

# Financial Computing Lab0

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## 1.1 Github repository

[https://github.com/RUI2190/Financial-Computing-2022-Spring\\_\(https://github.com/RUI2190/Financial-Computing-2022-Spring\)](https://github.com/RUI2190/Financial-Computing-2022-Spring_(https://github.com/RUI2190/Financial-Computing-2022-Spring))

## 1.2 Basic python

In [1]:

```
import numpy as np
```

Q1.

In [2]:

```
r1=np.random.normal(0.05, 1, 100)
r2=np.random.normal(0.05, 1, 100)
r3=np.random.normal(0.05, 1, 100)
```

Q2.

In [3]:

```
print(np.mean(r1))
print(np.std(r1))
```

```
0.06467222845571347
1.0653055687352049
```

In [4]:

```
print(np.mean(r2))
print(np.std(r2))
```

```
-0.0739758576221726
0.9118035625392975
```

In [5]:

```
print(np.mean(r3))
print(np.std(r3))
```

0.0978931481601349  
1.1167041363077475

**Q3.**

In [6]:

```
array=[r1,r2,r3]
for i in range(len(array)):
    if np.mean(array[i])<0:
        print("Alert: Warning!")
        break
```

Alert: Warning!

**Q4.**

In [7]:

```
def func(n, a, b):
    array=[]
    mean=[]
    var=[]
    for i in range(n):
        array.append(np.random.normal(a, b, 100))
    for i in range(n):
        mean.append(np.mean(array[i]))
        var.append(np.var(array[i]))
    print("the mean:", mean) # mean value
    print("the variance:", var) # standard deviation
    for i in range(n):
        if mean[i] < 0:
            print("Alert: Warning!")# give the warning
            break
```

In [8]:

```
func(5,0,1)
```

the mean: [0.10274685149106035, 0.018781910778203407, -0.05976430632779786, 0.066275  
85650991233, -0.03279450869020319]  
the variance: [1.2918563712821043, 0.952073616959475, 0.9504419446513325, 1.13048754  
63461304, 0.9355498365793276]  
Alert: Warning!

# Numerical Computing

## 2.1 Newton's method

In [9]:

```
def myfunc(x): # the function
    y = (1+ 0.5 * x) **5
    return y
```

In [10]:

```
def numerical_grad (func , x, dx = 0.00001) :# numerical gradient
    dy = func (x + dx) - func(x)
    ngrad = dy / dx
    return ngrad
```

In [11]:

```
def newton_method(func, func_value = 1.5 , x = -1, max_iteration = 1000000, max_err = 0.000001):
    for trial in range(max_iteration):
        error = func(x) - func_value
        if abs(error) < max_err :
            y = func(x)
            print("Iteration {}: f = {}, x = {}".format(trial, y, x))
            return x
        else :
            grad = numerical_grad(func, x)
            x = x - error/grad
            y = func(x)
            print ("Iteration {}: f = {}, x = {}".format(trial, y, x))
    raise ValueError("Max iteration reached.")
    print("Max Iteration {}: f = {}, x = {}".format(trial, y, x))
```

In [12]:

```
newton_method(myfunc, 1.5)
```

```
Iteration 0: f = 3801.696689769873, x = 8.399812001804369
Iteration 1: f = 1246.3574870933858, x = 6.320674271153399
Iteration 2: f = 409.0224182658389, x = 4.658546210051783
Iteration 3: f = 134.64449684776213, x = 3.3317247048456338
Iteration 4: f = 44.738347476161884, x = 2.2772632795179018
Iteration 5: f = 15.284733909463858, x = 1.4504963486778806
Iteration 6: f = 5.653834165222227, x = 0.8281250518039418
Iteration 7: f = 2.5541535710695324, x = 0.41256707667125636
Iteration 8: f = 1.66025286561306, x = 0.21342516561887517
Iteration 9: f = 1.5060702910043324, x = 0.17069619006190048
Iteration 10: f = 1.500009834506773, x = 0.1689463864532662
Iteration 11: f = 1.5000000001164746, x = 0.1689435424290808
Iteration 12: f = 1.5000000001164746, x = 0.1689435424290808
```

Out[12]:

