Министерство образования и науки Российской Федерации

Новосибирский государственный технический университет

Кафедра прикладной математики

Методы оптимизации

Лабораторная работа №1

Факультет ПМИ

Группа ПМ-01

Студенты Александров М.Е.

Жигалов П.С.

Преподаватели Черникова О.С.

Чимитова Е.В.

Вариант 4

Новосибирск

2013

1. Цель работы

Ознакомиться с методами одномерного поиска, используемыми в многомерных методах минимизации функций переменных. Сравнить различные алгоритмы по эффективности на тестовых примерах.

2. Задание

, , .

3. Результаты

3.1. Метод дихотомии.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *К-во итераций* | *Значение* | *Отн. погрешность* |
| 1.00E-01 | 12 | 15.0009704589843746 | 6.470E-05 |
| 1.00E-02 | 16 | 15.0010578536987325 | 7.052E-05 |
| 1.00E-03 | 19 | 15.0000474181175232 | 3.161E-06 |
| 1.00E-04 | 22 | 15.0000171872198607 | 1.146E-06 |
| 1.00E-05 | 26 | 14.9999991169792022 | 5.887E-08 |
| 1.00E-06 | 29 | 14.9999999284617189 | 4.769E-09 |
| 1.00E-07 | 32 | 14.9999999865597431 | 8.960E-10 |
| 1.00E-08 | 36 | 14.9999999454046957 | 3.640E-09 |
| 1.00E-09 | 39 | 14.9999994923498718 | 3.384E-08 |
| 1.00E-10 | 42 | 14.9999939738519323 | 4.017E-07 |
| 1.00E-11 | 46 | 14.9999513425250086 | 3.244E-06 |
| 1.00E-12 | 49 | 14.9995242650188256 | 3.172E-05 |
| 1.00E-13 | 52 | 14.9951931603784203 | 3.205E-04 |
| 1.00E-14 | 55 | 14.9374378216875634 | 4.171E-03 |

eps = 1.0E-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.010250000000E+02 | 9.902500000000E+01 | 1.999495077001E+00 |
| 2 | 2.000000000000E+00 | 5.153750000000E+01 | 4.953750000000E+01 | 1.998990663639E+00 |
| 3 | 2.000000000000E+00 | 2.679375000000E+01 | 2.479375000000E+01 | 1.997983362743E+00 |
| 4 | 1.437187500000E+01 | 2.679375000000E+01 | 1.242187500000E+01 | 1.995974842767E+00 |
| 5 | 1.437187500000E+01 | 2.060781250000E+01 | 6.235937500000E+00 | 1.991981959409E+00 |
| 6 | 1.437187500000E+01 | 1.751484375000E+01 | 3.142968750000E+00 | 1.984091474024E+00 |
| 7 | 1.437187500000E+01 | 1.596835937500E+01 | 1.596484375000E+00 | 1.968681184243E+00 |
| 8 | 1.437187500000E+01 | 1.519511718750E+01 | 8.232421875000E-01 | 1.939264531435E+00 |
| 9 | 1.475849609375E+01 | 1.519511718750E+01 | 4.366210937500E-01 | 1.885484231715E+00 |
| 10 | 1.495180664062E+01 | 1.519511718750E+01 | 2.433105468750E-01 | 1.794501304435E+00 |
| 11 | 1.495180664062E+01 | 1.509846191406E+01 | 1.466552734375E-01 | 1.659064424838E+00 |
| 12 | 1.495180664062E+01 | 1.505013427734E+01 | 9.832763671875E-02 | 1.491495965239E+00 |

Result: 15.0009704589843746

Error: 6.470E-05

eps = 1.0E-06

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.010000002500E+02 | 9.900000025000E+01 | 1.999999994949E+00 |
| 2 | 2.000000000000E+00 | 5.150000037500E+01 | 4.950000037500E+01 | 1.999999989899E+00 |
| 3 | 2.000000000000E+00 | 2.675000043750E+01 | 2.475000043750E+01 | 1.999999979798E+00 |
| 4 | 1.437499996875E+01 | 2.675000043750E+01 | 1.237500046875E+01 | 1.999999959596E+00 |
| 5 | 1.437499996875E+01 | 2.056250045312E+01 | 6.187500484375E+00 | 1.999999919192E+00 |
| 6 | 1.437499996875E+01 | 1.746875046094E+01 | 3.093750492187E+00 | 1.999999838384E+00 |
| 7 | 1.437499996875E+01 | 1.592187546484E+01 | 1.546875496094E+00 | 1.999999676768E+00 |
| 8 | 1.437499996875E+01 | 1.514843796680E+01 | 7.734379980469E-01 | 1.999999353536E+00 |
| 9 | 1.476171871777E+01 | 1.514843796680E+01 | 3.867192490234E-01 | 1.999998707072E+00 |
| 10 | 1.495507809229E+01 | 1.514843796680E+01 | 1.933598745117E-01 | 1.999997414148E+00 |
| 11 | 1.495507809229E+01 | 1.505175827954E+01 | 9.668018725586E-02 | 1.999994828310E+00 |
| 12 | 1.495507809229E+01 | 1.500341843591E+01 | 4.834034362793E-02 | 1.999989656673E+00 |
| 13 | 1.497924801410E+01 | 1.500341843591E+01 | 2.417042181396E-02 | 1.999979313559E+00 |
| 14 | 1.499133297501E+01 | 1.500341843591E+01 | 1.208546090698E-02 | 1.999958627974E+00 |
| 15 | 1.499737545546E+01 | 1.500341843591E+01 | 6.042980453490E-03 | 1.999917259372E+00 |
| 16 | 1.499737545546E+01 | 1.500039719569E+01 | 3.021740226744E-03 | 1.999834532435E+00 |
| 17 | 1.499888607557E+01 | 1.500039719569E+01 | 1.511120113372E-03 | 1.999669119618E+00 |
| 18 | 1.499964138563E+01 | 1.500039719569E+01 | 7.558100566865E-04 | 1.999338458127E+00 |
| 19 | 1.499964138563E+01 | 1.500001954066E+01 | 3.781550283435E-04 | 1.998677790951E+00 |
| 20 | 1.499983021314E+01 | 1.500001954066E+01 | 1.893275141711E-04 | 1.997359073767E+00 |
| 21 | 1.499992462690E+01 | 1.500001954066E+01 | 9.491375708492E-05 | 1.994732059776E+00 |
| 22 | 1.499997183378E+01 | 1.500001954066E+01 | 4.770687854183E-05 | 1.989519331090E+00 |
| 23 | 1.499999543722E+01 | 1.500001954066E+01 | 2.410343926940E-05 | 1.979256072489E+00 |
| 24 | 1.499999543722E+01 | 1.500000773894E+01 | 1.230171963407E-05 | 1.959355276042E+00 |
| 25 | 1.499999543722E+01 | 1.500000183808E+01 | 6.400859817290E-06 | 1.921885494326E+00 |
| 26 | 1.499999838765E+01 | 1.500000183808E+01 | 3.450429908014E-06 | 1.855090521452E+00 |
| 27 | 1.499999838765E+01 | 1.500000036286E+01 | 1.975214953376E-06 | 1.746862994388E+00 |
| 28 | 1.499999912526E+01 | 1.500000036286E+01 | 1.237607476057E-06 | 1.595994684574E+00 |
| 29 | 1.499999949406E+01 | 1.500000036286E+01 | 8.688037382854E-07 | 1.424496030023E+00 |

