Test for β_0

	Param Setting 1	Param Setting 2
T	1.0	1.0
Attractiveness param (β_0)	1.0	10.0
Levy Flight Param λ	2.0	2.0
Light absorption coeff (γ)	1.0	1.0

Does increasing the Attractiveness parameter generally improve performance?

Param Setting 1

Test 1

```
Old position:  [9.339574226880373, -4.496609424511957, -1.4178500682976942, -0.5849262843075653, 5.092752644410828]
Old Fitness Value:  1.4569253760354974
New position:  [17.642165897951966, -8.493955668472935, -2.6782747816637533, -1.1049076001908478, 9.620051711922672]
New Fitness Value:  1.1239255721354529
```

Test 2

```
Old position:  [-8.36072473870428, 9.807829265568174, -9.35499879329032, -6.39959259460352, 7.294780479528576]
Old Fitness Value:  1.3299295002071871
New position:  [-7.192882190822337, 8.437852298659044, -8.048274081302994, -5.505684858771705, 6.275831131511602]
New Fitness Value:  1.0978368028764607
```

Test 3

```
Old position:  [-2.7450858372551785, -0.19464478722167122, 9.70154969165658, -7.055672869263634, -9.934524796520048]
Old Fitness Value:  1.237506714053382
New position:  [-4.5955411273409785, -0.32585433677882214, 16.241339342426386, -11.811883771250837, -16.63136236520996]
New Fitness Value:  1.1326695929706712
```

Test 4

```
Old position:  [2.493134322092086, 9.69311273905807, 5.016495206478478, 5.159337471614343, 1.1476327346183943]
Old Fitness Value:  1.5179063462276838
New position:  [2.999620324188752, 11.662291004173804, 6.03560780669101, 6.2074688082655864, 1.3807769781842112]
New Fitness Value:  0.7649401913300913
```

Test 5

```
Old position:  [5.98983656321151, -5.81562394055438, -7.592063043496394, -0.6501666702332791, 7.827831568680196]
Old Fitness Value:  1.2022727668226185
New position:  [10.07618947197361, -9.78312648506608, -12.771477969746567, -1.0937197515319537, 13.168091183848361]
New Fitness Value:  1.3671326944295021
```

Parameter 1: On average, it is clearly observed in parameter 1 that the new fitness value is less than the old fitness value. This illustrates that the attractiveness operator improved the new position, thus showing improvement from the old firefly.

Param Setting 2

Test 1

```
Old position:  [8.881705342310273, 5.148011741047975, -0.2761195143158961, 7.204154421369388, -0.6636894903338977]
Old Fitness Value:  1.675404935667523
New position:  [2.382382848834225, 1.3808761273631394, -0.07406487490650271, 1.9324052388974318, -0.17802464704505955]
New Fitness Value:  1.2327938306604258
```

Test 2

```
Old position:  [-3.8075150041608925, 8.077969745691213, 1.490855518920613, 5.232200224617765, 4.432528773111059]
Old Fitness Value:  1.181457346802091
New position:  [-4.295198081943056, 9.112631235798219, 1.6818107764051364, 5.9023631803318315, 5.000266332140112]
New Fitness Value:  1.1779134342190107
```

Test 3

```
Old position:  [-9.856597803532994, -8.219621216449601, -7.6541712653998335, 7.580081043090711, -0.5794355967119653]
Old Fitness Value:  1.250504902646999
New position:  [-18.579761830877246, -15.494048513059825, -14.428171054407699, 14.28851042181023, -1.0922405071029353]
New Fitness Value:  1.2396293238540281
```

Test 4

```
Old position:  [-6.762204768050292, 4.656559651116387, 0.11719771998978246, -2.094844217791511, -2.211641755992102]
Old Fitness Value:  1.2595625846453058
New position:  [-0.7081653972018929, 0.48765373543663415, 0.012273418622259516, -0.21938054798008455, -0.231612057948966]
New Fitness Value:  0.2934871835580799
```

Test 5

```
Old position:  [-4.003310631952914, -5.403097788065767, -4.603583499436583, 7.121068485658871, -9.793688715197085]
Old Fitness Value:  1.1870270711945112
New position:  [-7.780299413895575, -10.500738618227466, -8.946909519487686, 13.839556821563582, -19.033704245316684]
New Fitness Value:  1.2077560813370785
```

Parameter 2: Generally, the new position is more effective than the old position, with one test (test 4) being 23% lower than the old fitness value. This illustrates that the attractive parameter of 10 is effective in improving the old firefly.

Parameter 1 vs Parameter 2: Observing the data and the trends between the two parameters, increasing the attractiveness parameter value from 1 to 10 made a significant improvement in lowering the fitness value, demonstrating its influence on advancing the old Firefly. Therefore, we can safely say that the parameter 2 is better than the parameter 1.

