**Simulated Annealing**

**Calculations across 10,000 trials**

**Per cooling schedule**

**Logarithmic multiplicative cooling: k = 0.01**

Average distance from optima: 2.6927 units

Average computation time: 32.7205 ms / trial

Grand Total Computation time: 5.4855 min

Number of trials ran: 10,000

Total plot points taken: 41

Accuracy Percentage across all trials: 17.48 %

**Linear cooling: k = 1**

Average distance from optima: 15.7762 units

Average computation time: 1.0163 sec / trial

Grand Total Computation time: 2.8299 hours == 2 hours: 49 mins: 47 secs

Number of trials ran: 10,000

Total plot points taken: 1002

Accuracy Percentage across all trials: 0.3 %

**Exponential cooling: k = 0.8**

Average distance from optima: 9.0752 units

Average computation time: 7.8201 ms / trial

Grand Total Computation time: 1.3375 min

Number of trials ran: 10,000

Total plot points taken: 44

Accuracy Percentage across all trials: 1.86 %

**Quadratic Multiplicative cooling: k=0.00001**

Average distance from optima: 8.7160 units

Average computation time: 17.1624 ms

Grand Total Computation time: 2.89595 min

Number of trials ran: 10000

Total plot points taken: 184

Accuracy Percentage across all trials: 1.75 %

**AFTER PRESENTATION & OPTIMIZATION:**

**Best performing during original experiments:**

**Logarithmic multiplicative cooling: k=0.001** (cFactor = 10 times smaller than o.g.)

Average distance from optima: 0.53 units

Average computation time: 0.33 sec

Grand Total Computation time: 0.55 min

Number of trials ran: **100**

Total plot points taken: 2087

Accuracy Percentage across all trials: 82.0 %

**Logarithmic multiplicative cooling: k=0.001** (cFactor = 10 times smaller than o.g.)

Average distance from optima: 0.75 units

Average computation time: 0.33 sec

Grand Total Computation time: 5.63 min

Number of trials ran: **1,000**

Total plot points taken: 2087

Accuracy Percentage across all trials: 69.1 %

**Logarithmic multiplicative cooling: k=0.0001** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 0.08 units

Average computation time: 2.49 sec

Grand Total Computation time: 4.20 min

Number of trials ran: **100**

Total plot points taken: 15,931

Accuracy Percentage across all trials: 100.0 %

**Logarithmic multiplicative cooling: k=0.0001** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 0.08 units

Average computation time: 0.27 sec

Grand Total Computation time: 4.53 min

Number of trials ran: **1,000**

Total plot points taken: 15,931

Accuracy Percentage across all trials: 100.0 %

**Logarithmic multiplicative cooling: k=0.0001** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 0.0833921003760048 units

