

1. **Extended Trigonometric function:**

$$f(x) = \sum_{i=1}^n \left((n - \sum_{j=1}^n \cos(x_j)) + i(1 - \cos(x_i)) - \sin(x_i) \right)^2,$$

$$x_0 = [0.2, 0.2, \dots, 0.2].$$

2. **Generalized Rosenbrock function:**

$$f(x) = \sum_{i=1}^{n-1} (c(x_{i+1} - x_i^2)^2 + (1 - x_i)^2),$$

$$x_0 = [-1.2, 1, -1.2, 1, \dots, -1.2, 1], \quad c = 100.$$

3. **Extended Penalty function:**

$$f(x) = \sum_{i=1}^{n-1} (x_i - 1)^2 + \left(\sum_{j=1}^n x_j^2 - 0.25 \right)^2,$$

$$x_0 = [1, 2, \dots, n].$$

4. **Perturbed Quadratic function:**

$$f(x) = \sum_{i=1}^n i x_i^2 + \frac{1}{100} \left(\sum_{i=1}^n x_i \right)^2$$

$$x_0 = [0.5, 0.5, \dots, 0.5].$$

5. **Generalized Tridiagonal 1 function:**

$$f(x) = \sum_{i=1}^{n-1} (x_i + x_{i+1} - 3)^2 + (x_i - x_{i+1} + 1)^4,$$

$$x_0 = [2, 2, \dots, 2].$$

6. **Generalized White & Holst function:**

$$f(x) = \sum_{i=1}^{n-1} c(x_{i+1} - x_i^3)^2 + (1 - x_i)^2, \quad c = 100,$$

$$x_0 = [-1.2, 1, -1.2, 1, \dots, -1.2, 1].$$

7. **Generalized PSC1 function:**

$$f(x) = \sum_{i=1}^{n-1} (x_i^2 + x_{i+1}^2 + x_i x_{i+1})^2 + \sin^2(x_i) + \cos^2(x_i),$$

$$x_0 = [3, 0.1, \dots, 3, 0.1].$$

8. **Full Hessian FH1 function:**

$$f(x) = (x_1 - 3)^2 + \sum_{i=2}^n \left(x_1 - 3 - 2 \left(\sum_{j=1}^i x_j \right)^2 \right)^2,$$

$$x_0 = [0.01, 0.01, \dots, 0.01].$$

9. **Full Hessian FH2 function:**

$$f(x) = (x_1 - 5)^2 + \sum_{i=2}^n \left(\sum_{j=1}^i x_j - 1 \right)^2,$$

$$x_0 = [0.01, 0.01, \dots, 0.01].$$

10. **Perturbed Quadratic Diagonal function:**

$$f(x) = \left(\sum_{i=1}^n x_i \right)^2 + \sum_{i=1}^n \frac{i}{100} x_i^2,$$

$$x_0 = [0.5, 0.5, \dots, 0.5].$$

11. **Quadratic QF1 function:**

$$f(x) = \frac{1}{2} \sum_{i=1}^n i x_i^2 - x_n,$$

$$x_0 = [1, 1, 1, \dots, 1]$$

12. **Extended quadratic penalty QP1 function:**

$$f(x) = \sum_{i=1}^{n-1} (x_i^2 - 2)^2 + \sum_{i=1}^n (x_i^2 - 0.5)^2$$

$$x_0 = [1, 1, 1, \dots, 1]$$

13. **Extended quadratic penalty QP2 function:**

$$f(x) = \left(\sum_{i=1}^n x_i^2 - 100 \right)^2 + \sum_{i=1}^{n-1} (x_i^2 - \sin x_i)^2$$

