2.3 binomial coefficient

#include <iostream>  
#include <math.h>  
*//2.3 Binomial coefficient*int binom(int n, int k)  
{  
 if ((n < 0) || (k < 0) || (k > n)) return 0;  
 if ((k == 0) || (k == n)) return 1;  
 int i = 0;  
 int denom = 1;  
 for (i = 1; i <= k; ++i) {  
 denom \*= i;  
 }  
 int num = 1;  
 for (i = 1; i <= k; ++i) {  
 num \*= (n+1-i);  
 }  
 int b = num/denom;  
 return b;  
}  
  
int factorial(int n)  
{  
 return (n == 1 || n == 0) ? 1 : factorial(n - 1) \* n;  
}  
  
int main(){  
  
 int n = 10;  
 int k = 2;  
  
 std::cout<<binom(n,k)<<'\n';  
 std::cout<<(factorial(n)/(factorial(k)\*factorial(n-k)));  
}

This is the original code and it works. I’ve tested it against my own factorial function.

Binom(10,2) returns 45,

Factorial(10) / (factorial(8)\*factorial(2)) also returns 45.

It’s not optimized because there is 2 loops and since the loops are independent, we can combine it into one for loop. Also the simplification of canceling n! with (n-k)! is not necessarily the best choice for a given n,k. I will explain on the following page.

Ink Drawings
Ink Drawings
￼
￼￼
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
￼
￼
￼


Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
Ink Drawings
￼
￼
￼￼￼
￼
￼
￼
￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼
￼
￼
￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼
￼
￼￼￼
￼
￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼￼￼￼￼￼￼￼￼￼￼￼
￼￼￼￼￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼


Ink Drawings
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼￼￼￼￼￼￼￼￼￼￼
￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼
￼￼￼￼￼￼￼￼￼￼￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼￼
￼￼￼


#include <iostream>  
#include <math.h>  
*//2.3 Binomial coefficient*int binom(int n, int k)  
{  
 if ((n < 0) || (k < 0) || (k > n)) return 0;  
 if ((k == 0) || (k == n)) return 1;  
 int i = 0;  
 int result = 1;  
  
 if (k > n-k)  
 k = n-k;  
 *//since k is smaller, the loop is smaller.* for (i = 1; i <= k; ++i) {  
 result /= i;  
 result \*= (n+1-i);  
 }  
 return result;  
}  
  
int factorial(int n)  
{  
 return (n == 1 || n == 0) ? 1 : factorial(n - 1) \* n;  
}  
  
int main(){  
  
 int n = 10;  
 int k = 2;  
  
 std::cout<<binom(n,k)<<'\n';  
 std::cout<<(factorial(n)/(factorial(k)\*factorial(n-k)));  
}

Console output

45

45

I’ve combined the two for loops into 1 loop. The main optimization made to the code is that we pick k to be the min( k, n-k) . since the k is the loop counter, the smaller, the faster the loop ends. Given n=10, k =2, the loop will pick k = 2 and not 10-2 = 8. The loop will calculate result = 1\*10, result / 1, result \* 9, result /2. That’s the end of the program. If the input is n= 10, k = 8. We change k to 2 because min(8, 10-8=2) is 2. The loop will be the same as n=10, k =2.

2.4 Bisection

#include <iostream>  
#include <cmath>  
  
using namespace std;  
*//2.4 Bisection  
  
//the error function is a build in c++ function called erf()*static double cum\_norm(double x) {  
 const double root = sqrt(0.5);  
 return 0.5 \* (1.0 + erf(x \* root));  
}  
  
static int cum\_norm\_bisection(double y\_target, double tol, int max\_iter, double &x, int &num\_iter) {  
 num\_iter = 0;  
 int error\_code = 1;  
 double x\_low = -10.0;  
 double x\_high = 10.0;  
 double y\_low = cum\_norm(x\_low);  
  
 if (abs(y\_low - y\_target) <= tol) {  
 x = x\_low;  
 error\_code = 0;  
 return error\_code;  
 }*//success, no need to test* if (y\_low > y\_target) {  
 x = 0;  
 error\_code = 1;  
 return error\_code;  
 }*//fail validation test* double y\_high = cum\_norm(x\_high);  
 if (abs(y\_high - y\_target) <= tol) {  
 x = x\_high;  
 error\_code = 0;  
 return error\_code;  
 }*//success, no need to do bisection loop* if (y\_high < y\_target) {  
 x = 0;  
 error\_code = 1;  
 return error\_code;  
 }*//fail validation test.  
  
 //we made it* int i = 0;  
 double y = 0.0;  
 for (i = 1; i <= max\_iter; ++i) {  
 x = (x\_low + x\_high) / 2;  
 y = cum\_norm(x);  
  
 if (abs(y - y\_target) <= tol) {  
 num\_iter = i;  
 error\_code = 0;  
 break;  
 }*// success, found* else if (y < y\_target) {  
 x\_low = x;  
 } else {  
 x\_high = x;  
 }  
  
 if (x\_high - x\_low <= tol) {  
 num\_iter = i;  
 error\_code = 0;  
 break;  
 }*//17* }*//forloop for bisection* return error\_code;  
}*//bisection*int main() {  
 double x = 0.0;  
 int num\_iter = 0;  
  
 int error\_code = 0;  
  
 for(double y\_target =.5; y\_target < 1.0; y\_target += .05 ) {  
  
 for (double gap = .01; gap > .00000000001; gap \*= .10) {  
 cout << gap << '\n';  
  
 error\_code = cum\_norm\_bisection(y\_target, gap, 100, x, num\_iter);  
 std::cout << "error code: " << error\_code << '\n';  
  
 cout << "x: " << x << '\n';  
 cout<<"y\_target: "<<y\_target<<'\n';  
 cout << "num\_iter: " << num\_iter << '\n';  
  
