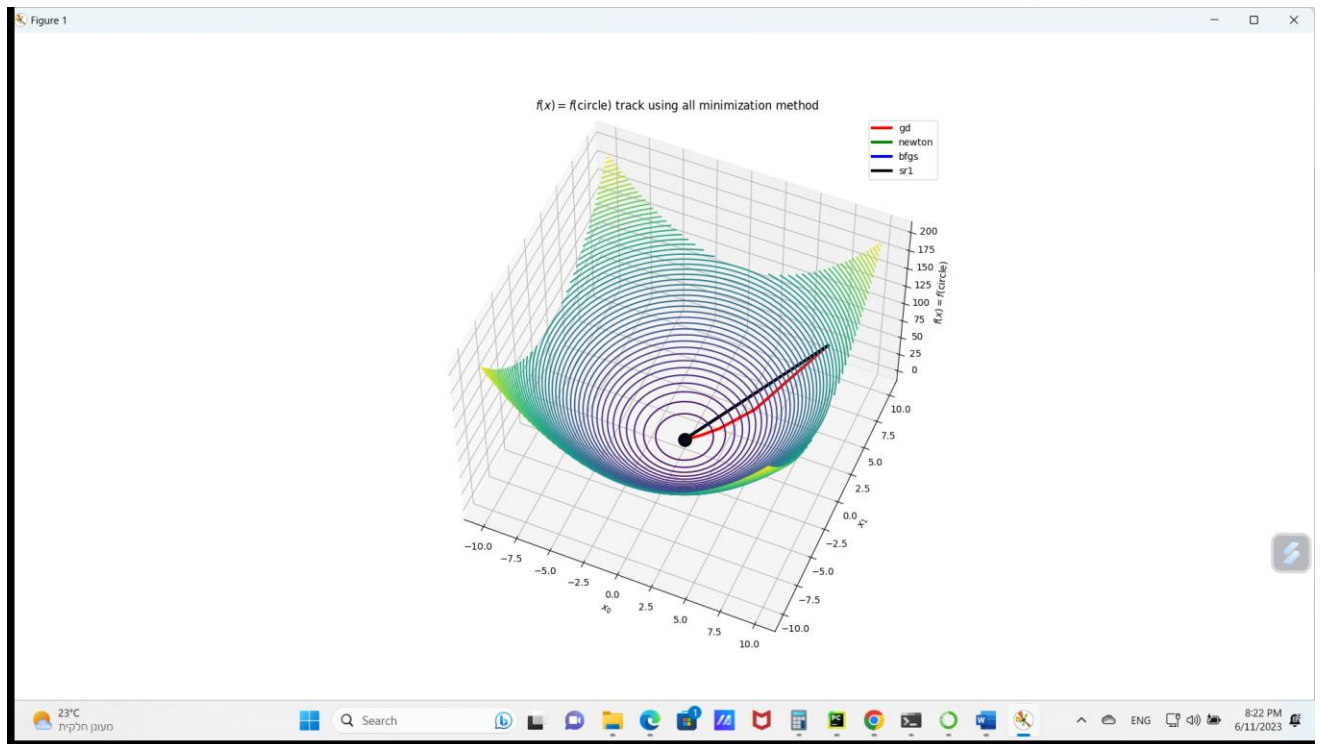**Name: Moti Marom**

ID: 025372830

Optimization programming assignment #1

Circular objective function

<u>Circular objective prints (<mark>final results are highlighted</mark>)</u>

Backend TkAgg is interactive backend. Turning interactive mode on.

The chosen method is = gd

GD: iter = 1, x = [8. 6.], f(x) = 100.0 :

 Backtrack: alpha = 0.25, f(x) = 100.0, f(x+ap) = 25.0, dgrad(x) = 0.01 :

GD: iter = 2, x = [4. 3.], f(x) = 25.0 :

 Backtrack: alpha = 0.25, f(x) = 25.0, f(x+ap) = 6.25, dgrad(x) = 0.0025 :

GD: iter = 3, x = [2. 1.5], f(x) = 6.25 :

 Backtrack: alpha = 0.25, f(x) = 6.25, f(x+ap) = 1.5625, dgrad(x) = 0.000625 :

GD: iter = 4, x = [1.   0.75], f(x) = 1.5625 :

 Backtrack: alpha = 0.25, f(x) = 1.5625, f(x+ap) = 0.390625, dgrad(x) = 0.00015625 :

GD: iter = 5, x = [0.5   0.375], f(x) = 0.390625 :

 Backtrack: alpha = 0.25, f(x) = 0.390625, f(x+ap) = 0.09765625, dgrad(x) = 3.90625e-05 :

GD: iter = 6, x = [0.25   0.1875], f(x) = 0.09765625 :

 Backtrack: alpha = 0.25, f(x) = 0.09765625, f(x+ap) = 0.0244140625, dgrad(x) = 9.765625e-06 :

GD: iter = 7, x = [0.125   0.09375], f(x) = 0.0244140625 :

 Backtrack: alpha = 0.25, f(x) = 0.0244140625, f(x+ap) = 0.006103515625, dgrad(x) = 2.44140625e-06
:

GD: iter = 8, x = [0.0625   0.046875], f(x) = 0.006103515625 :

 Backtrack: alpha = 0.25, f(x) = 0.006103515625, f(x+ap) = 0.00152587890625, dgrad(x) =
6.103515625e-07 :

GD: iter = 9, x = [0.03125   0.0234375], f(x) = 0.00152587890625 :

 Backtrack: alpha = 0.25, f(x) = 0.00152587890625, f(x+ap) = 0.0003814697265625, dgrad(x) =
1.52587890625e-07 :

GD: iter = 10, x = [0.015625   0.01171875], f(x) = 0.0003814697265625 :

 Backtrack: alpha = 0.25, f(x) = 0.0003814697265625, f(x+ap) = 9.5367431640625e-05, dgrad(x) =
3.814697265625e-08 :

GD: iter = 11, x = [0.0078125 0.00585938], f(x) = 9.5367431640625e-05 :

 Backtrack: alpha = 0.25, f(x) = 9.5367431640625e-05, f(x+ap) = 2.384185791015625e-05, dgrad(x) =
9.5367431640625e-09 :

GD: iter = 12, x = [0.00390625 0.00292969], f(x) = 2.384185791015625e-05 :

 Backtrack: alpha = 0.25, f(x) = 2.384185791015625e-05, f(x+ap) = 5.9604644775390625e-06,
dgrad(x) = 2.384185791015625e-09 :

GD: iter = 13, x = [0.00195312 0.00146484], f(x) = 5.9604644775390625e-06 :

 Backtrack: alpha = 0.25, f(x) = 5.9604644775390625e-06, f(x+ap) = 1.4901161193847656e-06, dgrad(x) = 5.960464477539063e-10 :

GD: iter = 14, x = [0.00097656 0.00073242], f(x) = 1.4901161193847656e-06 :

 Backtrack: alpha = 0.25, f(x) = 1.4901161193847656e-06, f(x+ap) = 3.725290298461914e-07, dgrad(x) = 1.4901161193847657e-10 :

GD: iter = 15, x = [0.00048828 0.00036621], f(x) = 3.725290298461914e-07 :

 Backtrack: alpha = 0.25, f(x) = 3.725290298461914e-07, f(x+ap) = 9.313225746154785e-08, dgrad(x) = 3.725290298461914e-11 :

GD: iter = 16, x = [0.00024414 0.00018311], f(x) = 9.313225746154785e-08 :

 Backtrack: alpha = 0.25, f(x) = 9.313225746154785e-08, f(x+ap) = 2.3283064365386963e-08, dgrad(x) = 9.313225746154785e-12 :

GD: iter = 17, x = [1.22070312e-04 9.15527344e-05], f(x) = 2.3283064365386963e-08 :

 Backtrack: alpha = 0.25, f(x) = 2.3283064365386963e-08, f(x+ap) = 5.820766091346741e-09, dgrad(x) = 2.3283064365386963e-12 :

GD: iter = 18, x = [6.10351562e-05 4.57763672e-05], f(x) = 5.820766091346741e-09 :

 Backtrack: alpha = 0.25, f(x) = 5.820766091346741e-09, f(x+ap) = 1.4551915228366852e-09, dgrad(x) = 5.820766091346741e-13 :

GD: iter = 19, x = [3.05175781e-05 2.28881836e-05], f(x) = 1.4551915228366852e-09 :

 Backtrack: alpha = 0.25, f(x) = 1.4551915228366852e-09, f(x+ap) = 3.637978807091713e-10, dgrad(x) = 1.4551915228366852e-13 :

GD: iter = 20, x = [1.52587891e-05 1.14440918e-05], f(x) = 3.637978807091713e-10 :

 Backtrack: alpha = 0.25, f(x) = 3.637978807091713e-10, f(x+ap) = 9.094947017729282e-11, dgrad(x) = 3.637978807091713e-14 :

GD: iter = 21, x = [7.62939453e-06 5.72204590e-06], f(x) = 9.094947017729282e-11 :

 Backtrack: alpha = 0.25, f(x) = 9.094947017729282e-11, f(x+ap) = 2.2737367544323206e-11, dgrad(x) = 9.094947017729283e-15 :

GD: iter = 22, x = [3.81469727e-06 2.86102295e-06], f(x) = 2.2737367544323206e-11 :

 Backtrack: alpha = 0.25, f(x) = 2.2737367544323206e-11, f(x+ap) = 5.6843418860808015e-12, dgrad(x) = 2.2737367544323206e-15 :

GD: iter = 23, x = [1.90734863e-06 1.43051147e-06], f(x) = 5.6843418860808015e-12 :

 Backtrack: alpha = 0.25, f(x) = 5.6843418860808015e-12, f(x+ap) = 1.4210854715202004e-12, dgrad(x) = 5.684341886080802e-16 :

GD: iter = 24, x = [9.53674316e-07 7.15255737e-07], f(x) = 1.4210854715202004e-12 :

Backtrack: alpha = 0.25, f(x) = 1.4210854715202004e-12, f(x+ap) = 3.552713678800501e-13, dgrad(x) = 1.4210854715202004e-16 :

GD: iter = 25, x = [4.76837158e-07 3.57627869e-07], f(x) = 3.552713678800501e-13 :

Backtrack: alpha = 0.25, f(x) = 3.552713678800501e-13, f(x+ap) = 8.881784197001252e-14, dgrad(x) = 3.552713678800501e-17 :

GD: iter = 26, x = [2.38418579e-07 1.78813934e-07], f(x) = 8.881784197001252e-14 :

GD termination: small df = 2.6645352591003757e-13

==GD final: iter = 26, x = [2.38418579e-07 1.78813934e-07], f(x) = 8.881784197001252e-14, OK = True:==

The chosen method is = newton

Newton: iter = 1, x = [8. 6.], f(x) = 100.0 :

Backtrack: alpha = 1.0, f(x) = 100.0, f(x+ap) = 0.0, dgrad(x) = 0.02 :

Newton: iter = 2, x = [0. 0.], f(x) = 0.0 :

Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

Newton: iter = 3, x = [0. 0.], f(x) = 0.0 :

Newton termination: small dx = [0. 0.]

==Newton final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :==

The chosen method is = bfgs

BFGS: iter = 1, x = [8. 6.], f(x) = 100.0 :

Backtrack: alpha = 1.0, f(x) = 100.0, f(x+ap) = 0.0, dgrad(x) = 0.02 :

BFGS: iter = 2, x = [0. 0.], f(x) = 0.0 :

Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

BFGS: iter = 3, x = [0. 0.], f(x) = 0.0 :

BFGS termination: small dx = [0. 0.]

==BFGS final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :==

The chosen method is = sr1

SR1: iter = 1, x = [8. 6.], f(x) = 100.0 :

Backtrack: alpha = 1.0, f(x) = 100.0, f(x+ap) = 0.0, dgrad(x) = 0.02 :

SR1: iter = 2, x = [0. 0.], f(x) = 0.0 :
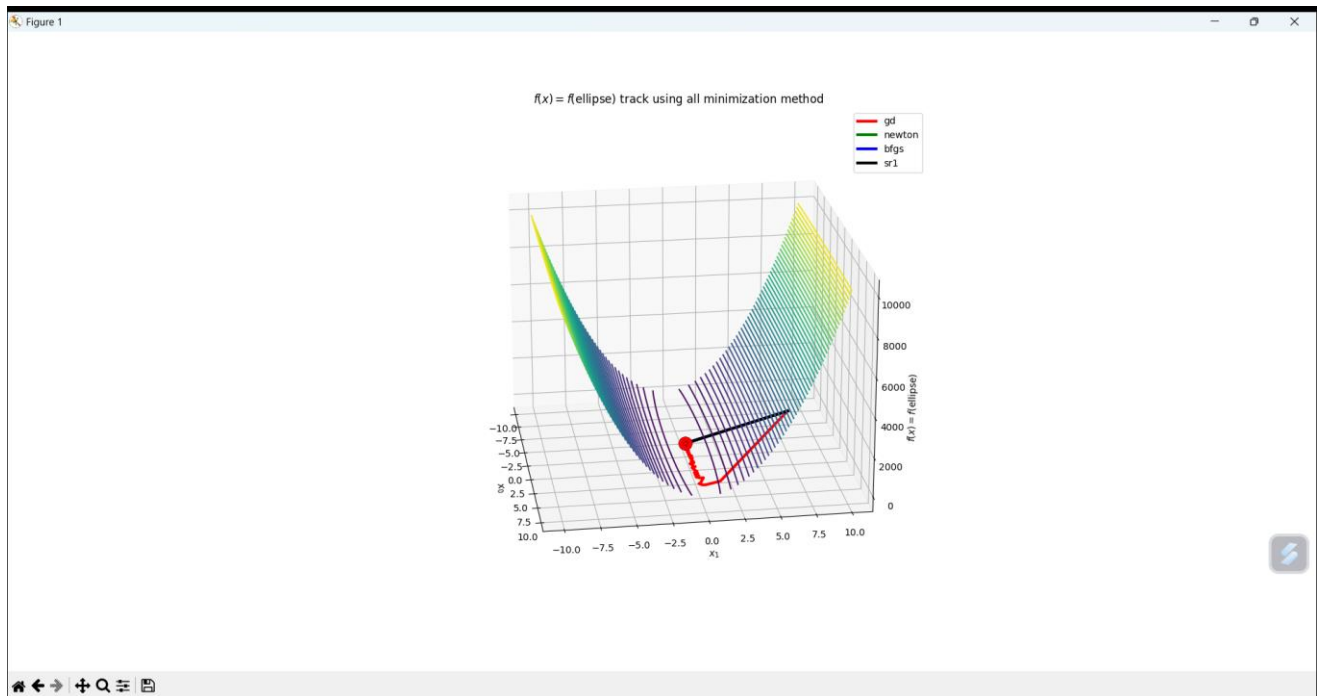
Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

SR1: iter = 3, x = [0. 0.], f(x) = 0.0 :

SR1 termination: small dx = [0. 0.]

==SR1 final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :==

Ellipse objective function

Ellipse objective prints (<mark>final results are highlighted</mark>)

You chose 2: ellipse

Backend TkAgg is interactive backend. Turning interactive mode on.

The chosen method is = gd

GD: iter = 1, x = [8. 6.], f(x) = 3664.0 :

 Backtrack: alpha = 0.00390625, f(x) = 3664.0, f(x+ap) = 235.26953125, dgrad(x) = 0.5626 :

GD: iter = 2, x = [7.9375 1.3125], f(x) = 235.26953125 :

 Backtrack: alpha = 0.00390625, f(x) = 235.26953125, f(x+ap) = 70.26649498939514, dgrad(x) = 0.027014947509765627 :

GD: iter = 3, x = [7.87548828 0.28710938], f(x) = 70.26649498939514 :

 Backtrack: alpha = 0.00390625, f(x) = 70.26649498939514, f(x+ap) = 61.45243597404624, dgrad(x) = 0.001384908199682832 :

GD: iter = 4, x = [7.81396103 0.06280518], f(x) = 61.45243597404624 :

 Backtrack: alpha = 0.015625, f(x) = 61.45243597404624, f(x+ap) = 59.08267353172688, dgrad(x) = 0.000628143050079325 :

GD: iter = 5, x = [7.56977475 -0.133461], f(x) = 59.08267353172688 :

 Backtrack: alpha = 0.00390625, f(x) = 59.08267353172688, f(x+ap) = 56.49488377580178, dgrad(x) = 0.00036784354846677587 :

GD: iter = 6, x = [7.51063588 -0.02919459], f(x) = 56.49488377580178 :

 Backtrack: alpha = 0.0625, f(x) = 56.49488377580178, f(x+ap) = 54.460627988708886, dgrad(x) = 0.0016233223550606568 :

GD: iter = 7, x = [6.5718064 0.33573782], f(x) = 54.460627988708886 :

 Backtrack: alpha = 0.00390625, f(x) = 54.460627988708886, f(x+ap) = 43.05583511945294, dgrad(x) = 0.0018287304795465585 :

GD: iter = 8, x = [6.52046416 0.07344265], f(x) = 43.05583511945294 :

 Backtrack: alpha = 0.015625, f(x) = 43.05583511945294, f(x+ap) = 42.336342585061324, dgrad(x) = 0.0006028417494473458 :

GD: iter = 9, x = [6.31669965 -0.15606563], f(x) = 42.336342585061324 :

 Backtrack: alpha = 0.00390625, f(x) = 42.336342585061324, f(x+ap) = 39.39623107816882, dgrad(x) = 0.0004429148454679516 :

GD: iter = 10, x = [6.26735044 -0.03413936], f(x) = 39.39623107816882 :

 Backtrack: alpha = 0.015625, f(x) = 39.39623107816882, f(x+ap) = 37.38935461434724, dgrad(x) = 0.00031834148798371483 :

GD: iter = 11, x = [6.07149574 0.07254613], f(x) = 37.38935461434724 :

Backtrack: alpha = 0.015625, f(x) = 37.38935461434724, f(x+ap) = 36.97166522588397, dgrad(x) = 0.0005593279607514069 :

GD: iter = 12, x = [5.8817615 -0.15416053], f(x) = 36.97166522588397 :

Backtrack: alpha = 0.00390625, f(x) = 36.97166522588397, f(x+ap) = 34.170402564108166, dgrad(x) = 0.0004253903319349432 :

GD: iter = 13, x = [5.83581023 -0.03372262], f(x) = 34.170402564108166 :

Backtrack: alpha = 0.015625, f(x) = 34.170402564108166, f(x+ap) = 32.47492056822086, dgrad(x) = 0.0002839301845645646 :

GD: iter = 14, x = [5.65344116 0.07166056], f(x) = 32.47492056822086 :

Backtrack: alpha = 0.015625, f(x) = 32.47492056822086, f(x+ap) = 32.31390188869735, dgrad(x) = 0.0005207109677347992 :

GD: iter = 15, x = [5.47677113 -0.15227869], f(x) = 32.31390188869735 :

Backtrack: alpha = 0.00390625, f(x) = 32.31390188869735, f(x+ap) = 29.639142538951653, dgrad(x) = 0.00040919220763471466 :

GD: iter = 16, x = [5.43398385 -0.03331096], f(x) = 29.639142538951653 :

Backtrack: alpha = 0.015625, f(x) = 29.639142538951653, f(x+ap) = 28.21256824654524, dgrad(x) = 0.00025390239501199324 :

GD: iter = 17, x = [5.26417186 0.0707858], f(x) = 28.21256824654524 :

Backtrack: alpha = 0.00390625, f(x) = 28.21256824654524, f(x+ap) = 27.304181091697874, dgrad(x) = 0.00012159030564883874 :

GD: iter = 18, x = [5.22304551 0.01548439], f(x) = 27.304181091697874 :

Backtrack: alpha = 0.0625, f(x) = 27.304181091697874, f(x+ap) = 24.057317542231996, dgrad(x) = 0.0007419467182364621 :

GD: iter = 19, x = [4.57016483 -0.17807052], f(x) = 24.057317542231996 :

Backtrack: alpha = 0.00390625, f(x) = 24.057317542231996, f(x+ap) = 20.713064280646638, dgrad(x) = 0.0005280898556813639 :

GD: iter = 20, x = [4.53446041 -0.03895293], f(x) = 20.713064280646638 :

Backtrack: alpha = 0.015625, f(x) = 20.713064280646638, f(x+ap) = 19.981496994886765, dgrad(x) = 0.00022334147423083725 :

GD: iter = 21, x = [4.39275852 0.08277497], f(x) = 19.981496994886765 :

Backtrack: alpha = 0.00390625, f(x) = 19.981496994886765, f(x+ap) = 19.028786527917998, dgrad(x) = 0.00013720825192870578 :

GD: iter = 22, x = [4.3584401 0.01810702], f(x) = 19.028786527917998 :

Backtrack: alpha = 0.0625, f(x) = 19.028786527917998, f(x+ap) = 18.879818331638614, dgrad(x) = 0.0005568660847735058 :

GD: iter = 23, x = [3.81363509 -0.20823078], f(x) = 18.879818331638614 :

 Backtrack: alpha = 0.00390625, f(x) = 18.879818331638614, f(x+ap) = 14.524937835700825, dgrad(x) = 0.0007002256069786381 :

GD: iter = 24, x = [3.78384106 -0.04555048], f(x) = 14.524937835700825 :

 Backtrack: alpha = 0.015625, f(x) = 14.524937835700825, f(x+ap) = 14.37351712418107, dgrad(x) = 0.00021916198901585342 :

GD: iter = 25, x = [3.66559603 0.09679478], f(x) = 14.37351712418107 :

 Backtrack: alpha = 0.00390625, f(x) = 14.37351712418107, f(x+ap) = 13.27230079194493, dgrad(x) = 0.0001673888777715603 :

GD: iter = 26, x = [3.63695856 0.02117386], f(x) = 13.27230079194493 :

 Backtrack: alpha = 0.015625, f(x) = 13.27230079194493, f(x+ap) = 12.61611831916261, dgrad(x) = 0.00011069243700428998 :

GD: iter = 27, x = [3.52330361 -0.04499445], f(x) = 12.61611831916261 :

 Backtrack: alpha = 0.015625, f(x) = 12.61611831916261, f(x+ap) = 12.564125142752223, dgrad(x) = 0.0002041166924445987 :

GD: iter = 28, x = [3.41320037 0.0956132], f(x) = 12.564125142752223 :

 Backtrack: alpha = 0.00390625, f(x) = 12.564125142752223, f(x+ap) = 11.512362885832593, dgrad(x) = 0.00016104496273282206 :

GD: iter = 29, x = [3.38653474 0.02091539], f(x) = 11.512362885832593 :

 Backtrack: alpha = 0.015625, f(x) = 11.512362885832593, f(x+ap) = 10.96056633296805, dgrad(x) = 9.901969906249399e-05 :

GD: iter = 30, x = [3.28070553 -0.0444452], f(x) = 10.96056633296805 :

 Backtrack: alpha = 0.00390625, f(x) = 10.96056633296805, f(x+ap) = 10.604965847925596, dgrad(x) = 4.768247695200336e-05 :

GD: iter = 31, x = [3.25507502 -0.00972239], f(x) = 10.604965847925596 :

 Backtrack: alpha = 0.0625, f(x) = 10.604965847925596, f(x+ap) = 9.362280550719648, dgrad(x) = 0.00028851903699158205 :

GD: iter = 32, x = [2.84819064 0.11180745], f(x) = 9.362280550719648 :

 Backtrack: alpha = 0.00390625, f(x) = 9.362280550719648, f(x+ap) = 8.045750872587544, dgrad(x) = 0.00020800195757504465 :

GD: iter = 33, x = [2.82593915 0.02445788], f(x) = 8.045750872587544 :

 Backtrack: alpha = 0.015625, f(x) = 8.045750872587544, f(x+ap) = 7.764729312378891, dgrad(x) = 8.729881919004994e-05 :

GD: iter = 34, x = [2.73762855 -0.051973], f(x) = 7.764729312378891 :

Backtrack: alpha = 0.00390625, f(x) = 7.764729312378891, f(x+ap) = 7.390889868276232, dgrad(x) = 5.391645686431538e-05 :

GD: iter = 35, x = [2.71624083 -0.01136909], f(x) = 7.390889868276232 :

Backtrack: alpha = 0.0625, f(x) = 7.390889868276232, f(x+ap) = 7.358168027680807, dgrad(x) = 0.00021676317324397532 :

GD: iter = 36, x = [2.37671073 0.13074457], f(x) = 7.358168027680807 :

Backtrack: alpha = 0.00390625, f(x) = 7.358168027680807, f(x+ap) = 5.642635003930273, dgrad(x) = 0.0002759221397012161 :

GD: iter = 37, x = [2.35814267 0.02860037], f(x) = 5.642635003930273 :

Backtrack: alpha = 0.015625, f(x) = 5.642635003930273, f(x+ap) = 5.588084784518785, dgrad(x) = 8.587906684386219e-05 :

GD: iter = 38, x = [2.28445071 -0.06077579], f(x) = 5.588084784518785 :

Backtrack: alpha = 0.00390625, f(x) = 5.588084784518785, f(x+ap) = 5.15516608662219, dgrad(x) = 6.586826076497901e-05 :

GD: iter = 39, x = [2.26660344 -0.01329471], f(x) = 5.15516608662219 :

Backtrack: alpha = 0.015625, f(x) = 5.15516608662219, f(x+ap) = 4.901228353960293, dgrad(x) = 4.315614365142483e-05 :

GD: iter = 40, x = [2.19577209 0.02825125], f(x) = 4.901228353960293 :

Backtrack: alpha = 0.015625, f(x) = 4.901228353960293, f(x+ap) = 4.8851919672862625, dgrad(x) = 8.00171580138213e-05 :

GD: iter = 41, x = [2.12715421 -0.0600339], f(x) = 4.8851919672862625 :

Backtrack: alpha = 0.00390625, f(x) = 4.8851919672862625, f(x+ap) = 4.471607464391747, dgrad(x) = 6.338356147878156e-05 :

GD: iter = 42, x = [2.11053582 -0.01313242], f(x) = 4.471607464391747 :

Backtrack: alpha = 0.015625, f(x) = 4.471607464391747, f(x+ap) = 4.258190430505343, dgrad(x) = 3.8618531037077107e-05 :

GD: iter = 43, x = [2.04458157 0.02790638], f(x) = 4.258190430505343 :

Backtrack: alpha = 0.00390625, f(x) = 4.258190430505343, f(x+ap) = 4.118978063345159, dgrad(x) = 1.8699963513124326e-05 :

GD: iter = 44, x = [2.02860828 0.00610452], f(x) = 4.118978063345159 :

Backtrack: alpha = 0.0625, f(x) = 4.118978063345159, f(x+ap) = 3.643571516478518, dgrad(x) = 0.00011219758451030909 :

GD: iter = 45, x = [1.77503224 -0.070202], f(x) = 3.643571516478518 :

Backtrack: alpha = 0.00390625, f(x) = 3.643571516478518, f(x+ap) = 3.125284249636881, dgrad(x) = 8.192803859158798e-05 :

GD: iter = 46, x = [1.7611648 -0.01535669], f(x) = 3.125284249636881 :

 Backtrack: alpha = 0.015625, f(x) = 3.125284249636881, f(x+ap) = 3.01736513749493, dgrad(x) = 3.41248740085017e-05 :

GD: iter = 47, x = [1.7061284 0.03263296], f(x) = 3.01736513749493 :

 Backtrack: alpha = 0.00390625, f(x) = 3.01736513749493, f(x+ap) = 2.8706651481043974, dgrad(x) = 2.1187460810735726e-05 :

GD: iter = 48, x = [1.69279928 0.00713846], f(x) = 2.8706651481043974 :

 Backtrack: alpha = 0.0625, f(x) = 2.8706651481043974, f(x+ap) = 2.867865970012162, dgrad(x) = 8.437863747427549e-05 :

GD: iter = 49, x = [1.48119937 -0.08209229], f(x) = 2.867865970012162 :

 Backtrack: alpha = 0.00390625, f(x) = 2.867865970012162, f(x+ap) = 2.192052834350524, dgrad(x) = 0.00010872717558144208 :

GD: iter = 50, x = [1.4696275 -0.01795769], f(x) = 2.192052834350524 :

 Backtrack: alpha = 0.015625, f(x) = 2.192052834350524, f(x+ap) = 2.17254558157858, dgrad(x) = 3.3653691992665803e-05 :

GD: iter = 51, x = [1.42370164 0.03816009], f(x) = 2.17254558157858 :

 Backtrack: alpha = 0.00390625, f(x) = 2.17254558157858, f(x+ap) = 2.0023474477032432, dgrad(x) = 2.5920077290883653e-05 :

GD: iter = 52, x = [1.41257897 0.00834752], f(x) = 2.0023474477032432 :

 Backtrack: alpha = 0.015625, f(x) = 2.0023474477032432, f(x+ap) = 1.9040821053689965, dgrad(x) = 1.682618821284718e-05 :

GD: iter = 53, x = [1.36843587 -0.01773848], f(x) = 1.9040821053689965 :

 Backtrack: alpha = 0.015625, f(x) = 1.9040821053689965, f(x+ap) = 1.8994926977526851, dgrad(x) = 3.136970559760079e-05 :

GD: iter = 54, x = [1.32567225 0.03769427], f(x) = 1.8994926977526851 :

 Backtrack: alpha = 0.00390625, f(x) = 1.8994926977526851, f(x+ap) = 1.736853731310154, dgrad(x) = 2.4946850367128714e-05 :

GD: iter = 55, x = [1.31531544 0.00824562], f(x) = 1.736853731310154 :

 Backtrack: alpha = 0.015625, f(x) = 1.736853731310154, f(x+ap) = 1.6543176454591335, dgrad(x) = 1.5062233314116656e-05 :

GD: iter = 56, x = [1.27421183 -0.01752194], f(x) = 1.6543176454591335 :

 Backtrack: alpha = 0.00390625, f(x) = 1.6543176454591335, f(x+ap) = 1.5998150250589034, dgrad(x) = 7.334064194470318e-06 :

GD: iter = 57, x = [1.26425705 -0.00383293], f(x) = 1.5998150250589034 :

Backtrack: alpha = 0.0625, f(x) = 1.5998150250589034, f(x+ap) = 1.4180262332275138, dgrad(x) = 4.363147642020041e-05 :

GD: iter = 58, x = [1.10622492 0.04407864], f(x) = 1.4180262332275138 :

Backtrack: alpha = 0.00390625, f(x) = 1.4180262332275138, f(x+ap) = 1.2139846356145898, dgrad(x) = 3.2270311612574524e-05 :

GD: iter = 59, x = [1.09758254 0.0096422], f(x) = 1.2139846356145898 :

Backtrack: alpha = 0.015625, f(x) = 1.2139846356145898, f(x+ap) = 1.1725536183079688, dgrad(x) = 1.3340050986398495e-05 :

GD: iter = 60, x = [1.06328308 -0.02048968], f(x) = 1.1725536183079688 :

Backtrack: alpha = 0.00390625, f(x) = 1.1725536183079688, f(x+ap) = 1.1149836884906301, dgrad(x) = 8.326314196537109e-06 :

GD: iter = 61, x = [1.05497618 -0.00448212], f(x) = 1.1149836884906301 :

Backtrack: alpha = 0.015625, f(x) = 1.1149836884906301, f(x+ap) = 1.0535723281949776, dgrad(x) = 8.211678362553213e-06 :

GD: iter = 62, x = [1.02200818 0.0095245], f(x) = 1.0535723281949776 :

Backtrack: alpha = 0.015625, f(x) = 1.0535723281949776, f(x+ap) = 1.0212034327575477, dgrad(x) = 1.2197885792494828e-05 :

GD: iter = 63, x = [0.99007042 -0.02023956], f(x) = 1.0212034327575477 :

Backtrack: alpha = 0.00390625, f(x) = 1.0212034327575477, f(x+ap) = 0.9669432221165659, dgrad(x) = 7.932247458327527e-06 :

GD: iter = 64, x = [0.9823355 -0.0044274], f(x) = 0.9669432221165659 :

Backtrack: alpha = 0.015625, f(x) = 0.9669432221165659, f(x+ap) = 0.9144654450189339, dgrad(x) = 7.256263254000213e-06 :

GD: iter = 65, x = [0.95163751 0.00940823], f(x) = 0.9144654450189339 :

Backtrack: alpha = 0.015625, f(x) = 0.9144654450189339, f(x+ap) = 0.8898674702813103, dgrad(x) = 1.1192266616649808e-05 :

GD: iter = 66, x = [0.92189884 -0.0199925], f(x) = 0.8898674702813103 :

Backtrack: alpha = 0.00390625, f(x) = 0.8898674702813103, f(x+ap) = 0.8385823266196012, dgrad(x) = 7.573276680698707e-06 :

GD: iter = 67, x = [0.91469651 -0.00437336], f(x) = 0.8385823266196012 :

Backtrack: alpha = 0.015625, f(x) = 0.8385823266196012, f(x+ap) = 0.79383160909378, dgrad(x) = 6.424577350594475e-06 :

GD: iter = 68, x = [0.88611224 0.00929339], f(x) = 0.79383160909378 :

Backtrack: alpha = 0.015625, f(x) = 0.79383160909378, f(x+ap) = 0.7758871363028798, dgrad(x) = 1.0305408914104074e-05 :

GD: iter = 69, x = [0.85842123 -0.01974845], f(x) = 0.7758871363028798 :

 Backtrack: alpha = 0.00390625, f(x) = 0.7758871363028798, f(x+ap) = 0.7272843474690005, dgrad(x) = 7.245155026451519e-06 :

GD: iter = 70, x = [0.85171482 -0.00431997], f(x) = 0.7272843474690005 :

 Backtrack: alpha = 0.015625, f(x) = 0.7272843474690005, f(x+ap) = 0.6892150487994285, dgrad(x) = 5.700248802239594e-06 :

GD: iter = 71, x = [0.82509873 0.00917994], f(x) = 0.6892150487994285 :

 Backtrack: alpha = 0.015625, f(x) = 0.6892150487994285, f(x+ap) = 0.6769572830909684, dgrad(x) = 9.521883917986437e-06 :

GD: iter = 72, x = [0.79931439 -0.01950738], f(x) = 0.6769572830909684 :

 Backtrack: alpha = 0.00390625, f(x) = 0.6769572830909684, f(x+ap) = 0.6307805623133933, dgrad(x) = 6.944190170470703e-06 :

GD: iter = 73, x = [0.79306975 -0.00426724], f(x) = 0.6307805623133933 :

 Backtrack: alpha = 0.015625, f(x) = 0.6307805623133933, f(x+ap) = 0.5984865212027776, dgrad(x) = 5.069080765890006e-06 :

GD: iter = 74, x = [0.76828632 0.00906788], f(x) = 0.5984865212027776 :

 Backtrack: alpha = 0.015625, f(x) = 0.5984865212027776, f(x+ap) = 0.5910792136838442, dgrad(x) = 8.828305611636815e-06 :

GD: iter = 75, x = [0.74427737 -0.01926925], f(x) = 0.5910792136838442 :

 Backtrack: alpha = 0.00390625, f(x) = 0.5910792136838442, f(x+ap) = 0.5471039166812757, dgrad(x) = 6.667170813726796e-06 :

GD: iter = 76, x = [0.73846271 -0.00421515], f(x) = 0.5471039166812757 :

 Backtrack: alpha = 0.015625, f(x) = 0.5471039166812757, f(x+ap) = 0.5197998940365006, dgrad(x) = 4.518762243222597e-06 :

GD: iter = 77, x = [0.71538575 0.00895719], f(x) = 0.5197998940365006 :

 Backtrack: alpha = 0.015625, f(x) = 0.5197998940365006, f(x+ap) = 0.516519934821056, dgrad(x) = 8.213059318755881e-06 :

GD: iter = 78, x = [0.69302994 -0.01903403], f(x) = 0.516519934821056 :

 Backtrack: alpha = 0.00390625, f(x) = 0.516519934821056, f(x+ap) = 0.47454891142141525, dgrad(x) = 6.411302962677514e-06 :

GD: iter = 79, x = [0.68761565 -0.00416369], f(x) = 0.47454891142141525 :

 Backtrack: alpha = 0.015625, f(x) = 0.47454891142141525, f(x+ap) = 0.4515545009430189, dgrad(x) = 4.038617366936428e-06 :

GD: iter = 80, x = [0.66612766 0.00884785], f(x) = 0.4515545009430189 :

Backtrack: alpha = 0.00390625, f(x) = 0.4515545009430189, f(x+ap) = 0.43719452192330593, dgrad(x) = 1.916516594401968e-06 :

GD: iter = 81, x = [0.66092353 0.00193547], f(x) = 0.43719452192330593 :

 Backtrack: alpha = 0.0625, f(x) = 0.43719452192330593, f(x+ap) = 0.38398154403128065, dgrad(x) = 1.1857006355070877e-05 :

GD: iter = 82, x = [0.57830809 -0.02225787], f(x) = 0.38398154403128065 :

 Backtrack: alpha = 0.00390625, f(x) = 0.38398154403128065, f(x+ap) = 0.3316056621774614, dgrad(x) = 8.263390059373444e-06 :

GD: iter = 83, x = [0.57379006 -0.00486891], f(x) = 0.3316056621774614 :

 Backtrack: alpha = 0.015625, f(x) = 0.3316056621774614, f(x+ap) = 0.31968423133789525, dgrad(x) = 3.539361661829462e-06 :

GD: iter = 84, x = [0.55585912 0.01034643], f(x) = 0.31968423133789525 :

 Backtrack: alpha = 0.00390625, f(x) = 0.31968423133789525, f(x+ap) = 0.3046826635727937, dgrad(x) = 2.1554159589680975e-06 :

GD: iter = 85, x = [0.55151647 0.00226328], f(x) = 0.3046826635727937 :

 Backtrack: alpha = 0.0625, f(x) = 0.3046826635727937, f(x+ap) = 0.30062483648882327, dgrad(x) = 8.884872183501548e-06 :

GD: iter = 86, x = [0.48257691 -0.02602775], f(x) = 0.30062483648882327 :

 Backtrack: alpha = 0.00390625, f(x) = 0.30062483648882327, f(x+ap) = 0.2324976068590662, dgrad(x) = 1.0948931921421948e-05 :

GD: iter = 87, x = [0.47880678 -0.00569357], f(x) = 0.2324976068590662 :

 Backtrack: alpha = 0.015625, f(x) = 0.2324976068590662, f(x+ap) = 0.22978950200526255, dgrad(x) = 3.4588954925019756e-06 :

GD: iter = 88, x = [0.46384407 0.01209884], f(x) = 0.22978950200526255 :

 Backtrack: alpha = 0.00390625, f(x) = 0.22978950200526255, f(x+ap) = 0.21250317259534457, dgrad(x) = 2.6233898271327646e-06 :

GD: iter = 89, x = [0.46022029 0.00264662], f(x) = 0.21250317259534457 :

 Backtrack: alpha = 0.015625, f(x) = 0.21250317259534457, f(x+ap) = 0.2019348958529933, dgrad(x) = 1.7615543708389796e-06 :

GD: iter = 90, x = [0.4458384 -0.00562407], f(x) = 0.2019348958529933 :

 Backtrack: alpha = 0.015625, f(x) = 0.2019348958529933, f(x+ap) = 0.20082573779238092, dgrad(x) = 3.2192080627081456e-06 :

GD: iter = 91, x = [0.43190595 0.01195114], f(x) = 0.20082573779238092 :

 Backtrack: alpha = 0.00390625, f(x) = 0.20082573779238092, f(x+ap) = 0.18432287065821168, dgrad(x) = 2.5231895297075684e-06 :

GD: iter = 92, x = [0.42853169 0.00261431], f(x) = 0.18432287065821168 :

 Backtrack: alpha = 0.015625, f(x) = 0.18432287065821168, f(x+ap) = 0.17542754326238166, dgrad(x) = 1.5749107791370325e-06 :

GD: iter = 93, x = [0.41514007 -0.00555541], f(x) = 0.17542754326238166 :

 Backtrack: alpha = 0.00390625, f(x) = 0.17542754326238166, f(x+ap) = 0.1698066487815444, dgrad(x) = 7.515119037076571e-07 :

GD: iter = 94, x = [0.41189679 -0.00121525], f(x) = 0.1698066487815444 :

 Backtrack: alpha = 0.0625, f(x) = 0.1698066487815444, f(x+ap) = 0.14942616000515874, dgrad(x) = 4.610680469548752e-06 :

GD: iter = 95, x = [0.36040969 0.01397534], f(x) = 0.14942616000515874 :

 Backtrack: alpha = 0.00390625, f(x) = 0.14942616000515874, f(x+ap) = 0.12880805208907403, dgrad(x) = 3.254682097748142e-06 :

GD: iter = 96, x = [0.35759399 0.00305711], f(x) = 0.12880805208907403 :

 Backtrack: alpha = 0.015625, f(x) = 0.12880805208907403, f(x+ap) = 0.12422650344329099, dgrad(x) = 1.3833276006124316e-06 :

GD: iter = 97, x = [0.34641918 -0.00649635], f(x) = 0.12422650344329099 :

 Backtrack: alpha = 0.00390625, f(x) = 0.12422650344329099, f(x+ap) = 0.1183404203916344, dgrad(x) = 8.469247416735124e-07 :

GD: iter = 98, x = [0.34371278 -0.00142108], f(x) = 0.1183404203916344 :

 Backtrack: alpha = 0.0625, f(x) = 0.1183404203916344, f(x+ap) = 0.11715710659994898, dgrad(x) = 3.4583264577928154e-06 :

