

**Table 1:** Test functions used in experiments.

Label	Name	Formulation	Type	Range	$f(x^*)$
F1	Rosenbrock	$f_1(\vec{X}) = \sum_{i=1}^{D-1} \left[ 100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2 \right]$	UN	$[-2.048, 2.048]^D$	0
F2	Ackley	$f_2(\vec{X}) = -20 \exp \left( -0.2 \sqrt{\frac{1}{D} \sum_{i=1}^D x_i^2} \right) - \exp \left( \frac{1}{D} \sum_{i=1}^D \cos(2\pi x_i) \right) + 20 + e$	MS	$\left[ \begin{array}{c} -32.768, \\ 32.768 \end{array} \right]^D$	0
F3	Rastrigin	$f_3(\vec{X}) = \sum_{i=1}^D \left[ x_i^2 - 10 \cos(2\pi x_i) + 10 \right]$	MS	$[-5.12, 5.12]^D$	0
F4	Griewank	$f_4(\vec{X}) = \frac{1}{4000} \sum_{i=1}^D x_i^2 - \prod_{i=1}^D \cos \left( \frac{x_i}{\sqrt{i}} \right) + 1$	MN	$[-600, 600]^D$	0
F5	Weierstrass	$f_5(\vec{X}) = \sum_{i=1}^D \left( \sum_{k=0}^{k_{\max}} \left[ a^k \cos(2\pi b^k (x_i + 0.5)) \right] \right) - D \sum_{k=0}^{k_{\max}} \left[ a^k \cos(2\pi b^k 0.5) \right], \quad a = 0.5, \quad b = 3, \quad k_{\max} = 20$	MS	$[-0.5, 0.5]^D$	0
F6	Schwefel 2.26	$f_6(\vec{X}) = 418.9829 \times D - \sum_{i=1}^D -x_i \sin \left( \sqrt{ x_i } \right)$	MS	$[-500, 500]^D$	$-418.98 \times D$
F7	Shifted Sphere	$f_7(\vec{X}) = \sum_{i=1}^D z_i^2 - f_{\text{bias}}, \quad z = x - o, \quad f_{\text{bias}} = -450$	US	$[-100, 100]^D$	$f_{\text{bias}}$
F8	Shifted Schwefel 1.2	$f_8(\vec{X}) = \sum_{i=1}^D \left( \sum_{j=1}^i z_j \right) + f_{\text{bias}}, \quad z = x - o, \quad f_{\text{bias}} = -450$	UN	$[-100, 100]^D$	$f_{\text{bias}}$
F9	Shifted Rosenbrock	$f_9(\vec{X}) = \sum_{i=1}^{D-1} \left( 100(z_i^2 - z_{i+1})^2 + (z_i - 1)^2 \right) + f_{\text{bias}}, \quad z = x - o + 1, \quad f_{\text{bias}} = 390$	MN	$[-100, 100]^D$	$f_{\text{bias}}$
F10	Shifted Rastrigin	$f_{10}(\vec{X}) = \sum_{i=1}^D \left[ z_i^2 - 10 \cos(2\pi z_i) + 10 \right] + f_{\text{bias}}, \quad z = x - o, \quad f_{\text{bias}} = -330$	MS	$[-5, 5]^D$	$f_{\text{bias}}$
F11	Step	$f_{11}(\vec{X}) = \sum_{i=1}^D (\lfloor x_i + 0.5 \rfloor^2)$	US	$[-100, 100]^D$	0
F12	Penalized 2	$f_{12}(\vec{X}) = \frac{1}{10} \left\{ \sin^2(\pi x_1) + \sum_{i=1}^{D-1} (x_i - 1)^2 \left[ 1 + \sin^2(3\pi x_{i+1}) \right] + (x_n - 1)^2 \right\} \\ \left[ 1 + \sin^2(2\pi x_{i+1}) \right] + \sum_{i=1}^D u(x_i, 5, 100, 4)$	MN	$\left[ \begin{array}{c} -50, 50 \\ \end{array} \right]^D$	0
F13	Alpine	$f_{13}(\vec{X}) = \sum_{i=1}^D  x_i \cdot \sin(x_i) + 0.1 \cdot x_i $	MS	$[-10, 10]^D$	0