  
 }*//iterate all tol, from [0.1 to 1e-011* }*//for y\_target, from [.50 to 1.0]*}  
  
*//y=.6  
//x: 0.253347  
//num\_iter 55  
  
//y=.4  
//error code: 0  
//x: -0.253347  
//num\_iter 55*

Console output: skip to page 32 for graphical insight.

max\_iter = 100

tolerance: 0.01 , error code: 0 , x: -5 , y\_target: 0 , num\_iter: 2

tolerance: 0.001 , error code: 0 , x: -5 , y\_target: 0 , num\_iter: 2

tolerance: 0.0001 , error code: 0 , x: -5 , y\_target: 0 , num\_iter: 2

tolerance: 1e-005 , error code: 0 , x: -5 , y\_target: 0 , num\_iter: 2

tolerance: 1e-006 , error code: 0 , x: -5 , y\_target: 0 , num\_iter: 2

tolerance: 1e-007 , error code: 0 , x: -7.5 , y\_target: 0 , num\_iter: 3

tolerance: 1e-008 , error code: 0 , x: -7.5 , y\_target: 0 , num\_iter: 3

tolerance: 1e-009 , error code: 0 , x: -7.5 , y\_target: 0 , num\_iter: 3

tolerance: 1e-010 , error code: 0 , x: -7.5 , y\_target: 0 , num\_iter: 3

tolerance: 1e-011 , error code: 0 , x: -7.5 , y\_target: 0 , num\_iter: 3

tolerance: 0.01 , error code: 0 , x: -5 , y\_target: 0.01 , num\_iter: 2

tolerance: 0.001 , error code: 0 , x: -2.34375 , y\_target: 0.01 , num\_iter: 7

tolerance: 0.0001 , error code: 0 , x: -2.32422 , y\_target: 0.01 , num\_iter: 10

tolerance: 1e-005 , error code: 0 , x: -2.32666 , y\_target: 0.01 , num\_iter: 13

tolerance: 1e-006 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 16

tolerance: 1e-007 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 21

tolerance: 1e-008 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 23

tolerance: 1e-009 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 31

tolerance: 1e-011 , error code: 0 , x: -2.32635 , y\_target: 0.01 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -2.1875 , y\_target: 0.02 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -2.07031 , y\_target: 0.02 , num\_iter: 9

tolerance: 0.0001 , error code: 0 , x: -2.05566 , y\_target: 0.02 , num\_iter: 12

tolerance: 1e-005 , error code: 0 , x: -2.05383 , y\_target: 0.02 , num\_iter: 15

tolerance: 1e-006 , error code: 0 , x: -2.05376 , y\_target: 0.02 , num\_iter: 18

tolerance: 1e-007 , error code: 0 , x: -2.05375 , y\_target: 0.02 , num\_iter: 21

tolerance: 1e-008 , error code: 0 , x: -2.05375 , y\_target: 0.02 , num\_iter: 25

tolerance: 1e-009 , error code: 0 , x: -2.05375 , y\_target: 0.02 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -2.05375 , y\_target: 0.02 , num\_iter: 30

tolerance: 1e-011 , error code: 0 , x: -2.05375 , y\_target: 0.02 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: -1.875 , y\_target: 0.03 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: -1.875 , y\_target: 0.03 , num\_iter: 5

tolerance: 0.0001 , error code: 0 , x: -1.87988 , y\_target: 0.03 , num\_iter: 12

tolerance: 1e-005 , error code: 0 , x: -1.8808 , y\_target: 0.03 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -1.8808 , y\_target: 0.03 , num\_iter: 16

tolerance: 1e-007 , error code: 0 , x: -1.88079 , y\_target: 0.03 , num\_iter: 22

tolerance: 1e-008 , error code: 0 , x: -1.88079 , y\_target: 0.03 , num\_iter: 22

tolerance: 1e-009 , error code: 0 , x: -1.88079 , y\_target: 0.03 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -1.88079 , y\_target: 0.03 , num\_iter: 29

tolerance: 1e-011 , error code: 0 , x: -1.88079 , y\_target: 0.03 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -1.875 , y\_target: 0.04 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: -1.75781 , y\_target: 0.04 , num\_iter: 9

tolerance: 0.0001 , error code: 0 , x: -1.75049 , y\_target: 0.04 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -1.75079 , y\_target: 0.04 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -1.75068 , y\_target: 0.04 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.75069 , y\_target: 0.04 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -1.75069 , y\_target: 0.04 , num\_iter: 23

tolerance: 1e-009 , error code: 0 , x: -1.75069 , y\_target: 0.04 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.75069 , y\_target: 0.04 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -1.75069 , y\_target: 0.04 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -1.5625 , y\_target: 0.05 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -1.64063 , y\_target: 0.05 , num\_iter: 8

tolerance: 0.0001 , error code: 0 , x: -1.64551 , y\_target: 0.05 , num\_iter: 12

tolerance: 1e-005 , error code: 0 , x: -1.6449 , y\_target: 0.05 , num\_iter: 15

tolerance: 1e-006 , error code: 0 , x: -1.64486 , y\_target: 0.05 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.64485 , y\_target: 0.05 , num\_iter: 22

tolerance: 1e-008 , error code: 0 , x: -1.64485 , y\_target: 0.05 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -1.64485 , y\_target: 0.05 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.64485 , y\_target: 0.05 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -1.64485 , y\_target: 0.05 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.5625 , y\_target: 0.06 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -1.5625 , y\_target: 0.06 , num\_iter: 6

tolerance: 0.0001 , error code: 0 , x: -1.55518 , y\_target: 0.06 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -1.55472 , y\_target: 0.06 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -1.55478 , y\_target: 0.06 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -1.55477 , y\_target: 0.06 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -1.55477 , y\_target: 0.06 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.55477 , y\_target: 0.06 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: -1.55477 , y\_target: 0.06 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -1.55477 , y\_target: 0.06 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -1.40625 , y\_target: 0.07 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -1.47461 , y\_target: 0.07 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -1.47583 , y\_target: 0.07 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.47583 , y\_target: 0.07 , num\_iter: 14