GD: iter = 99, x = [0.30074868 0.01634238], f(x) = 0.11715710659994898 :

 Backtrack: alpha = 0.00390625, f(x) = 0.11715710659994898, f(x+ap) = 0.09032000035317221, dgrad(x) = 4.3143491742660855e-06 :

GD: iter = 100, x = [0.29839908 0.0035749], f(x) = 0.09032000035317221 :

 Backtrack: alpha = 0.015625, f(x) = 0.09032000035317221, f(x+ap) = 0.08933475554195668, dgrad(x) = 1.3552549575392774e-06 :

GD: iter = 101, x = [0.28907411 -0.00759665], f(x) = 0.08933475554195668 :

 Backtrack: alpha = 0.00390625, f(x) = 0.08933475554195668, f(x+ap) = 0.08253940439306534, dgrad(x) = 1.0322737668270175e-06 :

GD: iter = 102, x = [0.28681572 -0.00166177], f(x) = 0.08253940439306534 :

 Backtrack: alpha = 0.015625, f(x) = 0.08253940439306534, f(x+ap) = 0.0784491161632391, dgrad(x) = 6.867373803994038e-07 :

GD: iter = 103, x = [0.27785273 0.00353126], f(x) = 0.0784491161632391 :

Backtrack: alpha = 0.015625, f(x) = 0.0784491161632391, f(x+ap) = 0.07808328000956027, dgrad(x) = 1.261874222121079e-06 :

GD: iter = 104, x = [0.26916983 -0.00750392], f(x) = 0.07808328000956027 :

 Backtrack: alpha = 0.00390625, f(x) = 0.07808328000956027, f(x+ap) = 0.07159419777230717, dgrad(x) = 9.930322114334582e-07 :

GD: iter = 105, x = [0.26706694 -0.00164148], f(x) = 0.07159419777230717 :

 Backtrack: alpha = 0.015625, f(x) = 0.07159419777230717, f(x+ap) = 0.06815332678367693, dgrad(x) = 6.141837643367146e-07 :

GD: iter = 106, x = [0.2587211 0.00348815], f(x) = 0.06815332678367693 :

 Backtrack: alpha = 0.00390625, f(x) = 0.06815332678367693, f(x+ap) = 0.06595303030573615, dgrad(x) = 2.9470085500215415e-07 :

GD: iter = 107, x = [0.25669984 0.00076303], f(x) = 0.06595303030573615 :

 Backtrack: alpha = 0.0625, f(x) = 0.06595303030573615, f(x+ap) = 0.05815056215912392, dgrad(x) = 1.7929250203501274e-06 :

GD: iter = 108, x = [0.22461236 -0.00877488], f(x) = 0.05815056215912392 :

 Backtrack: alpha = 0.00390625, f(x) = 0.05815056215912392, f(x+ap) = 0.05003394937793774, dgrad(x) = 1.2819307216838903e-06 :

GD: iter = 109, x = [0.22285758 -0.0019195], f(x) = 0.05003394937793774 :

 Backtrack: alpha = 0.015625, f(x) = 0.05003394937793774, f(x+ap) = 0.04827368855136936, dgrad(x) = 5.406905154371214e-07 :

GD: iter = 110, x = [0.21589328 0.00407895], f(x) = 0.04827368855136936 :

 Backtrack: alpha = 0.00390625, f(x) = 0.04827368855136936, f(x+ap) = 0.0459640868658315, dgrad(x) = 3.3279380202334294e-07 :

GD: iter = 111, x = [0.21420661 0.00089227], f(x) = 0.0459640868658315 :

 Backtrack: alpha = 0.0625, f(x) = 0.0459640868658315, f(x+ap) = 0.04565932111262407, dgrad(x) = 1.3461481406993748e-06 :

GD: iter = 112, x = [0.18743078 -0.0102611], f(x) = 0.04565932111262407 :

 Backtrack: alpha = 0.00390625, f(x) = 0.04565932111262407, f(x+ap) = 0.03508736254272611, dgrad(x) = 1.7000507771970333e-06 :

GD: iter = 113, x = [0.18596648 -0.00224462], f(x) = 0.03508736254272611 :

 Backtrack: alpha = 0.015625, f(x) = 0.03508736254272611, f(x+ap) = 0.03473094263254672, dgrad(x) = 5.31040923352856e-07 :

GD: iter = 114, x = [0.18015503 0.00476981], f(x) = 0.03473094263254672 :

 Backtrack: alpha = 0.00390625, f(x) = 0.03473094263254672, f(x+ap) = 0.03205956060156724, dgrad(x) = 4.061978723015431e-07 :

GD: iter = 115, x = [0.17874757 0.0010434], f(x) = 0.03205956060156724 :

 Backtrack: alpha = 0.015625, f(x) = 0.03205956060156724, f(x+ap) = 0.030476581344620505, dgrad(x) = 2.6773400355460487e-07 :

GD: iter = 116, x = [0.17316171 -0.00221722], f(x) = 0.030476581344620505 :

 Backtrack: alpha = 0.015625, f(x) = 0.030476581344620505, f(x+ap) = 0.03036010024274419, dgrad(x) = 4.946590348210651e-07 :

GD: iter = 117, x = [0.1677504 0.00471158], f(x) = 0.03036010024274419 :

 Backtrack: alpha = 0.00390625, f(x) = 0.03036010024274419, f(x+ap) = 0.0278084505683297, dgrad(x) = 3.90828812916659e-07 :

GD: iter = 118, x = [0.16643985 0.00103066], f(x) = 0.0278084505683297 :

 Backtrack: alpha = 0.015625, f(x) = 0.0278084505683297, f(x+ap) = 0.026477564550911107, dgrad(x) = 2.395300295601903e-07 :

GD: iter = 119, x = [0.16123861 -0.00219015], f(x) = 0.026477564550911107 :

 Backtrack: alpha = 0.00390625, f(x) = 0.026477564550911107, f(x+ap) = 0.025616211689386204, dgrad(x) = 1.1557105673521058e-07 :

GD: iter = 120, x = [0.15997893 -0.0004791], f(x) = 0.025616211689386204 :

 Backtrack: alpha = 0.0625, f(x) = 0.025616211689386204, f(x+ap) = 0.02263040451363334, dgrad(x) = 6.972145616736582e-07 :

GD: iter = 121, x = [0.13998156 0.0055096], f(x) = 0.02263040451363334 :

 Backtrack: alpha = 0.00390625, f(x) = 0.02263040451363334, f(x+ap) = 0.019435121699455674, dgrad(x) = 5.049241247593106e-07 :

GD: iter = 122, x = [0.13888796 0.00120522], f(x) = 0.019435121699455674 :

 Backtrack: alpha = 0.015625, f(x) = 0.019435121699455674, f(x+ap) = 0.018759010541067746, dgrad(x) = 2.113470175264072e-07 :

GD: iter = 123, x = [0.13454771 -0.0025611], f(x) = 0.018759010541067746 :

 Backtrack: alpha = 0.00390625, f(x) = 0.018759010541067746, f(x+ap) = 0.01785271751174191, dgrad(x) = 1.3077423324967567e-07 :

GD: iter = 124, x = [0.13349656 -0.00056024], f(x) = 0.01785271751174191 :

 Backtrack: alpha = 0.0625, f(x) = 0.01785271751174191, f(x+ap) = 0.01779538682733078, dgrad(x) = 5.240007609917291e-07 :

GD: iter = 125, x = [0.11680949 0.00644277], f(x) = 0.01779538682733078 :

 Backtrack: alpha = 0.00390625, f(x) = 0.01779538682733078, f(x+ap) = 0.013630722855021324, dgrad(x) = 6.699023774151718e-07 :

GD: iter = 126, x = [0.11589691 0.00140936], f(x) = 0.013630722855021324 :

Backtrack: alpha = 0.015625, f(x) = 0.013630722855021324, f(x+ap) = 0.013502637620781063, dgrad(x) = 2.0809341311488292e-07 :

GD: iter = 127, x = [0.11227513 -0.00299488], f(x) = 0.013502637620781063 :

Backtrack: alpha = 0.00390625, f(x) = 0.013502637620781063, f(x+ap) = 0.012452430553141278, dgrad(x) = 1.5984202453762234e-07 :

GD: iter = 128, x = [0.11139798 -0.00065513], f(x) = 0.012452430553141278 :

Backtrack: alpha = 0.015625, f(x) = 0.012452430553141278, f(x+ap) = 0.01183984397483009, dgrad(x) = 1.0438418904112693e-07 :

GD: iter = 129, x = [0.1079168 0.00139215], f(x) = 0.01183984397483009 :

Backtrack: alpha = 0.015625, f(x) = 0.01183984397483009, f(x+ap) = 0.0118046988719161, dgrad(x) = 1.9391821150322323e-07 :

GD: iter = 130, x = [0.1045444 -0.00295832], f(x) = 0.0118046988719161 :

Backtrack: alpha = 0.00390625, f(x) = 0.0118046988719161, f(x+ap) = 0.010801302379698981, dgrad(x) = 1.5382236130336366e-07 :

GD: iter = 131, x = [0.10372764 -0.00064713], f(x) = 0.010801302379698981 :

Backtrack: alpha = 0.015625, f(x) = 0.010801302379698981, f(x+ap) = 0.010286573475064118, dgrad(x) = 9.342024317969577e-08 :

GD: iter = 132, x = [0.10048616 0.00137516], f(x) = 0.010286573475064118 :

Backtrack: alpha = 0.00390625, f(x) = 0.010286573475064118, f(x+ap) = 0.009949359857804192, dgrad(x) = 4.532510642822828e-08 :

GD: iter = 133, x = [0.09970111 0.00030082], f(x) = 0.009949359857804192 :

Backtrack: alpha = 0.0625, f(x) = 0.009949359857804192, f(x+ap) = 0.008807283102365514, dgrad(x) = 2.711303157153953e-07 :

GD: iter = 134, x = [0.08723847 -0.00345938], f(x) = 0.008807283102365514 :

Backtrack: alpha = 0.00390625, f(x) = 0.008807283102365514, f(x+ap) = 0.0075493656721422565, dgrad(x) = 1.9888095631594058e-07 :

GD: iter = 135, x = [0.08655692 -0.00075674], f(x) = 0.0075493656721422565 :

Backtrack: alpha = 0.015625, f(x) = 0.0075493656721422565, f(x+ap) = 0.0072897500302876676, dgrad(x) = 8.261657938431187e-08 :

GD: iter = 136, x = [0.08385201 0.00160807], f(x) = 0.0072897500302876676 :

Backtrack: alpha = 0.00390625, f(x) = 0.0072897500302876676, f(x+ap) = 0.006934101576600075, dgrad(x) = 5.1390819175290026e-08 :

GD: iter = 137, x = [0.08319692 0.00035177], f(x) = 0.006934101576600075 :

Backtrack: alpha = 0.015625, f(x) = 0.006934101576600075, f(x+ap) = 0.006551755154014527, dgrad(x) = 5.0994496779122775e-08 :

GD: iter = 138, x = [0.08059702 -0.0007475], f(x) = 0.006551755154014527 :

 Backtrack: alpha = 0.015625, f(x) = 0.006551755154014527, f(x+ap) = 0.006348545310720679, dgrad(x) = 7.552172903185014e-08 :

GD: iter = 139, x = [0.07807836 0.00158844], f(x) = 0.006348545310720679 :

 Backtrack: alpha = 0.00390625, f(x) = 0.006348545310720679, f(x+ap) = 0.006013422512121476, dgrad(x) = 4.8949570576383666e-08 :

GD: iter = 140, x = [0.07746837 0.00034747], f(x) = 0.006013422512121476 :

 Backtrack: alpha = 0.015625, f(x) = 0.006013422512121476, f(x+ap) = 0.005686645378161584, dgrad(x) = 4.505447061439497e-08 :

GD: iter = 141, x = [0.07504749 -0.00073838], f(x) = 0.005686645378161584 :

 Backtrack: alpha = 0.015625, f(x) = 0.005686645378161584, f(x+ap) = 0.0055318100448774905, dgrad(x) = 6.927587103602128e-08 :

GD: iter = 142, x = [0.07270225 0.00156905], f(x) = 0.0055318100448774905 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0055318100448774905, f(x+ap) = 0.005215133062849461, dgrad(x) = 4.6726357551003054e-08 :

GD: iter = 143, x = [0.07213427 0.00034323], f(x) = 0.005215133062849461 :

 Backtrack: alpha = 0.015625, f(x) = 0.005215133062849461, f(x+ap) = 0.004936421449606047, dgrad(x) = 3.9883887554677165e-08 :

GD: iter = 144, x = [0.06988007 -0.00072936], f(x) = 0.004936421449606047 :

 Backtrack: alpha = 0.015625, f(x) = 0.004936421449606047, f(x+ap) = 0.004823010140000412, dgrad(x) = 6.37684060683169e-08 :

GD: iter = 145, x = [0.06769632 0.0015499], f(x) = 0.004823010140000412 :

 Backtrack: alpha = 0.00390625, f(x) = 0.004823010140000412, f(x+ap) = 0.004522959932268646, dgrad(x) = 4.469477408747198e-08 :

GD: iter = 146, x = [0.06716744 0.00033904], f(x) = 0.004522959932268646 :

 Backtrack: alpha = 0.015625, f(x) = 0.004522959932268646, f(x+ap) = 0.00428581062857949, dgrad(x) = 3.5380930109656953e-08 :

GD: iter = 147, x = [0.06506846 -0.00072046], f(x) = 0.00428581062857949 :

 Backtrack: alpha = 0.015625, f(x) = 0.00428581062857949, f(x+ap) = 0.004207809632116916, dgrad(x) = 5.8903385554100196e-08 :

GD: iter = 148, x = [0.06303507 0.00153098], f(x) = 0.004207809632116916 :

 Backtrack: alpha = 0.00390625, f(x) = 0.004207809632116916, f(x+ap) = 0.003922793657087661, dgrad(x) = 4.283186261761726e-08 :

GD: iter = 149, x = [0.06254261 0.0003349], f(x) = 0.003922793657087661 :

Backtrack: alpha = 0.015625, f(x) = 0.003922793657087661, f(x+ap) = 0.0037215708974244668, dgrad(x) = 3.145730740095527e-08 :

GD: iter = 150, x = [0.06058815 -0.00071167], f(x) = 0.0037215708974244668 :

Backtrack: alpha = 0.015625, f(x) = 0.0037215708974244668, f(x+ap) = 0.0036737784116531746, dgrad(x) = 5.459756491767615e-08 :

GD: iter = 151, x = [0.05869477 0.00151229], f(x) = 0.0036737784116531746 :

Backtrack: alpha = 0.00390625, f(x) = 0.0036737784116531746, f(x+ap) = 0.003402400883838291, dgrad(x) = 4.111765700154975e-08 :

GD: iter = 152, x = [0.05823622 0.00033081], f(x) = 0.003402400883838291 :

Backtrack: alpha = 0.015625, f(x) = 0.003402400883838291, f(x+ap) = 0.0032322209385539577, dgrad(x) = 2.803645682646487e-08 :

GD: iter = 153, x = [0.05641634 -0.00070298], f(x) = 0.0032322209385539577 :

Backtrack: alpha = 0.015625, f(x) = 0.0032322209385539577, f(x+ap) = 0.0032101388123962704, dgrad(x) = 5.07787156537034e-08 :

GD: iter = 154, x = [0.05465333 0.00149383], f(x) = 0.0032101388123962704 :

Backtrack: alpha = 0.00390625, f(x) = 0.0032101388123962704, f(x+ap) = 0.002951174903906084, dgrad(x) = 3.953478624459259e-08 :

GD: iter = 155, x = [0.05422635 0.00032678], f(x) = 0.002951174903906084 :

Backtrack: alpha = 0.015625, f(x) = 0.002951174903906084, f(x+ap) = 0.0028078060170611267, dgrad(x) = 2.5051984841447986e-08 :

GD: iter = 156, x = [0.05253177 -0.0006944], f(x) = 0.0028078060170611267 :

Backtrack: alpha = 0.015625, f(x) = 0.0028078060170611267, f(x+ap) = 0.002807545896169988, dgrad(x) = 4.73841618097274e-08 :

GD: iter = 157, x = [0.05089016 0.00147559], f(x) = 0.002807545896169988 :

Backtrack: alpha = 0.00390625, f(x) = 0.002807545896169988, f(x+ap) = 0.0025599193597873895, dgrad(x) = 3.8068130871728724e-08 :

GD: iter = 158, x = [0.05049258 0.00032279], f(x) = 0.0025599193597873895 :

Backtrack: alpha = 0.015625, f(x) = 0.0025599193597873895, f(x+ap) = 0.002439694993756433, dgrad(x) = 2.244631506132428e-08 :

GD: iter = 159, x = [0.04891468 -0.00068592], f(x) = 0.002439694993756433 :

Backtrack: alpha = 0.00390625, f(x) = 0.002439694993756433, f(x+ap) = 0.0023576585329906402, dgrad(x) = 1.1089877760192647e-08 :

GD: iter = 160, x = [0.04853254 -0.00015005], f(x) = 0.0023576585329906402 :

Backtrack: alpha = 0.0625, f(x) = 0.0023576585329906402, f(x+ap) = 0.0021011005105577444, dgrad(x) = 6.451357054804667e-08 :

GD: iter = 161, x = [0.04246597 0.00172552], f(x) = 0.0021011005105577444 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0021011005105577444, f(x+ap) = 0.0017895386240879437, dgrad(x) = 4.933991831517578e-08 :

GD: iter = 162, x = [0.0421342 0.00037746], f(x) = 0.0017895386240879437 :

 Backtrack: alpha = 0.015625, f(x) = 0.0017895386240879437, f(x+ap) = 0.001730405173652937, dgrad(x) = 2.0000204250565408e-08 :

GD: iter = 163, x = [0.04081751 -0.0008021], f(x) = 0.001730405173652937 :

 Backtrack: alpha = 0.00390625, f(x) = 0.001730405173652937, f(x+ap) = 0.001643217126556066, dgrad(x) = 1.2655730305139569e-08 :

GD: iter = 164, x = [0.04049862 -0.00017546], f(x) = 0.001643217126556066 :

 Backtrack: alpha = 0.015625, f(x) = 0.001643217126556066, f(x+ap) = 0.0015531332882262182, dgrad(x) = 1.2174976723959927e-08 :

GD: iter = 165, x = [0.03923304 0.00037285], f(x) = 0.0015531332882262182 :

 Backtrack: alpha = 0.015625, f(x) = 0.0015531332882262182, f(x+ap) = 0.0015073076355329878, dgrad(x) = 1.830876021364081e-08 :

GD: iter = 166, x = [0.03800701 -0.00079231], f(x) = 0.0015073076355329878 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0015073076355329878, f(x+ap) = 0.0014250539875675459, dgrad(x) = 1.2065655289440554e-08 :

GD: iter = 167, x = [0.03771008 -0.00017332], f(x) = 0.0014250539875675459 :

 Backtrack: alpha = 0.015625, f(x) = 0.0014250539875675459, f(x+ap) = 0.0013481250759352606, dgrad(x) = 1.0765235345488931e-08 :

GD: iter = 168, x = [0.03653164 0.0003683], f(x) = 0.0013481250759352606 :

 Backtrack: alpha = 0.015625, f(x) = 0.0013481250759352606, f(x+ap) = 0.0013137055699028411, dgrad(x) = 1.6818738752758212e-08 :

GD: iter = 169, x = [0.03539003 -0.00078263], f(x) = 0.0013137055699028411 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0013137055699028411, f(x+ap) = 0.0012358917762311731, dgrad(x) = 1.1527526598047637e-08 :

GD: iter = 170, x = [0.03511354 -0.0001712], f(x) = 0.0012358917762311731 :

 Backtrack: alpha = 0.015625, f(x) = 0.0012358917762311731, f(x+ap) = 0.0011703400386325511, dgrad(x) = 9.537871338197362e-09 :

GD: iter = 171, x = [0.03401624 0.0003638], f(x) = 0.0011703400386325511 :

 Backtrack: alpha = 0.015625, f(x) = 0.0011703400386325511, f(x+ap) = 0.0011456810957017757, dgrad(x) = 1.5503926740226586e-08 :

GD: iter = 172, x = [0.03295324 -0.00077308], f(x) = 0.0011456810957017757 :

Backtrack: alpha = 0.00390625, f(x) = 0.0011456810957017757, f(x+ap) = 0.001071874450133062, dgrad(x) = 1.1035080357133391e-08 :

GD: iter = 173, x = [0.03269579 -0.00016911], f(x) = 0.001071874450133062 :

Backtrack: alpha = 0.015625, f(x) = 0.001071874450133062, f(x+ap) = 0.001016159213551734, dgrad(x) = 8.468757221963938e-09 :

GD: iter = 174, x = [0.03167405 0.00035936], f(x) = 0.001016159213551734 :

Backtrack: alpha = 0.015625, f(x) = 0.001016159213551734, f(x+ap) = 0.0009998371907184859, dgrad(x) = 1.4341582765866069e-08 :

GD: iter = 175, x = [0.03068423 -0.00076364], f(x) = 0.0009998371907184859 :

Backtrack: alpha = 0.00390625, f(x) = 0.0009998371907184859, f(x+ap) = 0.0009296586981905327, dgrad(x) = 1.0582869984940892e-08 :

GD: iter = 176, x = [0.03044451 -0.00016705], f(x) = 0.0009296586981905327 :

Backtrack: alpha = 0.015625, f(x) = 0.0009296586981905327, f(x+ap) = 0.0008824448280814383, dgrad(x) = 7.53697074786161e-09 :

GD: iter = 177, x = [0.02949312 0.00035497], f(x) = 0.0008824448280814383 :

Backtrack: alpha = 0.015625, f(x) = 0.0008824448280814383, f(x+ap) = 0.0008732284356639234, dgrad(x) = 1.331197583996767e-08 :

GD: iter = 178, x = [0.02857146 -0.00075432], f(x) = 0.0008732284356639234 :

Backtrack: alpha = 0.00390625, f(x) = 0.0008732284356639234, f(x+ap) = 0.0008063457631286532, dgrad(x) = 1.0166157895680189e-08 :

GD: iter = 179, x = [0.02834825 -0.00016501], f(x) = 0.0008063457631286532 :

Backtrack: alpha = 0.015625, f(x) = 0.0008063457631286532, f(x+ap) = 0.0007664763166647835, dgrad(x) = 6.7243687726119346e-09 :

GD: iter = 180, x = [0.02746236 0.00035064], f(x) = 0.0007664763166647835 :

Backtrack: alpha = 0.015625, f(x) = 0.0007664763166647835, f(x+ap) = 0.0007633009671127694, dgrad(x) = 1.2397985426556761e-08 :

GD: iter = 181, x = [0.02660416 -0.00074511], f(x) = 0.0007633009671127694 :

Backtrack: alpha = 0.00390625, f(x) = 0.0007633009671127694, f(x+ap) = 0.0006994223294865992, dgrad(x) = 9.780821594313464e-09 :

GD: iter = 182, x = [0.02639632 -0.00016299], f(x) = 0.0006994223294865992 :

Backtrack: alpha = 0.015625, f(x) = 0.0006994223294865992, f(x+ap) = 0.0006658948454883948, dgrad(x) = 6.015217792989636e-09 :

GD: iter = 183, x = [0.02557143 0.00034636], f(x) = 0.0006658948454883948 :

Backtrack: alpha = 0.00390625, f(x) = 0.0006658948454883948, f(x+ap) = 0.0006442950285986952, dgrad(x) = 2.8961886630241904e-09 :

GD: iter = 184, x = [2.53716569e-02 7.57665667e-05], f(x) = 0.0006442950285986952 :

 Backtrack: alpha = 0.0625, f(x) = 0.0006442950285986952, f(x+ap) = 0.000568767941645298, dgrad(x) = 1.7528167439662378e-08 :

GD: iter = 185, x = [0.0222002 -0.00087132], f(x) = 0.000568767941645298 :

 Backtrack: alpha = 0.00390625, f(x) = 0.000568767941645298, f(x+ap) = 0.0004888110324788418, dgrad(x) = 1.2632431508252899e-08 :

GD: iter = 186, x = [0.02202676 -0.0001906], f(x) = 0.0004888110324788418 :

 Backtrack: alpha = 0.015625, f(x) = 0.0004888110324788418, f(x+ap) = 0.0004717329278132553, dgrad(x) = 5.302892579446565e-09 :

GD: iter = 187, x = [0.02133842 0.00040503], f(x) = 0.0004717329278132553 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0004717329278132553, f(x+ap) = 0.00044902662624099737, dgrad(x) = 3.274664840509575e-09 :

GD: iter = 188, x = [2.11717180e-02 8.85993439e-05], f(x) = 0.00044902662624099737 :

 Backtrack: alpha = 0.0625, f(x) = 0.00044902662624099737, f(x+ap) = 0.0004469991905637879, dgrad(x) = 1.3168501982575978e-08 :

GD: iter = 189, x = [0.01852525 -0.00101889], f(x) = 0.0004469991905637879 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0004469991905637879, f(x+ap) = 0.0003428113585600468, dgrad(x) = 1.6757192746904396e-08 :

GD: iter = 190, x = [0.01838052 -0.00022288], f(x) = 0.0003428113585600468 :

 Backtrack: alpha = 0.015625, f(x) = 0.0003428113585600468, f(x+ap) = 0.00033949052153170564, dgrad(x) = 5.216317354558008e-09 :

GD: iter = 191, x = [0.01780613 0.00047363], f(x) = 0.00033949052153170564 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00033949052153170564, f(x+ap) = 0.00031319711004003663, dgrad(x) = 4.000425420628368e-09 :

GD: iter = 192, x = [0.01766702 0.00010361], f(x) = 0.00031319711004003663 :

 Backtrack: alpha = 0.015625, f(x) = 0.00031319711004003663, f(x+ap) = 0.0002977679044751788, dgrad(x) = 2.621656166484677e-09 :

GD: iter = 193, x = [0.01711493 -0.00022016], f(x) = 0.0002977679044751788 :

 Backtrack: alpha = 0.015625, f(x) = 0.0002977679044751788, f(x+ap) = 0.0002967871032912992, dgrad(x) = 4.86021115459886e-09 :

GD: iter = 194, x = [0.01658009 0.00046784], f(x) = 0.0002967871032912992 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0002967871032912992, f(x+ap) = 0.0002716681251418954, dgrad(x) = 3.8495022950675715e-09 :

GD: iter = 195, x = [0.01645055 0.00010234], f(x) = 0.0002716681251418954 :

Backtrack: alpha = 0.015625, f(x) = 0.0002716681251418954, f(x+ap) = 0.00025870075357854825, dgrad(x) = 2.3459837894125143e-09 :

GD: iter = 196, x = [0.01593648 -0.00021747], f(x) = 0.00025870075357854825 :

Backtrack: alpha = 0.00390625, f(x) = 0.00025870075357854825, f(x+ap) = 0.00025024475453971077, dgrad(x) = 1.135816662242529e-09 :

GD: iter = 197, x = [1.58119714e-02 -4.75725390e-05], f(x) = 0.00025024475453971077 :

Backtrack: alpha = 0.0625, f(x) = 0.00025024475453971077, f(x+ap) = 0.00022135048004155822, dgrad(x) = 6.816247613555681e-09 :

GD: iter = 198, x = [0.01383547 0.00054708], f(x) = 0.00022135048004155822 :

Backtrack: alpha = 0.00390625, f(x) = 0.00022135048004155822, f(x+ap) = 0.0001898733107895635, dgrad(x) = 4.9756743248036846e-09 :

GD: iter = 199, x = [0.01372739 0.00011967], f(x) = 0.0001898733107895635 :

Backtrack: alpha = 0.015625, f(x) = 0.0001898733107895635, f(x+ap) = 0.0001833148534021968, dgrad(x) = 2.0728835666035165e-09 :

GD: iter = 200, x = [0.0132984 -0.00025431], f(x) = 0.0001833148534021968 :

Backtrack: alpha = 0.00390625, f(x) = 0.0001833148534021968, f(x+ap) = 0.0001744045840948065, dgrad(x) = 1.2868383769361167e-09 :

GD: iter = 201, x = [1.31945108e-02 -5.56300216e-05], f(x) = 0.0001744045840948065 :

Backtrack: alpha = 0.0625, f(x) = 0.0001744045840948065, f(x+ap) = 0.00017421897010317652, dgrad(x) = 5.126052680593039e-09 :

GD: iter = 202, x = [0.0115452 0.00063975], f(x) = 0.00017421897010317652 :

Backtrack: alpha = 0.00390625, f(x) = 0.00017421897010317652, f(x+ap) = 0.00013317546640352092, dgrad(x) = 6.603174068597171e-09 :

GD: iter = 203, x = [0.011455 0.00013994], f(x) = 0.00013317546640352092 :

Backtrack: alpha = 0.015625, f(x) = 0.00013317546640352092, f(x+ap) = 0.000131987684358017, dgrad(x) = 2.044131389485823e-09 :

GD: iter = 204, x = [0.01109703 -0.00029738], f(x) = 0.000131987684358017 :

Backtrack: alpha = 0.00390625, f(x) = 0.000131987684358017, f(x+ap) = 0.00012165067255734649, dgrad(x) = 1.5742221059111323e-09 :

GD: iter = 205, x = [1.10103358e-02 -6.50522207e-05], f(x) = 0.00012165067255734649 :

Backtrack: alpha = 0.015625, f(x) = 0.00012165067255734649, f(x+ap) = 0.00011568007961431726, dgrad(x) = 1.022158797647419e-09 :

GD: iter = 206, x = [0.01066626 0.00013824], f(x) = 0.00011568007961431726 :

Backtrack: alpha = 0.015625, f(x) = 0.00011568007961431726, f(x+ap) = 0.00011539868192538875, dgrad(x) = 1.9053812040488103e-09 :

GD: iter = 207, x = [0.01033294 -0.00029375], f(x) = 0.00011539868192538875 :

Backtrack: alpha = 0.00390625, f(x) = 0.00011539868192538875, f(x+ap) = 0.00010552084237121467, dgrad(x) = 1.5151074099097703e-09 :

GD: iter = 208, x = [1.02522159e-02 -6.42581262e-05], f(x) = 0.00010552084237121467 :

Backtrack: alpha = 0.015625, f(x) = 0.00010552084237121467, f(x+ap) = 0.00010050588020965839, dgrad(x) = 9.149937472445688e-10 :

GD: iter = 209, x = [0.00993183 0.00013655], f(x) = 0.00010050588020965839 :

Backtrack: alpha = 0.00390625, f(x) = 0.00010050588020965839, f(x+ap) = 9.71953018479046e-05, dgrad(x) = 4.454629824395986e-10 :

GD: iter = 210, x = [9.85424174e-03 2.98699884e-05], f(x) = 9.71953018479046e-05 :

Backtrack: alpha = 0.0625, f(x) = 9.71953018479046e-05, f(x+ap) = 8.614640198422588e-05, dgrad(x) = 2.6507060569161835e-09 :

GD: iter = 211, x = [0.00862246 -0.0003435], f(x) = 8.614640198422588e-05 :

Backtrack: alpha = 0.00390625, f(x) = 8.614640198422588e-05, f(x+ap) = 7.375433837828913e-05, dgrad(x) = 1.959848083883517e-09 :

GD: iter = 212, x = [8.55509854e-03 -7.51416895e-05], f(x) = 7.375433837828913e-05 :

Backtrack: alpha = 0.015625, f(x) = 7.375433837828913e-05, f(x+ap) = 7.123647379282669e-05, dgrad(x) = 8.103277875532724e-10 :

GD: iter = 213, x = [0.00828775 0.00015968], f(x) = 7.123647379282669e-05 :

Backtrack: alpha = 0.00390625, f(x) = 7.123647379282669e-05, f(x+ap) = 6.773979354876684e-05, dgrad(x) = 5.05705259469694e-10 :

GD: iter = 214, x = [8.22300365e-03 3.49291447e-05], f(x) = 6.773979354876684e-05 :

Backtrack: alpha = 0.015625, f(x) = 6.773979354876684e-05, f(x+ap) = 6.400863685460585e-05, dgrad(x) = 4.988640033878073e-10 :

GD: iter = 215, x = [7.96603479e-03 -7.42244325e-05], f(x) = 6.400863685460585e-05 :

Backtrack: alpha = 0.015625, f(x) = 6.400863685460585e-05, f(x+ap) = 6.204135184943918e-05, dgrad(x) = 7.409398378665397e-10 :

GD: iter = 216, x = [0.0077171 0.00015773], f(x) = 6.204135184943918e-05 :

Backtrack: alpha = 0.00390625, f(x) = 6.204135184943918e-05, f(x+ap) = 5.8745728088988955e-05, dgrad(x) = 4.817677873616164e-10 :

GD: iter = 217, x = [7.65680639e-03 3.45027636e-05], f(x) = 5.8745728088988955e-05 :

Backtrack: alpha = 0.015625, f(x) = 5.8745728088988955e-05, f(x+ap) = 5.55573272650635e-05, dgrad(x) = 4.408193184458159e-10 :

GD: iter = 218, x = [7.41753119e-03 -7.33183726e-05], f(x) = 5.55573272650635e-05 :

Backtrack: alpha = 0.015625, f(x) = 5.55573272650635e-05, f(x+ap) = 5.406217561641669e-05, dgrad(x) = 6.798475402520296e-10 :

GD: iter = 219, x = [0.00718573 0.0001558], f(x) = 5.406217561641669e-05 :

Backtrack: alpha = 0.00390625, f(x) = 5.406217561641669e-05, f(x+ap) = 5.094727739090347e-05, dgrad(x) = 4.5996244924563396e-10 :

GD: iter = 220, x = [7.12959479e-03 3.40815872e-05], f(x) = 5.094727739090347e-05 :

Backtrack: alpha = 0.015625, f(x) = 5.094727739090347e-05, f(x+ap) = 4.8228331072920015e-05, dgrad(x) = 3.9029167389785046e-10 :

GD: iter = 221, x = [6.90679496e-03 -7.24233729e-05], f(x) = 4.8228331072920015e-05 :

Backtrack: alpha = 0.015625, f(x) = 4.8228331072920015e-05, f(x+ap) = 4.71374245636947e-05, dgrad(x) = 6.259704124738653e-10 :

GD: iter = 222, x = [0.00669096 0.0001539], f(x) = 4.71374245636947e-05 :

Backtrack: alpha = 0.00390625, f(x) = 4.71374245636947e-05, f(x+ap) = 4.418546894125939e-05, dgrad(x) = 4.400312344920437e-10 :

GD: iter = 223, x = [6.63868451e-03 3.36655522e-05], f(x) = 4.418546894125939e-05 :

Backtrack: alpha = 0.015625, f(x) = 4.418546894125939e-05, f(x+ap) = 4.187245006512004e-05, dgrad(x) = 3.462864129998722e-10 :

GD: iter = 224, x = [6.43122562e-03 -7.15392985e-05], f(x) = 4.187245006512004e-05 :

Backtrack: alpha = 0.015625, f(x) = 4.187245006512004e-05, f(x+ap) = 4.112705150893368e-05, dgrad(x) = 5.783710954353331e-10 :

GD: iter = 225, x = [0.00623025 0.00015202], f(x) = 4.112705150893368e-05 :

Backtrack: alpha = 0.00390625, f(x) = 4.112705150893368e-05, f(x+ap) = 3.8322468536251806e-05, dgrad(x) = 4.2174982130570955e-10 :

GD: iter = 226, x = [6.18157599e-03 3.32545958e-05], f(x) = 3.8322468536251806e-05 :

Backtrack: alpha = 0.015625, f(x) = 3.8322468536251806e-05, f(x+ap) = 3.636032398789391e-05, dgrad(x) = 3.079410196126169e-10 :

GD: iter = 227, x = [5.98840174e-03 -7.06660161e-05], f(x) = 3.636032398789391e-05 :

Backtrack: alpha = 0.015625, f(x) = 3.636032398789391e-05, f(x+ap) = 3.590962741284364e-05, dgrad(x) = 5.362363354624848e-10 :

GD: iter = 228, x = [0.00580126 0.00015017], f(x) = 3.590962741284364e-05 :

Backtrack: alpha = 0.00390625, f(x) = 3.590962741284364e-05, f(x+ap) = 3.3238769535239516e-05, dgrad(x) = 4.049231121510242e-10 :

GD: iter = 229, x = [5.75594181e-03 3.28486559e-05], f(x) = 3.3238769535239516e-05 :

Backtrack: alpha = 0.015625, f(x) = 3.3238769535239516e-05, f(x+ap) = 3.157979272357706e-05, dgrad(x) = 2.745075504022952e-10 :

GD: iter = 230, x = [5.57606863e-03 -6.98033938e-05], f(x) = 3.157979272357706e-05 :

 Backtrack: alpha = 0.015625, f(x) = 3.157979272357706e-05, f(x+ap) = 3.1379865827374964e-05, dgrad(x) = 4.988604950416837e-10 :

GD: iter = 231, x = [0.00540182 0.00014833], f(x) = 3.1379865827374964e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 3.1379865827374964e-05, f(x+ap) = 2.883075585793748e-05, dgrad(x) = 3.8938136246498237e-10 :

GD: iter = 232, x = [5.35961479e-03 3.24476713e-05], f(x) = 2.883075585793748e-05 :

 Backtrack: alpha = 0.015625, f(x) = 2.883075585793748e-05, f(x+ap) = 2.7433609217010243e-05, dgrad(x) = 2.4533740295342077e-10 :

GD: iter = 233, x = [5.19212683e-03 -6.89513016e-05], f(x) = 2.7433609217010243e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 2.7433609217010243e-05, f(x+ap) = 2.6561354818461107e-05, dgrad(x) = 1.1640781395290282e-10 :

GD: iter = 234, x = [5.15156334e-03 -1.50830972e-05], f(x) = 2.6561354818461107e-05 :

 Backtrack: alpha = 0.0625, f(x) = 2.6561354818461107e-05, f(x+ap) = 2.3327304471666177e-05, dgrad(x) = 7.203400763680104e-10 :

GD: iter = 235, x = [0.00450762 0.00017346], f(x) = 2.3327304471666177e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 2.3327304471666177e-05, f(x+ap) = 2.014635133608907e-05, dgrad(x) = 5.018548964327494e-10 :

GD: iter = 236, x = [4.47240216e-03 3.79434165e-05], f(x) = 2.014635133608907e-05 :

 Backtrack: alpha = 0.015625, f(x) = 2.014635133608907e-05, f(x+ap) = 1.942188162958037e-05, dgrad(x) = 2.1499630982162218e-10 :

GD: iter = 237, x = [4.33263959e-03 -8.06297600e-05], f(x) = 1.942188162958037e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 1.942188162958037e-05, f(x+ap) = 1.8510711765070623e-05, dgrad(x) = 1.3091148081824245e-10 :

GD: iter = 238, x = [4.29879084e-03 -1.76377600e-05], f(x) = 1.8510711765070623e-05 :

 Backtrack: alpha = 0.0625, f(x) = 1.8510711765070623e-05, f(x+ap) = 1.826261871042005e-05, dgrad(x) = 5.397627120615959e-10 :

GD: iter = 239, x = [0.00376144 0.00020283], f(x) = 1.826261871042005e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 1.826261871042005e-05, f(x+ap) = 1.4125109510479796e-05, dgrad(x) = 6.649464602901123e-10 :

GD: iter = 240, x = [3.73205572e-03 4.43699900e-05], f(x) = 1.4125109510479796e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.4125109510479796e-05, f(x+ap) = 1.3960316004183406e-05, dgrad(x) = 2.1009500010143223e-10 :

GD: iter = 241, x = [3.61542898e-03 -9.42862287e-05], f(x) = 1.3960316004183406e-05 :

Backtrack: alpha = 0.00390625, f(x) = 1.3960316004183406e-05, f(x+ap) = 1.2910424569138817e-05, dgrad(x) = 1.5932852491282476e-10 :

GD: iter = 242, x = [3.58718344e-03 -2.06251125e-05], f(x) = 1.2910424569138817e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.2910424569138817e-05, f(x+ap) = 1.2268301071468625e-05, dgrad(x) = 1.0701148569250087e-10 :

GD: iter = 243, x = [3.47508396e-03 4.38283641e-05], f(x) = 1.2268301071468625e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.2268301071468625e-05, f(x+ap) = 1.2200656582998518e-05, dgrad(x) = 1.9553414712051904e-10 :

GD: iter = 244, x = [3.36648759e-03 -9.31352738e-05], f(x) = 1.2200656582998518e-05 :

Backtrack: alpha = 0.00390625, f(x) = 1.2200656582998518e-05, f(x+ap) = 1.1198355835908865e-05, dgrad(x) = 1.532422357058172e-10 :

GD: iter = 245, x = [3.34018690e-03 -2.03733411e-05], f(x) = 1.1198355835908865e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.1198355835908865e-05, f(x+ap) = 1.0657872274262445e-05, dgrad(x) = 9.567236764610704e-11 :

GD: iter = 246, x = [3.23580606e-03 4.32933499e-05], f(x) = 1.0657872274262445e-05 :

Backtrack: alpha = 0.00390625, f(x) = 1.0657872274262445e-05, f(x+ap) = 1.0316448172204412e-05, dgrad(x) = 4.564622238601376e-11 :

GD: iter = 247, x = [3.21052633e-03 9.47042029e-06], f(x) = 1.0316448172204412e-05 :

Backtrack: alpha = 0.0625, f(x) = 1.0316448172204412e-05, f(x+ap) = 9.077799009069577e-06, dgrad(x) = 2.8010919728817995e-10 :

