426070E-18	-3.5778671692E-18	9.6717300000E-19	9.6717300000E-19
9.9460000000E-01	1.3010426070E-18	2.2226144536E-18	7.2302000000E-19	7.2302000000E-19
9.9480000000E-01	3.4694469520E-18	2.7105054312E-19	5.3459700000E-19	5.3459700000E-19
9.9500000000E-01	-4.3368086899E-18	-9.7578195524E-19	3.9062500000E-19	3.9062500000E-19
9.9520000000E-01	-3.4694469520E-18	3.0899761916E-18	2.8179300000E-19	2.8179300000E-19
9.9540000000E-01	-3.0357660830E-18	1.0842021725E-18	2.0047600000E-19	2.0047600000E-19
9.9560000000E-01	-3.9031278209E-18	-1.5178830415E-18	1.4048200000E-19	1.4048200000E-19
9.9580000000E-01	2.1684043450E-18	-1.9515639105E-18	9.6826500000E-20	9.6826500000E-20
9.9600000000E-01	-2.6020852140E-18	-1.4094628242E-18	6.5536000000E-20	6.5536000000E-20
9.9620000000E-01	0.0000000000E+00	2.6020852140E-18	4.3477900000E-20	4.3477900000E-20
9.9640000000E-01	2.6020852140E-18	2.7105054312E-18	2.8211100000E-20	2.8211100000E-20
9.9660000000E-01	-2.1684043450E-18	-1.7347234760E-18	1.7857900000E-20	1.7857900000E-20
9.9680000000E-01	3.9031278209E-18	-4.3368086899E-19	1.0995100000E-20	1.0995100000E-20
9.9700000000E-01	-3.9031278209E-18	-1.0842021725E-18	6.5610000000E-21	6.5610000000E-21
9.9720000000E-01	0.0000000000E+00	-1.3010426070E-18	3.7780200000E-21	3.7780200000E-21
9.9740000000E-01	-4.3368086899E-18	5.4210108624E-19	2.0882700000E-21	2.0882700000E-21
9.9760000000E-01	3.4694469520E-18	5.4210108624E-20	1.1007500000E-21	1.1007500000E-21
9.9780000000E-01	-2.6020852140E-18	3.7947076037E-18	5.4875900000E-22	5.4875900000E-22
9.9800000000E-01	-5.6378512969E-18	1.0299920639E-18	2.5600000000E-22	2.5600000000E-22
9.9820000000E-01	2.1684043450E-18	2.1141942363E-18	1.1020000000E-22	1.1020000000E-22
9.9840000000E-01	-5.6378512969E-18	3.9573379296E-18	4.2949700000E-23	4.2949700000E-23
9.9860000000E-01	6.9388939039E-18	-1.7347234760E-18	1.4757900000E-23	1.4757900000E-23
9.9880000000E-01	6.0715321659E-18	-4.3368086899E-19	4.2998200000E-24	4.2998200000E-24
9.9900000000E-01	3.4694469520E-18	-1.7347234760E-18	1.0000000000E-24	1.0000000000E-24
9.9920000000E-01	-3.0357660830E-18	-2.1684043450E-18	1.6777200000E-25	1.6777200000E-25
9.9940000000E-01	-3.9031278209E-18	3.0357660830E-18	1.6796000000E-26	1.6796000000E-26
9.9960000000E-01	4.3368086899E-19	-1.5178830415E-18	6.5500000000E-28	6.5500000000E-28
9.9980000000E-01	-6.0715321659E-18	1.0842021725E-18	3.0000000000E-30	3.0000000000E-30
1.0000000000E+00	0.0000000000E+00	0.0000000000E+00	0.0000000000E+00	nan
1.0002000000E+00	-6.0715321659E-18	-3.2526065175E-19	3.0000000000E-30	3.0000000000E-30
1.0004000000E+00	0.0000000000E+00	-2.1684043450E-18	6.5500000000E-28	6.5500000000E-28
1.0006000000E+00	2.6020852140E-18	3.3610267347E-18	1.6796000000E-26	1.6796000000E-26
1.0008000000E+00	-6.0715321659E-18	-3.0357660830E-18	1.6777200000E-25	1.6777200000E-25
1.0010000000E+00	3.4694469520E-18	4.3368086899E-19	1.0000000000E-24	1.0000000000E-24
1.0012000000E+00	6.0715321659E-18	-7.5894152074E-19	4.2998200000E-24	4.2998200000E-24
1.0014000000E+00	-5.2041704279E-18	6.5052130349E-19	1.4757900000E-23	1.4757900000E-23
1.0016000000E+00	6.0715321659E-18	-3.0357660830E-18	4.2949700000E-23	4.2949700000E-23
1.0018000000E+00	-1.0408340856E-17	-1.3010426070E-18	1.1020000000E-22	1.1020000000E-22
1.0020000000E+00	-5.2041704279E-18	1.0842021725E-18	2.5600000000E-22	2.5600000000E-22
1.0022000000E+00	-9.5409791179E-18	2.4394548881E-18	5.4875900000E-22	5.4875900000E-22
1.0024000000E+00	-1.7347234760E-18	3.4694469520E-18	1.1007500000E-21	1.1007500000E-21
1.0026000000E+00	4.3368086899E-18	3.2526065175E-18	2.0882700000E-21	2.0882700000E-21
1.0028000000E+00	-5.2041704279E-18	-3.2526065175E-19	3.7780200000E-21	3.7780200000E-21
1.0030000000E+00	-4.3368086899E-18	2.0057740191E-18	6.5610000000E-21	6.5610000000E-21
1.0032000000E+00	7.8062556419E-18	2.1684043450E-18	1.0995100000E-20	1.0995100000E-20
1.0034000000E+00	0.0000000000E+00	-3.2526065175E-18	1.7857900000E-20	1.7857900000E-20