tolerance: 1e-006 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 31

tolerance: 1e-011 , error code: 0 , x: -1.47579 , y\_target: 0.07 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.40625 , y\_target: 0.08 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -1.40625 , y\_target: 0.08 , num\_iter: 7

tolerance: 0.0001 , error code: 0 , x: -1.40503 , y\_target: 0.08 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.40503 , y\_target: 0.08 , num\_iter: 14

tolerance: 1e-006 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 22

tolerance: 1e-008 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 25

tolerance: 1e-009 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 30

tolerance: 1e-011 , error code: 0 , x: -1.40507 , y\_target: 0.08 , num\_iter: 30

tolerance: 0.01 , error code: 0 , x: -1.32813 , y\_target: 0.09 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -1.33789 , y\_target: 0.09 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -1.34033 , y\_target: 0.09 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -1.34079 , y\_target: 0.09 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -1.34075 , y\_target: 0.09 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.34076 , y\_target: 0.09 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -1.34076 , y\_target: 0.09 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.34076 , y\_target: 0.09 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -1.34076 , y\_target: 0.09 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -1.34076 , y\_target: 0.09 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.25 , y\_target: 0.1 , num\_iter: 4

tolerance: 0.001 , error code: 0 , x: -1.2793 , y\_target: 0.1 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -1.28174 , y\_target: 0.1 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -1.28159 , y\_target: 0.1 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -1.28155 , y\_target: 0.1 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -1.25 , y\_target: 0.11 , num\_iter: 4

tolerance: 0.001 , error code: 0 , x: -1.23047 , y\_target: 0.11 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -1.22681 , y\_target: 0.11 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.2265 , y\_target: 0.11 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -1.22653 , y\_target: 0.11 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.17188 , y\_target: 0.12 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -1.17188 , y\_target: 0.12 , num\_iter: 8

tolerance: 0.0001 , error code: 0 , x: -1.17493 , y\_target: 0.12 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -1.175 , y\_target: 0.12 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -1.17498 , y\_target: 0.12 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -1.17499 , y\_target: 0.12 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -1.17499 , y\_target: 0.12 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.17499 , y\_target: 0.12 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.17499 , y\_target: 0.12 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -1.17499 , y\_target: 0.12 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: -1.09375 , y\_target: 0.13 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -1.12305 , y\_target: 0.13 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -1.12671 , y\_target: 0.13 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.1264 , y\_target: 0.13 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -1.12639 , y\_target: 0.13 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.09375 , y\_target: 0.14 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -1.08398 , y\_target: 0.14 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 14

tolerance: 1e-006 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 14

tolerance: 1e-007 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -1.08032 , y\_target: 0.14 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -1.01563 , y\_target: 0.15 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -1.03516 , y\_target: 0.15 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -1.03638 , y\_target: 0.15 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -1.03645 , y\_target: 0.15 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -1.03643 , y\_target: 0.15 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -1.01563 , y\_target: 0.16 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.996094 , y\_target: 0.16 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.994263 , y\_target: 0.16 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.994492 , y\_target: 0.16 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 22

tolerance: 1e-008 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.994458 , y\_target: 0.16 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -0.9375 , y\_target: 0.17 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -0.957031 , y\_target: 0.17 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.953979 , y\_target: 0.17 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.954132 , y\_target: 0.17 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 22

tolerance: 1e-008 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.954165 , y\_target: 0.17 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.9375 , y\_target: 0.18 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -0.917969 , y\_target: 0.18 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.915527 , y\_target: 0.18 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -0.915375 , y\_target: 0.18 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 21

tolerance: 1e-008 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.915365 , y\_target: 0.18 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -0.859375 , y\_target: 0.19 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.878906 , y\_target: 0.19 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.877686 , y\_target: 0.19 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.877914 , y\_target: 0.19 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.877895 , y\_target: 0.19 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.877897 , y\_target: 0.19 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.877896 , y\_target: 0.19 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.877896 , y\_target: 0.19 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -0.877896 , y\_target: 0.19 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.877896 , y\_target: 0.19 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.859375 , y\_target: 0.2 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.839844 , y\_target: 0.2 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.841675 , y\_target: 0.2 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.841599 , y\_target: 0.2 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.841622 , y\_target: 0.2 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.841621 , y\_target: 0.2 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.841621 , y\_target: 0.2 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.841621 , y\_target: 0.2 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -0.841621 , y\_target: 0.2 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.841621 , y\_target: 0.2 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -0.78125 , y\_target: 0.21 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.805664 , y\_target: 0.21 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.806274 , y\_target: 0.21 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.806427 , y\_target: 0.21 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.806422 , y\_target: 0.21 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.806421 , y\_target: 0.21 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.806421 , y\_target: 0.21 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.806421 , y\_target: 0.21 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.806421 , y\_target: 0.21 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.806421 , y\_target: 0.21 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.78125 , y\_target: 0.22 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.771484 , y\_target: 0.22 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.772095 , y\_target: 0.22 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.772171 , y\_target: 0.22 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.77219 , y\_target: 0.22 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.772193 , y\_target: 0.22 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.772193 , y\_target: 0.22 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.772193 , y\_target: 0.22 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -0.772193 , y\_target: 0.22 , num\_iter: 31

tolerance: 1e-011 , error code: 0 , x: -0.772193 , y\_target: 0.22 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -0.742188 , y\_target: 0.23 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.737305 , y\_target: 0.23 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.738525 , y\_target: 0.23 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.738831 , y\_target: 0.23 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -0.73885 , y\_target: 0.23 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.738847 , y\_target: 0.23 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.738847 , y\_target: 0.23 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.738847 , y\_target: 0.23 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -0.738847 , y\_target: 0.23 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.738847 , y\_target: 0.23 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.703125 , y\_target: 0.24 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.703125 , y\_target: 0.24 , num\_iter: 8