Result: 14.9999999284617189

Error: 4.769E-09

eps = 1.0E-07

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.010000000250E+02 | 9.900000002500E+01 | 1.999999999495E+00 |
| 2 | 2.000000000000E+00 | 5.150000003750E+01 | 4.950000003750E+01 | 1.999999998990E+00 |
| 3 | 2.000000000000E+00 | 2.675000004375E+01 | 2.475000004375E+01 | 1.999999997980E+00 |
| 4 | 1.437499999687E+01 | 2.675000004375E+01 | 1.237500004687E+01 | 1.999999995960E+00 |
| 5 | 1.437499999687E+01 | 2.056250004531E+01 | 6.187500048437E+00 | 1.999999991919E+00 |
| 6 | 1.437499999687E+01 | 1.746875004609E+01 | 3.093750049219E+00 | 1.999999983838E+00 |
| 7 | 1.437499999687E+01 | 1.592187504648E+01 | 1.546875049609E+00 | 1.999999967677E+00 |
| 8 | 1.437499999687E+01 | 1.514843754668E+01 | 7.734375498047E-01 | 1.999999935354E+00 |
| 9 | 1.476171874678E+01 | 1.514843754668E+01 | 3.867187999023E-01 | 1.999999870707E+00 |
| 10 | 1.495507812173E+01 | 1.514843754668E+01 | 1.933594249512E-01 | 1.999999741414E+00 |
| 11 | 1.495507812173E+01 | 1.505175785920E+01 | 9.667973747559E-02 | 1.999999482829E+00 |
| 12 | 1.495507812173E+01 | 1.500341801547E+01 | 4.833989373779E-02 | 1.999998965658E+00 |
| 13 | 1.497924804360E+01 | 1.500341801547E+01 | 2.416997186890E-02 | 1.999997931317E+00 |
| 14 | 1.499133300453E+01 | 1.500341801547E+01 | 1.208501093445E-02 | 1.999995862643E+00 |
| 15 | 1.499737548500E+01 | 1.500341801547E+01 | 6.042530467225E-03 | 1.999991725321E+00 |
| 16 | 1.499737548500E+01 | 1.500039677523E+01 | 3.021290233614E-03 | 1.999983450778E+00 |
| 17 | 1.499888610512E+01 | 1.500039677523E+01 | 1.510670116808E-03 | 1.999966902104E+00 |
| 18 | 1.499964141517E+01 | 1.500039677523E+01 | 7.553600584043E-04 | 1.999933806401E+00 |
| 19 | 1.499964141517E+01 | 1.500001912020E+01 | 3.777050292033E-04 | 1.999867621560E+00 |
| 20 | 1.499983024269E+01 | 1.500001912020E+01 | 1.888775146028E-04 | 1.999735278164E+00 |
| 21 | 1.499992465645E+01 | 1.500001912020E+01 | 9.446375730171E-05 | 1.999470696466E+00 |
| 22 | 1.499997186332E+01 | 1.500001912020E+01 | 4.725687865204E-05 | 1.998941952922E+00 |
| 23 | 1.499999546676E+01 | 1.500001912020E+01 | 2.365343932631E-05 | 1.997886142480E+00 |
| 24 | 1.499999546676E+01 | 1.500000731848E+01 | 1.185171966434E-05 | 1.995781202747E+00 |
| 25 | 1.499999546676E+01 | 1.500000141762E+01 | 5.950859831572E-06 | 1.991597853046E+00 |
| 26 | 1.499999841719E+01 | 1.500000141762E+01 | 3.000429916966E-06 | 1.983335720632E+00 |
| 27 | 1.499999989241E+01 | 1.500000141762E+01 | 1.525214958775E-06 | 1.967217735247E+00 |
| 28 | 1.499999989241E+01 | 1.500000068002E+01 | 7.876074796798E-07 | 1.936516600116E+00 |
| 29 | 1.499999989241E+01 | 1.500000031121E+01 | 4.188037401320E-07 | 1.880612335103E+00 |
| 30 | 1.499999989241E+01 | 1.500000012681E+01 | 2.344018703582E-07 | 1.786691119367E+00 |
| 31 | 1.499999989241E+01 | 1.500000003461E+01 | 1.422009354712E-07 | 1.648384868787E+00 |
| 32 | 1.499999993851E+01 | 1.500000003461E+01 | 9.610046802777E-08 | 1.479711164676E+00 |

