

**Table 1. Unimodal Benchmark Functions.**

Function Name	Function	D	S	$F_{min}$
Sphere	$f_1(x) = \sum_{i=1}^D x_i^2$	30	$[-100, 100]^D$	0
Schwefel's 2.22	$f_2(x) = \sum_{i=1}^D  x_i  + \prod_{i=1}^D  x_i $	30	$[-10, 10]^D$	0
Schwefel's 1.20	$f_3(x) = \sum_{i=1}^D \left( \sum_{j=1}^D x_j \right)^2$	30	$[-100, 100]^D$	0
Schwefel's 2.21	$f_4(x) = \max_i \{  x_i , 1 \leq i \leq D \}$	30	$[-100, 100]^D$	0
Rosenbrock	$f_5(x) = \sum_{i=1}^{D-1} [100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	30	$[-30, 30]^D$	0
Step	$f_6(x) = \sum_{i=1}^D (x_i + 0.5)^2$	30	$[-100, 100]^D$	0
Quartic Noise	$f_7(x) = \sum_{i=1}^n i x_i^4 + \text{random}[0, 1)$	30	$[-1.28, 1.28]^D$	0

**Table 2. Multimodal Benchmark Functions.**

Function Name	Function	D	S	$F_{min}$
Schwefel's 2.26	$f_8(x) = \sum_{i=1}^D -x_i \sin(\sqrt{ x_i })$	30	$[-500, 500]^D$	-12569.5
Rastrigin	$f_9(x) = \sum_{i=1}^D [x_i^2 - 10 \cos(2\pi x_i + 10)]$	30	$[-5.12, 5.12]^D$	0
Ackley	$f_{10}(X) = -20 \exp \left( -0.2 \sqrt{\frac{1}{n} \sum_{i=1}^n x_i^2} \right) - \exp \left( \frac{1}{n} \sum_{i=1}^n \cos(2\pi x_i) \right) + 20 + e$	30	$[-32, 32]^D$	0
Griewank	$f_{11}(X) = \frac{1}{4000} \sum_{i=1}^n x_i^2 - \prod_{i=1}^n \cos \left( \frac{x_i}{\sqrt{i}} \right) + 1$	30	$[-600, 600]^D$	0
Pendulized	$f_{12}(x) = \sum_{i=1}^D u(x_i, 10, 100, 4)$ $+ \frac{\pi}{D} \left\{ 10 \sin^2(3\pi y_i) + \sum_{i=1}^{D-1} (y_i - 1)^2 [1 + \sin^2(3\pi y_{i+1})] + (y_D - 1)^2 \right\}$ $y_i = 1 + \frac{1}{4} (x_i + 1)$ $u(x_i, a, k, m) = \begin{cases} k(x_i - 1)^m, & x_i > a, \\ 0, & -a \leq x_i \leq a, \\ k(-x_i - 1)^m, & x_i < -a, \end{cases}$	30	$[-50, 50]^D$	0