0.1689435424290808

## 2.2 Gradient Descent

In [13]:

```
import random
```

In [14]:

```
def Myfunc(x): # the function
    y = x**2 - 2*x + 3
    return y
```

In [15]:

```
def gradient_descent(func, func_value = 1.1, d = 0.01, max_iteration = 1000000, max_err = 0.000001)
    x = random.random() #initial guess for x
    grad = numerical_grad(func, x)
    x1 = x - d*grad
    for trial in range(max_iteration):
        df = Myfunc(x1) - Myfunc(x)
        if abs(df) < 0.000001:
            y = func(x)
            print("Iteration {}: f = {}, x = {}".format(trial, y, x))
            return x
        else :
            x = x1
            grad = numerical_grad(func, x)
            x1 = x - d*grad
            y = func(x)
            print ("Iteration {}: f = {}, x = {}".format(trial, y, x))
    raise ValueError ("Max iteration reached.")
    print ("Max Iteration {}: f = {}, x = {}".format(trial, y, x))
```

In [16]:

```
gradient_descent(Myfunc)
```

```
Iteration 0: f = 2.697105871262867, x = 0.16507133762047266
Iteration 1: f = 2.6695006424067054, x = 0.18176981086817312
Iteration 2: f = 2.642988577340379, x = 0.1981343146509018
Iteration 3: f = 2.6175263868429743, x = 0.21417152835814468
Iteration 4: f = 2.5930724959461453, x = 0.2298879977911361
Iteration 5: f = 2.569586976048528, x = 0.24529013783538778
Iteration 6: f = 2.5470314797202755, x = 0.26038423507859454
Iteration 7: f = 2.525369178088048, x = 0.275176450377026
Iteration 8: f = 2.5045647007011445, x = 0.28967282136951544
Iteration 9: f = 2.484584077777474, x = 0.3038792649421551
Iteration 10: f = 2.4653946847372405, x = 0.3178015796432532
Iteration 11: f = 2.4469651889326247, x = 0.33144544805032927
Iteration 12: f = 2.4292654984878235, x = 0.3448164390891484
Iteration 13: f = 2.412266713163575, x = 0.35792001030745757
Iteration 14: f = 2.395941077170675, x = 0.3707615101007611
Iteration 15: f = 2.380261933845137, x = 0.38334617989901565
Iteration 16: f = 2.365203682129164, x = 0.3956791563009232
Iteration 17: f = 2.35074173476373, x = 0.40776547317491696
Iteration 18: f = 2.3368524781446887, x = 0.4196100637117417
Iteration 19: f = 2.3235132337665925, x = 0.4312177624375102
Iteration 20: f = 2.3107022211909785, x = 0.44259330718856793
Iteration 21: f = 2.298398522483252, x = 0.4537413410450575
Iteration 22: f = 2.2865820480601897, x = 0.46466641422362676
Iteration 23: f = 2.2752335038825073, x = 0.475372985939051
Iteration 24: f = 2.264334359955369, x = 0.4858654262205575
Iteration 25: f = 2.253866820071493, x = 0.49614801769617634
Iteration 26: f = 2.243813792751464, x = 0.5062249573424515
Iteration 27: f = 2.234158863338507, x = 0.516100358195517
Iteration 28: f = 2.224886267194293, x = 0.5257782510319742
Iteration 29: f = 2.2159808639610588, x = 0.5352625860111337
Iteration 30: f = 2.2074281128366113, x = 0.5445572342910565
Iteration 31: f = 2.1992140488352216, x = 0.55366598960507
Iteration 32: f = 2.19132525998282, x = 0.5625925698129719
Iteration 33: f = 2.1837488654193713, x = 0.5713406184167069
Iteration 34: f = 2.176472494365898, x = 0.5799137060485093
Iteration 35: f = 2.169484265926317, x = 0.5883153319270717
Iteration 36: f = 2.1627727696855863, x = 0.5965489252888445
Iteration 37: f = 2.1563270470825744, x = 0.60461784678292
Iteration 38: f = 2.1501365735133584, x = 0.6125253898468208
Iteration 39: f = 2.1441912411469364, x = 0.620274782050314
Iteration 40: f = 2.1384813424238795, x = 0.6278691864090269
Iteration 41: f = 2.132997554201619, x = 0.6353117026807431
Iteration 42: f = 2.1277309225341994, x = 0.6426053686270605
Iteration 43: f = 2.122672848051132, x = 0.6497531612546203
Iteration 44: f = 2.117815071916586, x = 0.6567579980296911
Iteration 45: f = 2.113149662344051, x = 0.6636227380692161
Iteration 46: f = 2.108669001645149, x = 0.6703501833078795
Iteration 47: f = 2.10436577379143, x = 0.6769430796416365
Iteration 48: f = 2.1002329524685885, x = 0.6834041180485939
Iteration 49: f = 2.0962637896035945, x = 0.6897359356876875
Iteration 50: f = 2.092451804347127, x = 0.6959411169738217
Iteration 51: f = 2.088790772490525, x = 0.7020221946343574
Iteration 52: f = 2.085274716303589, x = 0.7079816507416203
Iteration 53: f = 2.0818978947735918, x = 0.7138219177267557
Iteration 54: f = 2.078654794231445, x = 0.7195453793722684
Iteration 55: f = 2.0755401193491303, x = 0.7251543717845776
Iteration 56: f = 2.0725487844924597, x = 0.7306511843492536
```