Result: 14.9999999865597431

Error: 8.960E-10

eps = 1.0E-08

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.010000000025E+02 | 9.900000000250E+01 | 1.999999999949E+00 |
| 2 | 2.000000000000E+00 | 5.150000000375E+01 | 4.950000000375E+01 | 1.999999999899E+00 |
| 3 | 2.000000000000E+00 | 2.675000000437E+01 | 2.475000000437E+01 | 1.999999999798E+00 |
| 4 | 1.437499999969E+01 | 2.675000000437E+01 | 1.237500000469E+01 | 1.999999999596E+00 |
| 5 | 1.437499999969E+01 | 2.056250000453E+01 | 6.187500004844E+00 | 1.999999999192E+00 |
| 6 | 1.437499999969E+01 | 1.746875000461E+01 | 3.093750004922E+00 | 1.999999998384E+00 |
| 7 | 1.437499999969E+01 | 1.592187500465E+01 | 1.546875004961E+00 | 1.999999996768E+00 |
| 8 | 1.437499999969E+01 | 1.514843750467E+01 | 7.734375049805E-01 | 1.999999993535E+00 |
| 9 | 1.476171874968E+01 | 1.514843750467E+01 | 3.867187549902E-01 | 1.999999987071E+00 |
| 10 | 1.495507812467E+01 | 1.514843750467E+01 | 1.933593799951E-01 | 1.999999974141E+00 |
| 11 | 1.495507812467E+01 | 1.505175781717E+01 | 9.667969249756E-02 | 1.999999948283E+00 |
| 12 | 1.495507812467E+01 | 1.500341797342E+01 | 4.833984874878E-02 | 1.999999896566E+00 |
| 13 | 1.497924804655E+01 | 1.500341797342E+01 | 2.416992687439E-02 | 1.999999793131E+00 |
| 14 | 1.499133300748E+01 | 1.500341797342E+01 | 1.208496593719E-02 | 1.999999586263E+00 |
| 15 | 1.499737548795E+01 | 1.500341797342E+01 | 6.042485468598E-03 | 1.999999172526E+00 |
| 16 | 1.499737548795E+01 | 1.500039673319E+01 | 3.021245234299E-03 | 1.999998345053E+00 |
| 17 | 1.499888610807E+01 | 1.500039673319E+01 | 1.510625117151E-03 | 1.999996690111E+00 |
| 18 | 1.499964141813E+01 | 1.500039673319E+01 | 7.553150585746E-04 | 1.999993380248E+00 |
| 19 | 1.499964141813E+01 | 1.500001907816E+01 | 3.776600292866E-04 | 1.999986760583E+00 |
| 20 | 1.499983024564E+01 | 1.500001907816E+01 | 1.888325146435E-04 | 1.999973521507E+00 |
| 21 | 1.499992465940E+01 | 1.500001907816E+01 | 9.441875732108E-05 | 1.999947044435E+00 |
| 22 | 1.499997186628E+01 | 1.500001907816E+01 | 4.721187866075E-05 | 1.999894094441E+00 |
| 23 | 1.499999546972E+01 | 1.500001907816E+01 | 2.360843933147E-05 | 1.999788211236E+00 |
| 24 | 1.499999546972E+01 | 1.500000727644E+01 | 1.180671966594E-05 | 1.999576512312E+00 |
| 25 | 1.499999546972E+01 | 1.500000137558E+01 | 5.905859833177E-06 | 1.999153383156E+00 |
| 26 | 1.499999842015E+01 | 1.500000137558E+01 | 2.955429916796E-06 | 1.998308198619E+00 |
| 27 | 1.499999989536E+01 | 1.500000137558E+01 | 1.480214958605E-06 | 1.996622111954E+00 |
| 28 | 1.499999989536E+01 | 1.500000063797E+01 | 7.426074795092E-07 | 1.993266967339E+00 |
| 29 | 1.499999989536E+01 | 1.500000026917E+01 | 3.738037399614E-07 | 1.986623995752E+00 |
| 30 | 1.499999989536E+01 | 1.500000008477E+01 | 1.894018701876E-07 | 1.973601103259E+00 |
| 31 | 1.499999989536E+01 | 1.499999999256E+01 | 9.720093530063E-08 | 1.948560161502E+00 |
| 32 | 1.499999994146E+01 | 1.499999999256E+01 | 5.110046785717E-08 | 1.902153529637E+00 |
| 33 | 1.499999994146E+01 | 1.499999996951E+01 | 2.805023413543E-08 | 1.821748353701E+00 |
| 34 | 1.499999994146E+01 | 1.499999995799E+01 | 1.652511727457E-08 | 1.697430261424E+00 |
| 35 | 1.499999994146E+01 | 1.499999995223E+01 | 1.076255884414E-08 | 1.535426427292E+00 |
| 36 | 1.499999994146E+01 | 1.499999994935E+01 | 7.881279628918E-09 | 1.365585203276E+00 |

Result: 14.9999999454046957

Error: 3.640E-09

eps = 1.0E-09

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.010000000002E+02 | 9.900000000025E+01 | 1.999999999995E+00 |
| 2 | 2.000000000000E+00 | 5.150000000037E+01 | 4.950000000037E+01 | 1.999999999990E+00 |
| 3 | 2.000000000000E+00 | 2.675000000044E+01 | 2.475000000044E+01 | 1.999999999980E+00 |
| 4 | 1.437499999997E+01 | 2.675000000044E+01 | 1.237500000047E+01 | 1.999999999960E+00 |
| 5 | 1.437499999997E+01 | 2.056250000045E+01 | 6.187500000484E+00 | 1.999999999919E+00 |
| 6 | 1.437499999997E+01 | 1.746875000046E+01 | 3.093750000492E+00 | 1.999999999838E+00 |
| 7 | 1.437499999997E+01 | 1.592187500046E+01 | 1.546875000496E+00 | 1.999999999677E+00 |
| 8 | 1.437499999997E+01 | 1.514843750047E+01 | 7.734375004980E-01 | 1.999999999354E+00 |
| 9 | 1.476171874997E+01 | 1.514843750047E+01 | 3.867187504990E-01 | 1.999999998707E+00 |
| 10 | 1.495507812497E+01 | 1.514843750047E+01 | 1.933593754995E-01 | 1.999999997414E+00 |
| 11 | 1.495507812497E+01 | 1.505175781297E+01 | 9.667968799975E-02 | 1.999999994828E+00 |
| 12 | 1.495507812497E+01 | 1.500341796922E+01 | 4.833984424988E-02 | 1.999999989657E+00 |
| 13 | 1.497924804684E+01 | 1.500341796922E+01 | 2.416992237494E-02 | 1.999999979313E+00 |
| 14 | 1.499133300778E+01 | 1.500341796922E+01 | 1.208496143747E-02 | 1.999999958626E+00 |
| 15 | 1.499737548825E+01 | 1.500341796922E+01 | 6.042480968734E-03 | 1.999999917253E+00 |
| 16 | 1.499737548825E+01 | 1.500039672898E+01 | 3.021240734366E-03 | 1.999999834506E+00 |
| 17 | 1.499888610837E+01 | 1.500039672898E+01 | 1.510620617182E-03 | 1.999999669011E+00 |
| 18 | 1.499964141842E+01 | 1.500039672898E+01 | 7.553105585902E-04 | 1.999999338023E+00 |
| 19 | 1.499964141842E+01 | 1.500001907395E+01 | 3.776555292934E-04 | 1.999998676051E+00 |
| 20 | 1.499983024594E+01 | 1.500001907395E+01 | 1.888280146467E-04 | 1.999997352088E+00 |
| 21 | 1.499992465970E+01 | 1.500001907395E+01 | 9.441425732248E-05 | 1.999994704208E+00 |
| 22 | 1.499997186657E+01 | 1.500001907395E+01 | 4.720737866037E-05 | 1.999989408472E+00 |
| 23 | 1.499999547001E+01 | 1.500001907395E+01 | 2.360393932932E-05 | 1.999978817169E+00 |
| 24 | 1.499999547001E+01 | 1.500000727223E+01 | 1.180221966379E-05 | 1.999957635235E+00 |
| 25 | 1.499999547001E+01 | 1.500000137137E+01 | 5.901359831029E-06 | 1.999915274059E+00 |
| 26 | 1.499999842044E+01 | 1.500000137137E+01 | 2.950929914647E-06 | 1.999830562474E+00 |
| 27 | 1.499999842044E+01 | 1.499999989616E+01 | 1.475714956456E-06 | 1.999661182356E+00 |
| 28 | 1.499999915805E+01 | 1.499999989616E+01 | 7.381074773605E-07 | 1.999322594229E+00 |
| 29 | 1.499999915805E+01 | 1.499999952736E+01 | 3.693037378127E-07 | 1.998646105593E+00 |
| 30 | 1.499999934245E+01 | 1.499999952736E+01 | 1.849018680389E-07 | 1.997295872290E+00 |
| 31 | 1.499999943465E+01 | 1.499999952736E+01 | 9.270093315195E-08 | 1.994606329753E+00 |
| 32 | 1.499999948075E+01 | 1.499999952736E+01 | 4.660046570848E-08 | 1.989270530725E+00 |
| 33 | 1.499999948075E+01 | 1.499999950431E+01 | 2.355023198675E-08 | 1.978768860311E+00 |
| 34 | 1.499999948075E+01 | 1.499999949278E+01 | 1.202511512588E-08 | 1.958420500779E+00 |
| 35 | 1.499999948652E+01 | 1.499999949278E+01 | 6.262556695447E-09 | 1.920160680481E+00 |
| 36 | 1.499999948940E+01 | 1.499999949278E+01 | 3.381277480230E-09 | 1.852127408077E+00 |
| 37 | 1.499999949084E+01 | 1.499999949278E+01 | 1.940637872622E-09 | 1.742353649763E+00 |
| 38 | 1.499999949156E+01 | 1.499999949278E+01 | 1.220318068818E-09 | 1.590272177566E+00 |
| 39 | 1.499999949192E+01 | 1.499999949278E+01 | 8.601581669154E-10 | 1.418713575892E+00 |

Result: 14.9999994923498718

Error: 3.384E-08

Заданная точность решения получается при значениях , а уже при  погрешность полученного решения становится больше. Такой эффект наблюдается из-за использования  в арифметических операциях с числами более высокого порядка.