Average computation time: 0.13021830306999993 sec

Grand Total Computation time: 21.868471355 min

Number of trials ran: **10,000**

Total plot points taken: 15,931

Accuracy Percentage across all trials: 99.96 %

**Worst performing during original experiments:**

**Linear cooling: k = 0.1** (cFactor = 10 times smaller than o.g.)

Average distance from optima: 5.58 units

Average computation time: 0.87 sec

Grand Total Computation time: 1.47 min

Number of trials ran: **100**

Total plot points taken: 100,001

Accuracy Percentage across all trials: 4.0 %

**Linear cooling: k = 0.01** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 2.48 units

Average computation time: 8.79 sec

Grand Total Computation time: 1.48 min

Number of trials ran: **10**

Total plot points taken: 1,000,001

Accuracy Percentage across all trials: 20.0 %

**Linear cooling: k = 0.01** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 1.82 units

Average computation time: 10.63 sec

Grand Total Computation time: 1.78 min

Number of trials ran: **10**

Total plot points taken: 1,000,001

Accuracy Percentage across all trials: 30.0 %

**Linear cooling: k = 0.01** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 2.02 units

Average computation time: 8.61 sec

Grand Total Computation time: 14.46 min

Number of trials ran: **100**

Total plot points taken: 1,000,001

Accuracy Percentage across all trials: 16.0 %

**Linear cooling: k = 0.01** (cFactor = 100 times smaller than o.g.)

Average distance from optima: 2.18 units

Average computation time: 9.51 sec

Grand Total Computation time: 159.64 min = 2hrs : 39min : 38sec

Number of trials ran:  **10,000**

Total plot points taken: 1,000,001

Accuracy Percentage across all trials: 19.7 %

**Gradient Decent Stats**

**Gradient Descent – Static LR: k = 0.001**

Average distance from optima: 18.14 units

Average computation time: 0.09 sec

Grand Total Computation time: 15.45 min

Number of trials ran: **10,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: 0.8 %