Iteration 57:  $f = 2.0696759054189346$ ,  $x = 0.7360380606622718$   
Iteration 58:  $f = 2.0669167913007644$ ,  $x = 0.7413171994492784$   
Iteration 59:  $f = 2.064266937067024$ ,  $x = 0.7464907554604294$   
Iteration 60:  $f = 2.061722016046871$ ,  $x = 0.751560840351464$   
Iteration 61:  $f = 2.0592778729053256$ ,  $x = 0.7565295235447933$   
Iteration 62:  $f = 2.0569305168583734$ ,  $x = 0.7613988330741583$   
Iteration 63:  $f = 2.0546761151567434$ ,  $x = 0.7661707564124121$   
Iteration 64:  $f = 2.052510986827264$ ,  $x = 0.7708472412837586$   
Iteration 65:  $f = 2.05043159666279$ ,  $x = 0.7754301964582289$   
Iteration 66:  $f = 2.0484345494505396$ ,  $x = 0.7799214925292808$   
Iteration 67:  $f = 2.046516584427579$ ,  $x = 0.784322962678965$   
Iteration 68:  $f = 2.0446745699569813$ ,  $x = 0.7886364034253268$   
Iteration 69:  $f = 2.042905498413914$ ,  $x = 0.7928635753569302$   
Iteration 70:  $f = 2.0412064812755433$ ,  $x = 0.7970062038496173$   
Iteration 71:  $f = 2.0395747444038315$ ,  $x = 0.8010659797726105$   
Iteration 72:  $f = 2.0380076235164646$ ,  $x = 0.8050445601772949$   
Iteration 73:  $f = 2.036502559836389$ ,  $x = 0.8089435689740099$   
Iteration 74:  $f = 2.035057095914067$ ,  $x = 0.8127645975941866$   
Iteration 75:  $f = 2.033668871613868$ ,  $x = 0.8165092056427148$   
Iteration 76:  $f = 2.0323356202619967$ ,  $x = 0.8201789215303257$   
Iteration 77:  $f = 2.031055164944706$ ,  $x = 0.8237752430993139$   
Iteration 78:  $f = 2.0298254149528248$ ,  $x = 0.8272996382377129$   
Iteration 79:  $f = 2.028644362370096$ ,  $x = 0.8307535454725978$   
Iteration 80:  $f = 2.0275100787926217$ ,  $x = 0.8341383745629449$   
Iteration 81:  $f = 2.0264207121814892$ ,  $x = 0.8374555070711742$   
Iteration 82:  $f = 2.0253744838378145$ ,  $x = 0.8407062969298074$   
Iteration 83:  $f = 2.024369685499401$ ,  $x = 0.8438920709912501$   
Iteration 84:  $f = 2.0234046765508094$ ,  $x = 0.8470141295713574$   
Iteration 85:  $f = 2.022477881344714$ ,  $x = 0.850073746979676$   
Iteration 86:  $f = 2.021587786629068$ ,  $x = 0.853072172039917$   
Iteration 87:  $f = 2.0207329390763613$ ,  $x = 0.8560106285993263$   
Iteration 88:  $f = 2.019911942910848$ ,  $x = 0.8588903160273964$   
Iteration 89:  $f = 2.0191234576291595$ ,  $x = 0.8617124097065854$   
Iteration 90:  $f = 2.018366195811443$ ,  $x = 0.864478061512377$   
Iteration 91:  $f = 2.0176389210197088$ ,  $x = 0.8671884002817953$   
Iteration 92:  $f = 2.0169404457784155$ ,  $x = 0.869844532276145$   
Iteration 93:  $f = 2.016269629636121$ ,  $x = 0.87244754163043$   
Iteration 94:  $f = 2.015625377302806$ ,  $x = 0.8749984907978869$   
Iteration 95:  $f = 2.0150066368619917$ ,  $x = 0.8774984209816394$   
Iteration 96:  $f = 2.014412398052599$ ,  $x = 0.8799483525619123$   
Iteration 97:  $f = 2.0138416906198167$ ,  $x = 0.8823492855108106$   
Iteration 98:  $f = 2.0132935827308582$ ,  $x = 0.8847021998004378$   
Iteration 99:  $f = 2.012767179453112$ ,  $x = 0.8870080558043525$   
Iteration 100:  $f = 2.012261621293276$ ,  $x = 0.8892677946879224$   
Iteration 101:  $f = 2.0117760827935687$ ,  $x = 0.8914823387942383$   
Iteration 102:  $f = 2.0113097711843877$ ,  $x = 0.8936525920184812$   
Iteration 103:  $f = 2.01086192508955$ ,  $x = 0.8957794401782926$   
Iteration 104:  $f = 2.010431813283225$ ,  $x = 0.8978637513748189$   
Iteration 105:  $f = 2.0100187334958806$ ,  $x = 0.899906376347539$   
Iteration 106:  $f = 2.009622011267791$ ,  $x = 0.9019081488206537$   
Iteration 107:  $f = 2.009240998847617$ ,  $x = 0.9038698858441463$   
Iteration 108:  $f = 2.008875074134842$ ,  $x = 0.9057923881268493$   
Iteration 109:  $f = 2.0085236396638284$ ,  $x = 0.9076764403641824$   
Iteration 110:  $f = 2.0081861216285484$ ,  $x = 0.9095228115570086$   
Iteration 111:  $f = 2.007861968945644$ ,  $x = 0.9113322553256054$   
Iteration 112:  $f = 2.0075506523542668$ ,  $x = 0.9131055102191943$   
Iteration 113:  $f = 2.007251663552367$ ,  $x = 0.9148433000148137$   
Iteration 114:  $f = 2.006964514366434$ ,  $x = 0.9165463340144142$   
Iteration 115:  $f = 2.006688735954406$ ,  $x = 0.9182153073344046$   
Iteration 116:  $f = 2.006423878040432$ ,  $x = 0.9198509011876488$   
Iteration 117:  $f = 2.0061695081792275$ ,  $x = 0.9214537831641301$