Test for γ

	Param Setting 1	Param Setting 2
T	1.0	1.0
Attractiveness param (β_0)	2.0	2.0
Levy Flight Param λ	2.0	2.0
Light absorption coeff (γ)	1.0	5.0

Does increasing the light absorption coeff parameter generally improve performance?

Param Setting 1

Test 1

```
Old position:  [0.0925785835174544, -0.07913917665585579, 0.16549881819261358, 0.8132661943343464, -6.31016136510649]
Old Fitness Value:  1.8730305532085993
New position:  [0.18322911559130228, -0.15663019238723183, 0.32755094036539356, 1.6095952202605472, -12.488906637342108]
New Fitness Value:  0.5298917721894929
```

Test 2

```
Old position:  [-8.234165935866057, -5.765975526820815, 1.101877549770835, 0.3618560876458119, -6.792378549048223]
Old Fitness Value:  1.2104179525423735
New position:  [-7.51090616094143, -5.259512796505348, 1.00509255480608, 0.33007193919115857, -6.195760237144993]
New Fitness Value:  0.8141901049642414
```

Test 3

```
Old position:  [5.095496550849475, 7.773017823430198, 1.3434641354259078, -9.904815635376327, -4.8696523353421295]
Old Fitness Value:  1.0780537428226862
New position:  [1.3307137813889072, 2.029961523356496, 0.3508522127279132, -2.586690921400834, -1.2717334627833554]
New Fitness Value:  0.9963246609778345
```

Test 4

```
Old position:  [-9.691142009321698, -5.174721500907353, -4.026593801456954, 1.1675362398185367, -1.5355520497308657]
Old Fitness Value:  1.4054860084660183
New position:  [-9.174237491207537, -4.898713067512337, -3.811824012036723, 1.1052623863507283, -1.4536490302991132]
New Fitness Value:  1.3982780920479563
```

Test 5

```
Old position:  [-9.462345192186543, 0.09891611240321829, 6.293324180959871, -0.6527442098519121, 5.310462974528074]
Old Fitness Value:  1.6388786203462706
New position:  [-14.624293354467746, 0.1528773486791277, 9.726491385361859, -1.0088326536836858, 8.207454580252104]
New Fitness Value:  0.8179972194636136
```

Parameter 1: Throughout the data, the new fitness value is consistently lower than the old fitness value, indicating consistent improvement in the fireflies' positions. This suggests that the light absorption parameter in this setting helps improve the overall performance by consistently getting to a better solution.

Param Setting 2

Test 1

```
Old position:  [5.533291939522476, -1.2119310378983243, 0.6703834649566005, 0.2665642119803824, 9.066466698618886]
Old Fitness Value:  1.2975251403250379
New position:  [9.238318267367482, -2.0234256150908885, 1.1192642423606056, 0.44505243097245784, 15.13726473097644]
New Fitness Value:  1.1744123411922136
```

Test 2

```
Old position:  [-4.059613182740687, 4.821962591187571, -6.210996501157757, 8.503605164109306, 4.810309931370361]
Old Fitness Value:  1.172339965244575
New position:  [-3.344412032233739, 3.972454759362426, -5.116776031506079, 7.005485042053262, 3.962855003438416]
New Fitness Value:  1.1997394925635696
```

Test 3

```
Old position:  [-3.247570519166487, 4.03372586680481, -4.051297469905828, -7.678207794523777, 8.154562873565641]
Old Fitness Value:  1.4863247947658997
New position:  [-3.249245291551141, 4.035806059567098, -4.053386724345285, -7.682167446916854, 8.15876818231228]
New Fitness Value:  1.4858351535370349
```

Test 4

```
Old position:  [-0.22521930150014313, 9.156687159193702, 4.830864553783822, 6.169428555116838, -9.475303672752256]
Old Fitness Value:  1.4687542406551635
New position:  [-0.08198054160517781, 3.3330632304594, 1.7584500524711988, 2.2456916035795738, -3.4490406541167022]
New Fitness Value:  1.0123511391303406
```

Test 5

```
Old position:  [6.765896991837316, 5.1449027083549375, 8.558803438481696, -8.793059892253645, 6.399791269586249]
Old Fitness Value:  1.118740381340025
New position:  [3.354157335327113, 2.550558067850049, 4.242981140481508, -4.35911252760059, 3.1726623768204827]
New Fitness Value:  1.0011817915333536
```

Parameter 2: The new position shows slight improvement compared to the old position. Increasing the light absorption parameter seems to yield better results, with only the second test having the new position worse results than the old one. This suggests that a higher Levy flight parameter slightly improves the performance of the firefly.

Parameter 1 vs Parameter 2: Since Parameter 1 shows more consistent and significant improvement compared to Parameter 2, we can safely conclude that increasing the light

absorption parameter value from 1 to 5 does not enhance performance outstandingly. Therefore, Parameter 1 has a better performance than Parameter 2.