GD: iter = 248, x = [0.00280921 -0.00010891], f(x) = 9.077799009069577e-06 :

Backtrack: alpha = 0.00390625, f(x) = 9.077799009069577e-06, f(x+ap) = 7.825596671802689e-06, dgrad(x) = 1.9766434670235617e-10 :

GD: iter = 249, x = [2.78726358e-03 -2.38240261e-05], f(x) = 7.825596671802689e-06 :

Backtrack: alpha = 0.015625, f(x) = 7.825596671802689e-06, f(x+ap) = 7.547172363665653e-06, dgrad(x) = 8.402925264323384e-11 :

GD: iter = 250, x = [2.70016159e-03 5.06260554e-05], f(x) = 7.547172363665653e-06 :

Backtrack: alpha = 0.00390625, f(x) = 7.547172363665653e-06, f(x+ap) = 7.189662073895329e-06, dgrad(x) = 5.143882410514545e-11 :

GD: iter = 251, x = [2.67906658e-03 1.10744496e-05], f(x) = 7.189662073895329e-06 :

Backtrack: alpha = 0.0625, f(x) = 7.189662073895329e-06, f(x+ap) = 7.11715455413483e-06, dgrad(x) = 2.1009580180142973e-10 :

GD: iter = 252, x = [0.00234418 -0.00012736], f(x) = 7.11715455413483e-06 :

Backtrack: alpha = 0.00390625, f(x) = 7.11715455413483e-06, f(x+ap) = 5.487281405872818e-06, dgrad(x) = 2.6201740126725123e-10 :

GD: iter = 253, x = [2.32586932e-03 -2.78591623e-05], f(x) = 5.487281405872818e-06 :

 Backtrack: alpha = 0.015625, f(x) = 5.487281405872818e-06, f(x+ap) = 5.4273192589002595e-06, dgrad(x) = 8.23187334607065e-11 :

GD: iter = 254, x = [2.25318591e-03 5.92007199e-05], f(x) = 5.4273192589002595e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 5.4273192589002595e-06, f(x+ap) = 5.0146015291517665e-06, dgrad(x) = 6.269390482166604e-11 :

GD: iter = 255, x = [2.23558289e-03 1.29501575e-05], f(x) = 5.0146015291517665e-06 :

 Backtrack: alpha = 0.015625, f(x) = 5.0146015291517665e-06, f(x+ap) = 4.766077137956135e-06, dgrad(x) = 4.1718104109941057e-11 :

GD: iter = 256, x = [2.16572093e-03 -2.75190846e-05], f(x) = 4.766077137956135e-06 :

 Backtrack: alpha = 0.015625, f(x) = 4.766077137956135e-06, f(x+ap) = 4.743749147052769e-06, dgrad(x) = 7.664592079570377e-11 :

GD: iter = 257, x = [2.09804215e-03 5.84780548e-05], f(x) = 4.743749147052769e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 4.743749147052769e-06, f(x+ap) = 4.3496354116514976e-06, dgrad(x) = 6.031032788416494e-11 :

GD: iter = 258, x = [2.08165119e-03 1.27920745e-05], f(x) = 4.3496354116514976e-06 :

 Backtrack: alpha = 0.015625, f(x) = 4.3496354116514976e-06, f(x+ap) = 4.140566333940856e-06, dgrad(x) = 3.731027121443457e-11 :

GD: iter = 259, x = [2.01659959e-03 -2.71831583e-05], f(x) = 4.140566333940856e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 4.140566333940856e-06, f(x+ap) = 4.006916221642765e-06, dgrad(x) = 1.7899867000986e-11 :

GD: iter = 260, x = [2.00084491e-03 -5.94631588e-06], f(x) = 4.006916221642765e-06 :

 Backtrack: alpha = 0.0625, f(x) = 4.006916221642765e-06, f(x+ap) = 3.532706528230469e-06, dgrad(x) = 1.0892417699584986e-10 :

GD: iter = 261, x = [1.75073930e-03 6.83826326e-05], f(x) = 3.532706528230469e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 3.532706528230469e-06, f(x+ap) = 3.0397594338672955e-06, dgrad(x) = 7.785458206878215e-11 :

GD: iter = 262, x = [1.73706165e-03 1.49587009e-05], f(x) = 3.0397594338672955e-06 :

 Backtrack: alpha = 0.015625, f(x) = 3.0397594338672955e-06, f(x+ap) = 2.9327862351031816e-06, dgrad(x) = 3.284381551558732e-11 :

GD: iter = 263, x = [1.68277847e-03 -3.17872394e-05], f(x) = 2.9327862351031816e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 2.9327862351031816e-06, f(x+ap) = 2.7925052806658154e-06, dgrad(x) = 2.02125457055594e-11 :

GD: iter = 264, x = [1.66963176e-03 -6.95345861e-06], f(x) = 2.7925052806658154e-06 :

Backtrack: alpha = 0.0625, f(x) = 2.7925052806658154e-06, f(x+ap) = 2.773746522922094e-06, dgrad(x) = 8.177940222675981e-11 :

GD: iter = 265, x = [1.46092779e-03 7.99647741e-05], f(x) = 2.773746522922094e-06 :

Backtrack: alpha = 0.00390625, f(x) = 2.773746522922094e-06, f(x+ap) = 2.131689723780952e-06, dgrad(x) = 1.0324681396004287e-10 :

GD: iter = 266, x = [1.44951429e-03 1.74922943e-05], f(x) = 2.131689723780952e-06 :

Backtrack: alpha = 0.015625, f(x) = 2.131689723780952e-06, f(x+ap) = 2.10999456126293e-06, dgrad(x) = 3.2255595601290606e-11 :

GD: iter = 267, x = [1.40421697e-03 -3.71711254e-05], f(x) = 2.10999456126293e-06 :

Backtrack: alpha = 0.00390625, f(x) = 2.10999456126293e-06, f(x+ap) = 1.9477474996702432e-06, dgrad(x) = 2.466992339726099e-11 :

GD: iter = 268, x = [1.39324653e-03 -8.13118369e-06], f(x) = 1.9477474996702432e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.9477474996702432e-06, f(x+ap) = 1.8515661057398212e-06, dgrad(x) = 1.6264358544302672e-11 :

GD: iter = 269, x = [1.34970757e-03 1.72787653e-05], f(x) = 1.8515661057398212e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.8515661057398212e-06, f(x+ap) = 1.844449211116403e-06, dgrad(x) = 3.0045424067500384e-11 :

GD: iter = 270, x = [1.30752921e-03 -3.67173764e-05], f(x) = 1.844449211116403e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.844449211116403e-06, f(x+ap) = 1.6894751598360064e-06, dgrad(x) = 2.3736390474459455e-11 :

GD: iter = 271, x = [1.29731414e-03 -8.03192608e-06], f(x) = 1.6894751598360064e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.6894751598360064e-06, f(x+ap) = 1.6086096819538413e-06, dgrad(x) = 1.455088963382822e-11 :

GD: iter = 272, x = [1.25677307e-03 1.70678429e-05], f(x) = 1.6086096819538413e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.6086096819538413e-06, f(x+ap) = 1.5562895769655461e-06, dgrad(x) = 7.019673709000411e-12 :

GD: iter = 273, x = [1.24695453e-03 3.73359064e-06], f(x) = 1.5562895769655461e-06 :

Backtrack: alpha = 0.0625, f(x) = 1.5562895769655461e-06, f(x+ap) = 1.3748194691039582e-06, dgrad(x) = 4.235731493923911e-11 :

GD: iter = 274, x = [1.09108522e-03 -4.29362923e-05], f(x) = 1.3748194691039582e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.3748194691039582e-06, f(x+ap) = 1.1807601195416944e-06, dgrad(x) = 3.066518584997714e-11 :

GD: iter = 275, x = [1.08256111e-03 -9.39231395e-06], f(x) = 1.1807601195416944e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.1807601195416944e-06, f(x+ap) = 1.1396717138525372e-06, dgrad(x) = 1.2838088602782496e-11 :

GD: iter = 276, x = [1.04873108e-03 1.99586671e-05], f(x) = 1.1396717138525372e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 1.1396717138525372e-06, f(x+ap) = 1.0846252113109325e-06, dgrad(x) = 7.94268877274598e-12 :

GD: iter = 277, x = [1.04053787e-03 4.36595844e-06], f(x) = 1.0846252113109325e-06 :

 Backtrack: alpha = 0.0625, f(x) = 1.0846252113109325e-06, f(x+ap) = 1.0810463425777161e-06, dgrad(x) = 3.183337456828453e-11 :

GD: iter = 278, x = [9.10470633e-04 -5.02085220e-05], f(x) = 1.0810463425777161e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 1.0810463425777161e-06, f(x+ap) = 8.28117799837101e-07, dgrad(x) = 4.0684240020206336e-11 :

GD: iter = 279, x = [9.03357582e-04 -1.09831142e-05], f(x) = 8.28117799837101e-07 :

 Backtrack: alpha = 0.015625, f(x) = 8.28117799837101e-07, f(x+ap) = 8.203198575401777e-07, dgrad(x) = 1.2639643086429159e-11 :

GD: iter = 280, x = [8.75127657e-04 2.33391177e-05], f(x) = 8.203198575401777e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 8.203198575401777e-07, f(x+ap) = 7.565353219791809e-07, dgrad(x) = 9.707800855618492e-12 :

GD: iter = 281, x = [8.68290722e-04 5.10543199e-06], f(x) = 7.565353219791809e-07 :

 Backtrack: alpha = 0.015625, f(x) = 7.565353219791809e-07, f(x+ap) = 7.193146616699139e-07, dgrad(x) = 6.3411446015588905e-12 :

GD: iter = 282, x = [8.41156637e-04 -1.08490430e-05], f(x) = 7.193146616699139e-07 :

 Backtrack: alpha = 0.015625, f(x) = 7.193146616699139e-07, f(x+ap) = 7.171636082357493e-07, dgrad(x) = 1.1778511393649832e-11 :

GD: iter = 283, x = [8.14870492e-04 2.30542163e-05], f(x) = 7.171636082357493e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 7.171636082357493e-07, f(x+ap) = 6.562225255889306e-07, dgrad(x) = 9.342160657882109e-12 :

GD: iter = 284, x = [8.08504317e-04 5.04310982e-06], f(x) = 6.562225255889306e-07 :

 Backtrack: alpha = 0.015625, f(x) = 6.562225255889306e-07, f(x+ap) = 6.249472061671902e-07, dgrad(x) = 5.675054978214696e-12 :

GD: iter = 285, x = [7.83238557e-04 -1.07166084e-05], f(x) = 6.249472061671902e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 6.249472061671902e-07, f(x+ap) = 6.044642803604268e-07, dgrad(x) = 2.7529993528356152e-12 :

GD: iter = 286, x = [7.77119505e-04 -2.34425808e-06], f(x) = 6.044642803604268e-07 :

 Backtrack: alpha = 0.0625, f(x) = 6.044642803604268e-07, f(x+ap) = 5.350508070769814e-07, dgrad(x) = 1.6471754631147697e-11 :

GD: iter = 287, x = [6.79979567e-04 2.69589679e-05], f(x) = 5.350508070769814e-07 :

Backtrack: alpha = 0.00390625, f(x) = 5.350508070769814e-07, f(x+ap) = 4.586536514021836e-07, dgrad(x) = 1.2078487075284145e-11 :

GD: iter = 288, x = [6.74667227e-04 5.89727423e-06], f(x) = 4.586536514021836e-07 :

Backtrack: alpha = 0.015625, f(x) = 4.586536514021836e-07, f(x+ap) = 4.428762529596343e-07, dgrad(x) = 5.018464380920256e-12 :

GD: iter = 289, x = [6.53583876e-04 -1.25317077e-05], f(x) = 4.428762529596343e-07 :

Backtrack: alpha = 0.00390625, f(x) = 4.428762529596343e-07, f(x+ap) = 4.212748735225005e-07, dgrad(x) = 3.1212638649398966e-12 :

GD: iter = 290, x = [6.48477752e-04 -2.74131107e-06], f(x) = 4.212748735225005e-07 :

Backtrack: alpha = 0.015625, f(x) = 4.212748735225005e-07, f(x+ap) = 3.980447458068821e-07, dgrad(x) = 3.097945366800132e-12 :

GD: iter = 291, x = [6.28212822e-04 5.82528602e-06], f(x) = 3.980447458068821e-07 :

Backtrack: alpha = 0.015625, f(x) = 3.980447458068821e-07, f(x+ap) = 3.8569434498110025e-07, dgrad(x) = 4.587443266062098e-12 :

GD: iter = 292, x = [6.08581172e-04 -1.23787328e-05], f(x) = 3.8569434498110025e-07 :

Backtrack: alpha = 0.00390625, f(x) = 3.8569434498110025e-07, f(x+ap) = 3.653398444983575e-07, dgrad(x) = 2.97297078035432e-12 :

GD: iter = 293, x = [6.03826631e-04 -2.70784780e-06], f(x) = 3.653398444983575e-07 :

Backtrack: alpha = 0.015625, f(x) = 3.653398444983575e-07, f(x+ap) = 3.454858039329925e-07, dgrad(x) = 2.73706873494968e-12 :

GD: iter = 294, x = [5.84957049e-04 5.75417657e-06], f(x) = 3.454858039329925e-07 :

Backtrack: alpha = 0.015625, f(x) = 3.454858039329925e-07, f(x+ap) = 3.360744641895224e-07, dgrad(x) = 4.2080014351327556e-12 :

GD: iter = 295, x = [5.66677141e-04 -1.22276252e-05], f(x) = 3.360744641895224e-07 :

Backtrack: alpha = 0.00390625, f(x) = 3.360744641895224e-07, f(x+ap) = 3.1684048729678594e-07, dgrad(x) = 2.8379236995125295e-12 :

GD: iter = 296, x = [5.62249976e-04 -2.67479302e-06], f(x) = 3.1684048729678594e-07 :

Backtrack: alpha = 0.015625, f(x) = 3.1684048729678594e-07, f(x+ap) = 2.9990664855448445e-07, dgrad(x) = 2.422938827290864e-12 :

GD: iter = 297, x = [5.44679664e-04 5.68393516e-06], f(x) = 2.9990664855448445e-07 :

Backtrack: alpha = 0.015625, f(x) = 2.9990664855448445e-07, f(x+ap) = 2.930120966013469e-07, dgrad(x) = 3.873419536391153e-12 :

GD: iter = 298, x = [5.27658425e-04 -1.20783622e-05], f(x) = 2.930120966013469e-07 :

Backtrack: alpha = 0.00390625, f(x) = 2.930120966013469e-07, f(x+ap) = 2.7478813229569945e-07, dgrad(x) = 2.714518362132986e-12 :

GD: iter = 299, x = [5.23536093e-04 -2.64214174e-06], f(x) = 2.7478813229569945e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.7478813229569945e-07, f(x+ap) = 2.603793979971381e-07, dgrad(x) = 2.1493698155140422e-12 :

GD: iter = 300, x = [5.07175590e-04 5.61455119e-06], f(x) = 2.603793979971381e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.603793979971381e-07, f(x+ap) = 2.556362735861928e-07, dgrad(x) = 3.5778683113016603e-12 :

GD: iter = 301, x = [4.91326353e-04 -1.19309213e-05], f(x) = 2.556362735861928e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 2.556362735861928e-07, f(x+ap) = 2.3832557163191757e-07, dgrad(x) = 2.6013600147200253e-12 :

GD: iter = 302, x = [4.87487866e-04 -2.60988903e-06], f(x) = 2.3832557163191757e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.3832557163191757e-07, f(x+ap) = 2.2609954529825164e-07, dgrad(x) = 1.9109976684996344e-12 :

GD: iter = 303, x = [4.72253870e-04 5.54601419e-06], f(x) = 2.2609954529825164e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.2609954529825164e-07, f(x+ap) = 2.231918149970433e-07, dgrad(x) = 3.316290321180373e-12 :

GD: iter = 304, x = [4.57495937e-04 -1.17852801e-05], f(x) = 2.231918149970433e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 2.231918149970433e-07, f(x+ap) = 2.0670957882238305e-07, dgrad(x) = 2.4972356450194457e-12 :

GD: iter = 305, x = [4.53921750e-04 -2.57803003e-06], f(x) = 2.0670957882238305e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.0670957882238305e-07, f(x+ap) = 1.9636955325823678e-07, dgrad(x) = 1.703170896039276e-12 :

GD: iter = 306, x = [4.39736695e-04 5.47831382e-06], f(x) = 1.9636955325823678e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.9636955325823678e-07, f(x+ap) = 1.950239334085469e-07, dgrad(x) = 3.084297398604938e-12 :

GD: iter = 307, x = [4.25994923e-04 -1.16414169e-05], f(x) = 1.950239334085469e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 1.950239334085469e-07, f(x+ap) = 1.7929575274228511e-07, dgrad(x) = 2.4010899062013894e-12 :

GD: iter = 308, x = [4.22666838e-04 -2.54655994e-06], f(x) = 1.7929575274228511e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.7929575274228511e-07, f(x+ap) = 1.705846308472423e-07, dgrad(x) = 1.5218558198825487e-12 :

GD: iter = 309, x = [4.09458499e-04 5.41143987e-06], f(x) = 1.705846308472423e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.705846308472423e-07, f(x+ap) = 1.705648855083647e-07, dgrad(x) = 2.87808173272189e-12 :

GD: iter = 310, x = [3.96662921e-04 -1.14993097e-05], f(x) = 1.705648855083647e-07 :

Backtrack: alpha = 0.00390625, f(x) = 1.705648855083647e-07, f(x+ap) = 1.5552537689147991e-07, dgrad(x) = 2.3120042402036744e-12 :

GD: iter = 311, x = [3.93563992e-04 -2.51547400e-06], f(x) = 1.5552537689147991e-07 :

Backtrack: alpha = 0.015625, f(x) = 1.5552537689147991e-07, f(x+ap) = 1.4822040091314674e-07, dgrad(x) = 1.3635544404281787e-12 :

GD: iter = 312, x = [3.81265117e-04 5.34538225e-06], f(x) = 1.4822040091314674e-07 :

Backtrack: alpha = 0.00390625, f(x) = 1.4822040091314674e-07, f(x+ap) = 1.4323739055387327e-07, dgrad(x) = 6.735846939014327e-13 :

GD: iter = 313, x = [3.78286484e-04 1.16930237e-06], f(x) = 1.4323739055387327e-07 :

Backtrack: alpha = 0.0625, f(x) = 1.4323739055387327e-07, f(x+ap) = 1.2764356534868695e-07, dgrad(x) = 3.919333600663354e-12 :

GD: iter = 314, x = [3.31000673e-04 -1.34469772e-05], f(x) = 1.2764356534868695e-07 :

Backtrack: alpha = 0.00390625, f(x) = 1.2764356534868695e-07, f(x+ap) = 1.0872149287483305e-07, dgrad(x) = 2.9965209564188856e-12 :

GD: iter = 315, x = [3.28414730e-04 -2.94152627e-06], f(x) = 1.0872149287483305e-07 :

Backtrack: alpha = 0.015625, f(x) = 1.0872149287483305e-07, f(x+ap) = 1.0512772805839017e-07, dgrad(x) = 1.2148875195009746e-12 :

GD: iter = 316, x = [3.18151770e-04 6.25074332e-06], f(x) = 1.0512772805839017e-07 :

Backtrack: alpha = 0.00390625, f(x) = 1.0512772805839017e-07, f(x+ap) = 9.983212041683423e-08, dgrad(x) = 7.686538588045723e-13 :

GD: iter = 317, x = [3.15666209e-04 1.36735010e-06], f(x) = 9.983212041683423e-08 :

Backtrack: alpha = 0.015625, f(x) = 9.983212041683423e-08, f(x+ap) = 9.43589054301737e-08, dgrad(x) = 7.39635117456595e-13 :

GD: iter = 318, x = [3.05801640e-04 -2.90561897e-06], f(x) = 9.43589054301737e-08 :

Backtrack: alpha = 0.015625, f(x) = 9.43589054301737e-08, f(x+ap) = 9.157367226736961e-08, dgrad(x) = 1.1121303689706034e-12 :

GD: iter = 319, x = [2.96245339e-04 6.17444030e-06], f(x) = 9.157367226736961e-08 :

Backtrack: alpha = 0.00390625, f(x) = 9.157367226736961e-08, f(x+ap) = 8.657781508282128e-08, dgrad(x) = 7.328100492429726e-13 :

GD: iter = 320, x = [2.93930922e-04 1.35065882e-06], f(x) = 8.657781508282128e-08 :

Backtrack: alpha = 0.015625, f(x) = 8.657781508282128e-08, f(x+ap) = 8.190382205026465e-08, dgrad(x) = 6.539886221189423e-13 :

GD: iter = 321, x = [2.84745581e-04 -2.87014998e-06], f(x) = 8.190382205026465e-08 :

Backtrack: alpha = 0.015625, f(x) = 8.190382205026465e-08, f(x+ap) = 7.981158673873483e-08, dgrad(x) = 1.0216103456114726e-12 :

GD: iter = 322, x = [2.75847282e-04 6.09906872e-06], f(x) = 7.981158673873483e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 7.981158673873483e-08, f(x+ap) = 7.508543521905377e-08, dgrad(x) = 7.001220546832773e-13 :

GD: iter = 323, x = [2.73692225e-04 1.33417128e-06], f(x) = 7.508543521905377e-08 :

 Backtrack: alpha = 0.015625, f(x) = 7.508543521905377e-08, f(x+ap) = 7.110265821374485e-08, dgrad(x) = 5.794222750792275e-13 :

GD: iter = 324, x = [2.65139343e-04 -2.83511397e-06], f(x) = 7.110265821374485e-08 :

 Backtrack: alpha = 0.015625, f(x) = 7.110265821374485e-08, f(x+ap) = 6.960344412183183e-08, dgrad(x) = 9.417348971715438e-13 :

GD: iter = 325, x = [2.56853738e-04 6.02461719e-06], f(x) = 6.960344412183183e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 6.960344412183183e-08, f(x+ap) = 6.51207104064011e-08, dgrad(x) = 6.702093223934851e-13 :

GD: iter = 326, x = [2.54847068e-04 1.31788501e-06], f(x) = 6.51207104064011e-08 :

 Backtrack: alpha = 0.015625, f(x) = 6.51207104064011e-08, f(x+ap) = 6.173554706776755e-08, dgrad(x) = 5.144702334255655e-13 :

GD: iter = 327, x = [2.46883098e-04 -2.80050565e-06], f(x) = 6.173554706776755e-08 :

 Backtrack: alpha = 0.015625, f(x) = 6.173554706776755e-08, f(x+ap) = 6.074286138066804e-08, dgrad(x) = 8.711223924302108e-13 :

GD: iter = 328, x = [2.39168001e-04 5.95107450e-06], f(x) = 6.074286138066804e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 6.074286138066804e-08, f(x+ap) = 5.6480520760762894e-08, dgrad(x) = 6.427409534118868e-13 :

GD: iter = 329, x = [2.37299501e-04 1.30179755e-06], f(x) = 5.6480520760762894e-08 :

 Backtrack: alpha = 0.015625, f(x) = 5.6480520760762894e-08, f(x+ap) = 5.3611856038378816e-08, dgrad(x) = 4.578613851951002e-13 :

GD: iter = 330, x = [2.29883891e-04 -2.76631979e-06], f(x) = 5.3611856038378816e-08 :

 Backtrack: alpha = 0.015625, f(x) = 5.3611856038378816e-08, f(x+ap) = 5.305089221179514e-08, dgrad(x) = 8.085740955094925e-13 :

GD: iter = 331, x = [2.22700020e-04 5.87842955e-06], f(x) = 5.305089221179514e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 5.305089221179514e-08, f(x+ap) = 4.898875486839519e-08, dgrad(x) = 6.174291231157797e-13 :

GD: iter = 332, x = [2.20960176e-04 1.28590646e-06], f(x) = 4.898875486839519e-08 :

 Backtrack: alpha = 0.015625, f(x) = 4.898875486839519e-08, f(x+ap) = 4.656629959427467e-08, dgrad(x) = 4.084934604966405e-13 :

GD: iter = 333, x = [2.14055170e-04 -2.73255124e-06], f(x) = 4.656629959427467e-08 :

Backtrack: alpha = 0.015625, f(x) = 4.656629959427467e-08, f(x+ap) = 4.637237893879718e-08, dgrad(x) = 7.530498662531274e-13 :

GD: iter = 334, x = [2.07365946e-04 5.80667138e-06], f(x) = 4.637237893879718e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 4.637237893879718e-08, f(x+ap) = 4.249271848942103e-08, dgrad(x) = 5.940233760957579e-13 :

GD: iter = 335, x = [2.05745900e-04 1.27020936e-06], f(x) = 4.249271848942103e-08 :

 Backtrack: alpha = 0.015625, f(x) = 4.249271848942103e-08, f(x+ap) = 4.045556889372731e-08, dgrad(x) = 3.6541058495806306e-13 :

GD: iter = 336, x = [1.9931634e-04 -2.6991949e-06], f(x) = 4.045556889372731e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 4.045556889372731e-08, f(x+ap) = 3.914355688494259e-08, dgrad(x) = 1.7591177280802504e-13 :

GD: iter = 337, x = [1.97759182e-04 -5.90448884e-07], f(x) = 3.914355688494259e-08 :

 Backtrack: alpha = 0.0625, f(x) = 3.914355688494259e-08, f(x+ap) = 3.455322399007533e-08, dgrad(x) = 1.064874818594928e-12 :

GD: iter = 338, x = [1.73039284e-04 6.79016217e-06], f(x) = 3.455322399007533e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 3.455322399007533e-08, f(x+ap) = 2.969719414820745e-08, dgrad(x) = 7.671962755056024e-13 :

GD: iter = 339, x = [1.71687414e-04 1.48534797e-06], f(x) = 2.969719414820745e-08 :

 Backtrack: alpha = 0.015625, f(x) = 2.969719414820745e-08, f(x+ap) = 2.865933213192203e-08, dgrad(x) = 3.221197145514308e-13 :

GD: iter = 340, x = [1.66322183e-04 -3.15636444e-06], f(x) = 2.865933213192203e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 2.865933213192203e-08, f(x+ap) = 2.7280194228081937e-08, dgrad(x) = 1.9888973995286176e-13 :

GD: iter = 341, x = [1.65022791e-04 -6.90454722e-07], f(x) = 2.7280194228081937e-08 :

 Backtrack: alpha = 0.0625, f(x) = 2.7280194228081937e-08, f(x+ap) = 2.715462338374531e-08, dgrad(x) = 7.999949672854852e-13 :

GD: iter = 342, x = [1.44394942e-04 7.94022931e-06], f(x) = 2.715462338374531e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 2.715462338374531e-08, f(x+ap) = 2.082708304221125e-08, dgrad(x) = 1.017691115093946e-12 :

GD: iter = 343, x = [1.43266856e-04 1.73692516e-06], f(x) = 2.082708304221125e-08 :

 Backtrack: alpha = 0.015625, f(x) = 2.082708304221125e-08, f(x+ap) = 2.0624922437020918e-08, dgrad(x) = 3.1684051427470054e-13 :

GD: iter = 344, x = [1.38789767e-04 -3.69096597e-06], f(x) = 2.0624922437020918e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 2.0624922437020918e-08, f(x+ap) = 1.9027986322513283e-08, dgrad(x) = 2.4296077677813575e-13 :

GD: iter = 345, x = [1.37705472e-04 -8.07398805e-07], f(x) = 1.9027986322513283e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.9027986322513283e-08, f(x+ap) = 1.8090510937319373e-08, dgrad(x) = 1.5926078341431837e-13 :

GD: iter = 346, x = [1.33402176e-04 1.71572246e-06], f(x) = 1.8090510937319373e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.8090510937319373e-08, f(x+ap) = 1.803052697860939e-08, dgrad(x) = 2.9520735135353334e-13 :

GD: iter = 347, x = [1.29233358e-04 -3.64591023e-06], f(x) = 1.803052697860939e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.803052697860939e-08, f(x+ap) = 1.6504930463454807e-08, dgrad(x) = 2.3379355450031943e-13 :

GD: iter = 348, x = [1.28223722e-04 -7.97542863e-07], f(x) = 1.6504930463454807e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.6504930463454807e-08, f(x+ap) = 1.5717023738226683e-08, dgrad(x) = 1.425129323837639e-13 :

GD: iter = 349, x = [1.24216731e-04 1.69477858e-06], f(x) = 1.5717023738226683e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.5717023738226683e-08, f(x+ap) = 1.520339176850936e-08, dgrad(x) = 6.898834493977811e-14 :

GD: iter = 350, x = [1.23246288e-04 3.70732815e-07], f(x) = 1.520339176850936e-08 :

Backtrack: alpha = 0.0625, f(x) = 1.520339176850936e-08, f(x+ap) = 1.3447255154090635e-08, dgrad(x) = 4.141018922141581e-13 :

GD: iter = 351, x = [1.07840502e-04 -4.26342737e-06], f(x) = 1.3447255154090635e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.3447255154090635e-08, f(x+ap) = 1.1535550468387457e-08, dgrad(x) = 3.0218391184628823e-13 :

GD: iter = 352, x = [1.06997998e-04 -9.32624738e-07], f(x) = 1.1535550468387457e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.1535550468387457e-08, f(x+ap) = 1.113698015129314e-08, dgrad(x) = 1.2591537873887887e-13 :

GD: iter = 353, x = [1.03654311e-04 1.98182757e-06], f(x) = 1.113698015129314e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.113698015129314e-08, f(x+ap) = 1.0595787872111678e-08, dgrad(x) = 7.81572206348766e-14 :

GD: iter = 354, x = [1.02844511e-04 4.33524781e-07], f(x) = 1.0595787872111678e-08 :

Backtrack: alpha = 0.0625, f(x) = 1.0595787872111678e-08, f(x+ap) = 1.0583566547626748e-08, dgrad(x) = 3.1141077130709777e-13 :

GD: iter = 355, x = [8.99889474e-05 -4.98553498e-06], f(x) = 1.0583566547626748e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.0583566547626748e-08, f(x+ap) = 8.090911227836076e-09, dgrad(x) = 4.0102125105531945e-13 :

GD: iter = 356, x = [8.92859087e-05 -1.09058578e-06], f(x) = 8.090911227836076e-09 :

Backtrack: alpha = 0.015625, f(x) = 8.090911227836076e-09, f(x+ap) = 8.018588484175628e-09, dgrad(x) = 1.2416091778299098e-13 :

GD: iter = 357, x = [8.64957241e-05 2.31749477e-06], f(x) = 8.018588484175628e-09 :

Backtrack: alpha = 0.00390625, f(x) = 8.018588484175628e-09, f(x+ap) = 7.390768349492894e-09, dgrad(x) = 9.560832901435832e-14 :

GD: iter = 358, x = [8.58199762e-05 5.06951982e-07], f(x) = 7.390768349492894e-09 :

Backtrack: alpha = 0.015625, f(x) = 7.390768349492894e-09, f(x+ap) = 7.0279957012896585e-09, dgrad(x) = 6.209419648465817e-14 :

GD: iter = 359, x = [8.31381020e-05 -1.07727296e-06], f(x) = 7.0279957012896585e-09 :

Backtrack: alpha = 0.015625, f(x) = 7.0279957012896585e-09, f(x+ap) = 7.010743416330926e-09, dgrad(x) = 1.1573196458297707e-13 :

GD: iter = 360, x = [8.05400363e-05 2.28920504e-06], f(x) = 7.010743416330926e-09 :

Backtrack: alpha = 0.00390625, f(x) = 7.010743416330926e-09, f(x+ap) = 6.410815131042722e-09, dgrad(x) = 9.201764802952458e-14 :

GD: iter = 361, x = [7.99108172e-05 5.00763603e-07], f(x) = 6.410815131042722e-09 :

Backtrack: alpha = 0.015625, f(x) = 6.410815131042722e-09, f(x+ap) = 6.106101818716274e-09, dgrad(x) = 5.558362859493057e-14 :

GD: iter = 362, x = [7.74136042e-05 -1.06412266e-06], f(x) = 6.106101818716274e-09 :

Backtrack: alpha = 0.00390625, f(x) = 6.106101818716274e-09, f(x+ap) = 5.905011863622912e-09, dgrad(x) = 2.7056931878810654e-14 :

GD: iter = 363, x = [7.68088104e-05 -2.32776831e-07], f(x) = 5.905011863622912e-09 :

Backtrack: alpha = 0.0625, f(x) = 5.905011863622912e-09, f(x+ap) = 5.233473492589534e-09, dgrad(x) = 1.6103609724004558e-13 :

GD: iter = 364, x = [6.72077091e-05 2.67693356e-06], f(x) = 5.233473492589534e-09 :

Backtrack: alpha = 0.00390625, f(x) = 5.233473492589534e-09, f(x+ap) = 4.480865964931725e-09, dgrad(x) = 1.1902595145046952e-13 :

GD: iter = 365, x = [6.66826489e-05 5.85579216e-07], f(x) = 4.480865964931725e-09 :

Backtrack: alpha = 0.015625, f(x) = 4.480865964931725e-09, f(x+ap) = 4.327849187335507e-09, dgrad(x) = 4.922253652612257e-14 :

GD: iter = 366, x = [6.45988161e-05 -1.24435583e-06], f(x) = 4.327849187335507e-09 :

Backtrack: alpha = 0.00390625, f(x) = 4.327849187335507e-09, f(x+ap) = 4.115467946845333e-09, dgrad(x) = 3.0714408522756625e-14 :

GD: iter = 367, x = [6.40941379e-05 -2.72202839e-07], f(x) = 4.115467946845333e-09 :

Backtrack: alpha = 0.015625, f(x) = 4.115467946845333e-09, f(x+ap) = 3.8887748733185675e-09, dgrad(x) = 3.030626476235247e-14 :

GD: iter = 368, x = [6.20911961e-05 5.78431032e-07], f(x) = 3.8887748733185675e-09 :

 Backtrack: alpha = 0.015625, f(x) = 3.8887748733185675e-09, f(x+ap) = 3.7692091874630995e-09, dgrad(x) = 4.500713260402983e-14 :

GD: iter = 369, x = [6.01508462e-05 -1.22916594e-06], f(x) = 3.7692091874630995e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 3.7692091874630995e-09, f(x+ap) = 3.5690415846487157e-09, dgrad(x) = 2.9260333525852335e-14 :

GD: iter = 370, x = [5.96809177e-05 -2.68880050e-07], f(x) = 3.5690415846487157e-09 :

 Backtrack: alpha = 0.015625, f(x) = 3.5690415846487157e-09, f(x+ap) = 3.375323402305222e-09, dgrad(x) = 2.677985468667799e-14 :

GD: iter = 371, x = [5.78158890e-05 5.71370106e-07], f(x) = 3.375323402305222e-09 :

 Backtrack: alpha = 0.015625, f(x) = 3.375323402305222e-09, f(x+ap) = 3.2844428506023454e-09, dgrad(x) = 4.129571879844195e-14 :

GD: iter = 372, x = [5.60091425e-05 -1.21416148e-06], f(x) = 3.2844428506023454e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 3.2844428506023454e-09, f(x+ap) = 3.0952537300352514e-09, dgrad(x) = 2.7935788974909584e-14 :

GD: iter = 373, x = [5.55715711e-05 -2.65597823e-07], f(x) = 3.0952537300352514e-09 :

 Backtrack: alpha = 0.015625, f(x) = 3.0952537300352514e-09, f(x+ap) = 2.9300570739446975e-09, dgrad(x) = 2.3710134656553636e-14 :

GD: iter = 374, x = [5.38349595e-05 5.64395374e-07], f(x) = 2.9300570739446975e-09 :

 Backtrack: alpha = 0.015625, f(x) = 2.9300570739446975e-09, f(x+ap) = 2.86373714175159e-09, dgrad(x) = 3.802265149133916e-14 :

GD: iter = 375, x = [5.21526170e-05 -1.19934017e-06], f(x) = 2.86373714175159e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 2.86373714175159e-09, f(x+ap) = 2.6844461496873433e-09, dgrad(x) = 2.672509979642595e-14 :

GD: iter = 376, x = [5.17451747e-05 -2.62355662e-07], f(x) = 2.6844461496873433e-09 :

 Backtrack: alpha = 0.015625, f(x) = 2.6844461496873433e-09, f(x+ap) = 2.543911483958931e-09, dgrad(x) = 2.103667521331744e-14 :

GD: iter = 377, x = [5.01281379e-05 5.57505782e-07], f(x) = 2.543911483958931e-09 :

 Backtrack: alpha = 0.015625, f(x) = 2.543911483958931e-09, f(x+ap) = 2.4985836199915134e-09, dgrad(x) = 3.513098238061794e-14 :

GD: iter = 378, x = [4.85616336e-05 -1.18469979e-06], f(x) = 2.4985836199915134e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 2.4985836199915134e-09, f(x+ap) = 2.32824484943727e-09, dgrad(x) = 2.5614637648806135e-14 :

GD: iter = 379, x = [4.81822459e-05 -2.59153078e-07], f(x) = 2.32824484943727e-09 :

Backtrack: alpha = 0.015625, f(x) = 2.32824484943727e-09, f(x+ap) = 2.2090274656012114e-09, dgrad(x) = 1.870707498236536e-14 :

GD: iter = 380, x = [4.66765507e-05 5.50700291e-07], f(x) = 2.2090274656012114e-09 :

Backtrack: alpha = 0.015625, f(x) = 2.2090274656012114e-09, f(x+ap) = 2.1816049730702736e-09, dgrad(x) = 3.257130307575008e-14 :

GD: iter = 381, x = [4.52179085e-05 -1.17023812e-06], f(x) = 2.1816049730702736e-09 :

Backtrack: alpha = 0.00390625, f(x) = 2.1816049730702736e-09, f(x+ap) = 2.0193893098818956e-09, dgrad(x) = 2.4592549681162873e-14 :

GD: iter = 382, x = [4.48646436e-05 -2.55989589e-07], f(x) = 2.0193893098818956e-09 :

Backtrack: alpha = 0.015625, f(x) = 2.0193893098818956e-09, f(x+ap) = 1.9185908310599214e-09, dgrad(x) = 1.6675893357177032e-14 :

GD: iter = 383, x = [4.34626235e-05 5.43977876e-07], f(x) = 1.9185908310599214e-09 :

Backtrack: alpha = 0.015625, f(x) = 1.9185908310599214e-09, f(x+ap) = 1.906404617460164e-09, dgrad(x) = 3.030074330740559e-14 :

GD: iter = 384, x = [4.21044165e-05 -1.15595299e-06], f(x) = 1.906404617460164e-09 :

Backtrack: alpha = 0.00390625, f(x) = 1.906404617460164e-09, f(x+ap) = 1.7515844284491072e-09, dgrad(x) = 2.3648523336805855e-14 :

GD: iter = 385, x = [4.17754757e-05 -2.52864716e-07], f(x) = 1.7515844284491072e-09 :

Backtrack: alpha = 0.015625, f(x) = 1.7515844284491072e-09, f(x+ap) = 1.6666934223404404e-09, dgrad(x) = 1.490372509960064e-14 :

GD: iter = 386, x = [4.04699921e-05 5.37337521e-07], f(x) = 1.6666934223404404e-09 :

Backtrack: alpha = 0.00390625, f(x) = 1.6666934223404404e-09, f(x+ap) = 1.6137109101390591e-09, dgrad(x) = 7.0705255813850056e-15 :

GD: iter = 387, x = [4.01538203e-05 1.17542583e-07], f(x) = 1.6137109101390591e-09 :

Backtrack: alpha = 0.0625, f(x) = 1.6137109101390591e-09, f(x+ap) = 1.4171596300175376e-09, dgrad(x) = 4.376229679003781e-14 :

GD: iter = 388, x = [3.51345928e-05 -1.35173970e-06], f(x) = 1.4171596300175376e-09 :

Backtrack: alpha = 0.00390625, f(x) = 1.4171596300175376e-09, f(x+ap) = 1.2239702721419923e-09, dgrad(x) = 3.047881528660465e-14 :

GD: iter = 389, x = [3.48601038e-05 -2.95693059e-07], f(x) = 1.2239702721419923e-09 :

Backtrack: alpha = 0.015625, f(x) = 1.2239702721419923e-09, f(x+ap) = 1.17994399111678e-09, dgrad(x) = 1.305981679803749e-14 :

GD: iter = 390, x = [3.37707255e-05 6.28347751e-07], f(x) = 1.17994399111678e-09 :

Backtrack: alpha = 0.00390625, f(x) = 1.17994399111678e-09, f(x+ap) = 1.124601072196912e-09, dgrad(x) = 7.951048230558882e-15 :

GD: iter = 391, x = [3.35068917e-05 1.37451071e-07], f(x) = 1.124601072196912e-09 :

 Backtrack: alpha = 0.0625, f(x) = 1.124601072196912e-09, f(x+ap) = 1.1094334539631437e-09, dgrad(x) = 3.279099401550884e-14 :

GD: iter = 392, x = [2.93185303e-05 -1.58068731e-06], f(x) = 1.1094334539631437e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 1.1094334539631437e-09, f(x+ap) = 8.58153861367891e-10, dgrad(x) = 4.038328124681763e-14 :

GD: iter = 393, x = [2.90894792e-05 -3.45775349e-07], f(x) = 8.58153861367891e-10 :