Iteration 118:  $f = 2.0059252110503816$ ,  $x = 0.9230246075009574$   
Iteration 119:  $f = 2.005690587780025$ ,  $x = 0.9245640153505952$   
Iteration 120:  $f = 2.005465255289438$ ,  $x = 0.9260726350433202$   
Iteration 121:  $f = 2.005248845669733$ ,  $x = 0.9275510823425726$   
Iteration 122:  $f = 2.0050410055811883$ ,  $x = 0.9289999606958665$   
Iteration 123:  $f = 2.0048413956762254$ ,  $x = 0.9304198614817039$   
Iteration 124:  $f = 2.0046496900451674$ ,  $x = 0.9318113642520465$   
Iteration 125:  $f = 2.0044655756843297$ ,  $x = 0.9331750369672398$   
Iteration 126:  $f = 2.0042887519849417$ ,  $x = 0.9345114362278273$   
Iteration 127:  $f = 2.0041189302421087$ ,  $x = 0.9358211075032563$   
Iteration 128:  $f = 2.003955833183558$ ,  $x = 0.9371045853534787$   
Iteration 129:  $f = 2.0037991945169824$ ,  $x = 0.9383623936465546$   
Iteration 130:  $f = 2.0036487584950944$ ,  $x = 0.9395950457735913$   
Iteration 131:  $f = 2.0035042794980944$ ,  $x = 0.9408030448579097$   
Iteration 132:  $f = 2.003365521632646$ ,  $x = 0.941986883960213$   
Iteration 133:  $f = 2.0032322583465643$ ,  $x = 0.943147046281092$   
Iteration 134:  $f = 2.003104272059222$ ,  $x = 0.9442840053555357$   
Iteration 135:  $f = 2.002981353806032$ ,  $x = 0.9453982252483306$   
Iteration 136:  $f = 2.0028633028972367$ ,  $x = 0.9464901607436871$   
Iteration 137:  $f = 2.002749926590415$ ,  $x = 0.947560257529092$   
Iteration 138:  $f = 2.0026410397756127$ ,  $x = 0.9486089523787178$   
Iteration 139:  $f = 2.0025364646731627$ ,  $x = 0.949636673331058$   
Iteration 140:  $f = 2.0024360305432927$ ,  $x = 0.9506438398647865$   
Iteration 141:  $f = 2.002339573407594$ ,  $x = 0.9516308630675119$   
Iteration 142:  $f = 2.002246935781$ ,  $x = 0.9525981458063071$   
Iteration 143:  $f = 2.00215796641484$ ,  $x = 0.9535460828902464$   
Iteration 144:  $f = 2.0020725200497846$ ,  $x = 0.9544750612324981$   
Iteration 145:  $f = 2.0019904571787395$ ,  $x = 0.9553854600075318$   
Iteration 146:  $f = 2.001911643818916$ ,  $x = 0.9562776508074378$   
Iteration 147:  $f = 2.00183595129329$ ,  $x = 0.9571519977911414$   
Iteration 148:  $f = 2.001763256020288$ ,  $x = 0.9580088578353929$   