3.2. Метод золотого сечения.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *К-во итераций* | *Значение* | *Отн. погрешность* |
| 1.00E-01 | 16 | 15.0134719537349124 | 8.981E-04 |
| 1.00E-02 | 21 | 14.9988378074574022 | 7.748E-05 |
| 1.00E-03 | 26 | 14.9998787482614127 | 8.083E-06 |
| 1.00E-04 | 31 | 14.9999977329256104 | 1.511E-07 |
| 1.00E-05 | 35 | 15.0000006983041878 | 4.655E-08 |
| 1.00E-06 | 40 | 14.9999999982732639 | 1.151E-10 |
| 1.00E-07 | 45 | 14.9999999833722395 | 1.109E-09 |
| 1.00E-08 | 50 | 14.9999999820286156 | 1.198E-09 |
| 1.00E-09 | 55 | 14.9999999792202114 | 1.385E-09 |
| 1.00E-10 | 59 | 14.9999999789493010 | 1.403E-09 |
| 1.00E-11 | 64 | 14.9999999789290470 | 1.405E-09 |
| 1.00E-12 | 69 | 14.9999999789269332 | 1.405E-09 |
| 1.00E-13 | 74 | 14.9999999789265903 | 1.405E-09 |
| 1.00E-14 | 79 | 14.9999999789265743 | 1.405E-09 |

eps = 1.0E-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |

Result: 15.0134719537349124

Error: 8.981E-04

eps = 1.0E-06

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103672E-03 | 1.618033988750E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244002E-03 | 1.618033988750E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859670E-03 | 1.618033988750E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384334E-03 | 1.618033988749E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475338E-03 | 1.618033988749E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349089975E-04 | 1.618033988749E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155663423E-04 | 1.618033988746E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193426569E-04 | 1.618033988751E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962236854E-04 | 1.618033988748E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231189716E-04 | 1.618033988755E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310471378E-05 | 1.618033988736E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001425957E-05 | 1.618033988716E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512309045599E-05 | 1.618033988723E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692380358E-05 | 1.618033988819E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596166650638E-06 | 1.618033988868E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930757151162E-06 | 1.618033988925E+00 |
| 37 | 1.499999816557E+01 | 1.500000183098E+01 | 3.665409497700E-06 | 1.618033989077E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265347651687E-06 | 1.618033989163E+00 |
| 39 | 1.499999956563E+01 | 1.500000096569E+01 | 1.400061844237E-06 | 1.618033989721E+00 |
| 40 | 1.499999956563E+01 | 1.500000043092E+01 | 8.652858056735E-07 | 1.618033989529E+00 |

Result: 14.9999999982732639

Error: 1.151E-10

eps = 1.0E-07

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103672E-03 | 1.618033988750E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244002E-03 | 1.618033988750E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859670E-03 | 1.618033988750E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384334E-03 | 1.618033988749E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475338E-03 | 1.618033988749E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349089975E-04 | 1.618033988749E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155663423E-04 | 1.618033988746E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193426569E-04 | 1.618033988751E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962236854E-04 | 1.618033988748E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231189716E-04 | 1.618033988755E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310471378E-05 | 1.618033988736E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001425957E-05 | 1.618033988716E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512309045599E-05 | 1.618033988723E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692380358E-05 | 1.618033988819E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596166650638E-06 | 1.618033988868E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930757151162E-06 | 1.618033988925E+00 |
| 37 | 1.499999816557E+01 | 1.500000183098E+01 | 3.665409497700E-06 | 1.618033989077E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265347651687E-06 | 1.618033989163E+00 |
| 39 | 1.499999956563E+01 | 1.500000096569E+01 | 1.400061844237E-06 | 1.618033989721E+00 |
| 40 | 1.499999956563E+01 | 1.500000043092E+01 | 8.652858056735E-07 | 1.618033989529E+00 |
| 41 | 1.499999989614E+01 | 1.500000043092E+01 | 5.347760385632E-07 | 1.618033986710E+00 |
| 42 | 1.499999989614E+01 | 1.500000022665E+01 | 3.305097688866E-07 | 1.618033985394E+00 |
| 43 | 1.499999989614E+01 | 1.500000010041E+01 | 2.042662714530E-07 | 1.618033983465E+00 |
| 44 | 1.499999989614E+01 | 1.500000002238E+01 | 1.262434974336E-07 | 1.618034002586E+00 |
| 45 | 1.499999994436E+01 | 1.500000002238E+01 | 7.802277224300E-08 | 1.618033989364E+00 |

Result: 14.9999999833722395

Error: 1.109E-09

eps = 1.0E-08

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103672E-03 | 1.618033988750E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244002E-03 | 1.618033988750E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859670E-03 | 1.618033988750E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384334E-03 | 1.618033988749E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475338E-03 | 1.618033988749E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349089975E-04 | 1.618033988749E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155663423E-04 | 1.618033988746E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193426569E-04 | 1.618033988751E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962236854E-04 | 1.618033988748E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231189716E-04 | 1.618033988755E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310471378E-05 | 1.618033988736E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001425957E-05 | 1.618033988716E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512309045599E-05 | 1.618033988723E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692380358E-05 | 1.618033988819E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596166650638E-06 | 1.618033988868E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930757151162E-06 | 1.618033988925E+00 |
| 37 | 1.499999816557E+01 | 1.500000183098E+01 | 3.665409497700E-06 | 1.618033989077E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265347651687E-06 | 1.618033989163E+00 |
| 39 | 1.499999956563E+01 | 1.500000096569E+01 | 1.400061844237E-06 | 1.618033989721E+00 |
| 40 | 1.499999956563E+01 | 1.500000043092E+01 | 8.652858056735E-07 | 1.618033989529E+00 |
| 41 | 1.499999989614E+01 | 1.500000043092E+01 | 5.347760385632E-07 | 1.618033986710E+00 |
| 42 | 1.499999989614E+01 | 1.500000022665E+01 | 3.305097688866E-07 | 1.618033985394E+00 |
| 43 | 1.499999989614E+01 | 1.500000010041E+01 | 2.042662714530E-07 | 1.618033983465E+00 |
| 44 | 1.499999989614E+01 | 1.500000002238E+01 | 1.262434974336E-07 | 1.618034002586E+00 |
| 45 | 1.499999994436E+01 | 1.500000002238E+01 | 7.802277224300E-08 | 1.618033989364E+00 |
| 46 | 1.499999997416E+01 | 1.500000002238E+01 | 4.822072519062E-08 | 1.618033987141E+00 |
| 47 | 1.499999997416E+01 | 1.500000000396E+01 | 2.980204705239E-08 | 1.618033992962E+00 |
| 48 | 1.499999997416E+01 | 1.499999999258E+01 | 1.841867813823E-08 | 1.618033977722E+00 |
| 49 | 1.499999997416E+01 | 1.499999998555E+01 | 1.138336891415E-08 | 1.618034017621E+00 |
| 50 | 1.499999997851E+01 | 1.499999998555E+01 | 7.035309224079E-09 | 1.618033913164E+00 |