 Backtrack: alpha = 0.015625, f(x) = 8.58153861367891e-10, f(x+ap) = 8.481258845113798e-10, dgrad(x) = 1.2761273283061079e-14 :

GD: iter = 394, x = [2.81804330e-05 7.34772618e-07], f(x) = 8.481258845113798e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 8.481258845113798e-10, f(x+ap) = 7.843603490713101e-10, dgrad(x) = 9.676632502005666e-15 :

GD: iter = 395, x = [2.79602734e-05 1.60731510e-07], f(x) = 7.843603490713101e-10 :

 Backtrack: alpha = 0.015625, f(x) = 7.843603490713101e-10, f(x+ap) = 7.453452306219272e-10, dgrad(x) = 6.500769191716685e-15 :

GD: iter = 396, x = [2.70865148e-05 -3.41554459e-07], f(x) = 7.453452306219272e-10 :

 Backtrack: alpha = 0.015625, f(x) = 7.453452306219272e-10, f(x+ap) = 7.412198462871662e-10, dgrad(x) = 1.187671106476311e-14 :

GD: iter = 397, x = [2.62400612e-05 7.25803225e-07], f(x) = 7.412198462871662e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 7.412198462871662e-10, f(x+ap) = 6.803451630700534e-10, dgrad(x) = 9.30694380242402e-15 :

GD: iter = 398, x = [2.60350608e-05 1.58769456e-07], f(x) = 6.803451630700534e-10 :

 Backtrack: alpha = 0.015625, f(x) = 6.803451630700534e-10, f(x+ap) = 6.475051727322378e-10, dgrad(x) = 5.8118861826152385e-15 :

GD: iter = 399, x = [2.52214651e-05 -3.37385093e-07], f(x) = 6.475051727322378e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 6.475051727322378e-10, f(x+ap) = 6.267664055972787e-10, dgrad(x) = 2.772514551068028e-15 :

GD: iter = 400, x = [2.50244224e-05 -7.38029891e-08], f(x) = 6.267664055972787e-10 :

 Backtrack: alpha = 0.0625, f(x) = 6.267664055972787e-10, f(x+ap) = 5.514860063193697e-10, dgrad(x) = 1.7017263237041677e-14 :

GD: iter = 401, x = [2.18963696e-05 8.48734375e-07], f(x) = 5.514860063193697e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 5.514860063193697e-10, f(x+ap) = 4.754358313873296e-10, dgrad(x) = 1.200461154692146e-14 :

GD: iter = 402, x = [2.17253042e-05 1.85660644e-07], f(x) = 4.754358313873296e-10 :

Backtrack: alpha = 0.015625, f(x) = 4.754358313873296e-10, f(x+ap) = 4.585157706441956e-10, dgrad(x) = 5.104297455703329e-15 :

GD: iter = 403, x = [2.10463885e-05 -3.94528869e-07], f(x) = 4.585157706441956e-10 :

Backtrack: alpha = 0.00390625, f(x) = 4.585157706441956e-10, f(x+ap) = 4.3680122631509145e-10, dgrad(x) = 3.1241886816897498e-15 :

GD: iter = 404, x = [2.08819636e-05 -8.63031902e-08], f(x) = 4.3680122631509145e-10 :

Backtrack: alpha = 0.0625, f(x) = 4.3680122631509145e-10, f(x+ap) = 4.323586654169487e-10, dgrad(x) = 1.2763470215890592e-14 :

GD: iter = 405, x = [1.82717181e-05 9.92486687e-07], f(x) = 4.323586654169487e-10 :

Backtrack: alpha = 0.00390625, f(x) = 4.323586654169487e-10, f(x+ap) = 3.333730864817478e-10, dgrad(x) = 1.5912740511417708e-14 :

GD: iter = 406, x = [1.81289703e-05 2.17106463e-07], f(x) = 3.333730864817478e-10 :

Backtrack: alpha = 0.015625, f(x) = 3.333730864817478e-10, f(x+ap) = 3.2972379473245807e-10, dgrad(x) = 5.000073293395622e-15 :

GD: iter = 407, x = [1.75624400e-05 -4.61351234e-07], f(x) = 3.2972379473245807e-10 :

Backtrack: alpha = 0.00390625, f(x) = 3.2972379473245807e-10, f(x+ap) = 3.046572566565257e-10, dgrad(x) = 3.807638914947894e-15 :

GD: iter = 408, x = [1.74252334e-05 -1.00920582e-07], f(x) = 3.046572566565257e-10 :

Backtrack: alpha = 0.015625, f(x) = 3.046572566565257e-10, f(x+ap) = 2.895570077518364e-10, dgrad(x) = 2.5343024978464225e-15 :

GD: iter = 409, x = [1.68806949e-05 2.14456237e-07], f(x) = 2.895570077518364e-10 :

Backtrack: alpha = 0.015625, f(x) = 2.895570077518364e-10, f(x+ap) = 2.881942995736115e-10, dgrad(x) = 4.65545398660158e-15 :

GD: iter = 410, x = [1.63531732e-05 -4.55719505e-07], f(x) = 2.881942995736115e-10 :

Backtrack: alpha = 0.00390625, f(x) = 2.881942995736115e-10, f(x+ap) = 2.642578423024469e-10, dgrad(x) = 3.662857721506042e-15 :

GD: iter = 411, x = [1.62254140e-05 -9.96886416e-08], f(x) = 2.642578423024469e-10 :

Backtrack: alpha = 0.015625, f(x) = 2.642578423024469e-10, f(x+ap) = 2.5155469907169917e-10, dgrad(x) = 2.2665144530336193e-15 :

GD: iter = 412, x = [1.57183698e-05 2.11838363e-07], f(x) = 2.5155469907169917e-10 :

Backtrack: alpha = 0.00390625, f(x) = 2.5155469907169917e-10, f(x+ap) = 2.4343654165564685e-10, dgrad(x) = 1.0872219878773473e-15 :

GD: iter = 413, x = [1.55955701e-05 4.63396420e-08], f(x) = 2.4343654165564685e-10 :

Backtrack: alpha = 0.0625, f(x) = 2.4343654165564685e-10, f(x+ap) = 2.1461556279550113e-10, dgrad(x) = 6.617385740739813e-15 :

GD: iter = 414, x = [1.36461238e-05 -5.32905883e-07], f(x) = 2.1461556279550113e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 2.1461556279550113e-10, f(x+ap) = 1.8467735488725095e-10, dgrad(x) = 4.728286714609081e-15 :

GD: iter = 415, x = [1.35395135e-05 -1.16573162e-07], f(x) = 1.8467735488725095e-10 :

 Backtrack: alpha = 0.015625, f(x) = 1.8467735488725095e-10, f(x+ap) = 1.7817646425734964e-10, dgrad(x) = 1.9950715344098275e-15 :

GD: iter = 416, x = [1.31164037e-05 2.47717969e-07], f(x) = 1.7817646425734964e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 1.7817646425734964e-10, f(x+ap) = 1.6965605707091048e-10, dgrad(x) = 1.227628073758918e-15 :

GD: iter = 417, x = [1.30139318e-05 5.41883057e-08], f(x) = 1.6965605707091048e-10 :

 Backtrack: alpha = 0.0625, f(x) = 1.6965605707091048e-10, f(x+ap) = 1.685016287135302e-10, dgrad(x) = 4.9681536153584444e-15 :

GD: iter = 418, x = [1.13871903e-05 -6.23165516e-07], f(x) = 1.685016287135302e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 1.685016287135302e-10, f(x+ap) = 1.2950819778379508e-10, dgrad(x) = 6.270344853643423e-15 :

GD: iter = 419, x = [1.12982279e-05 -1.36317457e-07], f(x) = 1.2950819778379508e-10 :

 Backtrack: alpha = 0.015625, f(x) = 1.2950819778379508e-10, f(x+ap) = 1.2818762610591354e-10, dgrad(x) = 1.959215266930547e-15 :

GD: iter = 420, x = [1.09451582e-05 2.89674595e-07], f(x) = 1.2818762610591354e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 1.2818762610591354e-10, f(x+ap) = 1.1833350966660154e-10, dgrad(x) = 1.4982971888215377e-15 :

GD: iter = 421, x = [1.08596492e-05 6.33663177e-08], f(x) = 1.1833350966660154e-10 :

 Backtrack: alpha = 0.015625, f(x) = 1.1833350966660154e-10, f(x+ap) = 1.124895542951183e-10, dgrad(x) = 9.880305179495461e-16 :

GD: iter = 422, x = [1.05202852e-05 -1.34653425e-07], f(x) = 1.124895542951183e-10 :

 Backtrack: alpha = 0.015625, f(x) = 1.124895542951183e-10, f(x+ap) = 1.1205473298723608e-10, dgrad(x) = 1.8249490557838603e-15 :

GD: iter = 423, x = [1.01915262e-05 2.86138529e-07], f(x) = 1.1205473298723608e-10 :

GD termination: small df = 4.3482130788222335e-13

<mark>GD final: iter = 423, x = [1.01915262e-05 2.86138529e-07], f(x) = 1.1205473298723608e-10, OK = True:</mark>

The chosen method is = newton

Newton: iter = 1, x = [8. 6.], f(x) = 3664.0 :

 Backtrack: alpha = 1.0, f(x) = 3664.0, f(x+ap) = 0.0, dgrad(x) = 0.7328 :

Newton: iter = 2, x = [0. 0.], f(x) = 0.0 :

 Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

Newton: iter = 3, x = [0. 0.], f(x) = 0.0 :

Newton termination: small dx = [0. 0.]

Newton final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :

The chosen method is = bfgs

BFGS: iter = 1, x = [8. 6.], f(x) = 3664.0 :

 Backtrack: alpha = 1.0, f(x) = 3664.0, f(x+ap) = 0.0, dgrad(x) = 0.7328 :

BFGS: iter = 2, x = [0. 0.], f(x) = 0.0 :

 Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

BFGS: iter = 3, x = [0. 0.], f(x) = 0.0 :

BFGS termination: small dx = [0. 0.]

BFGS final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :

The chosen method is = sr1

SR1: iter = 1, x = [8. 6.], f(x) = 3664.0 :

 Backtrack: alpha = 1.0, f(x) = 3664.0, f(x+ap) = 0.0, dgrad(x) = 0.7328 :
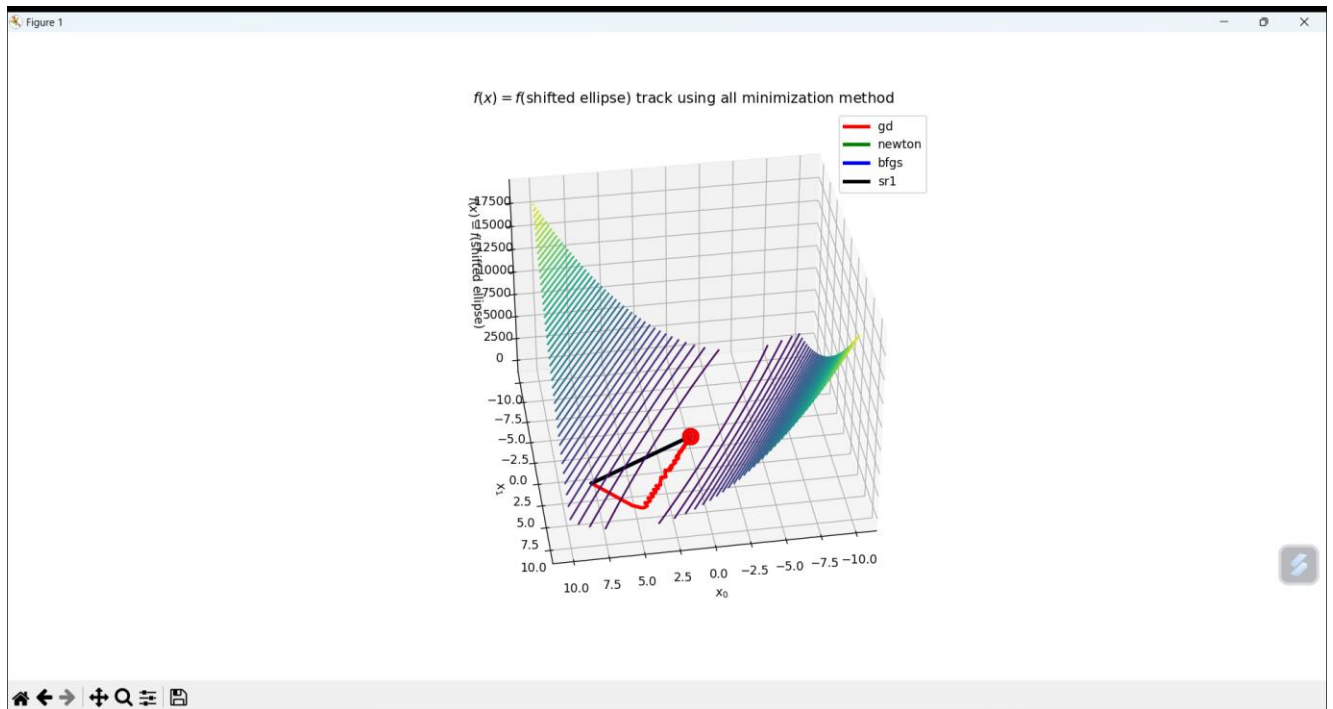
SR1: iter = 2, x = [0. 0.], f(x) = 0.0 :

 Backtrack: alpha = 1.0, f(x) = 0.0, f(x+ap) = 0.0, dgrad(x) = 0.0 :

SR1: iter = 3, x = [0. 0.], f(x) = 0.0 :

SR1 termination: small dx = [0. 0.]

SR1 final: iter = 3, x = [0. 0.], f(x) = 0.0, OK = True :

Shifted ellipse objective function

Shifted ellipse objective prints (<mark>final results are highlighted</mark>)

You chose 3: shifted ellipse

The chosen method is = gd

GD: iter = 1, x = [8. 6.], f(x) = 1627.6472812163474 :

 Backtrack: alpha = 0.00390625, f(x) = 1627.6472812163474, f(x+ap) = 157.09168334259536, dgrad(x) = 0.24123808656695483 :

GD: iter = 2, x = [5.30632457 7.47223484], f(x) = 157.09168334259536 :

 Backtrack: alpha = 0.00390625, f(x) = 157.09168334259536, f(x+ap) = 85.49053745294165, dgrad(x) = 0.01166737909195391 :

GD: iter = 3, x = [4.68929928 7.74616329], f(x) = 85.49053745294165 :

 Backtrack: alpha = 0.00390625, f(x) = 85.49053745294165, f(x+ap) = 80.85073463375537, dgrad(x) = 0.0006801358431880185 :

GD: iter = 4, x = [4.52675828 7.75833817], f(x) = 80.85073463375537 :

 Backtrack: alpha = 0.015625, f(x) = 80.85073463375537, f(x+ap) = 76.48132152919524, dgrad(x) = 0.0006099314939706278 :

GD: iter = 5, x = [4.27512946 7.5794954], f(x) = 76.48132152919524 :

 Backtrack: alpha = 0.015625, f(x) = 76.48132152919524, f(x+ap) = 74.50698682094331, dgrad(x) = 0.0009504076708901302 :

GD: iter = 6, x = [4.37563786 7.2074749], f(x) = 74.50698682094331 :

 Backtrack: alpha = 0.00390625, f(x) = 74.50698682094331, f(x+ap) = 70.11843025869022, dgrad(x) = 0.0006497118148574838 :

GD: iter = 7, x = [4.21708427 7.22297093], f(x) = 70.11843025869022 :

 Backtrack: alpha = 0.015625, f(x) = 70.11843025869022, f(x+ap) = 66.39462985992127, dgrad(x) = 0.0005403161178259498 :

GD: iter = 8, x = [3.97647759 7.06008196], f(x) = 66.39462985992127 :

 Backtrack: alpha = 0.015625, f(x) = 66.39462985992127, f(x+ap) = 64.97459380820439, dgrad(x) = 0.0008759030522017006 :

GD: iter = 9, x = [4.08346112 6.70594304], f(x) = 64.97459380820439 :

 Backtrack: alpha = 0.00390625, f(x) = 64.97459380820439, f(x+ap) = 60.81274928561883, dgrad(x) = 0.0006218770290042589 :

GD: iter = 10, x = [3.92870834 6.72448077], f(x) = 60.81274928561883 :

 Backtrack: alpha = 0.015625, f(x) = 60.81274928561883, f(x+ap) = 57.64714691994006, dgrad(x) = 0.00047967873413968154 :

GD: iter = 11, x = [3.6984418 6.57640267], f(x) = 57.64714691994006 :

Backtrack: alpha = 0.015625, f(x) = 57.64714691994006, f(x+ap) = 56.70062482784689, dgrad(x) = 0.0008100466333936755 :

GD: iter = 12, x = [3.81129109 6.2390085], f(x) = 56.70062482784689 :

Backtrack: alpha = 0.00390625, f(x) = 56.70062482784689, f(x+ap) = 52.744005105699046, dgrad(x) = 0.0005963225306944104 :

GD: iter = 13, x = [3.66016428 6.26032834], f(x) = 52.744005105699046 :

Backtrack: alpha = 0.015625, f(x) = 52.744005105699046, f(x+ap) = 50.06084763177585, dgrad(x) = 0.0004268323069717262 :

GD: iter = 14, x = [3.43960194 6.12599741], f(x) = 50.06084763177585 :

Backtrack: alpha = 0.015625, f(x) = 50.06084763177585, f(x+ap) = 49.517968498249914, dgrad(x) = 0.0007517190085214207 :

GD: iter = 15, x = [3.55775158 5.80428829], f(x) = 49.517968498249914 :

Backtrack: alpha = 0.00390625, f(x) = 49.517968498249914, f(x+ap) = 45.747733385009866, dgrad(x) = 0.0005727795891683439 :

GD: iter = 16, x = [3.41008688 5.82814913], f(x) = 45.747733385009866 :

Backtrack: alpha = 0.015625, f(x) = 45.747733385009866, f(x+ap) = 43.4813776414897, dgrad(x) = 0.00038074747586764896 :

GD: iter = 17, x = [3.19863562 5.70657545], f(x) = 43.4813776414897 :

Backtrack: alpha = 0.015625, f(x) = 43.4813776414897, f(x+ap) = 43.28172880384387, dgrad(x) = 0.0006999488774323745 :

GD: iter = 18, x = [3.3215611 5.3995635], f(x) = 43.28172880384387 :

Backtrack: alpha = 0.00390625, f(x) = 43.28172880384387, f(x+ap) = 39.68133827710915, dgrad(x) = 0.0005510143700568469 :

GD: iter = 19, x = [3.17720489 5.42574144], f(x) = 39.68133827710915 :

Backtrack: alpha = 0.015625, f(x) = 39.68133827710915, f(x+ap) = 37.77490586268239, dgrad(x) = 0.00034053159380709034 :

GD: iter = 20, x = [2.97431154 5.3160038], f(x) = 37.77490586268239 :

Backtrack: alpha = 0.00390625, f(x) = 37.77490586268239, f(x+ap) = 36.5545661308078, dgrad(x) = 0.00016347334254802307 :

GD: iter = 21, x = [3.00611526 5.24269485], f(x) = 36.5545661308078 :

Backtrack: alpha = 0.0625, f(x) = 36.5545661308078, f(x+ap) = 32.23547316219111, dgrad(x) = 0.0009938337244380293 :

GD: iter = 22, x = [2.8229927 4.47613618], f(x) = 32.23547316219111 :

Backtrack: alpha = 0.00390625, f(x) = 32.23547316219111, f(x+ap) = 27.73162211632774, dgrad(x) = 0.0007113664135000678 :

GD: iter = 23, x = [2.66247674 4.52110705], f(x) = 27.73162211632774 :

 Backtrack: alpha = 0.015625, f(x) = 27.73162211632774, f(x+ap) = 26.756916761733322, dgrad(x) = 0.00029984187981893544 :

GD: iter = 24, x = [2.45812069 4.44977055], f(x) = 26.756916761733322 :

 Backtrack: alpha = 0.00390625, f(x) = 26.756916761733322, f(x+ap) = 25.475691948378014, dgrad(x) = 0.00018463604501854928 :

GD: iter = 25, x = [2.5032795 4.37784679], f(x) = 25.475691948378014 :

 Backtrack: alpha = 0.0625, f(x) = 25.475691948378014, f(x+ap) = 25.314202918863373, dgrad(x) = 0.0007462452638084895 :

GD: iter = 26, x = [2.41563964 3.7005562], f(x) = 25.314202918863373 :

 Backtrack: alpha = 0.00390625, f(x) = 25.314202918863373, f(x+ap) = 19.4475595181512, dgrad(x) = 0.0009434240442074765 :

GD: iter = 27, x = [2.23485459 3.76512604], f(x) = 19.4475595181512 :

 Backtrack: alpha = 0.015625, f(x) = 19.4475595181512, f(x+ap) = 19.251272532227425, dgrad(x) = 0.00029455372943059787 :

GD: iter = 28, x = [2.02334162 3.72926124], f(x) = 19.251272532227425 :

 Backtrack: alpha = 0.00390625, f(x) = 19.251272532227425, f(x+ap) = 17.76911689574005, dgrad(x) = 0.00022538821265106646 :

GD: iter = 29, x = [2.08279845 3.65667259], f(x) = 17.76911689574005 :

 Backtrack: alpha = 0.015625, f(x) = 17.76911689574005, f(x+ap) = 16.892021315280843, dgrad(x) = 0.00014844017148374057 :

GD: iter = 30, x = [2.08356716 3.5043795], f(x) = 16.892021315280843 :

 Backtrack: alpha = 0.015625, f(x) = 16.892021315280843, f(x+ap) = 16.828690072585832, dgrad(x) = 0.0002743836045 6223405 :

GD: iter = 31, x = [1.87851134 3.47566454], f(x) = 16.828690072585832 :

 Backtrack: alpha = 0.00390625, f(x) = 16.828690072585832, f(x+ap) = 15.412933563009984, dgrad(x) = 0.00021686376658903897 :

GD: iter = 32, x = [1.9381809 3.40558756], f(x) = 15.412933563009984 :

 Backtrack: alpha = 0.015625, f(x) = 15.412933563009984, f(x+ap) = 14.675554279610509, dgrad(x) = 0.0001328069206249862 :

GD: iter = 33, x = [1.94266501 3.26160501], f(x) = 14.675554279610509 :

 Backtrack: alpha = 0.00390625, f(x) = 14.675554279610509, f(x+ap) = 14.197824054627645, dgrad(x) = 6.410863486046229e-05 :

GD: iter = 34, x = [1.89292893 3.25607637], f(x) = 14.197824054627645 :

Backtrack: alpha = 0.0625, f(x) = 14.197824054627645, f(x+ap) = 12.545079243079645, dgrad(x) = 0.0003864725698599095 :

GD: iter = 35, x = [1.53535627 2.91890112], f(x) = 12.545079243079645 :

Backtrack: alpha = 0.00390625, f(x) = 12.545079243079645, f(x+ap) = 10.772036455981274, dgrad(x) = 0.00028019178527733735 :

GD: iter = 36, x = [1.61029881 2.84590381], f(x) = 10.772036455981274 :

Backtrack: alpha = 0.015625, f(x) = 10.772036455981274, f(x+ap) = 10.397664248127025, dgrad(x) = 0.00011720380147894949 :

GD: iter = 37, x = [1.6360473 2.71305009], f(x) = 10.397664248127025 :

Backtrack: alpha = 0.00390625, f(x) = 10.397664248127025, f(x+ap) = 9.894906609726315, dgrad(x) = 7.255458389863703e-05 :

GD: iter = 38, x = [1.58285332 2.71518647], f(x) = 9.894906609726315 :

Backtrack: alpha = 0.0625, f(x) = 9.894906609726315, f(x+ap) = 9.866059284918027, dgrad(x) = 0.00029048365652497145 :

GD: iter = 39, x = [1.2435534 2.45745047], f(x) = 9.866059284918027 :

Backtrack: alpha = 0.00390625, f(x) = 9.866059284918027, f(x+ap) = 7.554981256403821, dgrad(x) = 0.0003717550049464198 :

GD: iter = 40, x = [1.33550048 2.37955685], f(x) = 7.554981256403821 :

Backtrack: alpha = 0.015625, f(x) = 7.554981256403821, f(x+ap) = 7.484486271817837, dgrad(x) = 0.00011542419956491926 :

GD: iter = 41, x = [1.38272063 2.25383777], f(x) = 7.484486271817837 :

Backtrack: alpha = 0.00390625, f(x) = 7.484486271817837, f(x+ap) = 6.901801036129473, dgrad(x) = 8.869220034613092e-05 :

GD: iter = 42, x = [1.32466103 2.26351356], f(x) = 6.901801036129473 :

Backtrack: alpha = 0.015625, f(x) = 6.901801036129473, f(x+ap) = 6.562381644356276, dgrad(x) = 5.787409568195889e-05 :

GD: iter = 43, x = [1.2419154 2.21665218], f(x) = 6.562381644356276 :

Backtrack: alpha = 0.015625, f(x) = 6.562381644356276, f(x+ap) = 6.543386764457786, dgrad(x) = 0.00010756544044249615 :

GD: iter = 44, x = [1.29097422 2.0966508], f(x) = 6.543386764457786 :

Backtrack: alpha = 0.00390625, f(x) = 6.543386764457786, f(x+ap) = 5.986661061240792, dgrad(x) = 8.535337948650774e-05 :

GD: iter = 45, x = [1.23420825 2.10722156], f(x) = 5.986661061240792 :

Backtrack: alpha = 0.015625, f(x) = 5.986661061240792, f(x+ap) = 5.701476768160505, dgrad(x) = 5.179685642058692e-05 :

GD: iter = 46, x = [1.15479404 2.06495287], f(x) = 5.701476768160505 :

 Backtrack: alpha = 0.00390625, f(x) = 5.701476768160505, f(x+ap) = 5.514447837538669, dgrad(x) = 2.5142483089639185e-05 :

GD: iter = 47, x = [1.16747123 2.0362925], f(x) = 5.514447837538669 :

 Backtrack: alpha = 0.0625, f(x) = 5.514447837538669, f(x+ap) = 4.882295026866092, dgrad(x) = 0.0001502902952561238 :

GD: iter = 48, x = [1.09748388 1.73790817], f(x) = 4.882295026866092 :

 Backtrack: alpha = 0.00390625, f(x) = 4.882295026866092, f(x+ap) = 4.184283233814088, dgrad(x) = 0.00011036286002699001 :

GD: iter = 49, x = [1.0343232 1.75584634], f(x) = 4.184283233814088 :

 Backtrack: alpha = 0.015625, f(x) = 4.184283233814088, f(x+ap) = 4.04053414255413, dgrad(x) = 4.581575235324456e-05 :

GD: iter = 50, x = [0.95423734 1.72855228], f(x) = 4.04053414255413 :

 Backtrack: alpha = 0.00390625, f(x) = 4.04053414255413, f(x+ap) = 3.843240660714038, dgrad(x) = 2.851212693762753e-05 :

GD: iter = 51, x = [0.97215659 1.70039814], f(x) = 3.843240660714038 :

 Backtrack: alpha = 0.015625, f(x) = 3.843240660714038, f(x+ap) = 3.631355743668284, dgrad(x) = 2.8269241725769246e-05 :

GD: iter = 52, x = [0.96397915 1.63444211], f(x) = 3.631355743668284 :

 Backtrack: alpha = 0.015625, f(x) = 3.631355743668284, f(x+ap) = 3.5188661431479322, dgrad(x) = 4.188280801249761e-05 :

GD: iter = 53, x = [0.88667459 1.6106053], f(x) = 3.5188661431479322 :

 Backtrack: alpha = 0.00390625, f(x) = 3.5188661431479322, f(x+ap) = 3.3329532703511697, dgrad(x) = 2.7158365862773928e-05 :

GD: iter = 54, x = [0.90481193 1.58355146], f(x) = 3.3329532703511697 :

 Backtrack: alpha = 0.015625, f(x) = 3.3329532703511697, f(x+ap) = 3.15186692981266, dgrad(x) = 2.4976843635754086e-05 :

GD: iter = 55, x = [0.89846799 1.52140336], f(x) = 3.15186692981266 :

 Backtrack: alpha = 0.015625, f(x) = 3.15186692981266, f(x+ap) = 3.066185555585812, dgrad(x) = 3.842043340759731e-05 :

GD: iter = 56, x = [0.82378658 1.5007665], f(x) = 3.066185555585812 :

 Backtrack: alpha = 0.00390625, f(x) = 3.066185555585812, f(x+ap) = 2.89050043646699, dgrad(x) = 2.5925468105686744e-05 :

GD: iter = 57, x = [0.84210927 1.47474742], f(x) = 2.89050043646699 :

Backtrack: alpha = 0.015625, f(x) = 2.89050043646699, f(x+ap) = 2.7360537207141555, dgrad(x) = 2.211091329658716e-05 :

GD: iter = 58, x = [0.83745707 1.41615401], f(x) = 2.7360537207141555 :

Backtrack: alpha = 0.015625, f(x) = 2.7360537207141555, f(x+ap) = 2.6733283418659544, dgrad(x) = 3.5367328400482056e-05 :

GD: iter = 59, x = [0.76525115 1.39847774], f(x) = 2.6733283418659544 :

Backtrack: alpha = 0.00390625, f(x) = 2.6733283418659544, f(x+ap) = 2.506862670105581, dgrad(x) = 2.479879770095999e-05 :

GD: iter = 60, x = [0.78372892 1.37343229], f(x) = 2.506862670105581 :

Backtrack: alpha = 0.015625, f(x) = 2.506862670105581, f(x+ap) = 2.3754511864274517, dgrad(x) = 1.961501819664779e-05 :

GD: iter = 61, x = [0.78063665 1.31815766], f(x) = 2.3754511864274517 :

Backtrack: alpha = 0.015625, f(x) = 2.3754511864274517, f(x+ap) = 2.3323487788524777, dgrad(x) = 3.267031305506232e-05 :

GD: iter = 62, x = [0.71076833 1.30321933], f(x) = 2.3323487788524777 :

Backtrack: alpha = 0.00390625, f(x) = 2.3323487788524777, f(x+ap) = 2.174219788771557, dgrad(x) = 2.3765629995974317e-05 :

GD: iter = 63, x = [0.72937321 1.27909044], f(x) = 2.174219788771557 :

Backtrack: alpha = 0.015625, f(x) = 2.174219788771557, f(x+ap) = 2.062719926527556, dgrad(x) = 1.7440222962720094e-05 :

GD: iter = 64, x = [0.72771834 1.22691481], f(x) = 2.062719926527556 :

Backtrack: alpha = 0.015625, f(x) = 2.062719926527556, f(x+ap) = 2.0363574649394978, dgrad(x) = 3.0283248646382717e-05 :

GD: iter = 65, x = [0.66005881 1.21450733], f(x) = 2.0363574649394978 :

Backtrack: alpha = 0.00390625, f(x) = 2.0363574649394978, f(x+ap) = 1.8857914454832396, dgrad(x) = 2.2814898349570377e-05 :

GD: iter = 66, x = [0.67876496 1.19124176], f(x) = 1.8857914454832396 :

Backtrack: alpha = 0.015625, f(x) = 1.8857914454832396, f(x+ap) = 1.7914964101572612, dgrad(x) = 1.5544092630830888e-05 :

GD: iter = 67, x = [0.67843356 1.14196038], f(x) = 1.7914964101572612 :

Backtrack: alpha = 0.015625, f(x) = 1.7914964101572612, f(x+ap) = 1.7793808667601896, dgrad(x) = 2.816610212451433e-05 :

GD: iter = 68, x = [0.6128625 1.13189116], f(x) = 1.7793808667601896 :

Backtrack: alpha = 0.00390625, f(x) = 1.7793808667601896, f(x+ap) = 1.6356988625951625, dgrad(x) = 2.193697449157093e-05 :

GD: iter = 69, x = [0.63164608 1.10943921], f(x) = 1.6356988625951625 :

Backtrack: alpha = 0.015625, f(x) = 1.6356988625951625, f(x+ap) = 1.5562632162584937, dgrad(x) = 1.3889828447765243e-05 :

GD: iter = 70, x = [0.63253227 1.06286131], f(x) = 1.5562632162584937 :

Backtrack: alpha = 0.00390625, f(x) = 1.5562632162584937, f(x+ap) = 1.5069789835560385, dgrad(x) = 6.571033739629028e-06 :

GD: iter = 71, x = [0.61663351 1.06088379], f(x) = 1.5069789835560385 :

Backtrack: alpha = 0.0625, f(x) = 1.5069789835560385, f(x+ap) = 1.3221449084403398, dgrad(x) = 4.0843681631823286e-05 :

GD: iter = 72, x = [0.50120448 0.95041461], f(x) = 1.3221449084403398 :

Backtrack: alpha = 0.00390625, f(x) = 1.3221449084403398, f(x+ap) = 1.1429616646356235, dgrad(x) = 2.826132838359304e-05 :

GD: iter = 73, x = [0.52485277 0.92707544], f(x) = 1.1429616646356235 :

Backtrack: alpha = 0.015625, f(x) = 1.1429616646356235, f(x+ap) = 1.1016297944822677, dgrad(x) = 1.2157488416642876e-05 :

GD: iter = 74, x = [0.53256957 0.88417954], f(x) = 1.1016297944822677 :

Backtrack: alpha = 0.00390625, f(x) = 1.1016297944822677, f(x+ap) = 1.0502126521307764, dgrad(x) = 7.381607669744519e-06 :

GD: iter = 75, x = [0.51559595 0.88466943], f(x) = 1.0502126521307764 :

Backtrack: alpha = 0.0625, f(x) = 1.0502126521307764, f(x+ap) = 1.034295583248387, dgrad(x) = 3.0588992001354364e-05 :

GD: iter = 76, x = [0.4063012 0.79997717], f(x) = 1.034295583248387 :

Backtrack: alpha = 0.00390625, f(x) = 1.034295583248387, f(x+ap) = 0.8013156783183915, dgrad(x) = 3.7436625040809344e-05 :

GD: iter = 77, x = [0.4353595 0.77511789], f(x) = 0.8013156783183915 :

Backtrack: alpha = 0.015625, f(x) = 0.8013156783183915, f(x+ap) = 0.7916538224636339, dgrad(x) = 1.1864497877799278e-05 :

GD: iter = 78, x = [0.44995797 0.73461218], f(x) = 0.7916538224636339 :

Backtrack: alpha = 0.00390625, f(x) = 0.7916538224636339, f(x+ap) = 0.7324687145057018, dgrad(x) = 8.97705067072982e-06 :

GD: iter = 79, x = [0.43145959 0.73752352], f(x) = 0.7324687145057018 :

Backtrack: alpha = 0.015625, f(x) = 0.7324687145057018, f(x+ap) = 0.6959696542029142, dgrad(x) = 6.059431368330123e-06 :

GD: iter = 80, x = [0.40486627 0.72204508], f(x) = 0.6959696542029142 :

Backtrack: alpha = 0.015625, f(x) = 0.6959696542029142, f(x+ap) = 0.6918272336934682, dgrad(x) = 1.1039717368010149e-05 :

GD: iter = 81, x = [0.42007338 0.68339667], f(x) = 0.6918272336934682 :

Backtrack: alpha = 0.00390625, f(x) = 0.6918272336934682, f(x+ap) = 0.6353329766116163, dgrad(x) = 8.633257909876195e-06 :

GD: iter = 82, x = [0.40199137 0.68660253], f(x) = 0.6353329766116163 :

Backtrack: alpha = 0.015625, f(x) = 0.6353329766116163, f(x+ap) = 0.6046022122761099, dgrad(x) = 5.41638428743304e-06 :

GD: iter = 83, x = [0.37647897 0.67262298], f(x) = 0.6046022122761099 :

Backtrack: alpha = 0.00390625, f(x) = 0.6046022122761099, f(x+ap) = 0.58531159635326, dgrad(x) = 2.576584980366636e-06 :

GD: iter = 84, x = [0.38041751 0.66339607], f(x) = 0.58531159635326 :

Backtrack: alpha = 0.0625, f(x) = 0.58531159635326, f(x+ap) = 0.5145045679955519, dgrad(x) = 1.5882208770715425e-05 :

GD: iter = 85, x = [0.35694453 0.56656942], f(x) = 0.5145045679955519 :

Backtrack: alpha = 0.00390625, f(x) = 0.5145045679955519, f(x+ap) = 0.44396870003652944, dgrad(x) = 1.1131141167752881e-05 :

GD: iter = 86, x = [0.33684897 0.57213526], f(x) = 0.44396870003652944 :

Backtrack: alpha = 0.015625, f(x) = 0.44396870003652944, f(x+ap) = 0.42808199288438575, dgrad(x) = 4.751500317543676e-06 :

GD: iter = 87, x = [0.31117887 0.56299918], f(x) = 0.42808199288438575 :

Backtrack: alpha = 0.00390625, f(x) = 0.42808199288438575, f(x+ap) = 0.4079082779780401, dgrad(x) = 2.900382517511308e-06 :

GD: iter = 88, x = [0.31679281 0.55395595], f(x) = 0.4079082779780401 :

Backtrack: alpha = 0.0625, f(x) = 0.4079082779780401, f(x+ap) = 0.40306860190034133, dgrad(x) = 1.1906202508479775e-05 :

GD: iter = 89, x = [0.30535127 0.46845468], f(x) = 0.40306860190034133 :

Backtrack: alpha = 0.00390625, f(x) = 0.40306860190034133, f(x+ap) = 0.31129226967925844, dgrad(x) = 1.4751578295566602e-05 :

GD: iter = 90, x = [0.28272747 0.47647944], f(x) = 0.31129226967925844 :

Backtrack: alpha = 0.015625, f(x) = 0.31129226967925844, f(x+ap) = 0.3077672043059502, dgrad(x) = 4.648574328658524e-06 :

GD: iter = 91, x = [0.25618376 0.47181345], f(x) = 0.3077672043059502 :

Backtrack: alpha = 0.00390625, f(x) = 0.3077672043059502, f(x+ap) = 0.28450166563030654, dgrad(x) = 3.532317189830213e-06 :

GD: iter = 92, x = [0.26358995 0.46269591], f(x) = 0.28450166563030654 :

 Backtrack: alpha = 0.015625, f(x) = 0.28450166563030654, f(x+ap) = 0.27037475912773024, dgrad(x) = 2.3621983622285187e-06 :

GD: iter = 93, x = [0.26358444 0.4434841], f(x) = 0.27037475912773024 :

 Backtrack: alpha = 0.015625, f(x) = 0.27037475912773024, f(x+ap) = 0.26898789686243507, dgrad(x) = 4.327251512349832e-06 :

GD: iter = 94, x = [0.23785512 0.43972441], f(x) = 0.26898789686243507 :

 Backtrack: alpha = 0.00390625, f(x) = 0.26898789686243507, f(x+ap) = 0.24677422595924645, dgrad(x) = 3.397681395076623e-06 :

GD: iter = 95, x = [0.24528966 0.43092387], f(x) = 0.24677422595924645 :

 Backtrack: alpha = 0.015625, f(x) = 0.24677422595924645, f(x+ap) = 0.23488650752418813, dgrad(x) = 2.1122295470313195e-06 :

GD: iter = 96, x = [0.24575555 0.41276296], f(x) = 0.23488650752418813 :

 Backtrack: alpha = 0.00390625, f(x) = 0.23488650752418813, f(x+ap) = 0.22733544020962726, dgrad(x) = 1.010363267432968e-06 :

GD: iter = 97, x = [0.23951589 0.41203222], f(x) = 0.22733544020962726 :

 Backtrack: alpha = 0.0625, f(x) = 0.22733544020962726, f(x+ap) = 0.20022132980025145, dgrad(x) = 6.1759532219890036e-06 :

GD: iter = 98, x = [0.19445748 0.36925711], f(x) = 0.20022132980025145 :

 Backtrack: alpha = 0.00390625, f(x) = 0.20022132980025145, f(x+ap) = 0.17245418328707668, dgrad(x) = 4.384221728748395e-06 :

GD: iter = 99, x = [0.20380501 0.36009838], f(x) = 0.17245418328707668 :

 Backtrack: alpha = 0.015625, f(x) = 0.17245418328707668, f(x+ap) = 0.16634946089514444, dgrad(x) = 1.857125439082669e-06 :

GD: iter = 100, x = [0.20694449 0.34335564], f(x) = 0.16634946089514444 :

 Backtrack: alpha = 0.00390625, f(x) = 0.16634946089514444, f(x+ap) = 0.15843384246743128, dgrad(x) = 1.1396627644166592e-06 :

GD: iter = 101, x = [0.2002764 0.34358956], f(x) = 0.15843384246743128 :

 Backtrack: alpha = 0.0625, f(x) = 0.15843384246743128, f(x+ap) = 0.15708337463144972, dgrad(x) = 4.634398325070663e-06 :

GD: iter = 102, x = [0.15756219 0.31084822], f(x) = 0.15708337463144972 :

 Backtrack: alpha = 0.00390625, f(x) = 0.15708337463144972, f(x+ap) = 0.1209300885661753, dgrad(x) = 5.812773199902395e-06 :

GD: iter = 103, x = [0.16903849 0.30108318], f(x) = 0.1209300885661753 :

Backtrack: alpha = 0.015625, f(x) = 0.1209300885661753, f(x+ap) = 0.11965068008030764, dgrad(x) = 1.821434893089366e-06 :

GD: iter = 104, x = [0.17487489 0.28525486], f(x) = 0.11965068008030764 :