Iteration 149:  $f = 2.0016934393121613$ ,  $x = 0.9588485806786529$   
Iteration 150:  $f = 2.0016263871810964$ ,  $x = 0.9596715090649766$   
Iteration 151:  $f = 2.0015619901531014$ ,  $x = 0.9604779788839024$   
Iteration 152:  $f = 2.0015001430893555$ ,  $x = 0.9612683193063432$   
Iteration 153:  $f = 2.0014407450144165$ ,  $x = 0.9620428529204772$   
Iteration 154:  $f = 2.0013836989514715$ ,  $x = 0.9628018958618667$   
Iteration 155:  $f = 2.001328911763811$ ,  $x = 0.963545757944908$   
Iteration 156:  $f = 2.0012762940030173$ ,  $x = 0.9642747427858445$   
Iteration 157:  $f = 2.0012257597626832$ ,  $x = 0.9649891479297756$   
Iteration 158:  $f = 2.0011772265381995$ ,  $x = 0.9656892649714499$   
Iteration 159:  $f = 2.0011306150921984$ ,  $x = 0.9663753796720598$   
Iteration 160:  $f = 2.0010858493249772$ ,  $x = 0.9670477720787019$   
Iteration 161:  $f = 2.0010428561503515$ ,  $x = 0.9677067166371756$   
Iteration 162:  $f = 2.0010015653762974$ ,  $x = 0.9683524823043377$   
Iteration 163:  $f = 2.00096190959032$ ,  $x = 0.9689853326582365$   
Iteration 164:  $f = 2.0009238240494245$ ,  $x = 0.9696055260051373$   
Iteration 165:  $f = 2.000887246574383$ ,  $x = 0.9702133154852155$   
Iteration 166:  $f = 2.0008521174482334$ ,  $x = 0.9708089491755856$   
Iteration 167:  $f = 2.0008183793187437$ ,  $x = 0.9713926701919973$   
Iteration 168:  $f = 2.0007859771047594$ ,  $x = 0.9719647167883116$   
Iteration 169:  $f = 2.000754857906343$ ,  $x = 0.9725253224524244$   
Iteration 170:  $f = 2.000724970918315$ ,  $x = 0.9730747160030773$   
Iteration 171:  $f = 2.00069626734731$ ,  $x = 0.9736131216831168$   
Iteration 172:  $f = 2.000668700332185$ ,  $x = 0.9741407592496443$   
Iteration 173:  $f = 2.0006422248674536$ ,  $x = 0.9746578440646103$   
Iteration 174:  $f = 2.0006167977297813$ ,  $x = 0.9751645871831882$   
Iteration 175:  $f = 2.0005923774074352$ ,  $x = 0.9756611954394834$   
Iteration 176:  $f = 2.000568924032506$ ,  $x = 0.9761478715309102$   
Iteration 177:  $f = 2.0005463993158434$ ,  $x = 0.9766248141003486$   
Iteration 178:  $f = 2.000524766484464$ ,  $x = 0.9770922178187447$