tolerance: 0.0001 , error code: 0 , x: -0.706177 , y\_target: 0.24 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.706329 , y\_target: 0.24 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.706301 , y\_target: 0.24 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -0.706303 , y\_target: 0.24 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.706303 , y\_target: 0.24 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.706303 , y\_target: 0.24 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -0.706303 , y\_target: 0.24 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.706303 , y\_target: 0.24 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.703125 , y\_target: 0.25 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.673828 , y\_target: 0.25 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.674438 , y\_target: 0.25 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.674515 , y\_target: 0.25 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.674491 , y\_target: 0.25 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.67449 , y\_target: 0.25 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.67449 , y\_target: 0.25 , num\_iter: 24

tolerance: 1e-009 , error code: 0 , x: -0.67449 , y\_target: 0.25 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.67449 , y\_target: 0.25 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.67449 , y\_target: 0.25 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.625 , y\_target: 0.26 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: -0.644531 , y\_target: 0.26 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.643311 , y\_target: 0.26 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.643349 , y\_target: 0.26 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.643344 , y\_target: 0.26 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.643345 , y\_target: 0.26 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.643345 , y\_target: 0.26 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -0.643345 , y\_target: 0.26 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -0.643345 , y\_target: 0.26 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.643345 , y\_target: 0.26 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: -0.625 , y\_target: 0.27 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: -0.615234 , y\_target: 0.27 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.612793 , y\_target: 0.27 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -0.612793 , y\_target: 0.27 , num\_iter: 13

tolerance: 1e-006 , error code: 0 , x: -0.612812 , y\_target: 0.27 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.612813 , y\_target: 0.27 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.612813 , y\_target: 0.27 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.612813 , y\_target: 0.27 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.612813 , y\_target: 0.27 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.612813 , y\_target: 0.27 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: -0.585938 , y\_target: 0.28 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.581055 , y\_target: 0.28 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.582886 , y\_target: 0.28 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.582848 , y\_target: 0.28 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.582843 , y\_target: 0.28 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.582842 , y\_target: 0.28 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.582841 , y\_target: 0.28 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.582842 , y\_target: 0.28 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.582842 , y\_target: 0.28 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.582842 , y\_target: 0.28 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -0.546875 , y\_target: 0.29 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.551758 , y\_target: 0.29 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.553589 , y\_target: 0.29 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.55336 , y\_target: 0.29 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.553384 , y\_target: 0.29 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.553385 , y\_target: 0.29 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: -0.553385 , y\_target: 0.29 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -0.553385 , y\_target: 0.29 , num\_iter: 26

tolerance: 1e-010 , error code: 0 , x: -0.553385 , y\_target: 0.29 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.553385 , y\_target: 0.29 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -0.546875 , y\_target: 0.3 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.522461 , y\_target: 0.3 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.524292 , y\_target: 0.3 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.524406 , y\_target: 0.3 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.524402 , y\_target: 0.3 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.5244 , y\_target: 0.3 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.524401 , y\_target: 0.3 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.524401 , y\_target: 0.3 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -0.524401 , y\_target: 0.3 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.524401 , y\_target: 0.3 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.46875 , y\_target: 0.31 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.498047 , y\_target: 0.31 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.495605 , y\_target: 0.31 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -0.495834 , y\_target: 0.31 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.495849 , y\_target: 0.31 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.49585 , y\_target: 0.31 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.49585 , y\_target: 0.31 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.49585 , y\_target: 0.31 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.49585 , y\_target: 0.31 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.49585 , y\_target: 0.31 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -0.46875 , y\_target: 0.32 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.46875 , y\_target: 0.32 , num\_iter: 7

tolerance: 0.0001 , error code: 0 , x: -0.467529 , y\_target: 0.32 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.467682 , y\_target: 0.32 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.467701 , y\_target: 0.32 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.467699 , y\_target: 0.32 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -0.467699 , y\_target: 0.32 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.467699 , y\_target: 0.32 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -0.467699 , y\_target: 0.32 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.467699 , y\_target: 0.32 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.429688 , y\_target: 0.33 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.439453 , y\_target: 0.33 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.440063 , y\_target: 0.33 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.439911 , y\_target: 0.33 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.439911 , y\_target: 0.33 , num\_iter: 17

tolerance: 1e-007 , error code: 0 , x: -0.439913 , y\_target: 0.33 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -0.439913 , y\_target: 0.33 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.439913 , y\_target: 0.33 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.439913 , y\_target: 0.33 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: -0.439913 , y\_target: 0.33 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.390625 , y\_target: 0.34 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.410156 , y\_target: 0.34 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.412598 , y\_target: 0.34 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: -0.412445 , y\_target: 0.34 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.412464 , y\_target: 0.34 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.412463 , y\_target: 0.34 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.412463 , y\_target: 0.34 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.412463 , y\_target: 0.34 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.412463 , y\_target: 0.34 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.412463 , y\_target: 0.34 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.390625 , y\_target: 0.35 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.385742 , y\_target: 0.35 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.385132 , y\_target: 0.35 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.385323 , y\_target: 0.35 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.385323 , y\_target: 0.35 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -0.38532 , y\_target: 0.35 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: -0.38532 , y\_target: 0.35 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -0.38532 , y\_target: 0.35 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.38532 , y\_target: 0.35 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.38532 , y\_target: 0.35 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.351563 , y\_target: 0.36 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.356445 , y\_target: 0.36 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.358276 , y\_target: 0.36 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.358467 , y\_target: 0.36 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.358458 , y\_target: 0.36 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -0.358459 , y\_target: 0.36 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.358459 , y\_target: 0.36 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.358459 , y\_target: 0.36 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -0.358459 , y\_target: 0.36 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.358459 , y\_target: 0.36 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.3125 , y\_target: 0.37 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -0.332031 , y\_target: 0.37 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.332031 , y\_target: 0.37 , num\_iter: 10