Backtrack: alpha = 0.00390625, f(x) = 0.11965068008030764, f(x+ap) = 0.1105047298131459, dgrad(x) = 1.3899413424308455e-06 :

GD: iter = 105, x = [0.16760179 0.28643665], f(x) = 0.1105047298131459 :

Backtrack: alpha = 0.015625, f(x) = 0.1105047298131459, f(x+ap) = 0.10503728532248274, dgrad(x) = 9.209138214316177e-07 :

GD: iter = 106, x = [0.15719571 0.28046956], f(x) = 0.10503728532248274 :

Backtrack: alpha = 0.015625, f(x) = 0.10503728532248274, f(x+ap) = 0.10458616881397881, dgrad(x) = 1.696247504652132e-06 :

GD: iter = 107, x = [0.16326646 0.26536377], f(x) = 0.10458616881397881 :

Backtrack: alpha = 0.00390625, f(x) = 0.10458616881397881, f(x+ap) = 0.09585142169563343, dgrad(x) = 1.337212499048126e-06 :

GD: iter = 108, x = [0.15615616 0.26665933], f(x) = 0.09585142169563343 :

Backtrack: alpha = 0.015625, f(x) = 0.09585142169563343, f(x+ap) = 0.0912531977866437, dgrad(x) = 8.237433930334016e-07 :

GD: iter = 109, x = [0.14617085 0.26127385], f(x) = 0.0912531977866437 :

Backtrack: alpha = 0.00390625, f(x) = 0.0912531977866437, f(x+ap) = 0.0882972638347211, dgrad(x) = 3.962167549358303e-07 :

GD: iter = 110, x = [0.14774115 0.25766673], f(x) = 0.0882972638347211 :

Backtrack: alpha = 0.0625, f(x) = 0.0882972638347211, f(x+ap) = 0.07791884343485399, dgrad(x) = 2.4016198464354632e-06 :

GD: iter = 111, x = [0.13876642 0.21997765], f(x) = 0.07791884343485399 :

Backtrack: alpha = 0.00390625, f(x) = 0.07791884343485399, f(x+ap) = 0.06698781553393429, dgrad(x) = 1.7268354514634923e-06 :

GD: iter = 112, x = [0.13085927 0.22219835], f(x) = 0.06698781553393429 :

Backtrack: alpha = 0.015625, f(x) = 0.06698781553393429, f(x+ap) = 0.06464263205860167, dgrad(x) = 7.258975801778321e-07 :

GD: iter = 113, x = [0.12079977 0.21870152], f(x) = 0.06464263205860167 :

Backtrack: alpha = 0.00390625, f(x) = 0.06464263205860167, f(x+ap) = 0.06153660856101613, dgrad(x) = 4.47830905026036e-07 :

GD: iter = 114, x = [0.12302766 0.21516177], f(x) = 0.06153660856101613 :

Backtrack: alpha = 0.0625, f(x) = 0.06153660856101613, f(x+ap) = 0.061220739274152614, dgrad(x) = 1.803954476983031e-06 :

GD: iter = 115, x = [0.11874996 0.18185752], f(x) = 0.061220739274152614 :

 Backtrack: alpha = 0.00390625, f(x) = 0.061220739274152614, f(x+ap) = 0.04697878326969538, dgrad(x) = 2.2905053755000735e-06 :

GD: iter = 116, x = [0.10984356 0.18504325], f(x) = 0.04697878326969538 :

 Backtrack: alpha = 0.015625, f(x) = 0.04697878326969538, f(x+ap) = 0.04651723420763579, dgrad(x) = 7.137250147669443e-07 :

GD: iter = 117, x = [0.09942961 0.18329132], f(x) = 0.04651723420763579 :

 Backtrack: alpha = 0.00390625, f(x) = 0.04651723420763579, f(x+ap) = 0.04292173269745403, dgrad(x) = 5.469452955852107e-07 :

GD: iter = 118, x = [0.10236165 0.17971806], f(x) = 0.04292173269745403 :

 Backtrack: alpha = 0.015625, f(x) = 0.04292173269745403, f(x+ap) = 0.0408058431481766, dgrad(x) = 3.590375627171065e-07 :

GD: iter = 119, x = [0.10240808 0.17222824], f(x) = 0.0408058431481766 :

 Backtrack: alpha = 0.015625, f(x) = 0.0408058431481766, f(x+ap) = 0.040665140908096635, dgrad(x) = 6.649502062459128e-07 :

GD: iter = 120, x = [0.09231172 0.17082758], f(x) = 0.040665140908096635 :

 Backtrack: alpha = 0.00390625, f(x) = 0.040665140908096635, f(x+ap) = 0.037230398482174853, dgrad(x) = 5.262934053980982e-07 :

GD: iter = 121, x = [0.09525409 0.16737783], f(x) = 0.037230398482174853 :

 Backtrack: alpha = 0.015625, f(x) = 0.037230398482174853, f(x+ap) = 0.035451925006530945, dgrad(x) = 3.212640218172273e-07 :

GD: iter = 122, x = [0.09548302 0.16029651], f(x) = 0.035451925006530945 :

 Backtrack: alpha = 0.00390625, f(x) = 0.035451925006530945, f(x+ap) = 0.03429473352659426, dgrad(x) = 1.5538541034907323e-07 :

GD: iter = 123, x = [0.09303407 0.16002741], f(x) = 0.03429473352659426 :

 Backtrack: alpha = 0.0625, f(x) = 0.03429473352659426, f(x+ap) = 0.030323953729319533, dgrad(x) = 9.339245428334809e-07 :

GD: iter = 124, x = [0.07544437 0.14346525], f(x) = 0.030323953729319533 :

 Backtrack: alpha = 0.00390625, f(x) = 0.030323953729319533, f(x+ap) = 0.026020678081186206, dgrad(x) = 6.801660569161736e-07 :

GD: iter = 125, x = [0.07913903 0.13987102], f(x) = 0.026020678081186206 :

 Backtrack: alpha = 0.015625, f(x) = 0.026020678081186206, f(x+ap) = 0.025120015627226048, dgrad(x) = 2.8374821879448893e-07 :

GD: iter = 126, x = [0.08041449 0.13333582], f(x) = 0.025120015627226048 :

Backtrack: alpha = 0.00390625, f(x) = 0.025120015627226048, f(x+ap) = 0.02390117921085419, dgrad(x) = 1.7598199882170008e-07 :

GD: iter = 127, x = [0.07779483 0.13344388], f(x) = 0.02390117921085419 :

Backtrack: alpha = 0.0625, f(x) = 0.02390117921085419, f(x+ap) = 0.02386075315941689, dgrad(x) = 7.022148981745351e-07 :

GD: iter = 128, x = [0.0611005 0.12078751], f(x) = 0.02386075315941689 :

Backtrack: alpha = 0.00390625, f(x) = 0.02386075315941689, f(x+ap) = 0.01825032222281005, dgrad(x) = 9.025728341675832e-07 :

GD: iter = 129, x = [0.06563283 0.11695153], f(x) = 0.01825032222281005 :

Backtrack: alpha = 0.015625, f(x) = 0.01825032222281005, f(x+ap) = 0.01808500180562086, dgrad(x) = 2.796865059255462e-07 :

GD: iter = 130, x = [0.06796526 0.110766], f(x) = 0.01808500180562086 :

Backtrack: alpha = 0.00390625, f(x) = 0.01808500180562086, f(x+ap) = 0.01667147224670803, dgrad(x) = 2.1522951726476738e-07 :

GD: iter = 131, x = [0.06510557 0.11124512], f(x) = 0.01667147224670803 :

Backtrack: alpha = 0.015625, f(x) = 0.01667147224670803, f(x+ap) = 0.015852682752784363, dgrad(x) = 1.3998425386704623e-07 :

GD: iter = 132, x = [0.0610334 0.10894513], f(x) = 0.015852682752784363 :

Backtrack: alpha = 0.015625, f(x) = 0.015852682752784363, f(x+ap) = 0.0158116395194893, dgrad(x) = 2.606824331730275e-07 :

GD: iter = 133, x = [0.06345605 0.1030407], f(x) = 0.0158116395194893 :

Backtrack: alpha = 0.00390625, f(x) = 0.0158116395194893, f(x+ap) = 0.014460961868956743, dgrad(x) = 2.0714051083040525e-07 :

GD: iter = 134, x = [0.06066002 0.10356377], f(x) = 0.014460961868956743 :

Backtrack: alpha = 0.015625, f(x) = 0.014460961868956743, f(x+ap) = 0.013773150211039543, dgrad(x) = 1.253001772277719e-07 :

GD: iter = 135, x = [0.05675164 0.10148946], f(x) = 0.013773150211039543 :

Backtrack: alpha = 0.00390625, f(x) = 0.013773150211039543, f(x+ap) = 0.01332010679334624, dgrad(x) = 6.094101143530826e-08 :

GD: iter = 136, x = [0.05737754 0.10007923], f(x) = 0.01332010679334624 :

Backtrack: alpha = 0.0625, f(x) = 0.01332010679334624, f(x+ap) = 0.011801587950377198, dgrad(x) = 3.631839627601775e-07 :

GD: iter = 137, x = [0.05394781 0.08540861], f(x) = 0.011801587950377198 :

Backtrack: alpha = 0.00390625, f(x) = 0.011801587950377198, f(x+ap) = 0.01010746221414383, dgrad(x) = 2.679072305182484e-07 :

GD: iter = 138, x = [0.05083645 0.08629437], f(x) = 0.01010746221414383 :

 Backtrack: alpha = 0.015625, f(x) = 0.01010746221414383, f(x+ap) = 0.009761668715534327, dgrad(x) = 1.1092122953349079e-07 :

GD: iter = 139, x = [0.04689415 0.08495656], f(x) = 0.009761668715534327 :

 Backtrack: alpha = 0.00390625, f(x) = 0.009761668715534327, f(x+ap) = 0.009283361659233809, dgrad(x) = 6.915741873865328e-08 :

GD: iter = 140, x = [0.04777817 0.08357093], f(x) = 0.009283361659233809 :

 Backtrack: alpha = 0.015625, f(x) = 0.009283361659233809, f(x+ap) = 0.008771866644441448, dgrad(x) = 6.83387281716211e-08 :

GD: iter = 141, x = [0.04737919 0.08032767], f(x) = 0.008771866644441448 :

 Backtrack: alpha = 0.015625, f(x) = 0.008771866644441448, f(x+ap) = 0.008501545152767971, dgrad(x) = 1.0141511097475e-07 :

GD: iter = 142, x = [0.04357366 0.07915972], f(x) = 0.008501545152767971 :

 Backtrack: alpha = 0.00390625, f(x) = 0.008501545152767971, f(x+ap) = 0.008050770164656808, dgrad(x) = 6.588047268081066e-08 :

GD: iter = 143, x = [0.04446836 0.07782819], f(x) = 0.008050770164656808 :

 Backtrack: alpha = 0.015625, f(x) = 0.008050770164656808, f(x+ap) = 0.007613661022197603, dgrad(x) = 6.03846713830145e-08 :

GD: iter = 144, x = [0.04415945 0.0747721], f(x) = 0.007613661022197603 :

 Backtrack: alpha = 0.015625, f(x) = 0.007613661022197603, f(x+ap) = 0.007408060435704616, dgrad(x) = 9.304579419779558e-08 :

GD: iter = 145, x = [0.04048292 0.07376139], f(x) = 0.007408060435704616 :

 Backtrack: alpha = 0.00390625, f(x) = 0.007408060435704616, f(x+ap) = 0.006982031786378485, dgrad(x) = 6.28956385785167e-08 :

GD: iter = 146, x = [0.04138669 0.07248073], f(x) = 0.006982031786378485 :

 Backtrack: alpha = 0.015625, f(x) = 0.006982031786378485, f(x+ap) = 0.006609262830368282, dgrad(x) = 5.3460771568141494e-08 :

GD: iter = 147, x = [0.04116089 0.06959937], f(x) = 0.006609262830368282 :

 Backtrack: alpha = 0.015625, f(x) = 0.006609262830368282, f(x+ap) = 0.0064590789808308, dgrad(x) = 8.566520626865757e-08 :

GD: iter = 148, x = [0.0376061 0.06873411], f(x) = 0.0064590789808308 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0064590789808308, f(x+ap) = 0.006055360121301762, dgrad(x) = 6.016755943992868e-08 :

GD: iter = 149, x = [0.03851745 0.06750134], f(x) = 0.006055360121301762 :

Backtrack: alpha = 0.015625, f(x) = 0.006055360121301762, f(x+ap) = 0.0057382251880510144, dgrad(x) = 4.743071629753706e-08 :

GD: iter = 150, x = [0.03836828 0.0647831], f(x) = 0.0057382251880510144 :

 Backtrack: alpha = 0.015625, f(x) = 0.0057382251880510144, f(x+ap) = 0.005635408021361396, dgrad(x) = 7.914488853292681e-08 :

GD: iter = 151, x = [0.03492845 0.06405237], f(x) = 0.005635408021361396 :

 Backtrack: alpha = 0.00390625, f(x) = 0.005635408021361396, f(x+ap) = 0.005251865668014515, dgrad(x) = 5.766549511188768e-08 :

GD: iter = 152, x = [0.03584601 0.06286466], f(x) = 0.005251865668014515 :

 Backtrack: alpha = 0.015625, f(x) = 0.005251865668014515, f(x+ap) = 0.004982819909357572, dgrad(x) = 4.217630235418069e-08 :

GD: iter = 153, x = [0.03576745 0.06029876], f(x) = 0.004982819909357572 :

 Backtrack: alpha = 0.015625, f(x) = 0.004982819909357572, f(x+ap) = 0.00492040631544142, dgrad(x) = 7.337339033203083e-08 :

GD: iter = 154, x = [0.03243626 0.05969236], f(x) = 0.00492040631544142 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00492040631544142, f(x+ap) = 0.0045551706277887835, dgrad(x) = 5.5362710433032966e-08 :

GD: iter = 155, x = [0.03335875 0.05854711], f(x) = 0.0045551706277887835 :

 Backtrack: alpha = 0.015625, f(x) = 0.0045551706277887835, f(x+ap) = 0.00432767600267801, dgrad(x) = 3.7595028152947994e-08 :

GD: iter = 156, x = [0.03334521 0.05612347], f(x) = 0.00432767600267801 :

 Backtrack: alpha = 0.015625, f(x) = 0.00432767600267801, f(x+ap) = 0.004299644883912327, dgrad(x) = 6.825400923171407e-08 :

GD: iter = 157, x = [0.03011672 0.05563195], f(x) = 0.004299644883912327 :

 Backtrack: alpha = 0.00390625, f(x) = 0.004299644883912327, f(x+ap) = 0.003951074925291274, dgrad(x) = 5.323594469411377e-08 :

GD: iter = 158, x = [0.03104298 0.05452671], f(x) = 0.003951074925291274 :

 Backtrack: alpha = 0.015625, f(x) = 0.003951074925291274, f(x+ap) = 0.003759466238455564, dgrad(x) = 3.359800628536357e-08 :

GD: iter = 159, x = [0.03108925 0.05223596], f(x) = 0.003759466238455564 :

 Backtrack: alpha = 0.00390625, f(x) = 0.003759466238455564, f(x+ap) = 0.0036400950928432035, dgrad(x) = 1.5925707922050624e-08 :

GD: iter = 160, x = [0.03030642 0.0521396], f(x) = 0.0036400950928432035 :

 Backtrack: alpha = 0.0625, f(x) = 0.0036400950928432035, f(x+ap) = 0.003195782494084978, dgrad(x) = 9.869808910699823e-08 :

GD: iter = 161, x = [0.02462833 0.04671322], f(x) = 0.003195782494084978 :

 Backtrack: alpha = 0.00390625, f(x) = 0.003195782494084978, f(x+ap) = 0.0027609055766743816, dgrad(x) = 6.860327787748744e-08 :

GD: iter = 162, x = [0.02579421 0.04556406], f(x) = 0.0027609055766743816 :

 Backtrack: alpha = 0.015625, f(x) = 0.0027609055766743816, f(x+ap) = 0.0026614337798400237, dgrad(x) = 2.9430986099502227e-08 :

GD: iter = 163, x = [0.02617664 0.04345401], f(x) = 0.0026614337798400237 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0026614337798400237, f(x+ap) = 0.002536790837838473, dgrad(x) = 1.7903292175093928e-08 :

GD: iter = 164, x = [0.02534074 0.04347905], f(x) = 0.002536790837838473 :

 Backtrack: alpha = 0.0625, f(x) = 0.002536790837838473, f(x+ap) = 0.002501284195072629, dgrad(x) = 7.394313489612761e-08 :

GD: iter = 165, x = [0.01996329 0.03932004], f(x) = 0.002501284195072629 :

 Backtrack: alpha = 0.00390625, f(x) = 0.002501284195072629, f(x+ap) = 0.001935704376915777, dgrad(x) = 9.089043670538867e-08 :

GD: iter = 166, x = [0.02139566 0.03809582], f(x) = 0.001935704376915777 :

 Backtrack: alpha = 0.015625, f(x) = 0.001935704376915777, f(x+ap) = 0.0019128648331046896, dgrad(x) = 2.8747085275172202e-08 :

GD: iter = 167, x = [0.02211685 0.03610293], f(x) = 0.0019128648331046896 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0019128648331046896, f(x+ap) = 0.0017692947093401318, dgrad(x) = 2.1783935730322307e-08 :

GD: iter = 168, x = [0.02120573 0.03624715], f(x) = 0.0017692947093401318 :

 Backtrack: alpha = 0.015625, f(x) = 0.0017692947093401318, f(x+ap) = 0.0016812396442568555, dgrad(x) = 1.465558856228674e-08 :

GD: iter = 169, x = [0.01989701 0.03548742], f(x) = 0.0016812396442568555 :

 Backtrack: alpha = 0.015625, f(x) = 0.0016812396442568555, f(x+ap) = 0.0016717200944953126, dgrad(x) = 2.6752693491531286e-08 :

GD: iter = 170, x = [0.02064806 0.03358583], f(x) = 0.0016717200944953126 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0016717200944953126, f(x+ap) = 0.001534664462027872, dgrad(x) = 2.0951083396139525e-08 :

GD: iter = 171, x = [0.01975743 0.03374451], f(x) = 0.001534664462027872 :

 Backtrack: alpha = 0.015625, f(x) = 0.001534664462027872, f(x+ap) = 0.0014605399911078296, dgrad(x) = 1.3101856077814976e-08 :

GD: iter = 172, x = [0.01850186 0.03305843], f(x) = 0.0014605399911078296 :

Backtrack: alpha = 0.00390625, f(x) = 0.0014605399911078296, f(x+ap) = 0.0014138153464857389, dgrad(x) = 6.2447840562258655e-09 :

GD: iter = 173, x = [0.01869633 0.03260443], f(x) = 0.0014138153464857389 :

Backtrack: alpha = 0.0625, f(x) = 0.0014138153464857389, f(x+ap) = 0.0012436301596463082, dgrad(x) = 3.83793184384854e-08 :

GD: iter = 174, x = [0.01754585 0.02784381], f(x) = 0.0012436301596463082 :

Backtrack: alpha = 0.00390625, f(x) = 0.0012436301596463082, f(x+ap) = 0.0010724387222335035, dgrad(x) = 2.7020539260148653e-08 :

GD: iter = 175, x = [0.01655593 0.02811867], f(x) = 0.0010724387222335035 :

Backtrack: alpha = 0.015625, f(x) = 0.0010724387222335035, f(x+ap) = 0.0010342084020527735, dgrad(x) = 1.1502706817277257e-08 :

GD: iter = 176, x = [0.01529232 0.02767081], f(x) = 0.0010342084020527735 :

Backtrack: alpha = 0.00390625, f(x) = 0.0010342084020527735, f(x+ap) = 0.0009853034215269536, dgrad(x) = 7.0346608944530146e-09 :

GD: iter = 177, x = [0.01556929 0.02722574], f(x) = 0.0009853034215269536 :

Backtrack: alpha = 0.0625, f(x) = 0.0009853034215269536, f(x+ap) = 0.0009747726221350133, dgrad(x) = 2.8781285585768056e-08 :

GD: iter = 178, x = [0.01501067 0.02302143], f(x) = 0.0009747726221350133 :

Backtrack: alpha = 0.00390625, f(x) = 0.0009747726221350133, f(x+ap) = 0.0007519763805170148, dgrad(x) = 3.581468105298171e-08 :

GD: iter = 179, x = [0.0138961 0.02341736], f(x) = 0.0007519763805170148 :

Backtrack: alpha = 0.015625, f(x) = 0.0007519763805170148, f(x+ap) = 0.0007436581734395626, dgrad(x) = 1.1263478716957386e-08 :

GD: iter = 180, x = [0.01258922 0.02318938], f(x) = 0.0007436581734395626 :

Backtrack: alpha = 0.00390625, f(x) = 0.0007436581734395626, f(x+ap) = 0.000687220371996984, dgrad(x) = 8.571684692451753e-09 :

GD: iter = 181, x = [0.01295445 0.02274057], f(x) = 0.000687220371996984 :

Backtrack: alpha = 0.015625, f(x) = 0.000687220371996984, f(x+ap) = 0.000653139565527669, dgrad(x) = 5.71339381336461e-09 :

GD: iter = 182, x = [0.01295526 0.02179573], f(x) = 0.000653139565527669 :

Backtrack: alpha = 0.015625, f(x) = 0.000653139565527669, f(x+ap) = 0.000649981378293749, dgrad(x) = 1.0486481896154476e-08 :

GD: iter = 183, x = [0.01168843 0.02161228], f(x) = 0.000649981378293749 :

Backtrack: alpha = 0.00390625, f(x) = 0.000649981378293749, f(x+ap) = 0.0005960901750790478, dgrad(x) = 8.245517496374158e-09 :

GD: iter = 184, x = [0.01205504 0.02117905], f(x) = 0.0005960901750790478 :

 Backtrack: alpha = 0.015625, f(x) = 0.0005960901750790478, f(x+ap) = 0.0005674170538630819, dgrad(x) = 5.109415774114074e-09 :

GD: iter = 185, x = [0.01207901 0.02028586], f(x) = 0.0005674170538630819 :

 Backtrack: alpha = 0.00390625, f(x) = 0.0005674170538630819, f(x+ap) = 0.0005491269235696063, dgrad(x) = 2.448828521592458e-09 :

GD: iter = 186, x = [0.01177178 0.02025028], f(x) = 0.0005491269235696063 :

 Backtrack: alpha = 0.0625, f(x) = 0.0005491269235696063, f(x+ap) = 0.00048396755668404876, dgrad(x) = 1.4924262610672e-08 :

GD: iter = 187, x = [0.00955528 0.01814913], f(x) = 0.00048396755668404876 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00048396755668404876, f(x+ap) = 0.00041657587394158634, dgrad(x) = 1.0642626757904142e-08 :

GD: iter = 188, x = [0.01001612 0.01769818], f(x) = 0.00041657587394158634 :

 Backtrack: alpha = 0.015625, f(x) = 0.00041657587394158634, f(x+ap) = 0.00040188669234649297, dgrad(x) = 4.495923216348486e-09 :

GD: iter = 189, x = [0.01017166 0.01687459], f(x) = 0.00040188669234649297 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00040188669234649297, f(x+ap) = 0.0003826973771017292, dgrad(x) = 2.7642043521731257e-09 :

GD: iter = 190, x = [0.00984328 0.01688647], f(x) = 0.0003826973771017292 :

 Backtrack: alpha = 0.0625, f(x) = 0.0003826973771017292, f(x+ap) = 0.00037989240480020074, dgrad(x) = 1.1203005730257333e-08 :

GD: iter = 191, x = [0.00774166 0.01527866], f(x) = 0.00037989240480020074 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00037989240480020074, f(x+ap) = 0.0002921263371192605, dgrad(x) = 1.4112600931496942e-08 :

GD: iter = 192, x = [0.00830736 0.01479777], f(x) = 0.0002921263371192605 :

 Backtrack: alpha = 0.015625, f(x) = 0.0002921263371192605, f(x+ap) = 0.00028911342620264064, dgrad(x) = 4.413414346842339e-09 :

GD: iter = 193, x = [0.00859566 0.014019], f(x) = 0.00028911342620264064 :

 Backtrack: alpha = 0.00390625, f(x) = 0.00028911342620264064, f(x+ap) = 0.0002669268082073223, dgrad(x) = 3.3729254699094867e-09 :

GD: iter = 194, x = [0.00823743 0.01407753], f(x) = 0.0002669268082073223 :

 Backtrack: alpha = 0.015625, f(x) = 0.0002669268082073223, f(x+ap) = 0.00025373704226615035, dgrad(x) = 2.2274257596235867e-09 :

GD: iter = 195, x = [0.00772532 0.01378466], f(x) = 0.00025373704226615035 :

Backtrack: alpha = 0.015625, f(x) = 0.00025373704226615035, f(x+ap) = 0.0002527229747162053, dgrad(x) = 4.110692408018791e-09 :

GD: iter = 196, x = [0.00802513 0.01304141], f(x) = 0.0002527229747162053 :

Backtrack: alpha = 0.00390625, f(x) = 0.0002527229747162053, f(x+ap) = 0.00023153190915127877, dgrad(x) = 3.245182668791708e-09 :

GD: iter = 197, x = [0.00767491 0.01310553], f(x) = 0.00023153190915127877 :

Backtrack: alpha = 0.015625, f(x) = 0.00023153190915127877, f(x+ap) = 0.00022044132256330092, dgrad(x) = 1.9926402447700608e-09 :

GD: iter = 198, x = [0.00718348 0.01284123], f(x) = 0.00022044132256330092 :

Backtrack: alpha = 0.00390625, f(x) = 0.00022044132256330092, f(x+ap) = 0.00021328134400560214, dgrad(x) = 9.603322221069091e-10 :

GD: iter = 199, x = [0.00726101 0.01266374], f(x) = 0.00021328134400560214 :

Backtrack: alpha = 0.0625, f(x) = 0.00021328134400560214, f(x+ap) = 0.0001883442410216849, dgrad(x) = 5.803576414585152e-09 :

GD: iter = 200, x = [0.00682118 0.0108107], f(x) = 0.0001883442410216849 :

Backtrack: alpha = 0.00390625, f(x) = 0.0001883442410216849, f(x+ap) = 0.0001618141316366272, dgrad(x) = 4.191883952244153e-09 :

GD: iter = 201, x = [0.00643166 0.01092036], f(x) = 0.0001618141316366272 :

Backtrack: alpha = 0.015625, f(x) = 0.0001618141316366272, f(x+ap) = 0.0001561717227109539, dgrad(x) = 1.7573625715833609e-09 :

GD: iter = 202, x = [0.00593648 0.01074895], f(x) = 0.0001561717227109539 :

Backtrack: alpha = 0.00390625, f(x) = 0.0001561717227109539, f(x+ap) = 0.00014864186554177164, dgrad(x) = 1.0862097539192018e-09 :

GD: iter = 203, x = [0.00604639 0.01057474], f(x) = 0.00014864186554177164 :

Backtrack: alpha = 0.0625, f(x) = 0.00014864186554177164, f(x+ap) = 0.0001480590780697609, dgrad(x) = 4.360849457637766e-09 :

GD: iter = 204, x = [0.00583761 0.00893708], f(x) = 0.0001480590780697609 :

Backtrack: alpha = 0.00390625, f(x) = 0.0001480590780697609, f(x+ap) = 0.00011348503409860014, dgrad(x) = 5.561040611053657e-09 :

GD: iter = 205, x = [0.00539883 0.00909425], f(x) = 0.00011348503409860014 :

Backtrack: alpha = 0.015625, f(x) = 0.00011348503409860014, f(x+ap) = 0.00011240071499679797, dgrad(x) = 1.7294190286510587e-09 :

GD: iter = 206, x = [0.0048861 0.00900868], f(x) = 0.00011240071499679797 :

Backtrack: alpha = 0.00390625, f(x) = 0.00011240071499679797, f(x+ap) = 0.00010367849588397352, dgrad(x) = 1.3272657907745316e-09 :

GD: iter = 207, x = [0.00503069 0.00883278], f(x) = 0.00010367849588397352 :

 Backtrack: alpha = 0.015625, f(x) = 0.00010367849588397352, f(x+ap) = 9.85742053219118e-05, dgrad(x) = 8.684216305483128e-10 :

GD: iter = 208, x = [0.0050334 0.00846443], f(x) = 9.85742053219118e-05 :

 Backtrack: alpha = 0.015625, f(x) = 9.85742053219118e-05, f(x+ap) = 9.826414439245644e-05, dgrad(x) = 1.6114726588562407e-09 :

GD: iter = 209, x = [0.00453628 0.00839611], f(x) = 9.826414439245644e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 9.826414439245644e-05, f(x+ap) = 8.993114215929043e-05, dgrad(x) = 1.277232803920832e-09 :

GD: iter = 210, x = [0.00468137 0.00822629], f(x) = 8.993114215929043e-05 :

 Backtrack: alpha = 0.015625, f(x) = 8.993114215929043e-05, f(x+ap) = 8.564171347723163e-05, dgrad(x) = 7.771518995778865e-10 :

GD: iter = 211, x = [0.00469304 0.00787801], f(x) = 8.564171347723163e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 8.564171347723163e-05, f(x+ap) = 8.283866406013892e-05, dgrad(x) = 3.7662288610813366e-10 :

GD: iter = 212, x = [0.00457246 0.00786492], f(x) = 8.283866406013892e-05 :

 Backtrack: alpha = 0.0625, f(x) = 8.283866406013892e-05, f(x+ap) = 7.329927118619884e-05, dgrad(x) = 2.2568662535534595e-09 :

GD: iter = 213, x = [0.00370719 0.00705138], f(x) = 7.329927118619884e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 7.329927118619884e-05, f(x+ap) = 6.285495149315308e-05, dgrad(x) = 1.6511069227040394e-09 :

GD: iter = 214, x = [0.00388933 0.00687441], f(x) = 6.285495149315308e-05 :

 Backtrack: alpha = 0.015625, f(x) = 6.285495149315308e-05, f(x+ap) = 6.068822459416349e-05, dgrad(x) = 6.869538521537077e-10 :

GD: iter = 215, x = [0.00395251 0.00655293], f(x) = 6.068822459416349e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 6.068822459416349e-05, f(x+ap) = 5.7733379239704606e-05, dgrad(x) = 4.268484256858575e-10 :

GD: iter = 216, x = [0.0038235 0.0065584], f(x) = 5.7733379239704606e-05 :

 Backtrack: alpha = 0.0625, f(x) = 5.7733379239704606e-05, f(x+ap) = 5.7706767956618496e-05, dgrad(x) = 1.6975396476037992e-09 :

GD: iter = 217, x = [0.0030021 0.0059369], f(x) = 5.7706767956618496e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 5.7706767956618496e-05, f(x+ap) = 4.408672692928796e-05, dgrad(x) = 2.1913314052028434e-09 :

GD: iter = 218, x = [0.00322551 0.00574799], f(x) = 4.408672692928796e-05 :

Backtrack: alpha = 0.015625, f(x) = 4.408672692928796e-05, f(x+ap) = 4.369944013092279e-05, dgrad(x) = 6.777180762504695e-10 :

GD: iter = 219, x = [0.00334072 0.00544365], f(x) = 4.369944013092279e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 4.369944013092279e-05, f(x+ap) = 4.027036019180381e-05, dgrad(x) = 5.222994123934704e-10 :

GD: iter = 220, x = [0.00319986 0.00546737], f(x) = 4.027036019180381e-05 :

 Backtrack: alpha = 0.015625, f(x) = 4.027036019180381e-05, f(x+ap) = 3.8295191861169996e-05, dgrad(x) = 3.3859183253571147e-10 :

GD: iter = 221, x = [0.00299946 0.00535449], f(x) = 3.8295191861169996e-05 :

 Backtrack: alpha = 0.015625, f(x) = 3.8295191861169996e-05, f(x+ap) = 3.820780201945718e-05, dgrad(x) = 6.317621601694218e-10 :

GD: iter = 222, x = [0.0031191 0.00506397], f(x) = 3.820780201945718e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 3.820780201945718e-05, f(x+ap) = 3.4930896994067815e-05, dgrad(x) = 5.027019328027662e-10 :

GD: iter = 223, x = [0.00298138 0.00508986], f(x) = 3.4930896994067815e-05 :

 Backtrack: alpha = 0.015625, f(x) = 3.4930896994067815e-05, f(x+ap) = 3.3272039967707315e-05, dgrad(x) = 3.031115041239424e-10 :

GD: iter = 224, x = [0.00278902 0.00498806], f(x) = 3.3272039967707315e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 3.3272039967707315e-05, f(x+ap) = 3.217461743106637e-05, dgrad(x) = 1.4771135931002762e-10 :

GD: iter = 225, x = [0.00281993 0.00491867], f(x) = 3.217461743106637e-05 :

 Backtrack: alpha = 0.0625, f(x) = 3.217461743106637e-05, f(x+ap) = 2.8527144731636164e-05, dgrad(x) = 8.77653967747971e-10 :

GD: iter = 226, x = [0.00265185 0.00419736], f(x) = 2.8527144731636164e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 2.8527144731636164e-05, f(x+ap) = 2.441536777262464e-05, dgrad(x) = 6.503491857185569e-10 :

GD: iter = 227, x = [0.00249859 0.0042411], f(x) = 2.441536777262464e-05 :

 Backtrack: alpha = 0.015625, f(x) = 2.441536777262464e-05, f(x+ap) = 2.358358185346085e-05, dgrad(x) = 2.6854526960114363e-10 :

GD: iter = 228, x = [0.00230452 0.00417553], f(x) = 2.358358185346085e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 2.358358185346085e-05, f(x+ap) = 2.2423994648757474e-05, dgrad(x) = 1.6774514694067059e-10 :

GD: iter = 229, x = [0.00234813 0.00410733], f(x) = 2.2423994648757474e-05 :

 Backtrack: alpha = 0.015625, f(x) = 2.2423994648757474e-05, f(x+ap) = 2.1189238438637453e-05, dgrad(x) = 1.6520424082987864e-10 :

GD: iter = 230, x = [0.00232867 0.00394785], f(x) = 2.1189238438637453e-05 :

 Backtrack: alpha = 0.015625, f(x) = 2.1189238438637453e-05, f(x+ap) = 2.053966945956142e-05, dgrad(x) = 2.4556844751517884e-10 :

GD: iter = 231, x = [0.00214133 0.00389063], f(x) = 2.053966945956142e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 2.053966945956142e-05, f(x+ap) = 1.944668845794395e-05, dgrad(x) = 1.5981284057000964e-10 :

GD: iter = 232, x = [0.00218547 0.00382509], f(x) = 1.944668845794395e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.944668845794395e-05, f(x+ap) = 1.8391591687315108e-05, dgrad(x) = 1.4598813389704254e-10 :

GD: iter = 233, x = [0.00217042 0.00367481], f(x) = 1.8391591687315108e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.8391591687315108e-05, f(x+ap) = 1.7898272613183686e-05, dgrad(x) = 2.2533791162515616e-10 :

GD: iter = 234, x = [0.00198943 0.00362531], f(x) = 1.7898272613183686e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 1.7898272613183686e-05, f(x+ap) = 1.686516643908309e-05, dgrad(x) = 1.5258653523332365e-10 :

GD: iter = 235, x = [0.00203401 0.00356228], f(x) = 1.686516643908309e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.686516643908309e-05, f(x+ap) = 1.5965464388870363e-05, dgrad(x) = 1.2926042981257308e-10 :

GD: iter = 236, x = [0.00202305 0.00342058], f(x) = 1.5965464388870363e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.5965464388870363e-05, f(x+ap) = 1.5605923175013736e-05, dgrad(x) = 2.0749598579356395e-10 :

GD: iter = 237, x = [0.00184804 0.00337823], f(x) = 1.5605923175013736e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 1.5605923175013736e-05, f(x+ap) = 1.4626803952090092e-05, dgrad(x) = 1.4598081684354863e-10 :

GD: iter = 238, x = [0.00189299 0.00331755], f(x) = 1.4626803952090092e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.4626803952090092e-05, f(x+ap) = 1.386146748256031e-05, dgrad(x) = 1.1469186662340202e-10 :

GD: iter = 239, x = [0.0018858 0.00318388], f(x) = 1.386146748256031e-05 :

 Backtrack: alpha = 0.015625, f(x) = 1.386146748256031e-05, f(x+ap) = 1.3616261324406995e-05, dgrad(x) = 1.9173237201132187e-10 :

GD: iter = 240, x = [0.00171645 0.00314813], f(x) = 1.3616261324406995e-05 :

 Backtrack: alpha = 0.00390625, f(x) = 1.3616261324406995e-05, f(x+ap) = 1.2685973767174577e-05, dgrad(x) = 1.3992142344007898e-10 :

GD: iter = 241, x = [0.0017617 0.00308967], f(x) = 1.2685973767174577e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.2685973767174577e-05, f(x+ap) = 1.2036778863416392e-05, dgrad(x) = 1.0199692487653625e-10 :

GD: iter = 242, x = [0.00175798 0.00296348], f(x) = 1.2036778863416392e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.2036778863416392e-05, f(x+ap) = 1.1889090401549257e-05, dgrad(x) = 1.7777785496447695e-10 :

GD: iter = 243, x = [0.00159396 0.00293385], f(x) = 1.1889090401549257e-05 :

Backtrack: alpha = 0.00390625, f(x) = 1.1889090401549257e-05, f(x+ap) = 1.1003115624072079e-05, dgrad(x) = 1.3434376727854582e-10 :

GD: iter = 244, x = [0.00163946 0.00287747], f(x) = 1.1003115624072079e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.1003115624072079e-05, f(x+ap) = 1.0454270184171175e-05, dgrad(x) = 9.092801215349769e-11 :

GD: iter = 245, x = [0.00163893 0.00275828], f(x) = 1.0454270184171175e-05 :

Backtrack: alpha = 0.015625, f(x) = 1.0454270184171175e-05, f(x+ap) = 1.0389557426029e-05, dgrad(x) = 1.653988435945174e-10 :

GD: iter = 246, x = [0.00147997 0.00273429], f(x) = 1.0389557426029e-05 :

Backtrack: alpha = 0.00390625, f(x) = 1.0389557426029e-05, f(x+ap) = 9.54392951150162e-06, dgrad(x) = 1.2919165331667166e-10 :

GD: iter = 247, x = [0.00152564 0.00267988], f(x) = 9.54392951150162e-06 :

Backtrack: alpha = 0.015625, f(x) = 9.54392951150162e-06, f(x+ap) = 9.08174976574834e-06, dgrad(x) = 8.127042086128574e-11 :

GD: iter = 248, x = [0.00152805 0.00256722], f(x) = 9.08174976574834e-06 :

Backtrack: alpha = 0.00390625, f(x) = 9.08174976574834e-06, f(x+ap) = 8.792619369757672e-06, dgrad(x) = 3.859815959008229e-11 :

GD: iter = 249, x = [0.00148951 0.00256252], f(x) = 8.792619369757672e-06 :

Backtrack: alpha = 0.0625, f(x) = 8.792619369757672e-06, f(x+ap) = 7.724612974944174e-06, dgrad(x) = 2.385028022669704e-10 :

GD: iter = 250, x = [0.00121019 0.00229597], f(x) = 7.724612974944174e-06 :

Backtrack: alpha = 0.00390625, f(x) = 7.724612974944174e-06, f(x+ap) = 6.6691660314875095e-06, dgrad(x) = 1.6653207080745423e-10 :

GD: iter = 251, x = [0.00126767 0.00223939], f(x) = 6.6691660314875095e-06 :

Backtrack: alpha = 0.015625, f(x) = 6.6691660314875095e-06, f(x+ap) = 6.42977902477787e-06, dgrad(x) = 7.124734937129338e-11 :

GD: iter = 252, x = [0.00128662 0.0021356], f(x) = 6.42977902477787e-06 :

Backtrack: alpha = 0.00390625, f(x) = 6.42977902477787e-06, f(x+ap) = 6.127623812644612e-06, dgrad(x) = 4.342271263218978e-11 :

GD: iter = 253, x = [0.00124546 0.00213688], f(x) = 6.127623812644612e-06 :

 Backtrack: alpha = 0.0625, f(x) = 6.127623812644612e-06, f(x+ap) = 6.048999108542235e-06, dgrad(x) = 1.7874423535350224e-10 :

GD: iter = 254, x = [0.00098088 0.00193264], f(x) = 6.048999108542235e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 6.048999108542235e-06, f(x+ap) = 4.676000944398317e-06, dgrad(x) = 2.206683670411256e-10 :

GD: iter = 255, x = [0.00105149 0.00187235], f(x) = 4.676000944398317e-06 :

 Backtrack: alpha = 0.015625, f(x) = 4.676000944398317e-06, f(x+ap) = 4.622042920694116e-06, dgrad(x) = 6.965322266329996e-11 :

GD: iter = 256, x = [0.00108711 0.0017743], f(x) = 4.622042920694116e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 4.622042920694116e-06, f(x+ap) = 4.273771688438382e-06, dgrad(x) = 5.2861608641218375e-11 :

GD: iter = 257, x = [0.00104224 0.00178144], f(x) = 4.273771688438382e-06 :

 Backtrack: alpha = 0.015625, f(x) = 4.273771688438382e-06, f(x+ap) = 4.0613379294727005e-06, dgrad(x) = 3.544679048361503e-11 :

GD: iter = 258, x = [0.00097783 0.00174415], f(x) = 4.0613379294727005e-06 :