Result: 14.9999999820286156

Error: 1.198E-09

eps = 1.0E-09

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103672E-03 | 1.618033988750E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244002E-03 | 1.618033988750E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859670E-03 | 1.618033988750E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384334E-03 | 1.618033988749E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475338E-03 | 1.618033988749E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349089975E-04 | 1.618033988749E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155663423E-04 | 1.618033988746E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193426569E-04 | 1.618033988751E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962236854E-04 | 1.618033988748E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231189716E-04 | 1.618033988755E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310471378E-05 | 1.618033988736E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001425957E-05 | 1.618033988716E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512309045599E-05 | 1.618033988723E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692380358E-05 | 1.618033988819E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596166650638E-06 | 1.618033988868E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930757151162E-06 | 1.618033988925E+00 |
| 37 | 1.499999816557E+01 | 1.500000183098E+01 | 3.665409497700E-06 | 1.618033989077E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265347651687E-06 | 1.618033989163E+00 |
| 39 | 1.499999956563E+01 | 1.500000096569E+01 | 1.400061844237E-06 | 1.618033989721E+00 |
| 40 | 1.499999956563E+01 | 1.500000043092E+01 | 8.652858056735E-07 | 1.618033989529E+00 |
| 41 | 1.499999989614E+01 | 1.500000043092E+01 | 5.347760385632E-07 | 1.618033986710E+00 |
| 42 | 1.499999989614E+01 | 1.500000022665E+01 | 3.305097688866E-07 | 1.618033985394E+00 |
| 43 | 1.499999989614E+01 | 1.500000010041E+01 | 2.042662714530E-07 | 1.618033983465E+00 |
| 44 | 1.499999989614E+01 | 1.500000002238E+01 | 1.262434974336E-07 | 1.618034002586E+00 |
| 45 | 1.499999994436E+01 | 1.500000002238E+01 | 7.802277224300E-08 | 1.618033989364E+00 |
| 46 | 1.499999997416E+01 | 1.500000002238E+01 | 4.822072519062E-08 | 1.618033987141E+00 |
| 47 | 1.499999997416E+01 | 1.500000000396E+01 | 2.980204705239E-08 | 1.618033992962E+00 |
| 48 | 1.499999997416E+01 | 1.499999999258E+01 | 1.841867813823E-08 | 1.618033977722E+00 |
| 49 | 1.499999997416E+01 | 1.499999998555E+01 | 1.138336891415E-08 | 1.618034017621E+00 |
| 50 | 1.499999997851E+01 | 1.499999998555E+01 | 7.035309224079E-09 | 1.618033913164E+00 |
| 51 | 1.499999997851E+01 | 1.499999998286E+01 | 4.348059690074E-09 | 1.618034186637E+00 |
| 52 | 1.499999997851E+01 | 1.499999998120E+01 | 2.687249534006E-09 | 1.618033470674E+00 |
| 53 | 1.499999997851E+01 | 1.499999998017E+01 | 1.660810156068E-09 | 1.618035345092E+00 |
| 54 | 1.499999997851E+01 | 1.499999997954E+01 | 1.026437601581E-09 | 1.618033237977E+00 |
| 55 | 1.499999997890E+01 | 1.499999997954E+01 | 6.343725544866E-10 | 1.618035954301E+00 |

Result: 14.9999999792202114

Error: 1.385E-09

Заданная точность решения получается при значениях , а уже при  погрешность полученного решения становится больше. Такой эффект наблюдается из-за неточности представления величины , вследствие чего происходит потеря точки минимума, так как она выпадает из интервала неопределенности.

3.3. Метод Фибоначчи.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *К-во итераций* | *Значение* | *Отн. погрешность* |
| 1.00E-01 | 15 | 14.9880030959752251 | 7.998E-04 |
| 1.00E-02 | 20 | 14.9998604180479447 | 9.305E-06 |
| 1.00E-03 | 25 | 14.9994525047905789 | 3.650E-05 |
| 1.00E-04 | 29 | 14.9999283848159237 | 4.774E-06 |
| 1.00E-05 | 34 | 14.9999934596739450 | 4.360E-07 |
| 1.00E-06 | 39 | 14.9999999514770188 | 3.235E-09 |
| 1.00E-07 | 44 | 14.9999999320143402 | 4.532E-09 |
| 1.00E-08 | 48 | 14.9999999788362448 | 1.411E-09 |
| 1.00E-09 | 53 | 14.9999999789861853 | 1.401E-09 |
| 1.00E-10 | 58 | 14.9999999789454410 | 1.404E-09 |
| 1.00E-11 | 63 | 14.9999999789279457 | 1.405E-09 |
| 1.00E-12 | 68 | 14.9999999789264891 | 1.405E-09 |
| 1.00E-13 | 72 | 14.9999999789266099 | 1.405E-09 |
| 1.00E-14 | 77 | 14.9999999789265743 | 1.405E-09 |

eps = 1.0E-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707430341E+02 | 1.223707430341E+02 | 1.618033813400E+00 |
| 2 | 2.000000000000E+00 | 7.762925696594E+01 | 7.562925696594E+01 | 1.618034447822E+00 |
| 3 | 2.000000000000E+00 | 4.874148606811E+01 | 4.674148606811E+01 | 1.618032786885E+00 |
| 4 | 2.000000000000E+00 | 3.088777089783E+01 | 2.888777089783E+01 | 1.618037135279E+00 |
| 5 | 2.000000000000E+00 | 1.985371517028E+01 | 1.785371517028E+01 | 1.618025751073E+00 |
| 6 | 8.819659442724E+00 | 1.985371517028E+01 | 1.103405572755E+01 | 1.618055555556E+00 |
| 7 | 1.303405572755E+01 | 1.985371517028E+01 | 6.819659442724E+00 | 1.617977528090E+00 |
| 8 | 1.303405572755E+01 | 1.724845201238E+01 | 4.214396284830E+00 | 1.618181818182E+00 |
| 9 | 1.303405572755E+01 | 1.563931888545E+01 | 2.605263157895E+00 | 1.617647058824E+00 |
| 10 | 1.403018575851E+01 | 1.563931888545E+01 | 1.609133126935E+00 | 1.619047619048E+00 |
| 11 | 1.464318885449E+01 | 1.563931888545E+01 | 9.961300309597E-01 | 1.615384615385E+00 |
| 12 | 1.464318885449E+01 | 1.525619195046E+01 | 6.130030959752E-01 | 1.625000000000E+00 |
| 13 | 1.487306501548E+01 | 1.525619195046E+01 | 3.831269349845E-01 | 1.600000000000E+00 |
| 14 | 1.487306501548E+01 | 1.510294117647E+01 | 2.298761609907E-01 | 1.666666666667E+00 |
| 15 | 1.494969040248E+01 | 1.510294117647E+01 | 1.532507739938E-01 | 1.500000000000E+00 |