tolerance: 1e-005 , error code: 0 , x: -0.331879 , y\_target: 0.37 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.331855 , y\_target: 0.37 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.331853 , y\_target: 0.37 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: -0.331853 , y\_target: 0.37 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: -0.331853 , y\_target: 0.37 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.331853 , y\_target: 0.37 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: -0.331853 , y\_target: 0.37 , num\_iter: 33

tolerance: 0.01 , error code: 0 , x: -0.3125 , y\_target: 0.38 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: -0.307617 , y\_target: 0.38 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 16

tolerance: 1e-005 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 16

tolerance: 1e-007 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 16

tolerance: 1e-008 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.305481 , y\_target: 0.38 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -0.273438 , y\_target: 0.39 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.27832 , y\_target: 0.39 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.279541 , y\_target: 0.39 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.279312 , y\_target: 0.39 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.279317 , y\_target: 0.39 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.279319 , y\_target: 0.39 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -0.279319 , y\_target: 0.39 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.279319 , y\_target: 0.39 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -0.279319 , y\_target: 0.39 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.279319 , y\_target: 0.39 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -0.234375 , y\_target: 0.4 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.253906 , y\_target: 0.4 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.253296 , y\_target: 0.4 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.253372 , y\_target: 0.4 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.253348 , y\_target: 0.4 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.253347 , y\_target: 0.4 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.253347 , y\_target: 0.4 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.253347 , y\_target: 0.4 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: -0.253347 , y\_target: 0.4 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.253347 , y\_target: 0.4 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: -0.234375 , y\_target: 0.41 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.229492 , y\_target: 0.41 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.227661 , y\_target: 0.41 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.227547 , y\_target: 0.41 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.227547 , y\_target: 0.41 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: -0.227545 , y\_target: 0.41 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.227545 , y\_target: 0.41 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.227545 , y\_target: 0.41 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -0.227545 , y\_target: 0.41 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.227545 , y\_target: 0.41 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: -0.195313 , y\_target: 0.42 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.200195 , y\_target: 0.42 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.202026 , y\_target: 0.42 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.201874 , y\_target: 0.42 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: -0.201893 , y\_target: 0.42 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.15625 , y\_target: 0.43 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.175781 , y\_target: 0.43 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: -0.176392 , y\_target: 0.43 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.176392 , y\_target: 0.43 , num\_iter: 15

tolerance: 1e-006 , error code: 0 , x: -0.176373 , y\_target: 0.43 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: -0.176374 , y\_target: 0.43 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.176374 , y\_target: 0.43 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.176374 , y\_target: 0.43 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: -0.176374 , y\_target: 0.43 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: -0.176374 , y\_target: 0.43 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: -0.15625 , y\_target: 0.44 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: -0.151367 , y\_target: 0.44 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.150757 , y\_target: 0.44 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.150986 , y\_target: 0.44 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.150971 , y\_target: 0.44 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.150969 , y\_target: 0.44 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -0.150969 , y\_target: 0.44 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.150969 , y\_target: 0.44 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: -0.150969 , y\_target: 0.44 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: -0.150969 , y\_target: 0.44 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.117188 , y\_target: 0.45 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.126953 , y\_target: 0.45 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.125732 , y\_target: 0.45 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.125656 , y\_target: 0.45 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.125661 , y\_target: 0.45 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.078125 , y\_target: 0.46 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.102539 , y\_target: 0.46 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.100403 , y\_target: 0.46 , num\_iter: 16

tolerance: 1e-005 , error code: 0 , x: -0.100441 , y\_target: 0.46 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.100431 , y\_target: 0.46 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -0.100434 , y\_target: 0.46 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: -0.100434 , y\_target: 0.46 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: -0.100434 , y\_target: 0.46 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.100434 , y\_target: 0.46 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: -0.100434 , y\_target: 0.46 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: -0.078125 , y\_target: 0.47 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: -0.0732422 , y\_target: 0.47 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.0750732 , y\_target: 0.47 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.075264 , y\_target: 0.47 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.0752687 , y\_target: 0.47 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.0752699 , y\_target: 0.47 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: -0.0752699 , y\_target: 0.47 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.0752699 , y\_target: 0.47 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: -0.0752699 , y\_target: 0.47 , num\_iter: 36

tolerance: 1e-011 , error code: 0 , x: -0.0752699 , y\_target: 0.47 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: -0.0390625 , y\_target: 0.48 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: -0.0488281 , y\_target: 0.48 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: -0.0500488 , y\_target: 0.48 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: -0.0501633 , y\_target: 0.48 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.0501537 , y\_target: 0.48 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: -0.0501537 , y\_target: 0.48 , num\_iter: 21

tolerance: 1e-008 , error code: 0 , x: -0.0501536 , y\_target: 0.48 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: -0.0501536 , y\_target: 0.48 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: -0.0501536 , y\_target: 0.48 , num\_iter: 27

tolerance: 1e-011 , error code: 0 , x: -0.0501536 , y\_target: 0.48 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0 , y\_target: 0.49 , num\_iter: 1

tolerance: 0.001 , error code: 0 , x: -0.0244141 , y\_target: 0.49 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: -0.0250244 , y\_target: 0.49 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: -0.0250626 , y\_target: 0.49 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: -0.0250673 , y\_target: 0.49 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: -0.0250691 , y\_target: 0.49 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: -0.0250689 , y\_target: 0.49 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: -0.0250689 , y\_target: 0.49 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: -0.0250689 , y\_target: 0.49 , num\_iter: 36

