

# Project 1 - Report

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Project 1 for CS 470 - Benchmark Functions.  
Construct modular, object-oriented, code that can perform 18 separate  
benchmark functions.

## 1 INTRODUCTION

Using the given 18 standard benchmark functions, we test each function against 10, 20, and 30 dimensional vectors. Each benchmark function is tested against a matrix that was constructed using a Mersenne Twister (MT). The results are saved to an Analysis.csv (Excel) file.

## 2 RESULTS

Below, you will find my results for running all the functions against 10-Dimensional, 20-Dimensional, and 30-Dimensional vectors.

I have also included an additional test result against 100-Dimensional vectors for comparison.

Function ID	Average Fitness	Standard Deviation	Range(min)	Range(max)	Median	Time(ms)
1	4252.761982	714.320638	2598.572988	5782.735209	4232.580741	0
2	34826.4601	7062.758192	19895.71369	47829.18262	35481.34818	0
3	18870191566	7068287542	5028879143	33656628592	20020878001	0
4	313280.8257	63246.79188	178276.8969	428144.2122	314906.7597	0
5	218.673328	44.14632	125.352281	300.060664	222.758487	0
6	-6.543233	0.686878	-7.876669	-5.187031	-6.532075	0
7	28.861316	5.467626	19.017049	40.959799	29.408532	0
8	188.62673	31.956364	118.619435	237.742752	197.322654	0
9	182.778031	9.196298	149.661029	195.508446	184.282466	0
10	40.022621	787.67555	-1214.453911	1802.889503	46.433934	0
11	190.692478	646.194038	-1133.361171	1310.886301	276.814342	0
12	4.49546	0.210152	3.881115	4.943585	4.500023	0
13	-1.248116	0.701222	-2.422084	-0.002885	-1.093832	0
14	0.002248	0.071519	-0.282891	0.259726	0	0
15	1150267486	457100615.8	358847201.8	2234035553	1134635961	0
16	583.638148	409.41998	117.153958	1683.0848	448.158323	0
17	35346.36988	7129.706271	20262.83574	48453.763	35985.64898	0
18	328.88282	67.797535	178.18728	502.233558	323.048638	0

Figure 2.1: Results For 10 Dimensions

Function ID	Average Fitness	Standard Deviation	Range(min)	Range(max)	Median	Time(ms)
1	8317.91429	947.999891	6273.182179	10505.19248	8364.262518	0
2	66949.78266	9283.410252	49416.67816	87197.56014	66841.89452	0
3	38123957302	7960959492	25279149303	53977150187	39143671001	0
4	1204678.171	166500.3795	895470.739	1567935.014	1195259.65	0
5	419.436147	58.02131	309.854239	545.984751	418.761841	0
6	-13.89092	0.965294	-15.298884	-12.196556	-13.644906	0
7	64.080042	8.63501	45.852888	82.724681	64.78242	0
8	388.0307	39.492819	302.353277	472.437438	391.399677	0
9	384.055799	13.287305	355.058301	402.943804	385.60364	0
10	-162.629364	1239.774372	-2212.528458	2620.465796	10.062963	0
11	502.162908	796.341502	-1004.241144	1986.566903	647.411916	0
12	9.553681	0.299447	8.676214	9.94332	9.613992	0
13	-2.10639	1.058051	-4.304343	-0.202124	-1.874791	0
14	0.013705	0.099443	-0.342791	0.333282	0	0
15	4031867673	1054794454	2525286995	7057414661	3704758361	0
16	881.107816	684.929752	219.439914	2683.328287	660.321987	0
17	67966.51245	9377.33192	50255.1951	88381.88199	67829.88504	0
18	635.804051	85.211591	474.993702	771.21442	630.070169	0

Figure 2.2: Results For 20 Dimensions

Function ID	Average Fitness	Standard Deviation	Range(min)	Range(max)	Median	Time(ms)
1	12487.20381	1161.251801	9583.303936	14993.46858	12519.60228	0
2	102502.452	16172.76214	72118.65533	149717.8064	102933.2466	0
3	60153931374	14790738076	37609709827	1.10934E+11	59234374398	0
4	2766367.179	434623.5941	1971002.005	4042728.445	2773052.601	0
5	641.640325	101.079763	451.741596	936.73629	644.332791	0
6	-21.195412	1.245078	-23.215628	-18.751855	-21.108009	0
7	99.046331	11.3059	76.572346	126.368853	99.702794	0
8	593.802492	59.1787	483.940154	713.266712	596.921495	0
9	584.612764	16.839674	542.104968	610.938337	585.464845	0
10	-54.283097	1512.589575	-3968.330939	2818.563898	-146.868603	0
11	366.597902	1050.495265	-1619.938728	2969.095833	373.994784	1
12	14.603526	0.309236	13.899373	15.141653	14.642476	0
13	-3.048995	1.240638	-5.131251	-0.642813	-2.466552	0
14	0.036264	0.155399	-0.342809	0.642204	0	0
15	8931221357	2085405826	5467248446	13675803837	8587796082	0
16	1576.219684	1120.928562	345.124812	4795.342275	1302.727849	0
17	104039.184	16322.77727	73289.42698	151606.4846	104523.9018	0
18	951.76243	113.958525	719.665985	1226.145128	963.62249	0