$$x_0 = [1, 1, 1, \dots, 1]$$

14. **Quadratic QF2 function:**

$$f(x) = \frac{1}{2} \sum_{i=1}^n i (x_i^2 - 1)^2 - x_n$$

$$x_0 = [0.5, 0.5, 0.5, \dots, 0.5]$$

15. **Extended Tridiagonal 2 function:**

$$f(x) = \sum_{i=1}^{n-1} (x_i x_{i+1} - 1)^2 + c(x_i + 1)(x_{i+1} + 1)$$

$$x_0 = [1, 1, 1, \dots, 1], \quad c = 0.1$$

16. **FLETGBV3 function (CUTE):**

$$f(x) = \frac{1}{2} p(x_1^2 + x_n^2) + \frac{p}{2} \sum_{i=1}^{n-1} (x_i - x_{i+1})^2 - \sum_{i=1}^n \left(\frac{p(h^2 + 2)}{h^2} x_i + \frac{cp}{h^2} \cos(x_i) \right),$$

where:

$$p = \frac{1}{10^8}, \quad h = \frac{1}{n+1}, \quad c = 1,$$

$$x_0 = [h, 2h, \dots, nh].$$

17. **FLETCHCR function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} c(x_{i+1} - x_i + 1 - x_i^2)^2$$

$$x_0 = [0, 0, 0, \dots, 0], \quad c = 100$$

18. **BDQRTIC function (CUTE):**

$$f(x) = \sum_{i=1}^{n-4} (-4x_i + 3)^2 + (x_i^2 + 2x_{i+1}^2 + 3x_{i+2}^2 + 4x_{i+3}^2 + 5x_n^2)^2,$$

$$x_0 = [1, 1, \dots, 1].$$

19. **TRIDIA function (CUTE):**

$$f(x) = \gamma(\delta x_1 - 1)^2 + \sum_{i=2}^n i(\alpha x_i - \beta x_{i-1})^2$$

where:

$$\alpha = 2, \quad \beta = 1, \quad \gamma = 1, \quad \delta = 1$$

$$x_0 = [1, 1, 1, \dots, 1]$$

20. **ARWHEAD function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} (-4x_i + 3) + \sum_{i=1}^{n-1} (x_i^2 + x_n^2)^2$$

$$x_0 = [1, 1, 1, \dots, 1]$$

21. **NONDIA function (CUTE):**

$$f(x) = (x_1 - 1)^2 + \sum_{i=2}^n 100(x_1 - x_{i-1}^2)^2,$$

$$x_0 = [-1, -1, -1, \dots, -1]$$

22. **NONDQUAR function (CUTE):**

$$f(x) = (x_1 - x_2)^2 + \sum_{i=1}^{n-2} (x_i + x_{i+1} + x_n)^4 + (x_{n+1} + x_n)^2,$$

$$x_0 = [1, -1, \dots, 1, -1]$$

23. **EG2 function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} \sin(x_1 + x_i^2 - 1) + \frac{1}{2} \sin(x_n^2)$$

$$x_0 = [1, 1, 1, \dots, 1]$$

24. **CURLY20 function (CUTE):**

$$f(x) = \sum_{i=1}^n (q_i^4 - 20q_i - 0.1q_i)$$

where:

$$q_i = \begin{cases} x_i + x_{i+1} + x_{i+2} + \cdots + x_{i+k}, & \text{if } i \leq n-k \\ x_i + x_{i+1} + x_{i+2} + \cdots + x_n, & \text{if } i > n-k \end{cases}$$

$$k = 20, \quad x_0 = \left[\frac{0.001}{n+1}, \dots, \frac{0.001}{n+1} \right].$$

25. **Partially Perturbed Quadratic function:**

$$f(x) = x_1^2 + \sum_{i=1}^n \left[ix_i^2 + \frac{1}{100} \left(\sum_{j=1}^i x_j \right)^2 \right],$$

$$x_0 = [0.5, 0.5, \dots, 0.5].$$

26. **Broyden Tridiagonal function:**

$$f(x) = (3x_1 - 2x_1^2)^2 + \sum_{i=2}^{n-1} (3x_i - 2x_i^2 - x_{i-1} - 2x_{i+1} + 1)^2 + (3x_n - 2x_n^2 - x_{n-1} + 1)^2,$$