tolerance: 1e-011 , error code: 0 , x: -0.0250689 , y\_target: 0.49 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 0.001 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 0.0001 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-005 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-006 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-007 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-008 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-009 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-010 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-011 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 0.01 , error code: 0 , x: 0.0390625 , y\_target: 0.51 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.0244141 , y\_target: 0.51 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.0250244 , y\_target: 0.51 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.0250626 , y\_target: 0.51 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.0250673 , y\_target: 0.51 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.0250691 , y\_target: 0.51 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 36

tolerance: 1e-011 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.0390625 , y\_target: 0.52 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.0488281 , y\_target: 0.52 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.0500488 , y\_target: 0.52 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: 0.0501633 , y\_target: 0.52 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.0501537 , y\_target: 0.52 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: 0.0501537 , y\_target: 0.52 , num\_iter: 21

tolerance: 1e-008 , error code: 0 , x: 0.0501536 , y\_target: 0.52 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: 0.0501536 , y\_target: 0.52 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: 0.0501536 , y\_target: 0.52 , num\_iter: 27

tolerance: 1e-011 , error code: 0 , x: 0.0501536 , y\_target: 0.52 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.078125 , y\_target: 0.53 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.0732422 , y\_target: 0.53 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.0750732 , y\_target: 0.53 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.075264 , y\_target: 0.53 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.0752687 , y\_target: 0.53 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.0752699 , y\_target: 0.53 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.0752699 , y\_target: 0.53 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.0752699 , y\_target: 0.53 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: 0.0752699 , y\_target: 0.53 , num\_iter: 36

tolerance: 1e-011 , error code: 0 , x: 0.0752699 , y\_target: 0.53 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.078125 , y\_target: 0.54 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.102539 , y\_target: 0.54 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.100403 , y\_target: 0.54 , num\_iter: 16

tolerance: 1e-005 , error code: 0 , x: 0.100441 , y\_target: 0.54 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.100431 , y\_target: 0.54 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: 0.100434 , y\_target: 0.54 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: 0.100434 , y\_target: 0.54 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.100434 , y\_target: 0.54 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.100434 , y\_target: 0.54 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.100434 , y\_target: 0.54 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: 0.117188 , y\_target: 0.55 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.126953 , y\_target: 0.55 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.125732 , y\_target: 0.55 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: 0.125656 , y\_target: 0.55 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.125661 , y\_target: 0.55 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.15625 , y\_target: 0.56 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: 0.151367 , y\_target: 0.56 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.150757 , y\_target: 0.56 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.150986 , y\_target: 0.56 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.150971 , y\_target: 0.56 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.150969 , y\_target: 0.56 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: 0.150969 , y\_target: 0.56 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.150969 , y\_target: 0.56 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: 0.150969 , y\_target: 0.56 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.150969 , y\_target: 0.56 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.15625 , y\_target: 0.57 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: 0.175781 , y\_target: 0.57 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: 0.176392 , y\_target: 0.57 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.176392 , y\_target: 0.57 , num\_iter: 15

tolerance: 1e-006 , error code: 0 , x: 0.176373 , y\_target: 0.57 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: 0.176374 , y\_target: 0.57 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.176374 , y\_target: 0.57 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: 0.176374 , y\_target: 0.57 , num\_iter: 27

tolerance: 1e-010 , error code: 0 , x: 0.176374 , y\_target: 0.57 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: 0.176374 , y\_target: 0.57 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: 0.195313 , y\_target: 0.58 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.200195 , y\_target: 0.58 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.202026 , y\_target: 0.58 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.201874 , y\_target: 0.58 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: 0.201893 , y\_target: 0.58 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.234375 , y\_target: 0.59 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.229492 , y\_target: 0.59 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.227661 , y\_target: 0.59 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.227547 , y\_target: 0.59 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.227547 , y\_target: 0.59 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: 0.227545 , y\_target: 0.59 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.227545 , y\_target: 0.59 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.227545 , y\_target: 0.59 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: 0.227545 , y\_target: 0.59 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.227545 , y\_target: 0.59 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: 0.234375 , y\_target: 0.6 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.253906 , y\_target: 0.6 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: 0.253296 , y\_target: 0.6 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.253372 , y\_target: 0.6 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.253348 , y\_target: 0.6 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.253347 , y\_target: 0.6 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.253347 , y\_target: 0.6 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.253347 , y\_target: 0.6 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.253347 , y\_target: 0.6 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.253347 , y\_target: 0.6 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: 0.273438 , y\_target: 0.61 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.27832 , y\_target: 0.61 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.279541 , y\_target: 0.61 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: 0.279312 , y\_target: 0.61 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.279317 , y\_target: 0.61 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.279319 , y\_target: 0.61 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: 0.279319 , y\_target: 0.61 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.279319 , y\_target: 0.61 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: 0.279319 , y\_target: 0.61 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.279319 , y\_target: 0.61 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: 0.3125 , y\_target: 0.62 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: 0.307617 , y\_target: 0.62 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 16

tolerance: 1e-005 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 16

tolerance: 1e-006 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 16

tolerance: 1e-007 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 16

tolerance: 1e-008 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.305481 , y\_target: 0.62 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: 0.3125 , y\_target: 0.63 , num\_iter: 6

tolerance: 0.001 , error code: 0 , x: 0.332031 , y\_target: 0.63 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: 0.332031 , y\_target: 0.63 , num\_iter: 10

tolerance: 1e-005 , error code: 0 , x: 0.331879 , y\_target: 0.63 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: 0.331855 , y\_target: 0.63 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.331853 , y\_target: 0.63 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: 0.331853 , y\_target: 0.63 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: 0.331853 , y\_target: 0.63 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.331853 , y\_target: 0.63 , num\_iter: 33

tolerance: 1e-011 , error code: 0 , x: 0.331853 , y\_target: 0.63 , num\_iter: 33