1.0036000000E+00	-8.6736173799E-19	-1.4094628242E-18	2.8211100000E-20	2.8211100000E-20
1.0038000000E+00	6.9388939039E-18	-8.6736173799E-19	4.3477900000E-20	4.3477900000E-20
1.0040000000E+00	-9.5409791179E-18	3.7947076037E-19	6.5536000000E-20	6.5536000000E-20
1.0042000000E+00	1.7347234760E-18	-2.8189256485E-18	9.6826500000E-20	9.6826500000E-20
1.0044000000E+00	1.7347234760E-18	-8.6736173799E-19	1.4048200000E-19	1.4048200000E-19
1.0046000000E+00	9.5409791179E-18	-2.2768245622E-18	2.0047600000E-19	2.0047600000E-19
1.0048000000E+00	-3.4694469520E-18	2.1684043450E-19	2.8179300000E-19	2.8179300000E-19
1.0050000000E+00	8.6736173799E-19	-9.7578195524E-19	3.9062500000E-19	3.9062500000E-19
1.0052000000E+00	-3.4694469520E-18	-3.7947076037E-18	5.3459700000E-19	5.3459700000E-19
1.0054000000E+00	-4.3368086899E-18	2.2768245622E-18	7.2302000000E-19	7.2302000000E-19
1.0056000000E+00	-3.4694469520E-18	7.5894152074E-19	9.6717300000E-19	9.6717300000E-19
1.0058000000E+00	5.2041704279E-18	3.7404974951E-18	1.2806300000E-18	1.2806300000E-18
1.0060000000E+00	7.8062556419E-18	3.3068166261E-18	1.6796200000E-18	1.6796200000E-18
1.0062000000E+00	-1.7347234760E-18	1.8973538019E-18	2.1834000000E-18	2.1834000000E-18
1.0064000000E+00	1.6479873022E-17	-1.7347234760E-18	2.8147500000E-18	2.8147500000E-18
1.0066000000E+00	0.0000000000E+00	4.1741783641E-18	3.6004100000E-18	3.6004100000E-18
1.0068000000E+00	2.6020852140E-18	4.6620693417E-18	4.5716300000E-18	4.5716300000E-18
1.0070000000E+00	4.3368086899E-18	3.9031278209E-18	5.7648000000E-18	5.7648000000E-18
1.0072000000E+00	1.7347234760E-17	4.9331198848E-18	7.2220400000E-18	7.2220400000E-18
1.0074000000E+00	1.9949319974E-17	7.4267848815E-18	8.9919500000E-18	8.9919500000E-18
1.0076000000E+00	1.5612511284E-17	8.8362477058E-18	1.1130300000E-17	1.1130300000E-17
1.0078000000E+00	1.6479873022E-17	1.0028870095E-17	1.3701100000E-17	1.3701100000E-17
1.0080000000E+00	1.9081958236E-17	1.8377226824E-17	1.6777200000E-17	1.6777200000E-17
1.0082000000E+00	1.2143064332E-17	2.1846673776E-17	2.0441400000E-17	2.0441400000E-17
1.0084000000E+00	2.5153490402E-17	2.0762471603E-17	2.4787600000E-17	2.4787600000E-17
1.0086000000E+00	2.9490299092E-17	3.1441863002E-17	2.9921800000E-17	2.9921800000E-17
1.0088000000E+00	3.5561831258E-17	3.5670251475E-17	3.5963500000E-17	3.5963500000E-17
1.0090000000E+00	4.3368086899E-17	4.3151246465E-17	4.3046700000E-17	4.3046700000E-17
1.0092000000E+00	4.4235448637E-17	4.6945954069E-17	5.1321900000E-17	5.1321900000E-17
1.0094000000E+00	6.5052130349E-17	6.4564239372E-17	6.0956900000E-17	6.0956900000E-17
1.0096000000E+00	7.2858385991E-17	7.1286292841E-17	7.2139000000E-17	7.2139000000E-17
1.0098000000E+00	8.5868812061E-17	8.8145636623E-17	8.5076300000E-17	8.5076300000E-17
1.0100000000E+00	1.0234868508E-16	9.9583969543E-17	1.0000000000E-16	1.0000000000E-16