 Backtrack: alpha = 0.015625, f(x) = 4.0613379294727005e-06, f(x+ap) = 4.039524723089978e-06, dgrad(x) = 6.483058608300022e-11 :

GD: iter = 259, x = [0.00101492 0.00165059], f(x) = 4.039524723089978e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 4.039524723089978e-06, f(x+ap) = 3.7070250401827177e-06, dgrad(x) = 5.084397512544166e-11 :

GD: iter = 260, x = [0.00097106 0.00165844], f(x) = 3.7070250401827177e-06 :

 Backtrack: alpha = 0.015625, f(x) = 3.7070250401827177e-06, f(x+ap) = 3.5282340164537027e-06, dgrad(x) = 3.169265130401339e-11 :

GD: iter = 261, x = [0.00090926 0.00162477], f(x) = 3.5282340164537027e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 3.5282340164537027e-06, f(x+ap) = 3.4150594226239055e-06, dgrad(x) = 1.513537443207535e-11 :

GD: iter = 262, x = [0.00091887 0.00160243], f(x) = 3.4150594226239055e-06 :

 Backtrack: alpha = 0.0625, f(x) = 3.4150594226239055e-06, f(x+ap) = 3.0060391387510383e-06, dgrad(x) = 9.274371885133097e-11 :

GD: iter = 263, x = [0.00086248 0.00136837], f(x) = 3.0060391387510383e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 3.0060391387510383e-06, f(x+ap) = 2.590554341813844e-06, dgrad(x) = 6.55917237816917e-11 :

GD: iter = 264, x = [0.00081371 0.00138195], f(x) = 2.590554341813844e-06 :

Backtrack: alpha = 0.015625, f(x) = 2.590554341813844e-06, f(x+ap) = 2.498558719446674e-06, dgrad(x) = 2.7846607580642315e-11 :

GD: iter = 265, x = [0.00075151 0.00135999], f(x) = 2.498558719446674e-06 :

Backtrack: alpha = 0.00390625, f(x) = 2.498558719446674e-06, f(x+ap) = 2.380002885237435e-06, dgrad(x) = 1.7062126166730618e-11 :

GD: iter = 266, x = [0.00076518 0.00133809], f(x) = 2.380002885237435e-06 :

Backtrack: alpha = 0.0625, f(x) = 2.380002885237435e-06, f(x+ap) = 2.3573811525454065e-06, dgrad(x) = 6.9574264009251e-11 :

GD: iter = 267, x = [0.0007379 0.00113135], f(x) = 2.3573811525454065e-06 :

Backtrack: alpha = 0.00390625, f(x) = 2.3573811525454065e-06, f(x+ap) = 1.8165202013415682e-06, dgrad(x) = 8.695290029505118e-11 :

GD: iter = 268, x = [0.000683   0.00115088], f(x) = 1.8165202013415682e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.8165202013415682e-06, f(x+ap) = 1.7969049383676329e-06, dgrad(x) = 2.7291552508251125e-11 :

GD: iter = 269, x = [0.00061865 0.00113975], f(x) = 1.7969049383676329e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.7969049383676329e-06, f(x+ap) = 1.6599969018379018e-06, dgrad(x) = 2.0800511861556442e-11 :

GD: iter = 270, x = [0.00063666 0.00111765], f(x) = 1.6599969018379018e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.6599969018379018e-06, f(x+ap) = 1.5777784848023905e-06, dgrad(x) = 1.3818924178957498e-11 :

GD: iter = 271, x = [0.00063676 0.00107119], f(x) = 1.5777784848023905e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.5777784848023905e-06, f(x+ap) = 1.5706155709415963e-06, dgrad(x) = 2.5412673088984033e-11 :

GD: iter = 272, x = [0.00057438 0.00106223], f(x) = 1.5706155709415963e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.5706155709415963e-06, f(x+ap) = 1.4398729548084696e-06, dgrad(x) = 2.0010337355151338e-11 :

GD: iter = 273, x = [0.00059246 0.00104091], f(x) = 1.4398729548084696e-06 :

Backtrack: alpha = 0.015625, f(x) = 1.4398729548084696e-06, f(x+ap) = 1.3707141952614325e-06, dgrad(x) = 1.2359582044709846e-11 :

GD: iter = 274, x = [0.00059369 0.00099698], f(x) = 1.3707141952614325e-06 :

Backtrack: alpha = 0.00390625, f(x) = 1.3707141952614325e-06, f(x+ap) = 1.3264116906391028e-06, dgrad(x) = 5.935290485948835e-12 :

GD: iter = 275, x = [0.00057856 0.00099525], f(x) = 1.3264116906391028e-06 :

Backtrack: alpha = 0.0625, f(x) = 1.3264116906391028e-06, f(x+ap) = 1.1698321332639948e-06, dgrad(x) = 3.606472864467754e-11 :

GD: iter = 276, x = [0.00046953 0.00089204], f(x) = 1.1698321332639948e-06 :

 Backtrack: alpha = 0.00390625, f(x) = 1.1698321332639948e-06, f(x+ap) = 1.0062701335876454e-06, dgrad(x) = 2.583484465091653e-11 :

GD: iter = 277, x = [0.00049225 0.00086983], f(x) = 1.0062701335876454e-06 :

 Backtrack: alpha = 0.015625, f(x) = 1.0062701335876454e-06, f(x+ap) = 9.709262790933003e-07, dgrad(x) = 1.0884274722391089e-11 :

GD: iter = 278, x = [0.00049995 0.00082932], f(x) = 9.709262790933003e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 9.709262790933003e-07, f(x+ap) = 9.244065990404809e-07, dgrad(x) = 6.704494053186205e-12 :

GD: iter = 279, x = [0.00048378 0.00082992], f(x) = 9.244065990404809e-07 :

 Backtrack: alpha = 0.0625, f(x) = 9.244065990404809e-07, f(x+ap) = 9.187411027405532e-07, dgrad(x) = 2.7081784747309604e-11 :

GD: iter = 280, x = [0.00038038 0.00075097], f(x) = 9.187411027405532e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 9.187411027405532e-07, f(x+ap) = 7.056790536271317e-07, dgrad(x) = 3.426345264516388e-11 :

GD: iter = 281, x = [0.00040826 0.00072729], f(x) = 7.056790536271317e-07 :

 Backtrack: alpha = 0.015625, f(x) = 7.056790536271317e-07, f(x+ap) = 6.985895576310129e-07, dgrad(x) = 1.0693963084913545e-11 :

GD: iter = 282, x = [0.0004225 0.00068897], f(x) = 6.985895576310129e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 6.985895576310129e-07, f(x+ap) = 6.447681268567988e-07, dgrad(x) = 8.184993609290681e-12 :

GD: iter = 283, x = [0.00040486 0.00069187], f(x) = 6.447681268567988e-07 :

 Backtrack: alpha = 0.015625, f(x) = 6.447681268567988e-07, f(x+ap) = 6.129491528548769e-07, dgrad(x) = 5.3875309641405806e-12 :

GD: iter = 284, x = [0.00037966 0.0006775], f(x) = 6.129491528548769e-07 :

 Backtrack: alpha = 0.015625, f(x) = 6.129491528548769e-07, f(x+ap) = 6.106832594701447e-07, dgrad(x) = 9.961932510054456e-12 :

GD: iter = 285, x = [0.00039446 0.00064093], f(x) = 6.106832594701447e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 6.106832594701447e-07, f(x+ap) = 5.592721493756155e-07, dgrad(x) = 7.875517155662781e-12 :

GD: iter = 286, x = [0.00037721 0.0006441], f(x) = 5.592721493756155e-07 :

 Backtrack: alpha = 0.015625, f(x) = 5.592721493756155e-07, f(x+ap) = 5.325227162550021e-07, dgrad(x) = 4.820235713184676e-12 :

GD: iter = 287, x = [0.00035303 0.00063113], f(x) = 5.325227162550021e-07 :

Backtrack: alpha = 0.00390625, f(x) = 5.325227162550021e-07, f(x+ap) = 5.151794161970774e-07, dgrad(x) = 2.3276245617291706e-12 :

GD: iter = 288, x = [0.00035686 0.00062239], f(x) = 5.151794161970774e-07 :

Backtrack: alpha = 0.0625, f(x) = 5.151794161970774e-07, f(x+ap) = 4.5526430214916526e-07, dgrad(x) = 1.402452185901213e-11 :

GD: iter = 289, x = [0.0003353 0.00053129], f(x) = 4.5526430214916526e-07 :

Backtrack: alpha = 0.00390625, f(x) = 4.5526430214916526e-07, f(x+ap) = 3.9087434624247424e-07, dgrad(x) = 1.0175792412906189e-11 :

GD: iter = 290, x = [0.00031611 0.0005367], f(x) = 3.9087434624247424e-07 :

Backtrack: alpha = 0.015625, f(x) = 3.9087434624247424e-07, f(x+ap) = 3.7729945557928213e-07, dgrad(x) = 4.25451800424632e-12 :

GD: iter = 291, x = [0.00029174 0.0005283], f(x) = 3.7729945557928213e-07 :

Backtrack: alpha = 0.00390625, f(x) = 3.7729945557928213e-07, f(x+ap) = 3.5904489681086145e-07, dgrad(x) = 2.6346042873376207e-12 :

GD: iter = 292, x = [0.00029716 0.00051973], f(x) = 3.5904489681086145e-07 :

Backtrack: alpha = 0.0625, f(x) = 3.5904489681086145e-07, f(x+ap) = 3.5807473294404685e-07, dgrad(x) = 1.0541882115767716e-11 :

GD: iter = 293, x = [0.00028697 0.0004392], f(x) = 3.5807473294404685e-07 :

Backtrack: alpha = 0.00390625, f(x) = 3.5807473294404685e-07, f(x+ap) = 2.74142010823516e-07, dgrad(x) = 1.3501474253310331e-11 :

GD: iter = 294, x = [0.00026535 0.00044695], f(x) = 2.74142010823516e-07 :

Backtrack: alpha = 0.015625, f(x) = 2.74142010823516e-07, f(x+ap) = 2.715970276392036e-07, dgrad(x) = 4.190563902300005e-12 :

GD: iter = 295, x = [0.00024011 0.00044277], f(x) = 2.715970276392036e-07 :

Backtrack: alpha = 0.00390625, f(x) = 2.715970276392036e-07, f(x+ap) = 2.5043796838475084e-07, dgrad(x) = 3.220870202228152e-12 :

GD: iter = 296, x = [0.00024724 0.00043411], f(x) = 2.5043796838475084e-07 :

Backtrack: alpha = 0.015625, f(x) = 2.5043796838475084e-07, f(x+ap) = 2.3812467920542857e-07, dgrad(x) = 2.1005048511568688e-12 :

GD: iter = 297, x = [0.00024739 0.000416], f(x) = 2.3812467920542857e-07 :

Backtrack: alpha = 0.015625, f(x) = 2.3812467920542857e-07, f(x+ap) = 2.3744810201507205e-07, dgrad(x) = 3.90534676986801e-12 :

GD: iter = 298, x = [0.00022292 0.00041267], f(x) = 2.3744810201507205e-07 :

Backtrack: alpha = 0.00390625, f(x) = 2.3744810201507205e-07, f(x+ap) = 2.1723138964622553e-07, dgrad(x) = 3.0996552948557753e-12 :

GD: iter = 299, x = [0.00023007 0.00040431], f(x) = 2.1723138964622553e-07 :

 Backtrack: alpha = 0.015625, f(x) = 2.1723138964622553e-07, f(x+ap) = 2.0688599476203589e-07, dgrad(x) = 1.879975439731889e-12 :

GD: iter = 300, x = [0.00023067 0.00038718], f(x) = 2.0688599476203589e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 2.0688599476203589e-07, f(x+ap) = 2.0009615853942524e-07, dgrad(x) = 9.128636814016882e-13 :

GD: iter = 301, x = [0.00022473 0.00038654], f(x) = 2.0009615853942524e-07 :

 Backtrack: alpha = 0.0625, f(x) = 2.0009615853942524e-07, f(x+ap) = 1.7718008593497738e-07, dgrad(x) = 5.453819766840557e-12 :

GD: iter = 302, x = [0.00018216 0.00034658], f(x) = 1.7718008593497738e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 1.7718008593497738e-07, f(x+ap) = 1.51831006963158e-07, dgrad(x) = 4.008077633878911e-12 :

GD: iter = 303, x = [0.00019114 0.00033786], f(x) = 1.51831006963158e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.51831006963158e-07, f(x+ap) = 1.4661870306066075e-07, dgrad(x) = 1.6631252534051676e-12 :

GD: iter = 304, x = [0.00019427 0.00032205], f(x) = 1.4661870306066075e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 1.4661870306066075e-07, f(x+ap) = 1.394551797745656e-07, dgrad(x) = 1.0353356372310732e-12 :

GD: iter = 305, x = [0.00018792 0.00032233], f(x) = 1.394551797745656e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.394551797745656e-07, f(x+ap) = 1.3176758095514376e-07, dgrad(x) = 1.0259149976974417e-12 :

GD: iter = 306, x = [0.00017782 0.0003147], f(x) = 1.3176758095514376e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.3176758095514376e-07, f(x+ap) = 1.276894609527031e-07, dgrad(x) = 1.5203991913876437e-12 :

GD: iter = 307, x = [0.00018125 0.00029967], f(x) = 1.276894609527031e-07 :

 Backtrack: alpha = 0.00390625, f(x) = 1.276894609527031e-07, f(x+ap) = 1.209390029044776e-07, dgrad(x) = 9.86195146843288e-13 :

GD: iter = 308, x = [0.00017506 0.00030009], f(x) = 1.209390029044776e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.209390029044776e-07, f(x+ap) = 1.1436893454958893e-07, dgrad(x) = 9.064443065948968e-13 :

GD: iter = 309, x = [0.00016541 0.00029312], f(x) = 1.1436893454958893e-07 :

 Backtrack: alpha = 0.015625, f(x) = 1.1436893454958893e-07, f(x+ap) = 1.112634830894075e-07, dgrad(x) = 1.3947485067116837e-12 :

GD: iter = 310, x = [0.00016912 0.00027884], f(x) = 1.112634830894075e-07 :

Backtrack: alpha = 0.00390625, f(x) = 1.112634830894075e-07, f(x+ap) = 1.0488425533846324e-07, dgrad(x) = 9.41440717364242e-13 :

GD: iter = 311, x = [0.00016308 0.00027938], f(x) = 1.0488425533846324e-07 :

Backtrack: alpha = 0.015625, f(x) = 1.0488425533846324e-07, f(x+ap) = 9.928080715534236e-08, dgrad(x) = 8.024484112045155e-13 :

GD: iter = 312, x = [0.00015386 0.00027303], f(x) = 9.928080715534236e-08 :

Backtrack: alpha = 0.015625, f(x) = 9.928080715534236e-08, f(x+ap) = 9.700824521956766e-08, dgrad(x) = 1.2839488671115997e-12 :

GD: iter = 313, x = [0.00015782 0.00025944], f(x) = 9.700824521956766e-08 :

Backtrack: alpha = 0.00390625, f(x) = 9.700824521956766e-08, f(x+ap) = 9.096365796425908e-08, dgrad(x) = 9.005412607763427e-13 :

GD: iter = 314, x = [0.00015193 0.0002601], f(x) = 9.096365796425908e-08 :

Backtrack: alpha = 0.015625, f(x) = 9.096365796425908e-08, f(x+ap) = 8.619604224973857e-08, dgrad(x) = 7.118796122899636e-13 :

GD: iter = 315, x = [0.0001431 0.00025433], f(x) = 8.619604224973857e-08 :

Backtrack: alpha = 0.015625, f(x) = 8.619604224973857e-08, f(x+ap) = 8.463543058762743e-08, dgrad(x) = 1.1860705883398863e-12 :

GD: iter = 316, x = [0.0001473 0.00024138], f(x) = 8.463543058762743e-08 :

Backtrack: alpha = 0.00390625, f(x) = 8.463543058762743e-08, f(x+ap) = 7.889344942902502e-08, dgrad(x) = 8.630350427800315e-13 :

GD: iter = 317, x = [0.00014154 0.00024215], f(x) = 7.889344942902502e-08 :

Backtrack: alpha = 0.015625, f(x) = 7.889344942902502e-08, f(x+ap) = 7.484832401667332e-08, dgrad(x) = 6.329622501105269e-13 :

GD: iter = 318, x = [0.00013309 0.00023691], f(x) = 7.484832401667332e-08 :

Backtrack: alpha = 0.015625, f(x) = 7.484832401667332e-08, f(x+ap) = 7.389505188058485e-08, dgrad(x) = 1.09943948214742e-12 :

GD: iter = 319, x = [0.00013749 0.00022456], f(x) = 7.389505188058485e-08 :

Backtrack: alpha = 0.00390625, f(x) = 7.389505188058485e-08, f(x+ap) = 6.842759961311803e-08, dgrad(x) = 8.285204915536005e-13 :

GD: iter = 320, x = [0.00013187 0.00022543], f(x) = 6.842759961311803e-08 :

Backtrack: alpha = 0.015625, f(x) = 6.842759961311803e-08, f(x+ap) = 6.500674681986172e-08, dgrad(x) = 5.641565373340136e-13 :

GD: iter = 321, x = [0.00012377 0.00022069], f(x) = 6.500674681986172e-08 :

Backtrack: alpha = 0.015625, f(x) = 6.500674681986172e-08, f(x+ap) = 6.457035477202937e-08, dgrad(x) = 1.022602909629373e-12 :

GD: iter = 322, x = [0.00012836 0.00020891], f(x) = 6.457035477202937e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 6.457035477202937e-08, f(x+ap) = 5.935279253526322e-08, dgrad(x) = 7.966482279231437e-13 :

GD: iter = 323, x = [0.00012286 0.00020987], f(x) = 5.935279253526322e-08 :

 Backtrack: alpha = 0.015625, f(x) = 5.935279253526322e-08, f(x+ap) = 5.6471106769603135e-08, dgrad(x) = 5.041272009274313e-13 :

GD: iter = 324, x = [0.00011509 0.00020558], f(x) = 5.6471106769603135e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 5.6471106769603135e-08, f(x+ap) = 5.468193689030969e-08, dgrad(x) = 2.3857508694941237e-13 :

GD: iter = 325, x = [0.00011628 0.00020277], f(x) = 5.468193689030969e-08 :

 Backtrack: alpha = 0.0625, f(x) = 5.468193689030969e-08, f(x+ap) = 4.798071987129447e-08, dgrad(x) = 1.482151705827647e-12 :

GD: iter = 326, x = [0.00010905 0.0001732], f(x) = 4.798071987129447e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 4.798071987129447e-08, f(x+ap) = 4.147351644537146e-08, dgrad(x) = 1.0263704530563825e-12 :

GD: iter = 327, x = [0.00010295 0.00017488], f(x) = 4.147351644537146e-08 :

 Backtrack: alpha = 0.015625, f(x) = 4.147351644537146e-08, f(x+ap) = 3.997471199632822e-08, dgrad(x) = 4.4131349471566986e-13 :

GD: iter = 328, x = [9.51354496e-05 1.72070499e-04], f(x) = 3.997471199632822e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 3.997471199632822e-08, f(x+ap) = 3.810783424027066e-08, dgrad(x) = 2.68038850359014e-13 :

GD: iter = 329, x = [9.68340424e-05 1.69316402e-04], f(x) = 3.810783424027066e-08 :

 Backtrack: alpha = 0.0625, f(x) = 3.810783424027066e-08, f(x+ap) = 3.753796958758683e-08, dgrad(x) = 1.1100917900750916e-12 :

GD: iter = 330, x = [9.32762221e-05 1.43217565e-04], f(x) = 3.753796958758683e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 3.753796958758683e-08, f(x+ap) = 2.9076728231132013e-08, dgrad(x) = 1.359628845014089e-12 :

GD: iter = 331, x = [8.64047515e-05 1.45645197e-04], f(x) = 2.9076728231132013e-08 :

 Backtrack: alpha = 0.015625, f(x) = 2.9076728231132013e-08, f(x+ap) = 2.8727445309281424e-08, dgrad(x) = 4.307444444490324e-13 :

GD: iter = 332, x = [7.83296966e-05 1.44196988e-04], f(x) = 2.8727445309281424e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 2.8727445309281424e-08, f(x+ap) = 2.6578272098575668e-08, dgrad(x) = 3.26001102351566e-13 :

GD: iter = 333, x = [8.05731649e-05 1.41421872e-04], f(x) = 2.6578272098575668e-08 :

Backtrack: alpha = 0.015625, f(x) = 2.6578272098575668e-08, f(x+ap) = 2.5254157538554774e-08, dgrad(x) = 2.1992126695881209e-13 :

GD: iter = 334, x = [8.05537451e-05 1.35559934e-04], f(x) = 2.5254157538554774e-08 :

Backtrack: alpha = 0.015625, f(x) = 2.5254157538554774e-08, f(x+ap) = 2.510511991753687e-08, dgrad(x) = 4.008110185697873e-13 :

GD: iter = 335, x = [7.27271459e-05 1.34389009e-04], f(x) = 2.510511991753687e-08 :

Backtrack: alpha = 0.00390625, f(x) = 2.510511991753687e-08, f(x+ap) = 2.3053625030749502e-08, dgrad(x) = 3.1351996202995693e-13 :

GD: iter = 336, x = [7.49795279e-05 1.31710642e-04], f(x) = 2.3053625030749502e-08 :

Backtrack: alpha = 0.015625, f(x) = 2.3053625030749502e-08, f(x+ap) = 2.1938810693923494e-08, dgrad(x) = 1.965865915819555e-13 :

GD: iter = 337, x = [7.51044101e-05 1.26169788e-04], f(x) = 2.1938810693923494e-08 :

Backtrack: alpha = 0.00390625, f(x) = 2.1938810693923494e-08, f(x+ap) = 2.1238499341710053e-08, dgrad(x) = 9.354858997251232e-14 :

GD: iter = 338, x = [7.32065359e-05 1.25941063e-04], f(x) = 2.1238499341710053e-08 :

Backtrack: alpha = 0.0625, f(x) = 2.1238499341710053e-08, f(x+ap) = 1.8671431241763023e-08, dgrad(x) = 5.763404634630578e-13 :

GD: iter = 339, x = [5.94667954e-05 1.12847846e-04], f(x) = 1.8671431241763023e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.8671431241763023e-08, f(x+ap) = 1.6109853507247384e-08, dgrad(x) = 4.0425147659403764e-13 :

GD: iter = 340, x = [6.23004998e-05 1.10061954e-04], f(x) = 1.6109853507247384e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.6109853507247384e-08, f(x+ap) = 1.5533768320308795e-08, dgrad(x) = 1.724787363681886e-13 :

GD: iter = 341, x = [6.32396119e-05 1.04956284e-04], f(x) = 1.5533768320308795e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.5533768320308795e-08, f(x+ap) = 1.4801289405639396e-08, dgrad(x) = 1.0531812203540686e-13 :

GD: iter = 342, x = [6.12123635e-05 1.05021500e-04], f(x) = 1.4801289405639396e-08 :

Backtrack: alpha = 0.0625, f(x) = 1.4801289405639396e-08, f(x+ap) = 1.4628713047193312e-08, dgrad(x) = 4.320835451833476e-13 :

GD: iter = 343, x = [4.81946568e-05 9.49919670e-05], f(x) = 1.4628713047193312e-08 :

Backtrack: alpha = 0.00390625, f(x) = 1.4628713047193312e-08, f(x+ap) = 1.1295626285946263e-08, dgrad(x) = 5.357502237051591e-13 :

GD: iter = 344, x = [5.16750645e-05 9.20230436e-05], f(x) = 1.1295626285946263e-08 :

Backtrack: alpha = 0.015625, f(x) = 1.1295626285946263e-08, f(x+ap) = 1.1168231037395939e-08, dgrad(x) = 1.6876856318902726e-13 :

GD: iter = 345, x = [5.34350310e-05 8.71988747e-05], f(x) = 1.1168231037395939e-08 :

 Backtrack: alpha = 0.00390625, f(x) = 1.1168231037395939e-08, f(x+ap) = 1.0323393851403002e-08, dgrad(x) = 1.282761023343634e-13 :

GD: iter = 346, x = [5.12247008e-05 8.75527469e-05], f(x) = 1.0323393851403002e-08 :

 Backtrack: alpha = 0.015625, f(x) = 1.0323393851403002e-08, f(x+ap) = 9.810899325539412e-09, dgrad(x) = 8.573395112432831e-14 :

GD: iter = 347, x = [4.80551685e-05 8.57224479e-05], f(x) = 9.810899325539412e-09 :

 Backtrack: alpha = 0.015625, f(x) = 9.810899325539412e-09, f(x+ap) = 9.761077941353064e-09, dgrad(x) = 1.5710689782890515e-13 :

GD: iter = 348, x = [4.98870603e-05 8.11189573e-05], f(x) = 9.761077941353064e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 9.761077941353064e-09, f(x+ap) = 8.954423855397751e-09, dgrad(x) = 1.2338823336851237e-13 :

GD: iter = 349, x = [4.77263342e-05 8.15076932e-05], f(x) = 8.954423855397751e-09 :

 Backtrack: alpha = 0.015625, f(x) = 8.954423855397751e-09, f(x+ap) = 8.523177297089234e-09, dgrad(x) = 7.666316044456483e-14 :

GD: iter = 350, x = [4.46852758e-05 7.98552459e-05], f(x) = 8.523177297089234e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 8.523177297089234e-09, f(x+ap) = 8.249048344658274e-09, dgrad(x) = 3.668357890040181e-14 :

GD: iter = 351, x = [4.51594027e-05 7.87560844e-05], f(x) = 8.249048344658274e-09 :

 Backtrack: alpha = 0.0625, f(x) = 8.249048344658274e-09, f(x+ap) = 7.2660669588638914e-09, dgrad(x) = 2.2411588993382028e-13 :

GD: iter = 352, x = [4.23957844e-05 6.72480504e-05], f(x) = 7.2660669588638914e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 7.2660669588638914e-09, f(x+ap) = 6.2576751576747955e-09, dgrad(x) = 1.5922262676205298e-13 :

GD: iter = 353, x = [3.99936279e-05 6.79183325e-05], f(x) = 6.2576751576747955e-09 :

 Backtrack: alpha = 0.015625, f(x) = 6.2576751576747955e-09, f(x+ap) = 6.036308923006265e-09, dgrad(x) = 6.741359653157129e-14 :

GD: iter = 354, x = [3.69317550e-05 6.68420848e-05], f(x) = 6.036308923006265e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 6.036308923006265e-09, f(x+ap) = 5.74890321088192e-09, dgrad(x) = 4.138330942686158e-14 :

GD: iter = 355, x = [3.76058889e-05 6.57640872e-05], f(x) = 5.74890321088192e-09 :

 Backtrack: alpha = 0.0625, f(x) = 5.74890321088192e-09, f(x+ap) = 5.701096961259934e-09, dgrad(x) = 1.6818550620952439e-13 :

GD: iter = 356, x = [3.62744742e-05 5.55982977e-05], f(x) = 5.701096961259934e-09 :

Backtrack: alpha = 0.00390625, f(x) = 5.701096961259934e-09, f(x+ap) = 4.388099167830025e-09, dgrad(x) = 2.111093362039253e-13 :

GD: iter = 357, x = [3.35693801e-05 5.65621050e-05], f(x) = 4.388099167830025e-09 :

Backtrack: alpha = 0.015625, f(x) = 4.388099167830025e-09, f(x+ap) = 4.34187766617285e-09, dgrad(x) = 6.61282261969682e-14 :

GD: iter = 358, x = [3.04013497e-05 5.60179371e-05], f(x) = 4.34187766617285e-09 :

Backtrack: alpha = 0.00390625, f(x) = 4.34187766617285e-09, f(x+ap) = 4.009761764141994e-09, dgrad(x) = 5.0475798107421785e-14 :

GD: iter = 359, x = [3.12895511e-05 5.49303668e-05], f(x) = 4.009761764141994e-09 :

Backtrack: alpha = 0.015625, f(x) = 4.009761764141994e-09, f(x+ap) = 3.811415152091851e-09, dgrad(x) = 3.342385906669711e-14 :

GD: iter = 360, x = [3.12967507e-05 5.26451040e-05], f(x) = 3.811415152091851e-09 :

Backtrack: alpha = 0.015625, f(x) = 3.811415152091851e-09, f(x+ap) = 3.795243941807831e-09, dgrad(x) = 6.158483038485558e-14 :

GD: iter = 361, x = [2.82256065e-05 5.22084083e-05], f(x) = 3.795243941807831e-09 :

Backtrack: alpha = 0.00390625, f(x) = 3.795243941807831e-09, f(x+ap) = 3.4780548818573e-09, dgrad(x) = 4.856150366984562e-14 :

GD: iter = 362, x = [2.91170643e-05 5.11585337e-05], f(x) = 3.4780548818573e-09 :

Backtrack: alpha = 0.015625, f(x) = 3.4780548818573e-09, f(x+ap) = 3.3112475451771898e-09, dgrad(x) = 2.98977661191386e-14 :

GD: iter = 363, x = [2.91801301e-05 4.89980827e-05], f(x) = 3.3112475451771898e-09 :

Backtrack: alpha = 0.00390625, f(x) = 3.3112475451771898e-09, f(x+ap) = 3.2039369059544913e-09, dgrad(x) = 1.438561248494982e-14 :

GD: iter = 364, x = [2.84352679e-05 4.89137132e-05], f(x) = 3.2039369059544913e-09 :

Backtrack: alpha = 0.0625, f(x) = 3.2039369059544913e-09, f(x+ap) = 2.8276928834135624e-09, dgrad(x) = 8.715119798612612e-14 :

GD: iter = 365, x = [2.30717357e-05 4.38439971e-05], f(x) = 2.8276928834135624e-09 :

Backtrack: alpha = 0.00390625, f(x) = 2.8276928834135624e-09, f(x+ap) = 2.430721153490458e-09, dgrad(x) = 6.271386627740745e-14 :

GD: iter = 366, x = [2.41917954e-05 4.27507329e-05], f(x) = 2.430721153490458e-09 :

Backtrack: alpha = 0.015625, f(x) = 2.430721153490458e-09, f(x+ap) = 2.3456828377817224e-09, dgrad(x) = 2.635014865934112e-14 :

GD: iter = 367, x = [2.45735710e-05 4.07578811e-05], f(x) = 2.3456828377817224e-09 :

Backtrack: alpha = 0.00390625, f(x) = 2.3456828377817224e-09, f(x+ap) = 2.2329068679776987e-09, dgrad(x) = 1.626162505535214e-14 :

GD: iter = 368, x = [2.37771501e-05 4.07884337e-05], f(x) = 2.2329068679776987e-09 :

 Backtrack: alpha = 0.0625, f(x) = 2.2329068679776987e-09, f(x+ap) = 2.221917018674217e-09, dgrad(x) = 6.546686365951359e-14 :

GD: iter = 369, x = [1.86894667e-05 3.69112869e-05], f(x) = 2.221917018674217e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 2.221917018674217e-09, f(x+ap) = 1.7046841062338848e-09, dgrad(x) = 8.318701951164266e-14 :

GD: iter = 370, x = [2.00639994e-05 3.57450309e-05], f(x) = 1.7046841062338848e-09 :

 Backtrack: alpha = 0.015625, f(x) = 1.7046841062338848e-09, f(x+ap) = 1.688016402475202e-09, dgrad(x) = 2.5912277360556674e-14 :

GD: iter = 371, x = [2.07674755e-05 3.38598479e-05], f(x) = 1.688016402475202e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 1.688016402475202e-09, f(x+ap) = 1.5574530694900548e-09, dgrad(x) = 1.986237910666411e-14 :

GD: iter = 372, x = [1.98984142e-05 3.40033980e-05], f(x) = 1.5574530694900548e-09 :

 Backtrack: alpha = 0.015625, f(x) = 1.5574530694900548e-09, f(x+ap) = 1.4806936639423568e-09, dgrad(x) = 1.3031026295297385e-14 :

GD: iter = 373, x = [1.86581252e-05 3.32978618e-05], f(x) = 1.4806936639423568e-09 :

 Backtrack: alpha = 0.015625, f(x) = 1.4806936639423568e-09, f(x+ap) = 1.4756661942009258e-09, dgrad(x) = 2.4142100908616755e-14 :

GD: iter = 374, x = [1.93892937e-05 3.14985298e-05], f(x) = 1.4756661942009258e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 1.4756661942009258e-09, f(x+ap) = 1.3509385013629271e-09, dgrad(x) = 1.9112619960057415e-14 :

GD: iter = 375, x = [1.85396276e-05 3.16555461e-05], f(x) = 1.3509385013629271e-09 :

 Backtrack: alpha = 0.015625, f(x) = 1.3509385013629271e-09, f(x+ap) = 1.286422078883339e-09, dgrad(x) = 1.1660309715742215e-14 :

GD: iter = 376, x = [1.73493503e-05 3.10190216e-05], f(x) = 1.286422078883339e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 1.286422078883339e-09, f(x+ap) = 1.244411876519855e-09, dgrad(x) = 5.641662778578285e-15 :

GD: iter = 377, x = [1.75383565e-05 3.05893076e-05], f(x) = 1.244411876519855e-09 :

 Backtrack: alpha = 0.0625, f(x) = 1.244411876519855e-09, f(x+ap) = 1.100465067448272e-09, dgrad(x) = 3.389076231511884e-14 :

GD: iter = 378, x = [1.64819800e-05 2.61098216e-05], f(x) = 1.100465067448272e-09 :

 Backtrack: alpha = 0.00390625, f(x) = 1.100465067448272e-09, f(x+ap) = 9.44186918115408e-10, dgrad(x) = 2.4701761007306553e-14 :

GD: iter = 379, x = [1.55367734e-05 2.63772111e-05], f(x) = 9.44186918115408e-10 :

Backtrack: alpha = 0.015625, f(x) = 9.44186918115408e-10, f(x+ap) = 9.115287395029375e-10, dgrad(x) = 1.0300121100063108e-14 :

GD: iter = 380, x = [1.43368633e-05 2.59653742e-05], f(x) = 9.115287395029375e-10 :

Backtrack: alpha = 0.00390625, f(x) = 9.115287395029375e-10, f(x+ap) = 8.672741275529413e-10, dgrad(x) = 6.390269034661972e-15 :

GD: iter = 381, x = [1.46043741e-05 2.55434051e-05], f(x) = 8.672741275529413e-10 :

Backtrack: alpha = 0.0625, f(x) = 8.672741275529413e-10, f(x+ap) = 8.659932031686647e-10, dgrad(x) = 2.5483951057264723e-14 :

GD: iter = 382, x = [1.41071387e-05 2.15835786e-05], f(x) = 8.659932031686647e-10 :

Backtrack: alpha = 0.00390625, f(x) = 8.659932031686647e-10, f(x+ap) = 6.622359757494483e-10, dgrad(x) = 3.277982957378583e-14 :

GD: iter = 383, x = [1.30422029e-05 2.19661669e-05], f(x) = 6.622359757494483e-10 :

Backtrack: alpha = 0.015625, f(x) = 6.622359757494483e-10, f(x+ap) = 6.562687200676094e-10, dgrad(x) = 1.0154244553503961e-14 :

GD: iter = 384, x = [1.17992507e-05 2.17620330e-05], f(x) = 6.562687200676094e-10 :

Backtrack: alpha = 0.00390625, f(x) = 6.562687200676094e-10, f(x+ap) = 6.049391583175036e-10, dgrad(x) = 7.816095440594723e-15 :

GD: iter = 385, x = [1.21508665e-05 2.13357905e-05], f(x) = 6.049391583175036e-10 :

Backtrack: alpha = 0.015625, f(x) = 6.049391583175036e-10, f(x+ap) = 5.752355619074862e-10, dgrad(x) = 5.080647484441299e-15 :

GD: iter = 386, x = [1.21594746e-05 2.04448489e-05], f(x) = 5.752355619074862e-10 :

Backtrack: alpha = 0.015625, f(x) = 5.752355619074862e-10, f(x+ap) = 5.737770347267142e-10, dgrad(x) = 9.46453114149284e-15 :

GD: iter = 387, x = [1.09543053e-05 2.02823686e-05], f(x) = 5.737770347267142e-10 :

Backtrack: alpha = 0.00390625, f(x) = 5.737770347267142e-10, f(x+ap) = 5.247290383884404e-10, dgrad(x) = 7.522426094088766e-15 :

GD: iter = 388, x = [1.13071047e-05 1.98708138e-05], f(x) = 5.247290383884404e-10 :

Backtrack: alpha = 0.015625, f(x) = 5.247290383884404e-10, f(x+ap) = 4.997779084341201e-10, dgrad(x) = 4.5477950617601155e-15 :

GD: iter = 389, x = [1.13373401e-05 1.90283894e-05], f(x) = 4.997779084341201e-10 :

Backtrack: alpha = 0.00390625, f(x) = 4.997779084341201e-10, f(x+ap) = 4.833307506146756e-10, dgrad(x) = 2.212625432160947e-15 :

GD: iter = 390, x = [1.10449890e-05 1.89973815e-05], f(x) = 4.833307506146756e-10 :

Backtrack: alpha = 0.0625, f(x) = 4.833307506146756e-10, f(x+ap) = 4.2828373880282833e-10, dgrad(x) = 1.3179431266326196e-14 :

GD: iter = 391, x = [8.95114174e-06 1.70344887e-05], f(x) = 4.2828373880282833e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 4.2828373880282833e-10, f(x+ap) = 3.6675964236384157e-10, dgrad(x) = 9.729661513871765e-15 :

GD: iter = 392, x = [9.39384042e-06 1.66054400e-05], f(x) = 3.6675964236384157e-10 :

 Backtrack: alpha = 0.015625, f(x) = 3.6675964236384157e-10, f(x+ap) = 3.5422134698148473e-10, dgrad(x) = 4.026478000819403e-15 :

GD: iter = 393, x = [9.54883368e-06 1.58275490e-05], f(x) = 3.5422134698148473e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 3.5422134698148473e-10, f(x+ap) = 3.368544919986106e-10, dgrad(x) = 2.511254207069183e-15 :

GD: iter = 394, x = [9.23594082e-06 1.58414746e-05], f(x) = 3.368544919986106e-10 :

 Backtrack: alpha = 0.015625, f(x) = 3.368544919986106e-10, f(x+ap) = 3.182964649139305e-10, dgrad(x) = 2.4800725447886547e-15 :

GD: iter = 395, x = [8.73881164e-06 1.54668095e-05], f(x) = 3.182964649139305e-10 :

 Backtrack: alpha = 0.015625, f(x) = 3.182964649139305e-10, f(x+ap) = 3.084965089500932e-10, dgrad(x) = 3.681501956828214e-15 :

GD: iter = 396, x = [8.90879909e-06 1.47276621e-05], f(x) = 3.084965089500932e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 3.084965089500932e-10, f(x+ap) = 2.9212894598353135e-10, dgrad(x) = 2.392303434971122e-15 :

GD: iter = 397, x = [8.60381533e-06 1.47485011e-05], f(x) = 2.9212894598353135e-10 :

 Backtrack: alpha = 0.015625, f(x) = 2.9212894598353135e-10, f(x+ap) = 2.762700199616217e-10, dgrad(x) = 2.1914449918778974e-15 :

GD: iter = 398, x = [8.12898532e-06 1.44065220e-05], f(x) = 2.762700199616217e-10 :

 Backtrack: alpha = 0.015625, f(x) = 2.762700199616217e-10, f(x+ap) = 2.6881829675326045e-10, dgrad(x) = 3.3777765930407133e-15 :

GD: iter = 399, x = [8.31262120e-06 1.37036312e-05], f(x) = 2.6881829675326045e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 2.6881829675326045e-10, f(x+ap) = 2.533489369200454e-10, dgrad(x) = 2.283953244274957e-15 :

GD: iter = 400, x = [8.01516843e-06 1.37308115e-05], f(x) = 2.533489369200454e-10 :

 Backtrack: alpha = 0.015625, f(x) = 2.533489369200454e-10, f(x+ap) = 2.398245976616586e-10, dgrad(x) = 1.940197684360845e-15 :

GD: iter = 401, x = [7.56124779e-06 1.34191836e-05], f(x) = 2.398245976616586e-10 :

 Backtrack: alpha = 0.015625, f(x) = 2.398245976616586e-10, f(x+ap) = 2.343835035143412e-10, dgrad(x) = 3.1099289458299422e-15 :

GD: iter = 402, x = [7.75728287e-06 1.27502317e-05], f(x) = 2.343835035143412e-10 :

Backtrack: alpha = 0.00390625, f(x) = 2.343835035143412e-10, f(x+ap) = 2.1972392837085811e-10, dgrad(x) = 2.184920653219595e-15 :

GD: iter = 403, x = [7.46700693e-06 1.27832218e-05], f(x) = 2.1972392837085811e-10 :

Backtrack: alpha = 0.015625, f(x) = 2.1972392837085811e-10, f(x+ap) = 2.0821826714402447e-10, dgrad(x) = 1.721384415677011e-15 :

GD: iter = 404, x = [7.03269983e-06 1.24997723e-05], f(x) = 2.0821826714402447e-10 :

Backtrack: alpha = 0.015625, f(x) = 2.0821826714402447e-10, f(x+ap) = 2.044957047340392e-10, dgrad(x) = 2.873297771381333e-15 :

GD: iter = 405, x = [7.23997463e-06 1.18625989e-05], f(x) = 2.044957047340392e-10 :