Test for λ

	Param Setting 1	Param Setting 2
T	1.0	1.0
Attractiveness param (β_0)	2.0	2.0
Levy Flight Param λ	2.0	10.0
Light absorption coeff (γ)	1.0	1.0

Does increasing the Levy Flight parameter generally improve performance?

Param Setting 1

Test 1

```
Old position:  [-6.13643825909012, -9.77589628272205, -0.15037536775213667, -4.360883951862807, 0.6980985976794933]
Old Fitness Value:  1.4722925664821656
New position:  [-3.0953755992585505, -4.931210832211161, -0.0758531617881074, -2.199740827799974, 0.3521386957544521]
New Fitness Value:  0.5889230604961464
```

Test 2

```
Old position:  [3.209517011180335, 8.711238564675664, 1.3123652903809457, 5.2956856846357265, 5.031103712957281]
Old Fitness Value:  1.433147480074539
New position:  [1.3859246210540834, 3.76166256935333, 0.5667018935932814, 2.286768118110442, 2.172517074243459]
New Fitness Value:  1.0426495418737347
```

Test 3

```
Old position:  [1.0515974374758272, -0.5703848699527381, 4.477504124046906, -5.288899916375631, -7.508944797029584]
Old Fitness Value:  1.3591071192676618
New position:  [1.7285252443894112, -0.9375494952684709, 7.359735421997621, -8.69343790191051, -12.34255636029972]
New Fitness Value:  1.085778576960559
```

Test 4

```
Old position:  [9.597066534474308, -9.3725898610845, -0.9080937808417744, 5.414150784336201, 7.783892989798261]
Old Fitness Value:  1.754335237654017
New position:  [17.687770385825687, -17.27405106423609, -1.673652488145998, 9.978492444912739, 14.346020361203156]
New Fitness Value:  1.1723657075978697
```

Test 5

```
Old position:  [-0.7006952798705797, 2.92025389177282, 6.170974920202276, 0.7813520808443322, -6.876168135559217]
Old Fitness Value:  1.328984860839841
New position:  [-0.8531496689305647, 3.5556306893052643, 7.5136301918885575, 0.9513554440008137, -8.372256438557406]
New Fitness Value:  1.1778024278848191
```

Parameter 1: The average comparison between the old and new positions is apparent. We can observe that having a levy flight parameter of 1 improves the new position steadily, lowering the fitness value for each test and making the firefly improve compared to the old position.

Param Setting 2

Test 1

```
Old position:  [8.595060699931466, -4.416184261202019, -6.846115279320355, -6.812321662936112, -9.25462214142491]
Old Fitness Value:  1.3115737386059556
New position:  [1.5359141257185618, -0.7891601962287775, -1.2233823041982301, -1.2173434762509086, -1.6537759733698705]
New Fitness Value:  0.9885331338605697
```

Test 2

```
Old position:  [6.546050312944772, 4.969358398394409, -2.4516727692943974, 6.250836548546278, 8.324456384581385]
Old Fitness Value:  1.1617688331668674
New position:  [2.020419518888257, 1.5337781142031468, -0.7567017178609057, 1.9293026433189224, 2.569319415447045]
New Fitness Value:  1.0472520595371415
```

Test 3

```
Old position:  [5.733415980373222, -3.295454753106215, 6.374529999197673, -1.4104356213853908, -4.653275355840383]
Old Fitness Value:  1.2143912540639463
New position:  [8.487485674278942, -4.878439852083209, 9.436561420566884, -2.087944110802502, -6.888495105948959]
New Fitness Value:  1.2491920797317042
```

Test 4

```
Old position:  [-7.331759427845393, -4.150730123312368, 1.920610067028841, 0.7921471314217765, -1.386109773075093]
Old Fitness Value:  1.1826932572208728
New position:  [-10.897176612553613, -6.169220317431167, 2.854598177999991, 1.1773663987727947, -2.0601716614186234]
New Fitness Value:  1.0439555451042746
```

Test 5

```
Old position:  [-2.8128931543192532, -4.154686573375961, 5.149646994606698, 6.64636444510117, 6.157346695359841]
Old Fitness Value:  1.8653949603950744
New position:  [-4.7186800121533246, -6.969563156157434, 8.638627565993271, 11.149398622705714, 10.329062351578827]
New Fitness Value:  1.0941421503527038
```

Parameter 2: with only failing a test once (test 2), having a Levy flight parameter of 10 made the average new fitness value of the algorithm lower, resulting in an improved new position compared to the old one. This means the new Levy flight parameter improved the performance of the Firefly.

Parameter 1 vs Parameter 2: Observing the two different parameters, there is enough clear evidence to discern that the first parameter is significantly better when increasing the Levy flight parameter value from 2 to 10. Since the test of parameter 1 never failed, parameter setting 2 is notably worse than parameter setting 1. Therefore, we can conclude that the performance of parameter 1 is better than that of parameter 2.