Figure 2.3: Results For 30 Dimensions

Function ID	Average Fitness	Standard Deviation	Range(min)	Range(max)	Median	Time(ms)
1	41924.98688	1886.452614	35990.29879	45695.26414	42291.67713	1
2	330485.8311	27287.45603	280742.7173	385414.5477	327101.7792	0
3	1.95422E+11	24240842417	1.5701E+11	2.54211E+11	1.90465E+11	0
4	29757751.98	2453170.562	25377150.62	34725025.64	29453828.23	0
5	2066.536444	170.5466	1755.641983	2409.840923	2045.38612	0
6	-72.425325	2.399348	-77.979204	-67.958151	-72.497496	0
7	337.327126	16.611262	287.605101	360.987111	342.142997	1
8	1982.482025	107.074238	1793.268556	2211.512304	1963.545451	1
9	1988.552973	32.846326	1935.838919	2070.682682	1988.500185	1
10	-226.209343	2587.448196	-5459.930855	6050.725565	-219.716751	2
11	949.579675	1620.364229	-2211.013996	3927.960345	1156.753966	2
12	49.885334	0.636732	48.950892	51.93546	49.90954	1
13	-11.452773	2.164771	-17.418506	-8.162075	-11.209714	0
14	0.039779	0.315153	-0.564117	0.900157	-0.008167	1
15	98002532743	12541149516	73457769056	1.25704E+11	95677195296	0
16	6550.301144	3936.567044	1213.024453	15686.57639	6154.623374	0
17	335481.3307	27546.61007	285217.2451	390859.4228	332060.2194	0
18	3174.241908	264.990467	2469.533125	3989.789748	3204.609111	0

Figure 2.4: Results For 100 Dimensions

## 2.1 LIST OF FUNCTIONS

- 1 Schwefel's Function
- 2 1st De Jong's Function
- 3 Rosenbrock
- 4 Rastrigin
- 5 Griewangk
- 6 Sine Envelope Sine Wave
- 7 Stretched V Sine Wave
- 8 Ackley's One
- 9 Ackley's Two
- 10 Egg Holder
- 11 Rana
- 12 Pathological
- 13 Michalewicz
- 14 Masters Cosine Wave
- 15 Quartic
- 16 Levy
- 17 Step
- 18 Alpine

## 3 ANALYSIS

Comparing the results, especially the 100-Dimensional results, we can see that functions 2, 3, 4, 5, 6, 13, 15, 16, 17, and 18 outperformed all the other functions in regards to Time(ms). And out of all the functions, function 7 seemed to have the best average fitness when compared with the globale best fitness for each function. Given a small data set, when refering to the number of dimensions, each function performs in under 1 ms. However, we see that as the number of dimensions increases, functions 1, 7, 8, 9, 10, 11, 12, and 14 take more time to execute. Of these functions, functions 10 and 11 seem to be the slowest.

## 4 CONCLUSION

Given the randomization of the data being passed to the functions, all function are nowhere near the desired global best fitness. If speed is desired, function 2, 3, 4, 5, 6, 13, 15, 16, 17, and 18 seem to be the optimal choice. However, if accuracy is desired, then function 7 is the best solution.

Table 4.1: Results For 10 Dimensions

Function	Range			Median	Time (ms)
	Avg	Standard Deviation	min	max	
$f_1$	4252.761982	714.320638	2598.57298799999	5782.735209	4232.580741
$f_2$	34826.460098	7062.758192	19895.713688	47829.182616	35481.348175
$f_3$	18870191565.8881	7068287541.97648	5028879143.46933	33656628592.0568	20020878000.7148
$f_4$	313280.82574	63246.79188	178276.896865	428144.212232	314906.759711
$f_5$	218.673328	44.14632	125.352281	300.060664	222.758487
$f_6$	-6.543233	0.686878	-7.876669	-5.187031	-6.532075
$f_7$	28.861316	5.467626	19.017049	40.959799	29.408532
$f_8$	188.62673	31.956364	118.619435	237.742752	197.322654
$f_9$	182.778031	9.196298	149.661029	195.508446	184.282466
$f_{10}$	40.022621	787.67555	-1214.453911	1802.889503	46.433934
$f_{11}$	190.692478	646.194038	-1133.361171	1310.886301	276.814342
$f_{12}$	4.49546	0.210152	3.881115	4.943585	4.500023
$f_{13}$	-1.248116	0.701222	-2.422084	-0.002885	-1.093832
$f_{14}$	0.002248	0.071519	-0.282891	0.259726	0
$f_{15}$	1150267486.18219	457100615.755741	358847201.810192	2234035553.07262	1134635961.32341
$f_{16}$	583.638148	409.41998	117.153958	1683.0848	448.158323
$f_{17}$	35346.369876	7129.706271	20262.835742	48453.763004	35985.648981
$f_{18}$	328.88282	67.797535	178.18728	502.233558	323.048638