Iteration 179:  $f = 2.0005039902216137$ ,  $x = 0.977550273462382$   
Iteration 180:  $f = 2.000484036608989$ ,  $x = 0.977999167993262$   
Iteration 181:  $f = 2.000464873071432$ ,  $x = 0.978439084633711$   
Iteration 182:  $f = 2.000446468323755$ ,  $x = 0.9788702029409868$   
Iteration 183:  $f = 2.000428792319578$ ,  $x = 0.9792926988823303$   
Iteration 184:  $f = 2.000411816202363$ ,  $x = 0.979706744904687$   
Iteration 185:  $f = 2.0003955122582533$ ,  $x = 0.9801125100062058$   
Iteration 186:  $f = 2.0003798538707893$ ,  $x = 0.9805101598059607$   
Iteration 187:  $f = 2.000364815477514$ ,  $x = 0.9808998566101201$   
Iteration 188:  $f = 2.000350372528235$ ,  $x = 0.9812817594781165$   
Iteration 189:  $f = 2.0003365014449086$ ,  $x = 0.981656024288371$   
Iteration 190:  $f = 2.0003231795831327$ ,  $x = 0.9820228038022427$   
Iteration 191:  $f = 2.000310385195181$ ,  $x = 0.9823822477262012$   
Iteration 192:  $f = 2.0002980973945377$ ,  $x = 0.9827345027717782$   
Iteration 193:  $f = 2.000286296121759$ ,  $x = 0.9830797127164081$   
Iteration 194:  $f = 2.000274962111725$ ,  $x = 0.9834180184620478$   
Iteration 195:  $f = 2.0002640768621758$ ,  $x = 0.9837495580929079$   
Iteration 196:  $f = 2.000253622603533$ ,  $x = 0.9840744669309642$   
Iteration 197:  $f = 2.000243582269847$ ,  $x = 0.9843928775923572$   
Iteration 198:  $f = 2.000233939470962$ ,  $x = 0.9847049200406821$   
Iteration 199:  $f = 2.0002246784657585$ ,  $x = 0.9850107216398363$   
Iteration 200:  $f = 2.000215784136428$ ,  $x = 0.9853104072068652$   
Iteration 201:  $f = 2.0002072419637997$ ,  $x = 0.9856040990625892$   
Iteration 202:  $f = 2.0001990380036396$ ,  $x = 0.9858919170813407$   
Iteration 203:  $f = 2.000191158863887$ ,  $x = 0.9861739787398149$   
Iteration 204:  $f = 2.000183591682787$ ,  $x = 0.9864503991650309$   
Iteration 205:  $f = 2.000176324107877$ ,  $x = 0.986721291181849$   
Iteration 206:  $f = 2.000169344275841$ ,  $x = 0.9869867653582687$   
Iteration 207:  $f = 2.00016264079312$ ,  $x = 0.9872469300511688$   
Iteration 208:  $f = 2.0001562027173208$ ,  $x = 0.9875018914502731$   
Iteration 209:  $f = 2.000150019539355$ ,  $x = 0.9877517536212266$   
Iteration 210:  $f = 2.0001440811662663$ ,  $x = 0.9879966185486722$   
Iteration 211:  $f = 2.0001383779047477$ ,  $x = 0.9882365861779951$   
Iteration 212:  $f = 2.00013290044536$ ,  $x = 0.988471754454403$   
Iteration 213:  $f = 2.000127639847264$ ,  $x = 0.9887022193655581$   
Iteration 214:  $f = 2.000122587523683$ ,  $x = 0.9889280749784368$   
Iteration 215:  $f = 2.0001177352278527$ ,  $x = 0.9891494134788537$   
Iteration 216:  $f = 2.000113075039556$ ,  $x = 0.9893663252092089$   
Iteration 217:  $f = 2.0001085993522025$ ,  $x = 0.9895788987049037$   
Iteration 218:  $f = 2.0001043008604023$ ,  $x = 0.9897872207307556$   
Iteration 219:  $f = 2.0001001725480463$ ,  $x = 0.9899913763160817$   
Iteration 220:  $f = 2.0000962076768434$ ,  $x = 0.9901914487897812$   
Iteration 221:  $f = 2.0000923997753333$ ,  $x = 0.9903875198136425$   
Iteration 222:  $f = 2.000088742628285$ ,  $x = 0.9905796694174263$   
Iteration 223:  $f = 2.0000852302666$ ,  $x = 0.9907679760290633$   
Iteration 224:  $f = 2.0000818569575305$ ,  $x = 0.9909525165084054$   
Iteration 225:  $f = 2.000078617195336$ ,  $x = 0.9911333661778676$   
Iteration 226:  $f = 2.000075505692269$ ,  $x = 0.9913105988544024$   
Iteration 227:  $f = 2.0000725173699854$ ,  $x = 0.9914842868774776$   
Iteration 228:  $f = 2.0000696473512196$ ,  $x = 0.9916545011401623$   
Iteration 229:  $f = 2.000066890951836$ ,  $x = 0.9918213111175489$   
Iteration 230:  $f = 2.0000642436731697$ ,  $x = 0.9919847848956187$   
Iteration 231:  $f = 2.000061701194701$ ,  $x = 0.9921449891978873$   
Iteration 232:  $f = 2.000059259366985$ ,  $x = 0.9923019894138263$   
Iteration 233:  $f = 2.000056914204873$ ,  $x = 0.9924558496255087$   
Iteration 234:  $f = 2.0000546618810247$ ,  $x = 0.9926066326329219$   
Iteration 235:  $f = 2.0000524987196475$ ,  $x = 0.9927543999801691$   
Iteration 236:  $f = 2.000050421190494$ ,  $x = 0.9928992119807822$   
Iteration 237:  $f = 2.0000484259031133$ ,  $x = 0.9930411277412587$   
Iteration 238:  $f = 2.0000465096013$ ,  $x = 0.9931802051863747$   
Iteration 239:  $f = 2.000044669157777$ ,  $x = 0.9933165010827216$