tolerance: 0.01 , error code: 0 , x: 0.351563 , y\_target: 0.64 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.356445 , y\_target: 0.64 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.358276 , y\_target: 0.64 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.358467 , y\_target: 0.64 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.358458 , y\_target: 0.64 , num\_iter: 21

tolerance: 1e-007 , error code: 0 , x: 0.358459 , y\_target: 0.64 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.358459 , y\_target: 0.64 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.358459 , y\_target: 0.64 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: 0.358459 , y\_target: 0.64 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.358459 , y\_target: 0.64 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: 0.390625 , y\_target: 0.65 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.385742 , y\_target: 0.65 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.385132 , y\_target: 0.65 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.385323 , y\_target: 0.65 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.385323 , y\_target: 0.65 , num\_iter: 19

tolerance: 1e-007 , error code: 0 , x: 0.38532 , y\_target: 0.65 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: 0.38532 , y\_target: 0.65 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: 0.38532 , y\_target: 0.65 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.38532 , y\_target: 0.65 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.38532 , y\_target: 0.65 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.390625 , y\_target: 0.66 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.410156 , y\_target: 0.66 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: 0.412598 , y\_target: 0.66 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: 0.412445 , y\_target: 0.66 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: 0.412464 , y\_target: 0.66 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: 0.412463 , y\_target: 0.66 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.412463 , y\_target: 0.66 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.412463 , y\_target: 0.66 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.412463 , y\_target: 0.66 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.412463 , y\_target: 0.66 , num\_iter: 39

tolerance: 0.01 , error code: 0 , x: 0.429688 , y\_target: 0.67 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.439453 , y\_target: 0.67 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.440063 , y\_target: 0.67 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.439911 , y\_target: 0.67 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: 0.439911 , y\_target: 0.67 , num\_iter: 17

tolerance: 1e-007 , error code: 0 , x: 0.439913 , y\_target: 0.67 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: 0.439913 , y\_target: 0.67 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.439913 , y\_target: 0.67 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.439913 , y\_target: 0.67 , num\_iter: 32

tolerance: 1e-011 , error code: 0 , x: 0.439913 , y\_target: 0.67 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: 0.46875 , y\_target: 0.68 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: 0.46875 , y\_target: 0.68 , num\_iter: 7

tolerance: 0.0001 , error code: 0 , x: 0.467529 , y\_target: 0.68 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: 0.467682 , y\_target: 0.68 , num\_iter: 17

tolerance: 1e-006 , error code: 0 , x: 0.467701 , y\_target: 0.68 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: 0.467699 , y\_target: 0.68 , num\_iter: 23

tolerance: 1e-008 , error code: 0 , x: 0.467699 , y\_target: 0.68 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.467699 , y\_target: 0.68 , num\_iter: 28

tolerance: 1e-010 , error code: 0 , x: 0.467699 , y\_target: 0.68 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.467699 , y\_target: 0.68 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: 0.46875 , y\_target: 0.69 , num\_iter: 7

tolerance: 0.001 , error code: 0 , x: 0.498047 , y\_target: 0.69 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.495605 , y\_target: 0.69 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: 0.495834 , y\_target: 0.69 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.495849 , y\_target: 0.69 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.49585 , y\_target: 0.69 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.49585 , y\_target: 0.69 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.49585 , y\_target: 0.69 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.49585 , y\_target: 0.69 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.49585 , y\_target: 0.69 , num\_iter: 37

tolerance: 0.01 , error code: 0 , x: 0.546875 , y\_target: 0.7 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.522461 , y\_target: 0.7 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.524292 , y\_target: 0.7 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.524406 , y\_target: 0.7 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.524402 , y\_target: 0.7 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.5244 , y\_target: 0.7 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.524401 , y\_target: 0.7 , num\_iter: 29

tolerance: 1e-009 , error code: 0 , x: 0.524401 , y\_target: 0.7 , num\_iter: 29

tolerance: 1e-010 , error code: 0 , x: 0.524401 , y\_target: 0.7 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.524401 , y\_target: 0.7 , num\_iter: 38

tolerance: 0.01 , error code: 0 , x: 0.546875 , y\_target: 0.71 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.551758 , y\_target: 0.71 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.553589 , y\_target: 0.71 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.55336 , y\_target: 0.71 , num\_iter: 18

tolerance: 1e-006 , error code: 0 , x: 0.553384 , y\_target: 0.71 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.553385 , y\_target: 0.71 , num\_iter: 26

tolerance: 1e-008 , error code: 0 , x: 0.553385 , y\_target: 0.71 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: 0.553385 , y\_target: 0.71 , num\_iter: 26

tolerance: 1e-010 , error code: 0 , x: 0.553385 , y\_target: 0.71 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.553385 , y\_target: 0.71 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: 0.585938 , y\_target: 0.72 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.581055 , y\_target: 0.72 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.582886 , y\_target: 0.72 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.582848 , y\_target: 0.72 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.582843 , y\_target: 0.72 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.582842 , y\_target: 0.72 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.582841 , y\_target: 0.72 , num\_iter: 27

tolerance: 1e-009 , error code: 0 , x: 0.582842 , y\_target: 0.72 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.582842 , y\_target: 0.72 , num\_iter: 35

tolerance: 1e-011 , error code: 0 , x: 0.582842 , y\_target: 0.72 , num\_iter: 35

tolerance: 0.01 , error code: 0 , x: 0.625 , y\_target: 0.73 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: 0.615234 , y\_target: 0.73 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.612793 , y\_target: 0.73 , num\_iter: 13

tolerance: 1e-005 , error code: 0 , x: 0.612793 , y\_target: 0.73 , num\_iter: 13

tolerance: 1e-006 , error code: 0 , x: 0.612812 , y\_target: 0.73 , num\_iter: 20

tolerance: 1e-007 , error code: 0 , x: 0.612813 , y\_target: 0.73 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.612813 , y\_target: 0.73 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.612813 , y\_target: 0.73 , num\_iter: 30