Result: 14.9880030959752251

Error: 7.998E-04

eps = 1.0E-06

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506471E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629979E-01 | 1.618033988751E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876492E-01 | 1.618033988748E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753487E-01 | 1.618033988754E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612123005E-01 | 1.618033988738E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304818E-02 | 1.618033988780E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925234E-02 | 1.618033988670E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379584E-02 | 1.618033988958E+00 |
| 19 | 1.498979340766E+01 | 1.501097214312E+01 | 2.117873545651E-02 | 1.618033988205E+00 |
| 20 | 1.498979340766E+01 | 1.500288258600E+01 | 1.308917833933E-02 | 1.618033990176E+00 |
| 21 | 1.499479302889E+01 | 1.500288258600E+01 | 8.089557117176E-03 | 1.618033985017E+00 |
| 22 | 1.499788296478E+01 | 1.500288258600E+01 | 4.999621222154E-03 | 1.618033998522E+00 |
| 23 | 1.499788296478E+01 | 1.500097290068E+01 | 3.089935895023E-03 | 1.618033963166E+00 |
| 24 | 1.499906321535E+01 | 1.500097290068E+01 | 1.909685327131E-03 | 1.618034055728E+00 |
| 25 | 1.499906321535E+01 | 1.500024346592E+01 | 1.180250567890E-03 | 1.618033813401E+00 |
| 26 | 1.499951403116E+01 | 1.500024346592E+01 | 7.294347592399E-04 | 1.618034447823E+00 |
| 27 | 1.499979265011E+01 | 1.500024346592E+01 | 4.508158086480E-04 | 1.618032786888E+00 |
| 28 | 1.499979265011E+01 | 1.500007126906E+01 | 2.786189505901E-04 | 1.618037135282E+00 |
| 29 | 1.499989907220E+01 | 1.500007126906E+01 | 1.721968580561E-04 | 1.618025751081E+00 |
| 30 | 1.499996484697E+01 | 1.500007126906E+01 | 1.064220925340E-04 | 1.618055555534E+00 |
| 31 | 1.499996484697E+01 | 1.500003062173E+01 | 6.577476552394E-05 | 1.617977528103E+00 |
| 32 | 1.499998997441E+01 | 1.500003062173E+01 | 4.064732701003E-05 | 1.618181818148E+00 |
| 33 | 1.499998997441E+01 | 1.500001510184E+01 | 2.512743851568E-05 | 1.617647058799E+00 |
| 34 | 1.499998997441E+01 | 1.500000549429E+01 | 1.551988849613E-05 | 1.619047618928E+00 |
| 35 | 1.499999588674E+01 | 1.500000549429E+01 | 9.607550021329E-06 | 1.615384615399E+00 |
| 36 | 1.499999588674E+01 | 1.500000179908E+01 | 5.912338474801E-06 | 1.624999999962E+00 |
| 37 | 1.499999810387E+01 | 1.500000179908E+01 | 3.695211546528E-06 | 1.600000000096E+00 |
| 38 | 1.499999958196E+01 | 1.500000179908E+01 | 2.217126928272E-06 | 1.666666666400E+00 |
| 39 | 1.499999958196E+01 | 1.500000106004E+01 | 1.478084618256E-06 | 1.500000000601E+00 |

Result: 14.9999999514770188

Error: 3.235E-09

eps = 1.0E-07

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304941E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925036E-02 | 1.618033988751E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379905E-02 | 1.618033988748E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545131E-02 | 1.618033988754E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834774E-02 | 1.618033988738E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103563E-03 | 1.618033988780E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244179E-03 | 1.618033988671E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859382E-03 | 1.618033988958E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384797E-03 | 1.618033988206E+00 |
| 25 | 1.499906321524E+01 | 1.500024346571E+01 | 1.180250474583E-03 | 1.618033990177E+00 |
| 26 | 1.499951403080E+01 | 1.500024346571E+01 | 7.294349102125E-04 | 1.618033985019E+00 |
| 27 | 1.499979265015E+01 | 1.500024346571E+01 | 4.508155643705E-04 | 1.618033998518E+00 |
| 28 | 1.499979265015E+01 | 1.500007126950E+01 | 2.786193458437E-04 | 1.618033963167E+00 |
| 29 | 1.499989907328E+01 | 1.500007126950E+01 | 1.721962185268E-04 | 1.618034055727E+00 |
| 30 | 1.499996484637E+01 | 1.500007126950E+01 | 1.064231273169E-04 | 1.618033813403E+00 |
| 31 | 1.499996484637E+01 | 1.500003061946E+01 | 6.577309120992E-05 | 1.618034447815E+00 |
| 32 | 1.499998996942E+01 | 1.500003061946E+01 | 4.065003610698E-05 | 1.618032786904E+00 |
| 33 | 1.499998996942E+01 | 1.500001509248E+01 | 2.512305510294E-05 | 1.618037135230E+00 |
| 34 | 1.499998996942E+01 | 1.500000549640E+01 | 1.552698100404E-05 | 1.618025751200E+00 |
| 35 | 1.499999590033E+01 | 1.500000549640E+01 | 9.596074097118E-06 | 1.618055555522E+00 |
| 36 | 1.499999590033E+01 | 1.500000183124E+01 | 5.930906906926E-06 | 1.617977528177E+00 |
| 37 | 1.499999816607E+01 | 1.500000183124E+01 | 3.665167190192E-06 | 1.618181817953E+00 |
| 38 | 1.499999956550E+01 | 1.500000183124E+01 | 2.265739716734E-06 | 1.617647059423E+00 |
| 39 | 1.499999956550E+01 | 1.500000096493E+01 | 1.399427471682E-06 | 1.619047619531E+00 |
| 40 | 1.499999956550E+01 | 1.500000043181E+01 | 8.663122432750E-07 | 1.615384617435E+00 |
| 41 | 1.499999989869E+01 | 1.500000043181E+01 | 5.331152266308E-07 | 1.625000000000E+00 |
| 42 | 1.499999989869E+01 | 1.500000023189E+01 | 3.331970166442E-07 | 1.600000000000E+00 |
| 43 | 1.499999989869E+01 | 1.500000009861E+01 | 1.999182099865E-07 | 1.666666666667E+00 |
| 44 | 1.499999989869E+01 | 1.500000003197E+01 | 1.332788066577E-07 | 1.500000000000E+00 |