Iteration 240:  $f = 2.000042901569107$ ,  $x = 0.9934500710609107$   
Iteration 241:  $f = 2.0000412039507682$ ,  $x = 0.9935809696395537$   
Iteration 242:  $f = 2.0000395735324603$ ,  $x = 0.9937092502465794$   
Iteration 243:  $f = 2.000038007653569$ ,  $x = 0.9938349652418821$   
Iteration 244:  $f = 2.000036503758841$ ,  $x = 0.9939581659373053$   
Iteration 245:  $f = 2.0000350593942025$ ,  $x = 0.9940789026184027$   
Iteration 246:  $f = 2.000033672202735$ ,  $x = 0.9941972245661979$   
Iteration 247:  $f = 2.00003233992086$ ,  $x = 0.9943131800749483$   
Iteration 248:  $f = 2.0000310603746208$ ,  $x = 0.9944268164734615$   
Iteration 249:  $f = 2.0000298314761373$ ,  $x = 0.994538180144191$   
Iteration 250:  $f = 2.0000286512202075$ ,  $x = 0.9946473165414438$   
Iteration 251:  $f = 2.0000275176810245$ ,  $x = 0.9947542702104761$   
Iteration 252:  $f = 2.00002642900903$ ,  $x = 0.9948590848061456$   
Iteration 253:  $f = 2.0000253834279045$ ,  $x = 0.9949618031097862$   
Iteration 254:  $f = 2.000024379231658$ ,  $x = 0.9950624670474162$   
Iteration 255:  $f = 2.000024379231658$ ,  $x = 0.9950624670474162$

Out[16]:

0.9950624670474162