Trial #: 73 was accurate. Distance from global optima = 0.0001877702661886253

Trial #: 232 was accurate. Distance from global optima = 0.00019150709274235847

Trial #: 433 was accurate. Distance from global optima = 0.00015507175073765193

Trial #: 442 was accurate. Distance from global optima = 0.00021598208001322392

Trial #: 495 was accurate. Distance from global optima = 0.00013998717914703076

Trial #: 794 was accurate. Distance from global optima = 0.00013930596060788409

Trial #: 835 was accurate. Distance from global optima = 0.00014274723376505113

Trial #: 966 was accurate. Distance from global optima = 0.00015621787649270965

Trial #: 1172 was accurate. Distance from global optima = 0.00017256150261850777

Trial #: 1502 was accurate. Distance from global optima = 0.00021738664618421304

Trial #: 1555 was accurate. Distance from global optima = 0.00018320444544982632

Trial #: 1715 was accurate. Distance from global optima = 0.00014060278184656729

Trial #: 1943 was accurate. Distance from global optima = 0.00021605607373793842

Trial #: 1967 was accurate. Distance from global optima = 0.0002134004617475613

Trial #: 2125 was accurate. Distance from global optima = 0.00019752294374906113

Trial #: 2182 was accurate. Distance from global optima = 0.00018861443412083453

Trial #: 2486 was accurate. Distance from global optima = 0.00020954258957592119

Trial #: 2932 was accurate. Distance from global optima = 0.0001427097448388623

Trial #: 2948 was accurate. Distance from global optima = 0.00020663823129338994

Trial #: 3043 was accurate. Distance from global optima = 0.00014865095544471432

Trial #: 3161 was accurate. Distance from global optima = 0.00014036310575334348

Trial #: 3260 was accurate. Distance from global optima = 0.00017367727652921105

Trial #: 3318 was accurate. Distance from global optima = 0.0001651530827383296

Trial #: 3389 was accurate. Distance from global optima = 0.0001424286390843851

Trial #: 3472 was accurate. Distance from global optima = 0.0002069451512360397

Trial #: 3509 was accurate. Distance from global optima = 0.0001926987878889546

Trial #: 3814 was accurate. Distance from global optima = 0.00014275760262802924

Trial #: 3829 was accurate. Distance from global optima = 0.0001407661247089729

Trial #: 3841 was accurate. Distance from global optima = 0.00013970814265153503

Trial #: 3863 was accurate. Distance from global optima = 0.00020855229934932916

Trial #: 3866 was accurate. Distance from global optima = 0.00014505776740204504

Trial #: 4056 was accurate. Distance from global optima = 0.0001420479955327392

Trial #: 4215 was accurate. Distance from global optima = 0.00016949879182235266

Trial #: 4395 was accurate. Distance from global optima = 0.00016058678668837587

Trial #: 4534 was accurate. Distance from global optima = 0.0001431141168049305

Trial #: 4535 was accurate. Distance from global optima = 0.00019101633639035046

Trial #: 4756 was accurate. Distance from global optima = 0.0001990725372920857

Trial #: 5019 was accurate. Distance from global optima = 0.00022118593256800442

Trial #: 5071 was accurate. Distance from global optima = 0.00022454262645698104

Trial #: 5189 was accurate. Distance from global optima = 0.00017590082965861654

Trial #: 5195 was accurate. Distance from global optima = 0.0001758248557714324

Trial #: 5244 was accurate. Distance from global optima = 0.00020754413054379126

Trial #: 5286 was accurate. Distance from global optima = 0.00015534907556346387

Trial #: 5288 was accurate. Distance from global optima = 0.0002208862334679761

Trial #: 5299 was accurate. Distance from global optima = 0.00013876144800084583

Trial #: 5431 was accurate. Distance from global optima = 0.00022374498290055593

Trial #: 5436 was accurate. Distance from global optima = 0.00019165129057092798

Trial #: 5458 was accurate. Distance from global optima = 0.0001814528799771455

Trial #: 5460 was accurate. Distance from global optima = 0.00016072284485581814

Trial #: 5529 was accurate. Distance from global optima = 0.00018472623975028667

Trial #: 5559 was accurate. Distance from global optima = 0.00020230630701169596

Trial #: 5568 was accurate. Distance from global optima = 0.0001591907681868676

Trial #: 5775 was accurate. Distance from global optima = 0.00015322419745808494

Trial #: 5814 was accurate. Distance from global optima = 0.00021545696899832658

Trial #: 5932 was accurate. Distance from global optima = 0.00021074776237076486

Trial #: 6057 was accurate. Distance from global optima = 0.00017359715979607568

Trial #: 6065 was accurate. Distance from global optima = 0.00014886608080610727

Trial #: 6131 was accurate. Distance from global optima = 0.00021282049085014006

Trial #: 6713 was accurate. Distance from global optima = 0.0002183767011091162

Trial #: 6879 was accurate. Distance from global optima = 0.00019637886295648636

Trial #: 6905 was accurate. Distance from global optima = 0.0001729914654653838

Trial #: 7018 was accurate. Distance from global optima = 0.00020889227707374073

Trial #: 7217 was accurate. Distance from global optima = 0.00018413044172888113

Trial #: 7287 was accurate. Distance from global optima = 0.00014284908814829936

Trial #: 7300 was accurate. Distance from global optima = 0.0002041037487803856

Trial #: 7398 was accurate. Distance from global optima = 0.00022189246917187313

Trial #: 7489 was accurate. Distance from global optima = 0.00016681087210729335

Trial #: 7885 was accurate. Distance from global optima = 0.00016007498616020136

Trial #: 7917 was accurate. Distance from global optima = 0.00014874586478794835

Trial #: 7952 was accurate. Distance from global optima = 0.0001755506918205905

Trial #: 8058 was accurate. Distance from global optima = 0.00013589401729709365

Trial #: 8075 was accurate. Distance from global optima = 0.0002139014283680653

Trial #: 8222 was accurate. Distance from global optima = 0.00018893878920981635

Trial #: 8354 was accurate. Distance from global optima = 0.00017822082511667346

Trial #: 8388 was accurate. Distance from global optima = 0.00014845903782848422

Trial #: 8579 was accurate. Distance from global optima = 0.0002211092883971072

Trial #: 9434 was accurate. Distance from global optima = 0.00015513238693558835

Trial #: 9441 was accurate. Distance from global optima = 0.0001810277118557488

Trial #: 9557 was accurate. Distance from global optima = 0.000209273627419096

Trial #: 9646 was accurate. Distance from global optima = 0.00020699037719913404

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**Gradient Descent – Static LR: k = 0.001**

Average distance from optima: 17.73 units

Average computation time: 0.092 sec

Grand Total Computation time: 1.56 min

Number of trials ran: **1,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: 1.09 %

Trial #: 44 was accurate. Distance from global optima = 0.00014160235117424957

Trial #: 79 was accurate. Distance from global optima = 0.00016781870453400936

Trial #: 267 was accurate. Distance from global optima = 0.0001890612352883619

Trial #: 400 was accurate. Distance from global optima = 0.00015383587320057056

Trial #: 454 was accurate. Distance from global optima = 0.00015587249000475827

Trial #: 573 was accurate. Distance from global optima = 0.0001496860087986658

Trial #: 811 was accurate. Distance from global optima = 0.00014070297272825985

Trial #: 839 was accurate. Distance from global optima = 0.00021428580949664215

Trial #: 886 was accurate. Distance from global optima = 0.00017665273212124345

Trial #: 977 was accurate. Distance from global optima = 0.00019817013891657384

Trial #: 993 was accurate. Distance from global optima = 0.00016119703453696

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**Gradient Descent – Scaling LR: k = 0.001**