Result: 14.9999999320143402

Error: 4.532E-09

eps = 1.0E-08

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304940E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103670E-03 | 1.618033988751E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244007E-03 | 1.618033988748E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859665E-03 | 1.618033988754E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384344E-03 | 1.618033988738E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475322E-03 | 1.618033988780E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349090223E-04 | 1.618033988672E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155662979E-04 | 1.618033988960E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193427227E-04 | 1.618033988210E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962235735E-04 | 1.618033990181E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231191492E-04 | 1.618033985003E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310442601E-05 | 1.618033998516E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001472320E-05 | 1.618033963183E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512308970282E-05 | 1.618034055685E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692502038E-05 | 1.618033813510E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596164680659E-06 | 1.618034447833E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930760339723E-06 | 1.618032786856E+00 |
| 37 | 1.499999816558E+01 | 1.500000183098E+01 | 3.665404340936E-06 | 1.618037135354E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265355998787E-06 | 1.618025750874E+00 |
| 39 | 1.499999956563E+01 | 1.500000096568E+01 | 1.400048342148E-06 | 1.618055556075E+00 |
| 40 | 1.499999956563E+01 | 1.500000043094E+01 | 8.653076566389E-07 | 1.617977526729E+00 |
| 41 | 1.499999989619E+01 | 1.500000043094E+01 | 5.347406872858E-07 | 1.618181816370E+00 |
| 42 | 1.499999989619E+01 | 1.500000022676E+01 | 3.305669711295E-07 | 1.617647054872E+00 |
| 43 | 1.499999989619E+01 | 1.500000010037E+01 | 2.041737161562E-07 | 1.619047629405E+00 |
| 44 | 1.499999989619E+01 | 1.500000002259E+01 | 1.263932531970E-07 | 1.615384611060E+00 |
| 45 | 1.499999994481E+01 | 1.500000002259E+01 | 7.778046295925E-08 | 1.625000011419E+00 |
| 46 | 1.499999997397E+01 | 1.500000002259E+01 | 4.861279023771E-08 | 1.599999970767E+00 |
| 47 | 1.499999997397E+01 | 1.500000000314E+01 | 2.916767449790E-08 | 1.666666646366E+00 |
| 48 | 1.499999997397E+01 | 1.499999999342E+01 | 1.944511751617E-08 | 1.499999908648E+00 |

Result: 14.9999999788362448

Error: 1.411E-09

eps = 1.0E-09

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Итерация* | *a* | *b* | *Длина отрезка* | *Отношение длин* |
| 1 | 2.000000000000E+00 | 1.243707297725E+02 | 1.223707297725E+02 | 1.618033988750E+00 |
| 2 | 2.000000000000E+00 | 7.762927022752E+01 | 7.562927022752E+01 | 1.618033988750E+00 |
| 3 | 2.000000000000E+00 | 4.874145954496E+01 | 4.674145954496E+01 | 1.618033988750E+00 |
| 4 | 2.000000000000E+00 | 3.088781068256E+01 | 2.888781068256E+01 | 1.618033988750E+00 |
| 5 | 2.000000000000E+00 | 1.985364886240E+01 | 1.785364886240E+01 | 1.618033988750E+00 |
| 6 | 8.819487042229E+00 | 1.985364886240E+01 | 1.103416182017E+01 | 1.618033988750E+00 |
| 7 | 1.303416182017E+01 | 1.985364886240E+01 | 6.819487042229E+00 | 1.618033988750E+00 |
| 8 | 1.303416182017E+01 | 1.724883659810E+01 | 4.214674777937E+00 | 1.618033988750E+00 |
| 9 | 1.303416182017E+01 | 1.563897408446E+01 | 2.604812264292E+00 | 1.618033988750E+00 |
| 10 | 1.402911157081E+01 | 1.563897408446E+01 | 1.609862513645E+00 | 1.618033988750E+00 |
| 11 | 1.464402433381E+01 | 1.563897408446E+01 | 9.949497506470E-01 | 1.618033988750E+00 |
| 12 | 1.464402433381E+01 | 1.525893709681E+01 | 6.149127629981E-01 | 1.618033988750E+00 |
| 13 | 1.487890010916E+01 | 1.525893709681E+01 | 3.800369876489E-01 | 1.618033988750E+00 |
| 14 | 1.487890010916E+01 | 1.511377588451E+01 | 2.348757753492E-01 | 1.618033988750E+00 |
| 15 | 1.496861467221E+01 | 1.511377588451E+01 | 1.451612122998E-01 | 1.618033988750E+00 |
| 16 | 1.496861467221E+01 | 1.505832923526E+01 | 8.971456304939E-02 | 1.618033988750E+00 |
| 17 | 1.496861467221E+01 | 1.502406132146E+01 | 5.544664925037E-02 | 1.618033988750E+00 |
| 18 | 1.498979340766E+01 | 1.502406132146E+01 | 3.426791379902E-02 | 1.618033988750E+00 |
| 19 | 1.498979340766E+01 | 1.501097214311E+01 | 2.117873545135E-02 | 1.618033988750E+00 |
| 20 | 1.498979340766E+01 | 1.500288258601E+01 | 1.308917834768E-02 | 1.618033988750E+00 |
| 21 | 1.499479302891E+01 | 1.500288258601E+01 | 8.089557103672E-03 | 1.618033988750E+00 |
| 22 | 1.499788296477E+01 | 1.500288258601E+01 | 4.999621244002E-03 | 1.618033988750E+00 |
| 23 | 1.499788296477E+01 | 1.500097290062E+01 | 3.089935859670E-03 | 1.618033988750E+00 |
| 24 | 1.499906321524E+01 | 1.500097290062E+01 | 1.909685384334E-03 | 1.618033988749E+00 |
| 25 | 1.499906321524E+01 | 1.500024346572E+01 | 1.180250475338E-03 | 1.618033988749E+00 |
| 26 | 1.499951403081E+01 | 1.500024346572E+01 | 7.294349089975E-04 | 1.618033988749E+00 |
| 27 | 1.499979265015E+01 | 1.500024346572E+01 | 4.508155663423E-04 | 1.618033988746E+00 |
| 28 | 1.499979265015E+01 | 1.500007126949E+01 | 2.786193426569E-04 | 1.618033988751E+00 |
| 29 | 1.499989907327E+01 | 1.500007126949E+01 | 1.721962236871E-04 | 1.618033988731E+00 |
| 30 | 1.499996484637E+01 | 1.500007126949E+01 | 1.064231189698E-04 | 1.618033988799E+00 |
| 31 | 1.499996484637E+01 | 1.500003061948E+01 | 6.577310471556E-05 | 1.618033988665E+00 |
| 32 | 1.499998996946E+01 | 1.500003061948E+01 | 4.065001425424E-05 | 1.618033988972E+00 |
| 33 | 1.499998996946E+01 | 1.500001509255E+01 | 2.512309046132E-05 | 1.618033988168E+00 |
| 34 | 1.499998996946E+01 | 1.500000549639E+01 | 1.552692379292E-05 | 1.618033990273E+00 |
| 35 | 1.499999590022E+01 | 1.500000549639E+01 | 9.596166666626E-06 | 1.618033985062E+00 |
| 36 | 1.499999590022E+01 | 1.500000183098E+01 | 5.930757126293E-06 | 1.618033998405E+00 |
| 37 | 1.499999816557E+01 | 1.500000183098E+01 | 3.665409540332E-06 | 1.618033963472E+00 |
| 38 | 1.499999956563E+01 | 1.500000183098E+01 | 2.265347585961E-06 | 1.618034054927E+00 |
| 39 | 1.499999956563E+01 | 1.500000096569E+01 | 1.400061956147E-06 | 1.618033813443E+00 |
| 40 | 1.499999956563E+01 | 1.500000043092E+01 | 8.652856298141E-07 | 1.618034447709E+00 |
| 41 | 1.499999989614E+01 | 1.500000043092E+01 | 5.347763263330E-07 | 1.618032787179E+00 |
| 42 | 1.499999989614E+01 | 1.500000022665E+01 | 3.305093034811E-07 | 1.618037134509E+00 |
| 43 | 1.499999989614E+01 | 1.500000010041E+01 | 2.042670228519E-07 | 1.618025753088E+00 |
| 44 | 1.499999989614E+01 | 1.500000002238E+01 | 1.262422806292E-07 | 1.618055550279E+00 |
| 45 | 1.499999994436E+01 | 1.500000002238E+01 | 7.802474222274E-08 | 1.617977541903E+00 |
| 46 | 1.499999997416E+01 | 1.500000002238E+01 | 4.821753840645E-08 | 1.618181782011E+00 |
| 47 | 1.499999997416E+01 | 1.500000000397E+01 | 2.980720559265E-08 | 1.617647057071E+00 |
| 48 | 1.499999997416E+01 | 1.499999999257E+01 | 1.841033281380E-08 | 1.619047623642E+00 |