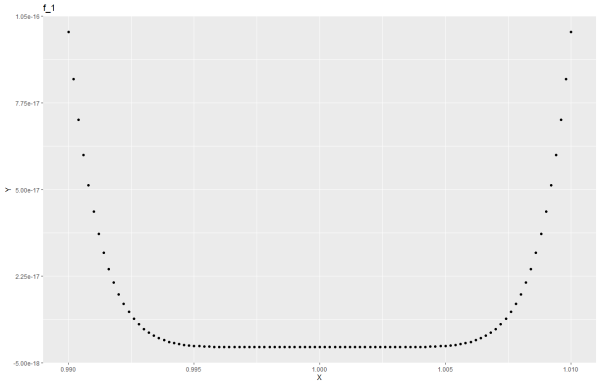
3.3.1 Wykresy



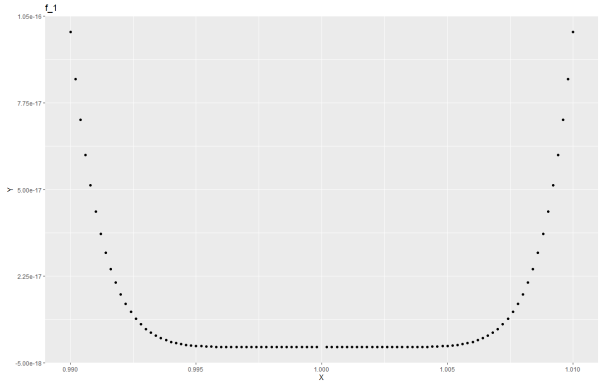
(a) Pierwszy wzór funkcji



(b) Drugi wzór funkcji



(c) Trzeci wzór funkcji



(d) Czwarty wzór funkcji

Rysunek 3: Wykresy dla typu long double

4 Wnioski

Możemy wyróżnić dwa rodzaje błędów które wpływaja na poprawność otrzymanych wyników:

- błąd reprezentacji (precyzji)
- błędy operacji arytmetycznych

Dla typu float i double pierwsze dwa wzory całkowicie odbiegają od rzeczywistych wartości. W przypadku typu long double wykresy nie są idealne, ale można dostrzec w nich charakterystyczny wygląd paraboli. Jest to spowodowane błędami operacji dodawania, mnożenia i potęgowania. Uwzględniając jeszcze dokładność reprezentacji otrzymujemy wszytskie czynniki wpływające na błędną reprezentację wyników.
W przypadku zastosowania trzeciego i czwartego wzoru, dla każdego typy wykresy są bardzo podobne. W przyapdku wzoru trzeciego jest to spowodowane tym, że najpierw wykonujemy operacje dodawania, a następnie potęgowania do stałej potęgi co ogranicza powielanie błędów. Natomiast jeśli chodzi o wzór czwarty, funkcja $ln(x)$ jest bardzo dobrze określona dla miennych rzeczywistych. Podobnie jak we wcześniejszym przyapdku raz obliczmy wartość logarytmu, a następnie podnosimy e do wyliczonej potęgi, co analogicznie ogranicza ilość błędów.
Możemy zatem wnioskować, że głownym czynnikiem wpływającym na wynik obliczeń są będy spowodowane przez dodawanie i mnozenie, następnie błedy reprezentacji. Najdokładniejszy sposób to korzystanie z operacji, które minimalizują powielanie błędów.