tolerance: 1e-010 , error code: 0 , x: 0.612813 , y\_target: 0.73 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.612813 , y\_target: 0.73 , num\_iter: 34

tolerance: 0.01 , error code: 0 , x: 0.625 , y\_target: 0.74 , num\_iter: 5

tolerance: 0.001 , error code: 0 , x: 0.644531 , y\_target: 0.74 , num\_iter: 10

tolerance: 0.0001 , error code: 0 , x: 0.643311 , y\_target: 0.74 , num\_iter: 14

tolerance: 1e-005 , error code: 0 , x: 0.643349 , y\_target: 0.74 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.643344 , y\_target: 0.74 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.643345 , y\_target: 0.74 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.643345 , y\_target: 0.74 , num\_iter: 26

tolerance: 1e-009 , error code: 0 , x: 0.643345 , y\_target: 0.74 , num\_iter: 31

tolerance: 1e-010 , error code: 0 , x: 0.643345 , y\_target: 0.74 , num\_iter: 34

tolerance: 1e-011 , error code: 0 , x: 0.643345 , y\_target: 0.74 , num\_iter: 36

tolerance: 0.01 , error code: 0 , x: 0.703125 , y\_target: 0.75 , num\_iter: 8

tolerance: 0.001 , error code: 0 , x: 0.673828 , y\_target: 0.75 , num\_iter: 11

tolerance: 0.0001 , error code: 0 , x: 0.674438 , y\_target: 0.75 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.674515 , y\_target: 0.75 , num\_iter: 18

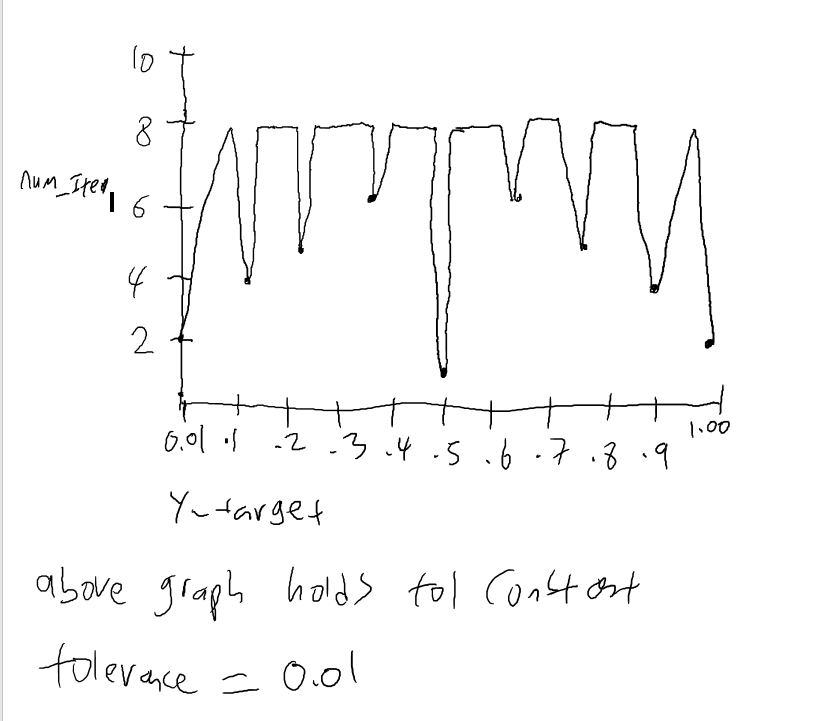
tolerance: 1e-006 , error code: 0 , x: 0.674491 , y\_target: 0.75 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.67449 , y\_target: 0.75 , num\_iter: 24

tolerance: 1e-008 , error code: 0 , x: 0.67449 , y\_target: 0.75 , num\_iter: 24

tolerance: 1e-009 , error code: 0 , x: 0.67449 , y\_target: 0.75 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.67449 , y\_target: 0.75 , num\_iter: 35



The graph above plots the number of iteration vs the y\_target.

We can see that certain value are computed in less iterations.

Y=.5 only takes 1 iteration because the when u take the mid point (-10 ,10) you get 0. Depends if u check x\_high first or x\_low first, you update that x value. When x=0, the cum\_norm(0) = .5, which is the right answer.

When you increase the tolerance by a factor of 10,

Ex .1 -> .01 - > .001 - > …..000000000001

We see that the number of iterations increases. For y\_target = 0.51

tolerance: 0.01 , error code: 0 , x: 0.0390625 , y\_target: 0.51 , num\_iter: 9

tolerance: 0.001 , error code: 0 , x: 0.0244141 , y\_target: 0.51 , num\_iter: 12

tolerance: 0.0001 , error code: 0 , x: 0.0250244 , y\_target: 0.51 , num\_iter: 15

tolerance: 1e-005 , error code: 0 , x: 0.0250626 , y\_target: 0.51 , num\_iter: 19

tolerance: 1e-006 , error code: 0 , x: 0.0250673 , y\_target: 0.51 , num\_iter: 22

tolerance: 1e-007 , error code: 0 , x: 0.0250691 , y\_target: 0.51 , num\_iter: 25

tolerance: 1e-008 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 28

tolerance: 1e-009 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 32

tolerance: 1e-010 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 36

tolerance: 1e-011 , error code: 0 , x: 0.0250689 , y\_target: 0.51 , num\_iter: 39

the iteration increase about 3,5 iteration per extra factor of 10.

However for y\_target = .5

tolerance: 0.01 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 0.001 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 0.0001 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-005 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-006 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-007 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-008 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-009 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-010 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

tolerance: 1e-011 , error code: 0 , x: 0 , y\_target: 0.5 , num\_iter: 1

y\_target = .5 and y\_target = .51 are very close, but the iteration is very different.