Average distance from optima: 43.24 units

Average computation time: 0.08 sec

Grand Total Computation time: 1.38 min

Number of trials ran: **1,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: 0.89 %

Trial #: 42 was accurate. Distance from global optima = 0.0001764795271246192

Trial #: 284 was accurate. Distance from global optima = 0.0001728209555771729

Trial #: 363 was accurate. Distance from global optima = 0.00016267311994004044

Trial #: 495 was accurate. Distance from global optima = 0.00021877104757958297

Trial #: 498 was accurate. Distance from global optima = 0.0001718402234519404

Trial #: 644 was accurate. Distance from global optima = 0.00022466771875900455

Trial #: 735 was accurate. Distance from global optima = 0.0001645897347481451

Trial #: 798 was accurate. Distance from global optima = 0.0001680717370556105

Trial #: 828 was accurate. Distance from global optima = 0.00017110108509038718

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**Gradient Descent – Cosine LR: k = 0.001**

Average distance from optima: 17.71 units

Average computation time: 0.088 sec

Grand Total Computation time: 1.495 min

Number of trials ran: **1,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: 1.3 %

Trial #: 36 was accurate. Distance from global optima = 0.00014825464318360157

Trial #: 69 was accurate. Distance from global optima = 0.00019761695396529135

Trial #: 89 was accurate. Distance from global optima = 0.00020442992924602196

Trial #: 170 was accurate. Distance from global optima = 0.000212300441479257

Trial #: 206 was accurate. Distance from global optima = 0.00019008038332296625

Trial #: 353 was accurate. Distance from global optima = 0.0002103837500588798

Trial #: 412 was accurate. Distance from global optima = 0.00021194767009369135

Trial #: 472 was accurate. Distance from global optima = 0.00015080233839752887

Trial #: 536 was accurate. Distance from global optima = 0.00019290723569798004

Trial #: 565 was accurate. Distance from global optima = 0.00020561801231382013

Trial #: 751 was accurate. Distance from global optima = 0.00022024712839919012

Trial #: 762 was accurate. Distance from global optima = 0.00014137007488180275

Trial #: 935 was accurate. Distance from global optima = 0.00021341111546129254

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**Gradient Descent – Periodic LR: k = 0.001**

Average distance from optima: 18.21 units

Average computation time: 0.094 sec

Grand Total Computation time: 1.60 min

Number of trials ran: **1,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: 1.2 %

Trial #: 152 was accurate. Distance from global optima = 0.00021352424189869005

Trial #: 160 was accurate. Distance from global optima = 0.000212399276398146

Trial #: 173 was accurate. Distance from global optima = 0.00018621797447574532

Trial #: 241 was accurate. Distance from global optima = 0.00021024982923473017

Trial #: 350 was accurate. Distance from global optima = 0.0001920921845992395

Trial #: 424 was accurate. Distance from global optima = 0.00020752627605577398

Trial #: 595 was accurate. Distance from global optima = 0.00021639318442878613

Trial #: 636 was accurate. Distance from global optima = 0.0001976793496392474

Trial #: 695 was accurate. Distance from global optima = 0.00020713594026961822

Trial #: 731 was accurate. Distance from global optima = 0.0001898527834141267

Trial #: 732 was accurate. Distance from global optima = 0.0002030799225599285

Trial #: 783 was accurate. Distance from global optima = 0.0002011873968354511

**Gradient Descent – Momentum+Static LR: k = 0.001**

Average distance from optima: 38.10 units

Average computation time: 0.10 sec

Grand Total Computation time: 1.64 min

Number of trials ran: **1,000**

Total plot points taken: 1002

Accuracy Percentage across all trials: **0.0 %**