Backtrack: alpha = 0.00390625, f(x) = 2.044957047340392e-10, f(x+ap) = 1.9056850020943914e-10, dgrad(x) = 2.09409020622628e-15 :

GD: iter = 406, x = [6.95654378e-06 1.19009049e-05], f(x) = 1.9056850020943914e-10 :

Backtrack: alpha = 0.015625, f(x) = 1.9056850020943914e-10, f(x+ap) = 1.8080774748373726e-10, dgrad(x) = 1.5307160861191097e-15 :

GD: iter = 407, x = [6.54064181e-06 1.16436114e-05], f(x) = 1.8080774748373726e-10 :

Backtrack: alpha = 0.015625, f(x) = 1.8080774748373726e-10, f(x+ap) = 1.7855105996581553e-10, dgrad(x) = 2.6638389746658836e-15 :

GD: iter = 408, x = [6.75808046e-06 1.10362028e-05], f(x) = 1.7855105996581553e-10 :

Backtrack: alpha = 0.00390625, f(x) = 1.7855105996581553e-10, f(x+ap) = 1.6528837137735533e-10, dgrad(x) = 2.010491772547911e-15 :

GD: iter = 409, x = [6.48118380e-06 1.10793662e-05], f(x) = 1.6528837137735533e-10 :

Backtrack: alpha = 0.015625, f(x) = 1.6528837137735533e-10, f(x+ap) = 1.5703529036797563e-10, dgrad(x) = 1.3644733419140012e-15 :

GD: iter = 410, x = [6.08256005e-06 1.08463467e-05], f(x) = 1.5703529036797563e-10 :

Backtrack: alpha = 0.015625, f(x) = 1.5703529036797563e-10, f(x+ap) = 1.5602600242412932e-10, dgrad(x) = 2.478043611874816e-15 :

GD: iter = 411, x = [6.30916441e-06 1.02668255e-05], f(x) = 1.5602600242412932e-10 :

Backtrack: alpha = 0.00390625, f(x) = 1.5602600242412932e-10, f(x+ap) = 1.4336828118832263e-10, dgrad(x) = 1.9332812952121774e-15 :

GD: iter = 412, x = [6.03851049e-06 1.03144203e-05], f(x) = 1.4336828118832263e-10 :

Backtrack: alpha = 0.015625, f(x) = 1.4336828118832263e-10, f(x+ap) = 1.3641730696618187e-10, dgrad(x) = 1.2194308302973276e-15 :

GD: iter = 413, x = [5.65611392e-06 1.01039234e-05], f(x) = 1.3641730696618187e-10 :

Backtrack: alpha = 0.00390625, f(x) = 1.3641730696618187e-10, f(x+ap) = 1.3208376038418455e-10, dgrad(x) = 5.782166986171596e-16 :

GD: iter = 414, x = [5.71482500e-06 9.96557748e-06], f(x) = 1.3208376038418455e-10 :

 Backtrack: alpha = 0.0625, f(x) = 1.3208376038418455e-10, f(x+ap) = 1.1597520613642233e-10, dgrad(x) = 3.581596637224007e-15 :

GD: iter = 415, x = [5.36062002e-06 8.51194867e-06], f(x) = 1.1597520613642233e-10 :

 Backtrack: alpha = 0.00390625, f(x) = 1.1597520613642233e-10, f(x+ap) = 1.001822461094866e-10, dgrad(x) = 2.4914751660047994e-15 :

GD: iter = 416, x = [5.05988370e-06 8.59489993e-06], f(x) = 1.001822461094866e-10 :

 Backtrack: alpha = 0.015625, f(x) = 1.001822461094866e-10, f(x+ap) = 9.657515263688945e-11, dgrad(x) = 1.068337989021848e-15 :

GD: iter = 417, x = [4.67526291e-06 8.45707881e-06], f(x) = 9.657515263688945e-11 :

 Backtrack: alpha = 0.00390625, f(x) = 9.657515263688945e-11, f(x+ap) = 9.204955333700357e-11, dgrad(x) = 6.500998353390996e-16 :

GD: iter = 418, x = [4.75906524e-06 8.32153658e-06], f(x) = 9.204955333700357e-11 :

 Backtrack: alpha = 0.0625, f(x) = 9.204955333700357e-11, f(x+ap) = 9.077986142860122e-11, dgrad(x) = 2.68343972104781e-15 :

GD: iter = 419, x = [4.58532944e-06 7.03819497e-06], f(x) = 9.077986142860122e-11 :

 Backtrack: alpha = 0.00390625, f(x) = 9.077986142860122e-11, f(x+ap) = 7.023942670749805e-11, dgrad(x) = 3.3009727452388473e-15 :

GD: iter = 420, x = [4.24680689e-06 7.15797280e-06], f(x) = 7.023942670749805e-11 :

 Backtrack: alpha = 0.015625, f(x) = 7.023942670749805e-11, f(x+ap) = 6.941384507224354e-11, dgrad(x) = 1.043673492609661e-15 :

GD: iter = 421, x = [3.84923197e-06 7.08720442e-06], f(x) = 6.941384507224354e-11 :

GD termination: small df = 8.255816352545095e-13

==GD final: iter = 421, x = [3.84923197e-06 7.08720442e-06], f(x) = 6.941384507224354e-11, OK = True:==

The chosen method is = newton

Newton: iter = 1, x = [8. 6.], f(x) = 1627.6472812163474 :

 Backtrack: alpha = 1.0, f(x) = 1627.6472812163474, f(x+ap) = 4.8163066455670087e-29, dgrad(x) = 0.32552945624326945 :

Newton: iter = 2, x = [1.77635684e-15 1.77635684e-15], f(x) = 4.8163066455670087e-29 :

 Backtrack: alpha = 1.0, f(x) = 4.8163066455670087e-29, f(x+ap) = 1.3594283980401594e-60, dgrad(x) = 9.632613291134015e-33 :

Newton: iter = 3, x = [5.91645679e-31 9.86076132e-31], f(x) = 1.3594283980401594e-60 :

Newton termination: small dx = [1.77635684e-15 1.77635684e-15]

The chosen method is = bfgs

BFGS: iter = 1, x = [8. 6.], f(x) = 1627.6472812163474 :

 Backtrack: alpha = 1.0, f(x) = 1627.6472812163474, f(x+ap) = 4.8163066455670087e-29, dgrad(x) = 0.32552945624326945 :

BFGS: iter = 2, x = [1.77635684e-15 1.77635684e-15], f(x) = 4.8163066455670087e-29 :

 Backtrack: alpha = 1.0, f(x) = 4.8163066455670087e-29, f(x+ap) = 1.4709286358868733e-58, dgrad(x) = 9.632613291134009e-33 :

BFGS: iter = 3, x = [6.11367202e-30 1.04524070e-29], f(x) = 1.4709286358868733e-58 :

BFGS termination: small dx = [1.77635684e-15 1.77635684e-15]

BFGS final: iter = 3, x = [6.11367202e-30 1.04524070e-29], f(x) = 1.4709286358868733e-58, OK = True :

The chosen method is = sr1

SR1: iter = 1, x = [8. 6.], f(x) = 1627.6472812163474 :

 Backtrack: alpha = 1.0, f(x) = 1627.6472812163474, f(x+ap) = 4.8163066455670087e-29, dgrad(x) = 0.32552945624326945 :

SR1: iter = 2, x = [1.77635684e-15 1.77635684e-15], f(x) = 4.8163066455670087e-29 :

 Backtrack: alpha = 1.0, f(x) = 4.8163066455670087e-29, f(x+ap) = 1.3594283980401594e-60, dgrad(x) = 9.632613291134015e-33 :

SR1: iter = 3, x = [5.91645679e-31 9.86076132e-31], f(x) = 1.3594283980401594e-60 :

SR1 termination: small dx = [1.77635684e-15 1.77635684e-15]

SR1 final: iter = 3, x = [5.91645679e-31 9.86076132e-31], f(x) = 1.3594283980401594e-60, OK = True

Rosenbrock objective function
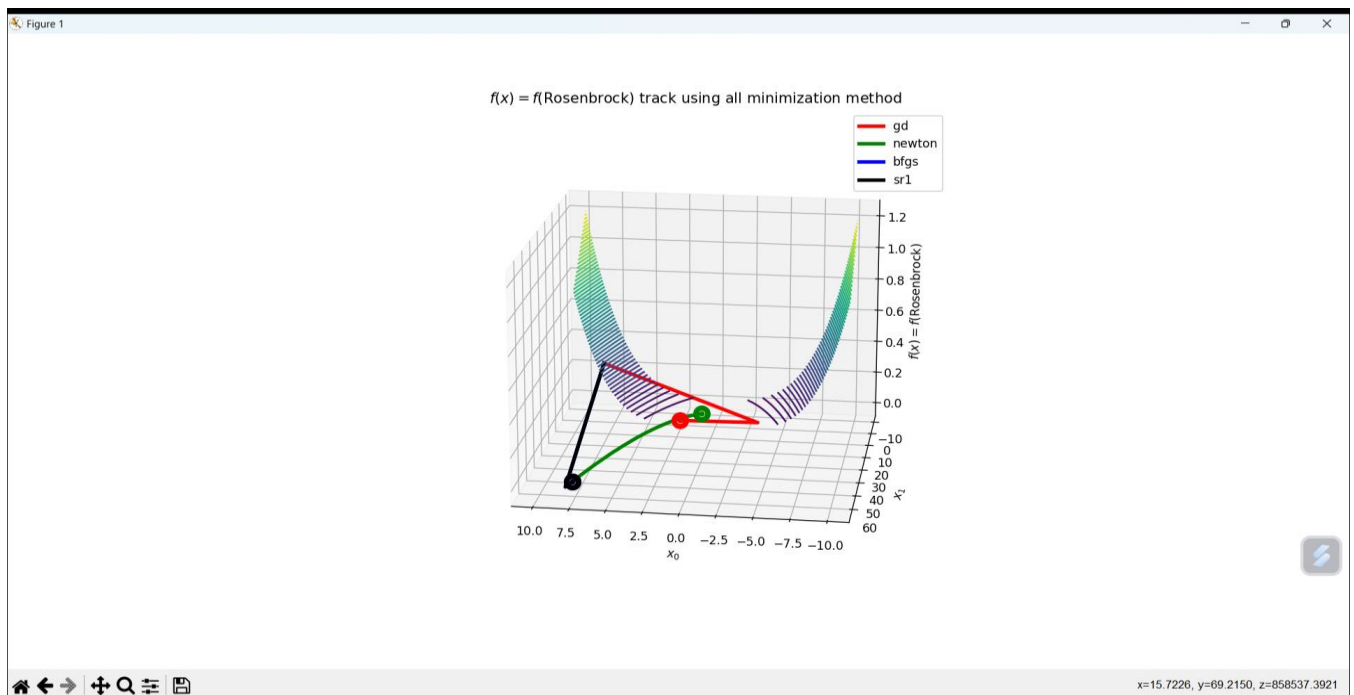
Rosenbrock objective prints (<mark>final results are highlighted</mark>)

You chose 4: Rosenbrock

The chosen method is = gd

GD: iter = 1, x = [8. 6.], f(x) = 336449.0 :

 Backtrack: alpha = 6.103515625e-05, f(x) = 336449.0, f(x+ap) = 1932.0122110902885, dgrad(x) = 211.10300900878906 :

GD: iter = 2, x = [-3.32897949 6.70800781], f(x) = 1932.0122110902885 :

 Backtrack: alpha = 0.0009765625, f(x) = 1932.0122110902885, f(x+ap) = 385.00627189398097, dgrad(x) = 3.3975753375859084 :

GD: iter = 3, x = [2.36747478 7.56232356], f(x) = 385.00627189398097 :

GD termination: small dx = [-5.69645427 -0.85431575]

<mark>GD final: iter = 3, x = [2.36747478 7.56232356], f(x) = 385.00627189398097, OK = True:</mark>

The chosen method is = newton

Newton: iter = 1, x = [8. 6.], f(x) = 336449.0 :

 Backtrack: alpha = 1.0, f(x) = 336449.0, f(x+ap) = 48.99155281647511, dgrad(x) = 67.28000084475475 :

Newton: iter = 2, x = [7.9993966 63.99034566], f(x) = 48.99155281647511 :

Backtrack: alpha = 0.0625, f(x) = 48.99155281647511, f(x+ap) = 46.720718719741505, dgrad(x) = 0.0006123498204785612 :

Newton: iter = 3, x = [7.56196617 56.99198661], f(x) = 46.720718719741505 :

Backtrack: alpha = 1.0, f(x) = 46.720718719741505, f(x+ap) = 40.972253827800756, dgrad(x) = 0.0009515677276450668 :

Newton: iter = 4, x = [7.39486383 54.65608782], f(x) = 40.972253827800756 :

Backtrack: alpha = 0.25, f(x) = 40.972253827800756, f(x+ap) = 38.48622185976122, dgrad(x) = 0.0003144264518502681 :

Newton: iter = 5, x = [7.15206903 51.07219975], f(x) = 38.48622185976122 :

Backtrack: alpha = 1.0, f(x) = 38.48622185976122, f(x+ap) = 35.244735974895605, dgrad(x) = 0.0005734917516629143 :

Newton: iter = 6, x = [6.78972097 45.96901476], f(x) = 35.244735974895605 :

Backtrack: alpha = 1.0, f(x) = 35.244735974895605, f(x+ap) = 31.31007145039983, dgrad(x) = 0.0005907148891954227 :

Newton: iter = 7, x = [6.57732604 43.2161062], f(x) = 31.31007145039983 :

Backtrack: alpha = 0.25, f(x) = 31.31007145039983, f(x+ap) = 29.856961462965455, dgrad(x) = 0.00016536171340835224 :

Newton: iter = 8, x = [6.43820343 41.39727461], f(x) = 29.856961462965455 :

Backtrack: alpha = 1.0, f(x) = 29.856961462965455, f(x+ap) = 29.478070993239186, dgrad(x) = 0.0005648240385908808 :

Newton: iter = 9, x = [5.97091394 35.43345387], f(x) = 29.478070993239186 :

Backtrack: alpha = 1.0, f(x) = 29.478070993239186, f(x+ap) = 23.6314123056156, dgrad(x) = 0.0010642458912958146 :

Newton: iter = 10, x = [5.85963785 34.32297332], f(x) = 23.6314123056156 :

Backtrack: alpha = 0.25, f(x) = 23.6314123056156, f(x+ap) = 22.06859461928925, dgrad(x) = 0.00034042225267271045 :

Newton: iter = 11, x = [5.51017185 30.23058054], f(x) = 22.06859461928925 :

Backtrack: alpha = 1.0, f(x) = 22.06859461928925, f(x+ap) = 18.952483815571245, dgrad(x) = 0.0004945067372627475 :

Newton: iter = 12, x = [5.34485904 28.54018984], f(x) = 18.952483815571245 :

Backtrack: alpha = 0.25, f(x) = 18.952483815571245, f(x+ap) = 17.683530971997087, dgrad(x) = 0.00014971917276654964 :

Newton: iter = 13, x = [5.17686166 26.7511773], f(x) = 17.683530971997087 :

Backtrack: alpha = 1.0, f(x) = 17.683530971997087, f(x+ap) = 16.633982348115634, dgrad(x) = 0.0003722366096871041 :

Newton: iter = 14, x = [4.7880948 22.7747121], f(x) = 16.633982348115634 :

 Backtrack: alpha = 1.0, f(x) = 16.633982348115634, f(x+ap) = 13.467002338961848, dgrad(x) = 0.0005487667612444128 :

Newton: iter = 15, x = [4.66679011 21.76421513], f(x) = 13.467002338961848 :

 Backtrack: alpha = 0.25, f(x) = 13.467002338961848, f(x+ap) = 12.218058897562383, dgrad(x) = 0.00017158057920341123 :

Newton: iter = 16, x = [4.43430074 19.5979356], f(x) = 12.218058897562383 :

 Backtrack: alpha = 1.0, f(x) = 12.218058897562383, f(x+ap) = 10.531938661594625, dgrad(x) = 0.00025300902354173893 :

Newton: iter = 17, x = [4.18929955 17.4902051], f(x) = 10.531938661594625 :

 Backtrack: alpha = 1.0, f(x) = 10.531938661594625, f(x+ap) = 9.029200468917553, dgrad(x) = 0.00022848648566593967 :

Newton: iter = 18, x = [3.94406533 15.49551154], f(x) = 9.029200468917553 :

 Backtrack: alpha = 1.0, f(x) = 9.029200468917553, f(x+ap) = 7.648770945046472, dgrad(x) = 0.00020539620779077838 :

Newton: iter = 19, x = [3.71808487 13.7730879], f(x) = 7.648770945046472 :

 Backtrack: alpha = 1.0, f(x) = 7.648770945046472, f(x+ap) = 6.474259558942642, dgrad(x) = 0.0001839273723293242 :

Newton: iter = 20, x = [3.47568947 12.02166177], f(x) = 6.474259558942642 :

 Backtrack: alpha = 1.0, f(x) = 6.474259558942642, f(x+ap) = 5.347499802036718, dgrad(x) = 0.00016517768320273982 :

Newton: iter = 21, x = [3.28153458 10.7307731], f(x) = 5.347499802036718 :

 Backtrack: alpha = 1.0, f(x) = 5.347499802036718, f(x+ap) = 4.567218789415832, dgrad(x) = 0.00015033735104513768 :

Newton: iter = 22, x = [3.01435169 9.01492943], f(x) = 4.567218789415832 :

 Backtrack: alpha = 1.0, f(x) = 4.567218789415832, f(x+ap) = 3.5740280046427393, dgrad(x) = 0.00015504057374467447 :

Newton: iter = 23, x = [2.88249943 8.29141797], f(x) = 3.5740280046427393 :

 Backtrack: alpha = 0.25, f(x) = 3.5740280046427393, f(x+ap) = 3.217104265410921, dgrad(x) = 4.1089050913410456e-05 :

Newton: iter = 24, x = [2.77737893 7.68974466], f(x) = 3.217104265410921 :

 Backtrack: alpha = 1.0, f(x) = 3.217104265410921, f(x+ap) = 3.0375334442522117, dgrad(x) = 0.00012020572821722516 :

Newton: iter = 25, x = [2.47187275 6.01682088], f(x) = 3.0375334442522117 :

Backtrack: alpha = 1.0, f(x) = 3.0375334442522117, f(x+ap) = 1.9548364538381653, dgrad(x) = 0.00019625593532149535 :

Newton: iter = 26, x = [2.39703229 5.74016272], f(x) = 1.9548364538381653 :

Backtrack: alpha = 0.25, f(x) = 1.9548364538381653, f(x+ap) = 1.6167694591400914, dgrad(x) = 4.618275113811348e-05 :

Newton: iter = 27, x = [2.23230493 4.95184936], f(x) = 1.6167694591400914 :

Backtrack: alpha = 1.0, f(x) = 1.6167694591400914, f(x+ap) = 1.2120844900190195, dgrad(x) = 6.14314770727869e-05 :

Newton: iter = 28, x = [2.06273378 4.22611627], f(x) = 1.2120844900190195 :

Backtrack: alpha = 1.0, f(x) = 1.2120844900190195, f(x+ap) = 0.8810027057819537, dgrad(x) = 4.9995739324228186e-05 :

Newton: iter = 29, x = [1.90531214 3.60543278], f(x) = 0.8810027057819537 :

Backtrack: alpha = 1.0, f(x) = 0.8810027057819537, f(x+ap) = 0.6208594793409687, dgrad(x) = 3.9802566903025665e-05 :

Newton: iter = 30, x = [1.75332014 3.05102996], f(x) = 0.6208594793409687 :

Backtrack: alpha = 1.0, f(x) = 0.6208594793409687, f(x+ap) = 0.4157895106704008, dgrad(x) = 3.0867939613395534e-05 :

Newton: iter = 31, x = [1.61928489 2.6041181], f(x) = 0.4157895106704008 :

Backtrack: alpha = 1.0, f(x) = 0.4157895106704008, f(x+ap) = 0.2677446088887046, dgrad(x) = 2.3154745493779327e-05 :

Newton: iter = 32, x = [1.4844552 2.18542819], f(x) = 0.2677446088887046 :

Backtrack: alpha = 1.0, f(x) = 0.2677446088887046, f(x+ap) = 0.15629027795431918, dgrad(x) = 1.6734942388154216e-05 :

Newton: iter = 33, x = [1.37995236 1.89334768], f(x) = 0.15629027795431918 :

Backtrack: alpha = 1.0, f(x) = 0.15629027795431918, f(x+ap) = 0.0882000567183907, dgrad(x) = 1.1452893935672007e-05 :

Newton: iter = 34, x = [1.2606269 1.57494163], f(x) = 0.0882000567183907 :

Backtrack: alpha = 1.0, f(x) = 0.0882000567183907, f(x+ap) = 0.039312148707898405, dgrad(x) = 7.585475305285222e-06 :

Newton: iter = 35, x = [1.19289137 1.41840171], f(x) = 0.039312148707898405 :

Backtrack: alpha = 1.0, f(x) = 0.039312148707898405, f(x+ap) = 0.018757397245080312, dgrad(x) = 4.301560332847595e-06 :

Newton: iter = 36, x = [1.09230246 1.18300653], f(x) = 0.018757397245080312 :

Backtrack: alpha = 1.0, f(x) = 0.018757397245080312, f(x+ap) = 0.0039030417822099516, dgrad(x) = 2.611075587450814e-06 :

Newton: iter = 37, x = [1.06177538 1.12643506], f(x) = 0.0039030417822099516 :

 Backtrack: alpha = 1.0, f(x) = 0.0039030417822099516, f(x+ap) = 0.0008293181222909253, dgrad(x) = 6.60703362393327e-07 :

Newton: iter = 38, x = [1.00970492 1.01679269], f(x) = 0.0008293181222909253 :

 Backtrack: alpha = 1.0, f(x) = 0.0008293181222909253, f(x+ap) = 1.1800480934536997e-05, dgrad(x) = 1.5924043611599807e-07 :

Newton: iter = 39, x = [1.00341228 1.00679662], f(x) = 1.1800480934536997e-05 :

 Backtrack: alpha = 1.0, f(x) = 1.1800480934536997e-05, f(x+ap) = 1.3855275331291105e-08, dgrad(x) = 2.3417987830516263e-09 :

Newton: iter = 40, x = [1.00002681 1.00004216], f(x) = 1.3855275331291105e-08 :

 Backtrack: alpha = 1.0, f(x) = 1.3855275331291105e-08, f(x+ap) = 3.811108321941893e-15, dgrad(x) = 2.770726265647542e-12 :

Newton: iter = 41, x = [1.00000006 1.00000012], f(x) = 3.811108321941893e-15 :

 Backtrack: alpha = 1.0, f(x) = 3.811108321941893e-15, f(x+ap) = 1.5432584496451807e-27, dgrad(x) = 7.622220376294559e-19 :

Newton: iter = 42, x = [1. 1.], f(x) = 1.5432584496451807e-27 :

Newton termination: small df = 3.81110832194035e-15

<mark>Newton final: iter = 42, x = [1. 1.], f(x) = 1.5432584496451807e-27, OK = True :</mark>

The chosen method is = bfgs

BFGS: iter = 1, x = [8. 6.], f(x) = 336449.0 :

 Backtrack: alpha = 1.0, f(x) = 336449.0, f(x+ap) = 48.99155281647511, dgrad(x) = 67.28000084475475 :

BFGS: iter = 2, x = [7.9993966 63.99034566], f(x) = 48.99155281647511 :

 Backtrack: alpha = 1.0, f(x) = 48.99155281647511, f(x+ap) = 48.983107088947534, dgrad(x) = 8.446091578358519e-07 :

BFGS: iter = 3, x = [7.99879326 63.98069324], f(x) = 48.983107088947534 :

 Backtrack: alpha = 0.0625, f(x) = 48.983107088947534, f(x+ap) = 46.72213804281681, dgrad(x) = 0.0006122442724921525 :

BFGS: iter = 4, x = [7.56140052 56.98320114], f(x) = 46.72213804281681 :

 Backtrack: alpha = 1.0, f(x) = 46.72213804281681, f(x+ap) = 45.354714313613336, dgrad(x) = 0.0006512643972463908 :

BFGS: iter = 5, x = [7.73414819 59.82476996], f(x) = 45.354714313613336 :

BFGS termination: small dx = [-0.17274768 -2.84156882]

<mark>BFGS final: iter = 5, x = [7.73414819 59.82476996], f(x) = 45.354714313613336, OK = True :</mark>

The chosen method is = sr1

SR1: iter = 1, x = [8. 6.], f(x) = 336449.0 :

 Backtrack: alpha = 1.0, f(x) = 336449.0, f(x+ap) = 48.99155281647511, dgrad(x) = 67.28000084475475 :

SR1: iter = 2, x = [7.9993966 63.99034566], f(x) = 48.99155281647511 :

 Backtrack: alpha = 1.0, f(x) = 48.99155281647511, f(x+ap) = 48.96622218773917, dgrad(x) = 2.5333905970495208e-06 :

SR1: iter = 3, x = [7.99758688 63.96139122], f(x) = 48.96622218773917 :

 Backtrack: alpha = 0.0625, f(x) = 48.96622218773917, f(x+ap) = 46.721243472801866, dgrad(x) = 0.00061176592491326 :

SR1: iter = 4, x = [7.56046048 56.96868763], f(x) = 46.721243472801866 :

 Backtrack: alpha = 1.0, f(x) = 46.721243472801866, f(x+ap) = 45.361515417135976, dgrad(x) = 0.0006521736728661269 :

SR1: iter = 5, x = [7.73470148 59.83289493], f(x) = 45.361515417135976 :

SR1 termination: small dx = [-0.174241 -2.8642073]

SR1 final: iter = 5, x = [7.73470148 59.83289493], f(x) = 45.361515417135976, OK = True :
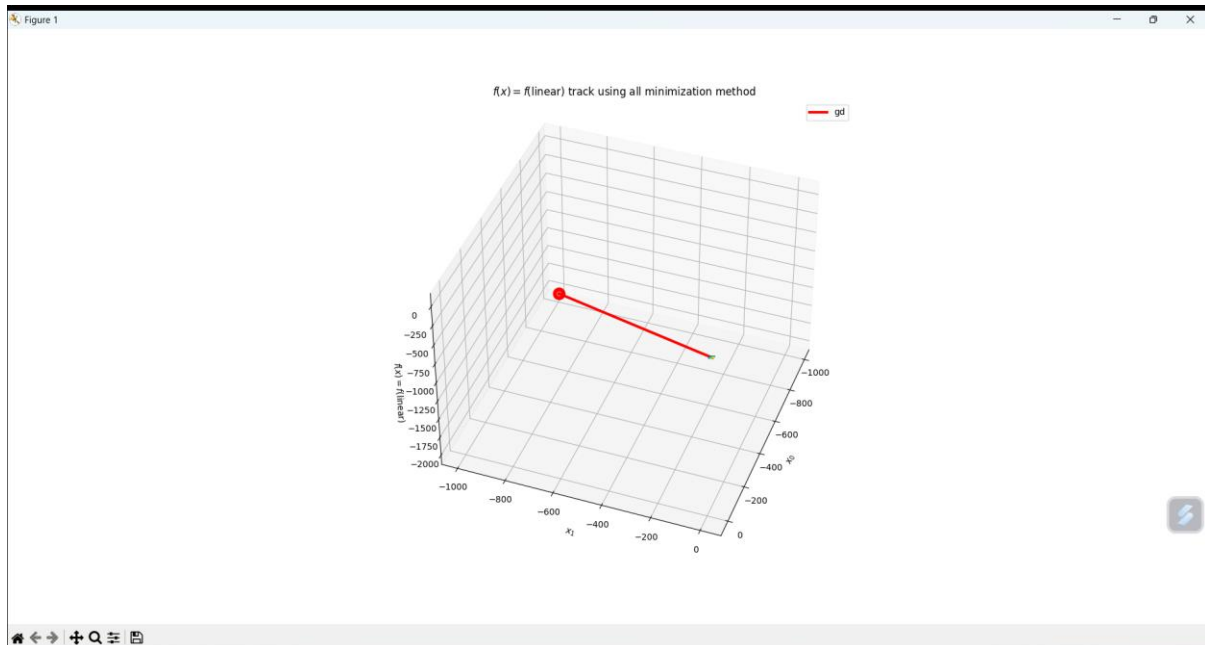
Linear objective function

Linear function leads to singularity in all the methods that involves the Hessian matrix.

Gradient descent leads to rubbished results.

Hence, total failure in all methods for the linear case.

Linear objective prints (<mark>final results are highlighted</mark>)

*

*

Backtrack: alpha = 1.0, f(x) = -1956.0, f(x+ap) = -1958.0, dgrad(x) = 0.0002 :

GD: iter = 987, x = [-978. -980.], f(x) = -1958.0 :

 Backtrack: alpha = 1.0, f(x) = -1958.0, f(x+ap) = -1960.0, dgrad(x) = 0.0002 :

GD: iter = 988, x = [-979. -981.], f(x) = -1960.0 :

 Backtrack: alpha = 1.0, f(x) = -1960.0, f(x+ap) = -1962.0, dgrad(x) = 0.0002 :

GD: iter = 989, x = [-980. -982.], f(x) = -1962.0 :

 Backtrack: alpha = 1.0, f(x) = -1962.0, f(x+ap) = -1964.0, dgrad(x) = 0.0002 :

GD: iter = 990, x = [-981. -983.], f(x) = -1964.0 :

 Backtrack: alpha = 1.0, f(x) = -1964.0, f(x+ap) = -1966.0, dgrad(x) = 0.0002 :

GD: iter = 991, x = [-982. -984.], f(x) = -1966.0 :

 Backtrack: alpha = 1.0, f(x) = -1966.0, f(x+ap) = -1968.0, dgrad(x) = 0.0002 :

GD: iter = 992, x = [-983. -985.], f(x) = -1968.0 :

Backtrack: alpha = 1.0, f(x) = -1968.0, f(x+ap) = -1970.0, dgrad(x) = 0.0002 :

GD: iter = 993, x = [-984. -986.], f(x) = -1970.0 :

Backtrack: alpha = 1.0, f(x) = -1970.0, f(x+ap) = -1972.0, dgrad(x) = 0.0002 :

GD: iter = 994, x = [-985. -987.], f(x) = -1972.0 :

Backtrack: alpha = 1.0, f(x) = -1972.0, f(x+ap) = -1974.0, dgrad(x) = 0.0002 :

GD: iter = 995, x = [-986. -988.], f(x) = -1974.0 :

Backtrack: alpha = 1.0, f(x) = -1974.0, f(x+ap) = -1976.0, dgrad(x) = 0.0002 :

GD: iter = 996, x = [-987. -989.], f(x) = -1976.0 :

Backtrack: alpha = 1.0, f(x) = -1976.0, f(x+ap) = -1978.0, dgrad(x) = 0.0002 :

GD: iter = 997, x = [-988. -990.], f(x) = -1978.0 :

Backtrack: alpha = 1.0, f(x) = -1978.0, f(x+ap) = -1980.0, dgrad(x) = 0.0002 :

GD: iter = 998, x = [-989. -991.], f(x) = -1980.0 :

Backtrack: alpha = 1.0, f(x) = -1980.0, f(x+ap) = -1982.0, dgrad(x) = 0.0002 :

GD: iter = 999, x = [-990. -992.], f(x) = -1982.0 :

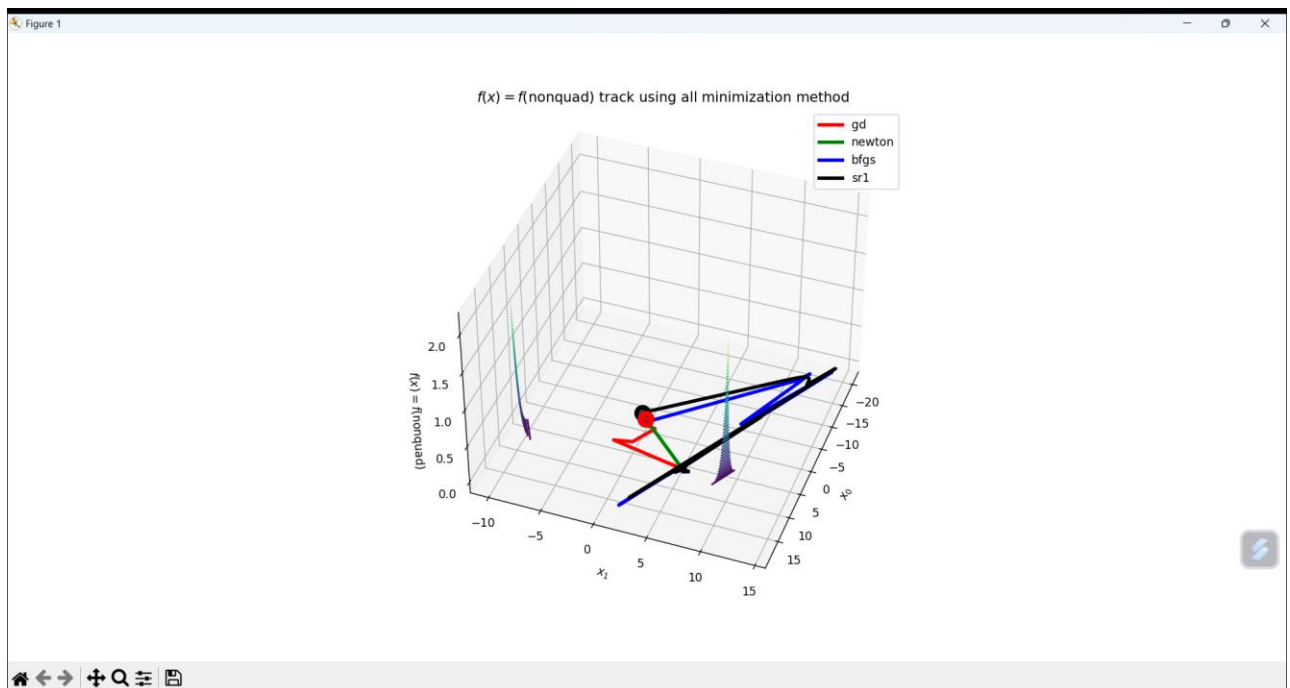Backtrack: alpha = 1.0, f(x) = -1982.0, f(x+ap) = -1984.0, dgrad(x) = 0.0002 :

GD: iter = 1000, x = [-991. -993.], f(x) = -1984.0 :

Backtrack: alpha = 1.0, f(x) = -1984.0, f(x+ap) = -1986.0, dgrad(x) = 0.0002 :

GD final: iter = 1000, x = [-992. -994.], f(x) = -1984.0, OK = False:

End of linear analysis

Non-quad objective function

f(x) = f(nonquad) track using all minimization method

Non-quad objective prints (<mark>final results are highlighted</mark>)

You chose 6: nonquad

The chosen method is = gd

GD: iter = 1, x = [8. 6.], f(x) = 177103474428.77737 :

 Backtrack: alpha = 1.4551915228366852e-11, f(x) = 177103474428.77737, f(x+ap) = 36959.900492217406, dgrad(x) = 456430143.8912583 :

GD: iter = 2, x = [5.42280525 -1.73158424], f(x) = 36959.900492217406 :

 Backtrack: alpha = 1.52587890625e-05, f(x) = 36959.900492217406, f(x+ap) = 234.8929541391677, dgrad(x) = 20.841715873987905 :

GD: iter = 3, x = [4.85884205 -0.03979851], f(x) = 234.8929541391677 :

 Backtrack: alpha = 0.015625, f(x) = 234.8929541391677, f(x+ap) = 133.90338790197126, dgrad(x) = 0.09715583168175566 :

GD: iter = 4, x = [1.18885905 1.26856821], f(x) = 133.90338790197126 :

 Backtrack: alpha = 0.00390625, f(x) = 133.90338790197126, f(x+ap) = 5.476864678460088, dgrad(x) = 0.06959866412322264 :

GD: iter = 5, x = [0.66795195 -0.29583378], f(x) = 5.476864678460088 :

 Backtrack: alpha = 0.0625, f(x) = 5.476864678460088, f(x+ap) = 5.101585724523295, dgrad(x) = 0.0008422002171026517 :

GD: iter = 6, x = [0.3836432 0.37165679], f(x) = 5.101585724523295 :

Backtrack: alpha = 0.0625, f(x) = 5.101585724523295, f(x+ap) = 3.81281295688913, dgrad(x) = 0.0008282600393426176 :

GD: iter = 7, x = [0.14186073 -0.30598896], f(x) = 3.81281295688913 :

Backtrack: alpha = 0.0625, f(x) = 3.81281295688913, f(x+ap) = 2.8076921845744347, dgrad(x) = 0.00030240519116580053 :

GD: iter = 8, x = [0.00170561 0.1055445], f(x) = 2.8076921845744347 :

Backtrack: alpha = 0.0625, f(x) = 2.8076921845744347, f(x+ap) = 2.6645518281189617, dgrad(x) = 2.5423278438043767e-05 :

GD: iter = 9, x = [-0.06086322 -0.00388443], f(x) = 2.6645518281189617 :

Backtrack: alpha = 0.25, f(x) = 2.6645518281189617, f(x+ap) = 2.5729420001782444, dgrad(x) = 1.382724233917449e-05 :

GD: iter = 10, x = [-0.24619159 0.01099847], f(x) = 2.5729420001782444 :

Backtrack: alpha = 0.25, f(x) = 2.5729420001782444, f(x+ap) = 2.5643565772594314, dgrad(x) = 2.155935684335249e-06 :

GD: iter = 11, x = [-0.31071813 -0.02401817], f(x) = 2.5643565772594314 :

Backtrack: alpha = 0.0625, f(x) = 2.5643565772594314, f(x+ap) = 2.560630650250162, dgrad(x) = 5.713261041584128e-07 :

GD: iter = 12, x = [-0.31666988 -0.00608341], f(x) = 2.560630650250162 :

Backtrack: alpha = 0.25, f(x) = 2.560630650250162, f(x+ap) = 2.5602468291475278, dgrad(x) = 2.776027123105543e-07 :

GD: iter = 13, x = [-0.33586052 0.01196447], f(x) = 2.5602468291475278 :

Backtrack: alpha = 0.0625, f(x) = 2.5602468291475278, f(x+ap) = 2.5594308069093783, dgrad(x) = 1.2627562438311062e-07 :

GD: iter = 14, x = [-0.33762623 0.00325789], f(x) = 2.5594308069093783 :

Backtrack: alpha = 0.0625, f(x) = 2.5594308069093783, f(x+ap) = 2.559343526887906, dgrad(x) = 1.2252628599911101e-08 :

GD: iter = 15, x = [-0.33906127 0.00089177], f(x) = 2.559343526887906 :

Backtrack: alpha = 0.25, f(x) = 2.559343526887906, f(x+ap) = 2.5592926488336722, dgrad(x) = 1.1922480189648716e-08 :

GD: iter = 16, x = [-0.34386898 -0.00169515], f(x) = 2.5592926488336722 :

Backtrack: alpha = 0.0625, f(x) = 2.5592926488336722, f(x+ap) = 2.559274580129076, dgrad(x) = 2.6958962067201607e-09 :

GD: iter = 17, x = [-0.34430263 -0.00047168], f(x) = 2.559274580129076 :

Backtrack: alpha = 0.25, f(x) = 2.559274580129076, f(x+ap) = 2.5592721115523105, dgrad(x) = 1.585944200563583e-09 :

GD: iter = 18, x = [-0.34575595 0.00088946], f(x) = 2.5592721115523105 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592721115523105, f(x+ap) = 2.5592676562830965, dgrad(x) = 6.84392492594479e-10 :

GD: iter = 19, x = [-3.45887020e-01 2.48708577e-04], f(x) = 2.5592676562830965 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592676562830965, f(x+ap) = 2.559267150167806, dgrad(x) = 7.065132966658957e-11 :

GD: iter = 20, x = [-3.45996862e-01 6.95667278e-05], f(x) = 2.559267150167806 :

 Backtrack: alpha = 0.25, f(x) = 2.559267150167806, f(x+ap) = 2.5592668504755185, dgrad(x) = 7.053228128607052e-11 :

GD: iter = 21, x = [-3.46365869e-01 -1.30843609e-04], f(x) = 2.5592668504755185 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592668504755185, f(x+ap) = 2.559266743351823, dgrad(x) = 1.5964801912496168e-11 :

GD: iter = 22, x = [-3.46399101e-01 -3.66436281e-05], f(x) = 2.559266743351823 :

 Backtrack: alpha = 0.25, f(x) = 2.559266743351823, f(x+ap) = 2.5592667290328106, dgrad(x) = 9.439592741359263e-12 :

GD: iter = 23, x = [-3.46510744e-01 6.88782020e-05], f(x) = 2.5592667290328106 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592667290328106, f(x+ap) = 2.5592667023689004, dgrad(x) = 4.0950141972060246e-12 :

GD: iter = 24, x = [-3.46520798e-01 1.92969859e-05], f(x) = 2.5592667023689004 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592667023689004, f(x+ap) = 2.559266699343185, dgrad(x) = 4.228102582124755e-13 :

GD: iter = 25, x = [-3.46529243e-01 5.40640259e-06], f(x) = 2.559266699343185 :

 Backtrack: alpha = 0.25, f(x) = 2.559266699343185, f(x+ap) = 2.559266697579154, dgrad(x) = 4.1896841105408513e-13 :

GD: iter = 26, x = [-3.46557617e-01 -1.01602671e-05], f(x) = 2.559266697579154 :