Result: 14.9999999789861853

Error: 1.401E-09

Заданная точность решения получается при значениях , а уже при  погрешность полученного решения становится больше. Такой эффект наблюдается из-за неточности представления величины , вследствие чего происходит потеря точки минимума, так как она выпадает из интервала неопределенности.

3.4. Исследование зависимости количества вычислений функции от задаваемой точности.

График зависимости количества вычислений минимизируемой функции от логарифма задаваемой точности  :

График показывает линейную зависимость между количеством вычислений минимизируемой функции от логарифма задаваемой точности . Из этого следует, что чем точнее необходимо решение, тем большее количество итераций необходимо сделать, однако нельзя выходить за предел, по достижении которого точность решения не гарантируется.

Также можно увидеть, что количество вычислений минимизируемой функции для равной точности у методов золотого сечения и Фибоначчи меньше, чем у метода дихотомии, несмотря на то, что количество итераций у метода дихотомии меньше. Это значит, что методоы золотого сечения и Фибоначчи эффективно использовать для функций, вычисление которых затратно по времени и/или ресурсам. Для простых функций, наоборот, они будут неэффективны.

Метод золотого сечения и метод Фибоначчи обладают приблизительно одинаковой скоростью сходимости, лучшей, чем у метода дихотомии.

Метод Фибоначчи также позволяет заранее предсказать количество итераций ценой большей вычислительной сложности.

3.5. Поиск интервала, содержащего минимум функции

Зависимость длины интервала от  (=0) :

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Интервал* | *Длина интервала* | *К-во итераций* |
| 1.0E-01 | [6.300000, 25.500000] | 19.200000 | 6 |
| 1.0E-02 | [5.110000, 20.470000] | 15.360000 | 9 |
| 1.0E-03 | [8.191000, 32.767000] | 24.576000 | 13 |
| 1.0E-04 | [6.553500, 26.214300] | 19.660800 | 16 |
| 1.0E-05 | [5.242870, 20.971510] | 15.728640 | 19 |
| 1.0E-06 | [8.388607, 33.554431] | 25.165824 | 23 |
| 1.0E-07 | [6.710886, 26.843546] | 20.132659 | 26 |
| 1.0E-08 | [5.368709, 21.474836] | 16.106127 | 29 |
| 1.0E-09 | [8.589935, 34.359738] | 25.769804 | 33 |
| 1.0E-10 | [6.871948, 27.487791] | 20.615843 | 36 |
| 1.0E-11 | [5.497558, 21.990233] | 16.492674 | 39 |
| 1.0E-12 | [8.796093, 35.184372] | 26.388279 | 43 |
| 1.0E-13 | [7.036874, 28.147498] | 21.110623 | 46 |
| 1.0E-14 | [5.629500, 22.517998] | 16.888499 | 49 |

Зависимость длины интервала от начального приближения (=) :

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | *Интервал* | *Длина интервала* | *К-во итераций* |
| -100.00 | 115.00 | [-57.050327, 71.798692] | 128.849019 | 32 |
| -90.00 | 105.00 | [-47.050327, 81.798692] | 128.849019 | 32 |
| -80.00 | 95.00 | [-37.050327, 91.798692] | 128.849019 | 32 |
| -70.00 | 85.00 | [-27.050327, 101.798692] | 128.849019 | 32 |
| -60.00 | 75.00 | [-17.050327, 111.798692] | 128.849019 | 32 |
| -50.00 | 65.00 | [-7.050327, 121.798692] | 128.849019 | 32 |
| -40.00 | 55.00 | [-18.525164, 45.899346] | 64.424509 | 31 |
| -30.00 | 45.00 | [-8.525164, 55.899346] | 64.424509 | 31 |
| -20.00 | 35.00 | [1.474836, 65.899346] | 64.424509 | 31 |
| -10.00 | 25.00 | [0.737418, 32.949673] | 32.212255 | 30 |
| 0.00 | 15.00 | [5.368709, 21.474836] | 16.106127 | 29 |
| 10.00 | 5.00 | [12.684355, 20.737418] | 8.053064 | 28 |
| 20.00 | 5.00 | [9.262582, 17.315645] | 8.053064 | 28 |
| 30.00 | 15.00 | [8.525164, 24.631291] | 16.106127 | 29 |
| 40.00 | 25.00 | [-2.949673, 29.262582] | 32.212255 | 30 |
| 50.00 | 35.00 | [-35.899346, 28.525164] | 64.424509 | 31 |
| 60.00 | 45.00 | [-25.899346, 38.525164] | 64.424509 | 31 |
| 70.00 | 55.00 | [-15.899346, 48.525164] | 64.424509 | 31 |
| 80.00 | 65.00 | [-91.798692, 37.050327] | 128.849019 | 32 |
| 90.00 | 75.00 | [-81.798692, 47.050327] | 128.849019 | 32 |
| 100.00 | 85.00 | [-71.798692, 57.050327] | 128.849019 | 32 |

Длина интервала, содержащего минимум функции, не зависит каким-либо определенным образом от параметра , однако количество итераций обратно пропорционально логарифму .

Чем ближе к минимуму выбирается начальное приближение, тем меньше получается интервал, содержащий минимум при приблизительно одинаковом количестве итераций.