 Backtrack: alpha = 0.0625, f(x) = 2.559266697579154, f(x+ap) = 2.5592666969352793, dgrad(x) = 9.602257193390861e-14 :

GD: iter = 27, x = [-3.46560172e-01 -2.84685344e-06], f(x) = 2.5592666969352793 :

 Backtrack: alpha = 0.25, f(x) = 2.5592666969352793, f(x+ap) = 2.5592666968529145, dgrad(x) = 5.635642990911835e-14 :

GD: iter = 28, x = [-3.46568757e-01 5.34984589e-06], f(x) = 2.5592666968529145 :

 Backtrack: alpha = 0.0625, f(x) = 2.5592666968529145, f(x+ap) = 2.5592666966922475, dgrad(x) = 2.4682120592141972e-14 :

GD: iter = 29, x = [-3.4656953e-01 1.4990416e-06], f(x) = 2.5592666966922475 :

Backtrack: alpha = 0.0625, f(x) = 2.5592666966922475, f(x+ap) = 2.5592666966741158, dgrad(x) = 2.537559617878369e-15 :

GD: iter = 30, x = [-3.46570180e-01 4.20036431e-07], f(x) = 2.5592666966741158 :

Backtrack: alpha = 0.25, f(x) = 2.5592666966741158, f(x+ap) = 2.5592666966637343, dgrad(x) = 2.489657548749892e-15 :

GD: iter = 31, x = [-3.46572362e-01 -7.89326100e-07], f(x) = 2.5592666966637343 :

Backtrack: alpha = 0.0625, f(x) = 2.5592666966637343, f(x+ap) = 2.5592666966598596, dgrad(x) = 5.782491048373577e-16 :

GD: iter = 32, x = [-3.46572558e-01 -2.21173402e-07], f(x) = 2.5592666966598596 :

Backtrack: alpha = 0.25, f(x) = 2.5592666966598596, f(x+ap) = 2.559266696659387, dgrad(x) = 3.365715241846812e-16 :

GD: iter = 33, x = [-3.46573219e-01 4.15624192e-07], f(x) = 2.559266696659387 :

GD termination: small df = 4.725109192804666e-13

==GD final: iter = 33, x = [-3.46573219e-01 4.15624192e-07], f(x) = 2.559266696659387, OK = True:==

The chosen method is = newton

Newton: iter = 1, x = [8. 6.], f(x) = 177103474428.77737 :

Backtrack: alpha = 1.0, f(x) = 177103474428.77737, f(x+ap) = 65152727202.37975, dgrad(x) = 17710347.442877695 :

Newton: iter = 2, x = [8.29837011 5.56720996], f(x) = 65152727202.37975 :

Backtrack: alpha = 1.0, f(x) = 65152727202.37975, f(x+ap) = 23968348874.007393, dgrad(x) = 6515272.720237904 :

Newton: iter = 3, x = [7.73482212 5.42172596], f(x) = 23968348874.007393 :

Backtrack: alpha = 1.0, f(x) = 23968348874.007393, f(x+ap) = 8817462789.572691, dgrad(x) = 2396834.8874006374 :

Newton: iter = 4, x = [7.4487224 5.1837592], f(x) = 8817462789.572691 :

Backtrack: alpha = 1.0, f(x) = 8817462789.572691, f(x+ap) = 3243763283.5789495, dgrad(x) = 881746.2789571269 :

Newton: iter = 5, x = [7.09717674 4.96760775], f(x) = 3243763283.5789495 :

Backtrack: alpha = 1.0, f(x) = 3243763283.5789495, f(x+ap) = 1193313824.0567975, dgrad(x) = 324376.32835769636 :

Newton: iter = 6, x = [6.77090768 4.74303077], f(x) = 1193313824.0567975 :

Backtrack: alpha = 1.0, f(x) = 1193313824.0567975, f(x+ap) = 438995622.73802835, dgrad(x) = 119331.38240540252 :

Newton: iter = 7, x = [6.43501913 4.52166029], f(x) = 438995622.73802835 :

Backtrack: alpha = 1.0, f(x) = 438995622.73802835, f(x+ap) = 161497464.37216747, dgrad(x) = 43899.56227341594 :

Newton: iter = 8, x = [6.10249898 4.29916701], f(x) = 161497464.37216747 :

Backtrack: alpha = 1.0, f(x) = 161497464.37216747, f(x+ap) = 59411596.94745598, dgrad(x) = 16149.746436676804 :

Newton: iter = 9, x = [5.76887759 4.0770408], f(x) = 59411596.94745598 :

Backtrack: alpha = 1.0, f(x) = 59411596.94745598, f(x+ap) = 21856305.089182403, dgrad(x) = 5941.159693992042 :

Newton: iter = 10, x = [5.43564271 3.85478576], f(x) = 21856305.089182403 :

Backtrack: alpha = 1.0, f(x) = 21856305.089182403, f(x+ap) = 8040485.309327933, dgrad(x) = 2185.6305078665673 :

Newton: iter = 11, x = [5.10227596 3.63257468], f(x) = 8040485.309327933 :

Backtrack: alpha = 1.0, f(x) = 8040485.309327933, f(x+ap) = 2957929.2521775514, dgrad(x) = 804.048529465066 :

Newton: iter = 12, x = [4.76895372 3.41034876], f(x) = 2957929.2521775514 :

Backtrack: alpha = 1.0, f(x) = 2957929.2521775514, f(x+ap) = 1088161.3740413007, dgrad(x) = 295.79292316937665 :

Newton: iter = 13, x = [4.43561671 3.18812777], f(x) = 1088161.3740413007 :

Backtrack: alpha = 1.0, f(x) = 1088161.3740413007, f(x+ap) = 400312.21734222834, dgrad(x) = 108.81613454538761 :

Newton: iter = 14, x = [4.10228458 2.96590514], f(x) = 400312.21734222834 :

Backtrack: alpha = 1.0, f(x) = 400312.21734222834, f(x+ap) = 147266.66154370562, dgrad(x) = 40.03121774452636 :

Newton: iter = 15, x = [3.76895085 2.74368306], f(x) = 147266.66154370562 :

Backtrack: alpha = 1.0, f(x) = 147266.66154370562, f(x+ap) = 54176.41446182888, dgrad(x) = 14.72666058630073 :

Newton: iter = 16, x = [3.43561768 2.52146082], f(x) = 54176.41446182888 :

Backtrack: alpha = 1.0, f(x) = 54176.41446182888, f(x+ap) = 19930.44114710834, dgrad(x) = 5.417633675316208 :

Newton: iter = 17, x = [3.10228442 2.29923869], f(x) = 19930.44114710834 :

Backtrack: alpha = 1.0, f(x) = 19930.44114710834, f(x+ap) = 7332.072221307487, dgrad(x) = 1.993033269596753 :

Newton: iter = 18, x = [2.76895156 2.07701676], f(x) = 7332.072221307487 :

Backtrack: alpha = 1.0, f(x) = 7332.072221307487, f(x+ap) = 2697.420050108278, dgrad(x) = 0.7331920865760296 :

Newton: iter = 19, x = [2.43561994 1.85479569], f(x) = 2697.420050108278 :

 Backtrack: alpha = 1.0, f(x) = 2697.420050108278, f(x+ap) = 992.4669208729596, dgrad(x) = 0.2697208817550747 :

Newton: iter = 20, x = [2.10229314 1.63257782], f(x) = 992.4669208729596 :

 Backtrack: alpha = 1.0, f(x) = 992.4669208729596, f(x+ap) = 365.30570640439976, dgrad(x) = 0.09921721280457182 :

Newton: iter = 21, x = [1.76898456 1.4103721], f(x) = 365.30570640439976 :

 Backtrack: alpha = 1.0, f(x) = 365.30570640439976, f(x+ap) = 134.6641074980264, dgrad(x) = 0.036489432139331215 :

Newton: iter = 22, x = [1.43574513 1.18821248], f(x) = 134.6641074980264 :

 Backtrack: alpha = 1.0, f(x) = 134.6641074980264, f(x+ap) = 49.924711043337325, dgrad(x) = 0.01340901402485988 :

Newton: iter = 23, x = [1.10276783 0.96622762], f(x) = 49.924711043337325 :

 Backtrack: alpha = 1.0, f(x) = 49.924711043337325, f(x+ap) = 18.902204481691587, dgrad(x) = 0.004912455612086467 :

Newton: iter = 24, x = [0.77078227 0.7449039], f(x) = 18.902204481691587 :

 Backtrack: alpha = 1.0, f(x) = 18.902204481691587, f(x+ap) = 7.697710142269728, dgrad(x) = 0.0017790119868953934 :

Newton: iter = 25, x = [0.4425202 0.52606253], f(x) = 7.697710142269728 :

 Backtrack: alpha = 1.0, f(x) = 7.697710142269728, f(x+ap) = 3.8500116037200596, dgrad(x) = 0.0006169319118011547 :

Newton: iter = 26, x = [0.12784639 0.31627998], f(x) = 3.8500116037200596 :

 Backtrack: alpha = 1.0, f(x) = 3.8500116037200596, f(x+ap) = 2.746213001726382, dgrad(x) = 0.00018277442027090577 :

Newton: iter = 27, x = [-0.14202873 0.13636324], f(x) = 2.746213001726382 :

 Backtrack: alpha = 1.0, f(x) = 2.746213001726382, f(x+ap) = 2.566293032236114, dgrad(x) = 3.216772057726681e-05 :

Newton: iter = 28, x = [-0.30440239 0.02811414], f(x) = 2.566293032236114 :

 Backtrack: alpha = 1.0, f(x) = 2.566293032236114, f(x+ap) = 2.5592791256055154, dgrad(x) = 1.3651257637858116e-06 :

Newton: iter = 29, x = [-0.34477533 0.00119884], f(x) = 2.5592791256055154 :

 Backtrack: alpha = 1.0, f(x) = 2.5592791256055154, f(x+ap) = 2.5592666966984075, dgrad(x) = 2.482806953242349e-09 :

Newton: iter = 30, x = [-3.46570355e-01 2.15711369e-06], f(x) = 2.5592666966984075 :

Backtrack: alpha = 1.0, f(x) = 2.5592666966984075, f(x+ap) = 2.5592666966582156, dgrad(x) = 8.038321816986992e-15 :

Newton: iter = 31, x = [-3.46573590e-01 6.97972854e-12], f(x) = 2.5592666966582156 :

Backtrack: alpha = 1.0, f(x) = 2.5592666966582156, f(x+ap) = 2.5592666966582156, dgrad(x) = 8.415842171877473e-26 :

Newton: iter = 32, x = [-3.46573590e-01 -3.21818854e-18], f(x) = 2.5592666966582156 :

Newton termination: small dx = [1.04696252e-11 6.97973176e-12]

C:\Runi\Optimization\HW\Wet_11\examples.py:119: RuntimeWarning: overflow encountered in exp

  func_x = np.exp(X[0]+3*X[1]-0.1) + np.exp(X[0]-3*X[1]-0.1) + np.exp(-X[0]-0.1)

C:\Runi\Optimization\HW\Wet_11\examples.py:122: RuntimeWarning: overflow encountered in exp

  grad_x[0] = np.exp(X[0]+3*X[1]-0.1) + np.exp(X[0]-3*X[1]-0.1) - np.exp(-X[0]-0.1)

C:\Runi\Optimization\HW\Wet_11\examples.py:122: RuntimeWarning: invalid value encountered in scalar subtract

  grad_x[0] = np.exp(X[0]+3*X[1]-0.1) + np.exp(X[0]-3*X[1]-0.1) - np.exp(-X[0]-0.1)

C:\Runi\Optimization\HW\Wet_11\examples.py:123: RuntimeWarning: overflow encountered in exp

  grad_x[1] = 3*np.exp(X[0]+3*X[1]-0.1) - 3*np.exp(X[0]-3*X[1]-0.1)

==Newton final: iter = 32, x = [-3.46573590e-01 -3.21818854e-18], f(x) = 2.5592666966582156, OK = True :==

The chosen method is = bfgs

BFGS: iter = 1, x = [8. 6.], f(x) = 177103474428.77737 :

Backtrack: alpha = 1.0, f(x) = 177103474428.77737, f(x+ap) = 65152727202.37975, dgrad(x) = 17710347.442877695 :

BFGS: iter = 2, x = [8.29837011 5.56720996], f(x) = 65152727202.37975 :

Backtrack: alpha = 1.0, f(x) = 65152727202.37975, f(x+ap) = 36406868656.08751, dgrad(x) = 3791736.9620796274 :

BFGS: iter = 3, x = [7.49742245 5.64020028], f(x) = 36406868656.08751 :

Backtrack: alpha = 1.0, f(x) = 36406868656.08751, f(x+ap) = 17421047857.03089, dgrad(x) = 2683471.4096696908 :

BFGS: iter = 4, x = [8.75685592 4.97469635], f(x) = 17421047857.03089 :

Backtrack: alpha = 1.0, f(x) = 17421047857.03089, f(x+ap) = 8858250820.778969, dgrad(x) = 1178237.4315732862 :

BFGS: iter = 5, x = [-5.59737989 9.53399834], f(x) = 8858250820.778969 :

Backtrack: alpha = 1.52587890625e-05, f(x) = 8858250820.778969, f(x+ap) = 8858152148.930666, dgrad(x) = 10.2156882567048 :

BFGS: iter = 6, x = [9.68018673 4.44147243], f(x) = 8858152148.930666 :

 Backtrack: alpha = 0.00390625, f(x) = 8858152148.930666, f(x+ap) = 8538343892.548483, dgrad(x) = 32572.41494641958 :

BFGS: iter = 7, x = [-1.72647813 8.23143701], f(x) = 8538343892.548483 :

 Backtrack: alpha = 0.015625, f(x) = 8538343892.548483, f(x+ap) = 8408370674.008836, dgrad(x) = 13097.312451279768 :

BFGS: iter = 8, x = [-6.36521328 9.77256892], f(x) = 8408370674.008836 :

 Backtrack: alpha = 0.015625, f(x) = 8408370674.008836, f(x+ap) = 8278435380.856515, dgrad(x) = 13119.659648130435 :

BFGS: iter = 9, x = [17.69383001 1.7476873], f(x) = 8278435380.856515 :

 Backtrack: alpha = 0.0009765625, f(x) = 8278435380.856515, f(x+ap) = 7470942172.867957, dgrad(x) = 111125.17903504432 :

BFGS: iter = 10, x = [-19.29858555 14.03443375], f(x) = 7470942172.867957 :

 Backtrack: alpha = 0.25, f(x) = 7470942172.867957, f(x+ap) = 1554177652.088578, dgrad(x) = 1451869.0608241383 :

BFGS: iter = 11, x = [-3.93259425 8.39893554], f(x) = 1554177652.088578 :

 Backtrack: alpha = 1.0, f(x) = 1554177652.088578, f(x+ap) = 903891998.1373076, dgrad(x) = 84235.35060634496 :

BFGS: iter = 12, x = [-7.12355747 9.28192556], f(x) = 903891998.1373076 :

 Backtrack: alpha = 1.0, f(x) = 903891998.1373076, f(x+ap) = 425634043.53726006, dgrad(x) = 68094.23491173256 :

BFGS: iter = 13, x = [-11.55858899 10.50915231], f(x) = 425634043.53726006 :

 Backtrack: alpha = 1.0, f(x) = 425634043.53726006, f(x+ap) = 222824924.93472433, dgrad(x) = 28411.647140010366 :

BFGS: iter = 14, x = [-15.47433921 11.59155785], f(x) = 222824924.93472433 :

 Backtrack: alpha = 1.0, f(x) = 222824924.93472433, f(x+ap) = 173183461.58985227, dgrad(x) = 11121.985788540384 :

BFGS: iter = 15, x = [-17.80141143 12.18033602], f(x) = 173183461.58985227 :

 Backtrack: alpha = 1.0, f(x) = 173183461.58985227, f(x+ap) = 82036407.48691651, dgrad(x) = 16158.405131419651 :

BFGS: iter = 16, x = [-15.75314252 11.33205146], f(x) = 82036407.48691651 :

 Backtrack: alpha = 1.0, f(x) = 82036407.48691651, f(x+ap) = 45504188.77350207, dgrad(x) = 4837.406742057327 :

BFGS: iter = 17, x = [-15.24842571 10.96490923], f(x) = 45504188.77350207 :

Backtrack: alpha = 1.0, f(x) = 45504188.77350207, f(x+ap) = 21880837.802927792, dgrad(x) = 3332.9891762774705 :

BFGS: iter = 18, x = [-14.59138821 10.49945867], f(x) = 21880837.802927792 :

Backtrack: alpha = 1.0, f(x) = 21880837.802927792, f(x+ap) = 11118805.484610008, dgrad(x) = 1481.63990471112 :

BFGS: iter = 19, x = [-13.97191302 10.06535616], f(x) = 11118805.484610008 :

Backtrack: alpha = 1.0, f(x) = 11118805.484610008, f(x+ap) = 5530069.598434277, dgrad(x) = 776.7529639270937 :

BFGS: iter = 20, x = [-13.32742468   9.61576545], f(x) = 5530069.598434277 :

Backtrack: alpha = 1.0, f(x) = 5530069.598434277, f(x+ap) = 2773166.4083231897, dgrad(x) = 381.7719747204882 :

BFGS: iter = 21, x = [-12.68781294   9.17055425], f(x) = 2773166.4083231897 :

Backtrack: alpha = 1.0, f(x) = 2773166.4083231897, f(x+ap) = 1386221.8696539202, dgrad(x) = 192.33423647943002 :

BFGS: iter = 22, x = [-12.04375373   8.72273414], f(x) = 1386221.8696539202 :

Backtrack: alpha = 1.0, f(x) = 1386221.8696539202, f(x+ap) = 693791.7133724305, dgrad(x) = 95.97014816188306 :

BFGS: iter = 23, x = [-11.39995658   8.27534457], f(x) = 693791.7133724305 :

Backtrack: alpha = 1.0, f(x) = 693791.7133724305, f(x+ap) = 347077.5059154237, dgrad(x) = 48.06432148866355 :

BFGS: iter = 24, x = [-10.75513387   7.82737032], f(x) = 347077.5059154237 :

Backtrack: alpha = 1.0, f(x) = 347077.5059154237, f(x+ap) = 173665.53906723333, dgrad(x) = 24.03775420537355 :

BFGS: iter = 25, x = [-10.11004771   7.37927942], f(x) = 173665.53906723333 :

Backtrack: alpha = 1.0, f(x) = 173665.53906723333, f(x+ap) = 86892.27877085147, dgrad(x) = 12.028550028063298 :

BFGS: iter = 26, x = [-9.46453103 6.93092396], f(x) = 86892.27877085147 :

Backtrack: alpha = 1.0, f(x) = 86892.27877085147, f(x+ap) = 43478.31535516906, dgrad(x) = 6.017973428525168 :

BFGS: iter = 27, x = [-8.81870607 6.48237232], f(x) = 43478.31535516906 :

Backtrack: alpha = 1.0, f(x) = 43478.31535516906, f(x+ap) = 21755.661203848264, dgrad(x) = 3.011164126495024 :

BFGS: iter = 28, x = [-8.17254699 6.03359798], f(x) = 21755.661203848264 :

Backtrack: alpha = 1.0, f(x) = 21755.661203848264, f(x+ap) = 10886.462158305088, dgrad(x) = 1.506665711885891 :

BFGS: iter = 29, x = [-7.52606622 5.58460508], f(x) = 10886.462158305088 :

 Backtrack: alpha = 1.0, f(x) = 10886.462158305088, f(x+ap) = 5447.710998730456, dgrad(x) = 0.7539063833773005 :

BFGS: iter = 30, x = [-6.87925134 5.13538265], f(x) = 5447.710998730456 :

 Backtrack: alpha = 1.0, f(x) = 5447.710998730456, f(x+ap) = 2726.185732070077, dgrad(x) = 0.37724979226452515 :

BFGS: iter = 31, x = [-6.23209409 4.68592376], f(x) = 2726.185732070077 :

 Backtrack: alpha = 1.0, f(x) = 2726.185732070077, f(x+ap) = 1364.3029636126619, dgrad(x) = 0.18877952928232591 :

BFGS: iter = 32, x = [-5.58458157 4.23621882], f(x) = 1364.3029636126619 :

 Backtrack: alpha = 1.0, f(x) = 1364.3029636126619, f(x+ap) = 682.7796943197684, dgrad(x) = 0.09447008451958808 :

BFGS: iter = 33, x = [-4.93670094 3.78625858], f(x) = 682.7796943197684 :

 Backtrack: alpha = 1.0, f(x) = 682.7796943197684, f(x+ap) = 341.7156948311576, dgrad(x) = 0.047276784896731684 :

BFGS: iter = 34, x = [-4.28843823 3.33603315], f(x) = 341.7156948311576 :

 Backtrack: alpha = 1.0, f(x) = 341.7156948311576, f(x+ap) = 171.02674397589735, dgrad(x) = 0.02366006168037123 :

BFGS: iter = 35, x = [-3.63977916 2.88553255], f(x) = 171.02674397589735 :

 Backtrack: alpha = 1.0, f(x) = 171.02674397589735, f(x+ap) = 85.6008749589296, dgrad(x) = 0.011841271450133676 :

BFGS: iter = 36, x = [-2.99070913 2.43474658], f(x) = 85.6008749589296 :

 Backtrack: alpha = 1.0, f(x) = 85.6008749589296, f(x+ap) = 42.84596484640024, dgrad(x) = 0.005926448324822471 :

BFGS: iter = 37, x = [-2.34121427 1.98366559], f(x) = 42.84596484640024 :

 Backtrack: alpha = 1.0, f(x) = 42.84596484640024, f(x+ap) = 21.448363279434545, dgrad(x) = 0.0029661275984337308 :

BFGS: iter = 38, x = [-1.69129517 1.53228998], f(x) = 21.448363279434545 :

 Backtrack: alpha = 1.0, f(x) = 21.448363279434545, f(x+ap) = 10.75097673544503, dgrad(x) = 0.0014837687356003312 :

BFGS: iter = 39, x = [-1.04117012 1.08077133], f(x) = 10.75097673544503 :

 Backtrack: alpha = 1.0, f(x) = 10.75097673544503, f(x+ap) = 5.490004306324355, dgrad(x) = 0.0007363459630385531 :

BFGS: iter = 40, x = [-0.39428335 0.63150171], f(x) = 5.490004306324355 :

Backtrack: alpha = 1.0, f(x) = 5.490004306324355, f(x+ap) = 3.4434638983765646, dgrad(x) = 0.00032458398428533366 :

BFGS: iter = 41, x = [0.20082612 0.21819196], f(x) = 3.4434638983765646 :

 Backtrack: alpha = 1.0, f(x) = 3.4434638983765646, f(x+ap) = 3.3716778961623635, dgrad(x) = 2.3110263270465857e-05 :

BFGS: iter = 42, x = [0.38221352 0.0922165], f(x) = 3.3716778961623635 :

 Backtrack: alpha = 1.0, f(x) = 3.3716778961623635, f(x+ap) = 3.3572395591568025, dgrad(x) = 3.373408854224582e-06 :

BFGS: iter = 43, x = [0.32489801 0.13202271], f(x) = 3.3572395591568025 :

 Backtrack: alpha = 1.0, f(x) = 3.3572395591568025, f(x+ap) = 3.3570051700813313, dgrad(x) = 4.447250593514767e-08 :

BFGS: iter = 44, x = [0.33111155 0.12770733], f(x) = 3.3570051700813313 :

 Backtrack: alpha = 1.0, f(x) = 3.3570051700813313, f(x+ap) = 3.357004484470827, dgrad(x) = 1.3268441403746976e-10 :

BFGS: iter = 45, x = [0.33145313 0.12747007], f(x) = 3.357004484470827 :

 Backtrack: alpha = 1.0, f(x) = 3.357004484470827, f(x+ap) = 3.3570044288786405, dgrad(x) = 5.6355054511507265e-12 :

BFGS: iter = 46, x = [0.33146489 0.12746189], f(x) = 3.3570044288786405 :

 Backtrack: alpha = 1.0, f(x) = 3.3570044288786405, f(x+ap) = 3.3570014180702303, dgrad(x) = 3.996278981945517e-10 :

BFGS: iter = 47, x = [0.33188648 0.12716772], f(x) = 3.3570014180702303 :

 Backtrack: alpha = 1.0, f(x) = 3.3570014180702303, f(x+ap) = 3.3569962696745503, dgrad(x) = 6.189328928531373e-10 :

BFGS: iter = 48, x = [0.33231782 0.12686535], f(x) = 3.3569962696745503 :

 Backtrack: alpha = 1.0, f(x) = 3.3569962696745503, f(x+ap) = 3.3569799985669087, dgrad(x) = 2.032599870194037e-09 :

BFGS: iter = 49, x = [0.3331634 0.12626845], f(x) = 3.3569799985669087 :

 Backtrack: alpha = 1.0, f(x) = 3.3569799985669087, f(x+ap) = 3.3569401507377217, dgrad(x) = 4.905869100720221e-09 :

BFGS: iter = 50, x = [0.33442334 0.12536854], f(x) = 3.3569401507377217 :

 Backtrack: alpha = 1.0, f(x) = 3.3569401507377217, f(x+ap) = 3.35683296050758, dgrad(x) = 1.3271240290615972e-08 :

BFGS: iter = 51, x = [0.336482   0.12386984], f(x) = 3.35683296050758 :

 Backtrack: alpha = 1.0, f(x) = 3.35683296050758, f(x+ap) = 3.3565547944958123, dgrad(x) = 3.436876731688784e-08 :

BFGS: iter = 52, x = [0.33967955 0.12146699], f(x) = 3.3565547944958123 :

 Backtrack: alpha = 1.0, f(x) = 3.3565547944958123, f(x+ap) = 3.3558225495709966, dgrad(x) = 9.055910043061084e-08 :

BFGS: iter = 53, x = [0.34461392 0.1175556], f(x) = 3.3558225495709966 :

 Backtrack: alpha = 1.0, f(x) = 3.3558225495709966, f(x+ap) = 3.353904532028592, dgrad(x) = 2.3719603423608067e-07 :

BFGS: iter = 54, x = [0.35189562 0.1112224], f(x) = 3.353904532028592 :

 Backtrack: alpha = 1.0, f(x) = 3.353904532028592, f(x+ap) = 3.348872581776092, dgrad(x) = 6.226899052628987e-07 :

BFGS: iter = 55, x = [0.3618479 0.10095457], f(x) = 3.348872581776092 :

 Backtrack: alpha = 1.0, f(x) = 3.348872581776092, f(x+ap) = 3.3357239105773537, dgrad(x) = 1.628714925290481e-06 :

BFGS: iter = 56, x = [0.37305189 0.08439974], f(x) = 3.3357239105773537 :

 Backtrack: alpha = 1.0, f(x) = 3.3357239105773537, f(x+ap) = 3.3017434628313023, dgrad(x) = 4.217867203898445e-06 :

BFGS: iter = 57, x = [0.37825014 0.05811044], f(x) = 3.3017434628313023 :

 Backtrack: alpha = 1.0, f(x) = 3.3017434628313023, f(x+ap) = 3.21697679927168, dgrad(x) = 1.0574885937892925e-05 :

BFGS: iter = 58, x = [0.35385269 0.0181836], f(x) = 3.21697679927168 :

 Backtrack: alpha = 1.0, f(x) = 3.21697679927168, f(x+ap) = 3.028670393623838, dgrad(x) = 2.3973084341051167e-05 :

BFGS: iter = 59, x = [0.24224801 -0.03507041], f(x) = 3.028670393623838 :

 Backtrack: alpha = 1.0, f(x) = 3.028670393623838, f(x+ap) = 2.7512843123717587, dgrad(x) = 3.849994357656027e-05 :

BFGS: iter = 60, x = [-0.01787211 -0.08082302], f(x) = 2.7512843123717587 :

 Backtrack: alpha = 1.0, f(x) = 2.7512843123717587, f(x+ap) = 2.6094477898793755, dgrad(x) = 2.263139317082524e-05 :

BFGS: iter = 61, x = [-0.26919181 -0.08245398], f(x) = 2.6094477898793755 :

 Backtrack: alpha = 1.0, f(x) = 2.6094477898793755, f(x+ap) = 2.577984782012127, dgrad(x) = 4.514655633640208e-06 :

BFGS: iter = 62, x = [-0.34693446 -0.05695475], f(x) = 2.577984782012127 :

 Backtrack: alpha = 1.0, f(x) = 2.577984782012127, f(x+ap) = 2.5618689674474426, dgrad(x) = 2.496986541845093e-06 :

BFGS: iter = 63, x = [-0.3651453 -0.01954965], f(x) = 2.5618689674474426 :

Backtrack: alpha = 1.0, f(x) = 2.5618689674474426, f(x+ap) = 2.5593051879803923, dgrad(x) = 4.784984531668657e-07 :

BFGS: iter = 64, x = [-0.35189369 -0.00062997], f(x) = 2.5593051879803923 :

BFGS termination: small dx = [-0.01325161 -0.01891968]

<mark>BFGS final: iter = 64, x = [-0.35189369 -0.00062997], f(x) = 2.5593051879803923, OK = True :</mark>

The chosen method is = sr1

SR1: iter = 1, x = [8. 6.], f(x) = 177103474428.77737 :

 Backtrack: alpha = 1.0, f(x) = 177103474428.77737, f(x+ap) = 65152727202.37975, dgrad(x) = 17710347.442877695 :

SR1: iter = 2, x = [8.29837011 5.56720996], f(x) = 65152727202.37975 :

 Backtrack: alpha = 1.0, f(x) = 65152727202.37975, f(x+ap) = 36406868656.08762, dgrad(x) = 3791736.9620796265 :

SR1: iter = 3, x = [7.52060961 5.63247123], f(x) = 36406868656.08762 :

 Backtrack: alpha = 1.0, f(x) = 36406868656.08762, f(x+ap) = 17421047857.03077, dgrad(x) = 2683471.409669714 :

SR1: iter = 4, x = [8.75599823 4.97498224], f(x) = 17421047857.03077 :

 Backtrack: alpha = 1.0, f(x) = 17421047857.03077, f(x+ap) = 8858251136.78696, dgrad(x) = 1178237.4315738012 :

SR1: iter = 5, x = [-6.42804553 9.81088689], f(x) = 8858251136.78696 :

 Backtrack: alpha = 3.814697265625e-06, f(x) = 8858251136.78696, f(x+ap) = 8858219598.66223, dgrad(x) = 3.806876869980327 :

SR1: iter = 6, x = [6.23245059 5.59072035], f(x) = 8858219598.66223 :

 Backtrack: alpha = 0.25, f(x) = 8858219598.66223, f(x+ap) = 7436715553.399025, dgrad(x) = 154944.87924415863 :

SR1: iter = 7, x = [10.38546442 4.1480769], f(x) = 7436715553.399025 :

 Backtrack: alpha = 0.25, f(x) = 7436715553.399025, f(x+ap) = 5915985126.465532, dgrad(x) = 170131.6181864192 :

SR1: iter = 8, x = [15.80899002 2.26397753], f(x) = 5915985126.465532 :

 Backtrack: alpha = 0.015625, f(x) = 5915985126.465532, f(x+ap) = 5832829242.255091, dgrad(x) = 8427.743662930352 :

SR1: iter = 9, x = [-11.83690623 11.47455093], f(x) = 5832829242.255091 :

 Backtrack: alpha = 0.0625, f(x) = 5832829242.255091, f(x+ap) = 5523441113.022543, dgrad(x) = 31949.533125610502 :

SR1: iter = 10, x = [-14.59136363 12.37442486], f(x) = 5523441113.022543 :

Backtrack: alpha = 0.25, f(x) = 5523441113.022543, f(x+ap) = 5053987141.821989, dgrad(x) = 112330.58927975807 :

SR1: iter = 11, x = [-20.23982221 14.18875972], f(x) = 5053987141.821989 :

Backtrack: alpha = 1.0, f(x) = 5053987141.821989, f(x+ap) = 2750184797.5289283, dgrad(x) = 495977.59434012795 :

SR1: iter = 12, x = [-15.32347064 12.38563906], f(x) = 2750184797.5289283 :

Backtrack: alpha = 1.0, f(x) = 2750184797.5289283, f(x+ap) = 900768131.1454655, dgrad(x) = 309369.53540435556 :

SR1: iter = 13, x = [-16.407252   12.37083544], f(x) = 900768131.1454655 :

Backtrack: alpha = 1.0, f(x) = 900768131.1454655, f(x+ap) = 539691023.6727087, dgrad(x) = 46778.38222333486 :

SR1: iter = 14, x = [-16.7626219   12.31222256], f(x) = 539691023.6727087 :

Backtrack: alpha = 1.0, f(x) = 539691023.6727087, f(x+ap) = 272072759.925125, dgrad(x) = 38097.19629026071 :

SR1: iter = 15, x = [-17.01491989 12.15048098], f(x) = 272072759.925125 :

Backtrack: alpha = 1.0, f(x) = 272072759.925125, f(x+ap) = 150811020.86763462, dgrad(x) = 16504.993867180085 :

SR1: iter = 16, x = [-16.96937686 11.91648243], f(x) = 150811020.86763462 :

Backtrack: alpha = 1.0, f(x) = 150811020.86763462, f(x+ap) = 79771909.42978163, dgrad(x) = 9807.57603428623 :

SR1: iter = 17, x = [-16.70399994 11.59026464], f(x) = 79771909.42978163 :

Backtrack: alpha = 1.0, f(x) = 79771909.42978163, f(x+ap) = 41820383.67466465, dgrad(x) = 5224.140048164749 :

SR1: iter = 18, x = [-16.30759297 11.2177821], f(x) = 41820383.67466465 :

Backtrack: alpha = 1.0, f(x) = 41820383.67466465, f(x+ap) = 21582466.8853837, dgrad(x) = 2796.320589343735 :

SR1: iter = 19, x = [-15.83584464 10.81440793], f(x) = 21582466.8853837 :

Backtrack: alpha = 1.0, f(x) = 21582466.8853837, f(x+ap) = 11102299.14834395, dgrad(x) = 1447.9816124280292 :

SR1: iter = 20, x = [-15.32621947 10.39604378], f(x) = 11102299.14834395 :

Backtrack: alpha = 1.0, f(x) = 11102299.14834395, f(x+ap) = 5695686.106158625, dgrad(x) = 747.4802034893237 :

SR1: iter = 21, x = [-14.79278913   9.96653134], f(x) = 5695686.106158625 :

Backtrack: alpha = 1.0, f(x) = 5695686.106158625, f(x+ap) = 2921026.577358175, dgrad(x) = 383.5954714704428 :

SR1: iter = 22, x = [-14.24375977 9.52872175], f(x) = 2921026.577358175 :

 Backtrack: alpha = 1.0, f(x) = 2921026.577358175, f(x+ap) = 1497853.129232138, dgrad(x) = 196.7611698601216 :

SR1: iter = 23, x = [-13.68224086 9.08316279], f(x) = 1497853.129232138 :

 Backtrack: alpha = 1.0, f(x) = 1497853.129232138, f(x+ap) = 768162.679957425, dgrad(x) = 100.87693647110247 :

SR1: iter = 24, x = [-13.10978491 8.63007458], f(x) = 768162.679957425 :

 Backtrack: alpha = 1.0, f(x) = 768162.679957425, f(x+ap) = 393892.9610264056, dgrad(x) = 51.73949507645719 :

SR1: iter = 25, x = [-12.52682338 8.16926402], f(x) = 393892.9610264056 :

 Backtrack: alpha = 1.0, f(x) = 393892.9610264056, f(x+ap) = 201880.30197122987, dgrad(x) = 26.543688484305598 :

SR1: iter = 26, x = [-11.93345079 7.70052499], f(x) = 201880.30197122987 :

 Backtrack: alpha = 1.0, f(x) = 201880.30197122987, f(x+ap) = 103372.0491860774, dgrad(x) = 13.618248851652352 :

SR1: iter = 27, x = [-11.32964318 7.22369275], f(x) = 103372.0491860774 :

 Backtrack: alpha = 1.0, f(x) = 103372.0491860774, f(x+ap) = 52858.37405951283, dgrad(x) = 6.98392015245653 :

SR1: iter = 28, x = [-10.71547153 6.73874907], f(x) = 52858.37405951283 :

 Backtrack: alpha = 1.0, f(x) = 52858.37405951283, f(x+ap) = 26981.07925513684, dgrad(x) = 3.578290396885673 :

SR1: iter = 29, x = [-10.09118018 6.24584978], f(x) = 26981.07925513684 :

 Backtrack: alpha = 1.0, f(x) = 26981.07925513684, f(x+ap) = 13744.199415259149, dgrad(x) = 1.8307513933048654 :

SR1: iter = 30, x = [-9.45722529 5.74533698], f(x) = 13744.199415259149 :

 Backtrack: alpha = 1.0, f(x) = 13744.199415259149, f(x+ap) = 6985.992104002179, dgrad(x) = 0.9349256104994653 :

SR1: iter = 31, x = [-8.81426151 5.23771891], f(x) = 6985.992104002179 :

 Backtrack: alpha = 1.0, f(x) = 6985.992104002179, f(x+ap) = 3543.0170129346334, dgrad(x) = 0.4764189096321266 :

SR1: iter = 32, x = [-8.1631013   4.72363306], f(x) = 3543.0170129346334 :

 Backtrack: alpha = 1.0, f(x) = 3543.0170129346334, f(x+ap) = 1793.0367103183903, dgrad(x) = 0.24221381651605803 :

SR1: iter = 33, x = [-7.50465667 4.20379762], f(x) = 1793.0367103183903 :

Backtrack: alpha = 1.0, f(x) = 1793.0367103183903, f(x+ap) = 905.6173466257707, dgrad(x) = 0.12285725057380037 :

SR1: iter = 34, x = [-6.8398777   3.67896189], f(x) = 905.6173466257707 :

Backtrack: alpha = 1.0, f(x) = 905.6173466257707, f(x+ap) = 456.5939970871522, dgrad(x) = 0.06217824596888038 :

SR1: iter = 35, x = [-6.1696977   3.14986236], f(x) = 456.5939970871522 :

Backtrack: alpha = 1.0, f(x) = 456.5939970871522, f(x+ap) = 229.85056869500025, dgrad(x) = 0.03140444101285116 :

SR1: iter = 36, x = [-5.49499128 2.61718937], f(x) = 229.85056869500025 :

Backtrack: alpha = 1.0, f(x) = 229.85056869500025, f(x+ap) = 115.55569947391022, dgrad(x) = 0.015832816643735814 :

SR1: iter = 37, x = [-4.81654725 2.08156563], f(x) = 115.55569947391022 :

Backtrack: alpha = 1.0, f(x) = 115.55569947391022, f(x+ap) = 58.031416824274615, dgrad(x) = 0.007969787412698532 :

SR1: iter = 38, x = [-4.13505573 1.54353595], f(x) = 58.031416824274615 :

Backtrack: alpha = 1.0, f(x) = 58.031416824274615, f(x+ap) = 29.118435552476527, dgrad(x) = 0.004006396510319167 :

SR1: iter = 39, x = [-3.45111409 1.00357193], f(x) = 29.118435552476527 :

Backtrack: alpha = 1.0, f(x) = 29.118435552476527, f(x+ap) = 14.615868706678826, dgrad(x) = 0.002010983049889999 :

SR1: iter = 40, x = [-2.76540127 0.46220958], f(x) = 14.615868706678826 :

Backtrack: alpha = 1.0, f(x) = 14.615868706678826, f(x+ap) = 7.489635586261253, dgrad(x) = 0.0010001991086257332 :

SR1: iter = 41, x = [-2.08209603 -0.077252], f(x) = 7.489635586261253 :

Backtrack: alpha = 1.0, f(x) = 7.489635586261253, f(x+ap) = 5.092624662608009, dgrad(x) = 0.00042066726558172746 :

SR1: iter = 42, x = [-1.47254765 -0.5584834], f(x) = 5.092624662608009 :

Backtrack: alpha = 1.0, f(x) = 5.092624662608009, f(x+ap) = 5.091184390561885, dgrad(x) = 6.450541255869304e-07 :

SR1: iter = 43, x = [-1.44820664 -0.57770033], f(x) = 5.091184390561885 :

Backtrack: alpha = 1.0, f(x) = 5.091184390561885, f(x+ap) = 5.090534511670754, dgrad(x) = 1.3288003468866248e-07 :

SR1: iter = 44, x = [-1.45702801 -0.57073595], f(x) = 5.090534511670754 :

Backtrack: alpha = 1.0, f(x) = 5.090534511670754, f(x+ap) = 5.090534258551567, dgrad(x) = 4.6929495058652656e-11 :

SR1: iter = 45, x = [-1.4568695 -0.57086109], f(x) = 5.090534258551567 :

 Backtrack: alpha = 1.0, f(x) = 5.090534258551567, f(x+ap) = 5.0905339893259205, dgrad(x) = 2.708019260302702e-11 :

SR1: iter = 46, x = [-1.45685591 -0.57087173], f(x) = 5.0905339893259205 :

 Backtrack: alpha = 3.552713678800501e-15, f(x) = 5.0905339893259205, f(x+ap) = 5.0905339893259205, dgrad(x) = -4.072750354528818e-20 :

SR1: iter = 47, x = [-1.45685591 -0.57087173], f(x) = 5.0905339893259205 :

SR1 termination: small dx = [0.00000000e+00 1.11022302e-16]

SR1 final: iter = 47, x = [-1.45685591 -0.57087173], f(x) = 5.0905339893259205, OK = True :