$$x_0 = [-1, -1, \dots, -1].$$

27. **Perturbed Tridiagonal Quadratic function:**

$$f(x) = x_1^2 + \sum_{i=2}^{n-1} ix_i^2 + (x_{i-1} + x_i + x_{i+1})^2,$$

$$x_0 = [0.5, 0.5, \dots, 0.5].$$

28. **Staircase 1 function:**

$$f(x) = \sum_{i=1}^n \left(\sum_{j=1}^i x_j \right)^2,$$

$$x_0 = [1, 1, \dots, 1].$$

29. **Staircase 2 function:**

$$f(x) = \sum_{i=1}^n \left[\left(\sum_{j=1}^i x_j \right) - i \right]^2,$$

$$x_0 = [0, 0, \dots, 0].$$

30. **LIARWHD function (CUTE):**

$$f(x) = \sum_{i=1}^n 4(-x_1 + x_i^2)^2 + \sum_{i=1}^n (x_i - 1)^2$$

$$x_0 = [4, 4, \dots, 4].$$

31. **ENGVAL1 function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} (x_i^2 + x_{i+1}^2)^2 + \sum_{i=1}^{n-1} (-4x_i + 3),$$

$$x_0 = [2, 2, \dots, 2].$$

32. **EDENSCH function (CUTE):**

$$f(x) = 16 + \sum_{i=1}^{n-1} [(x_i - 2)^4 + (x_i x_{i+1} - 2x_{i+1})^2 + (x_{i+1} + 1)^2]$$

$$x_0 = [0, 0, \dots, 0].$$

33. **INDEF function (CUTE):**

$$f(x) = \sum_{i=2}^{n-1} \cos(2x_i - x_n - x_1) + \sum_{i=1}^n x_i,$$

$$x_0 = \left[\frac{1}{n+1}, \frac{2}{n+1}, \dots, \frac{n}{n+1} \right].$$

34. **CUBE function (CUTE):**

$$f(x) = (x_1 - 1)^2 + \sum_{i=2}^n 100 (x_i - x_{i-1}^3)^2,$$

$$x_0 = [-1.2, 1, -1.2, 1, \dots].$$

35. **EXPLIN1 function (CUTE):**

$$f(x) = \sum_{i=1}^n \exp(0.1x_i x_{i+1}) - 10 \sum_{i=1}^n i x_i,$$

$$x_0 = [0, 0, \dots, 0].$$

36. **BDEXP function (CUTE):**

$$f(x) = \sum_{i=1}^{n-2} (x_i + x_{i+1}) \exp(-x_{i+2}(x_i + x_{i+1}))$$

$$x_0 = [1, 1, \dots, 1].$$

37. **HARKERP2 function (CUTE):**

$$f(x) = \left(\sum_{i=1}^n x_i \right)^2 - \sum_{i=1}^n \left(x_i + \frac{1}{2} x_i^2 \right) + 2 \sum_{i=2}^n \left(\sum_{j=i}^n x_j \right)^2,$$

$$x_0 = [1, 2, \dots, n].$$

38. **GENHUMPS function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} (\sin(2x_i)^2 \sin(2x_{i+1})^2 + 0.05(x_i^2 + x_{i+1}^2)),$$

$$x_0 = [-506, 506.2, \dots, 506.2].$$

39. **MCCORMCK function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} (-1.5x_i + 2.5x_{i+1} + 1 + (x_i - x_{i+1})^2 + \sin(x_i + x_{i+1}))$$

$$x_0 = [1, 1, \dots].$$

40. **NONSCOMP function (CUTE):**

$$f(x) = (x_1 - 1)^2 + \sum_{i=2}^n 4(x_i - x_{i-1}^2)^2$$

$$x_0 = [3, 3, \dots].$$

41. **SINQUAD function (CUTE):**

$$f(x) = (x_1 - 1)^4 + \sum_{i=2}^{n-1} (\sin(x_i - x_n) - x_1^2 + x_i^2)^2 + (x_n^2 - x_1^2)^2,$$

$$x_0 = [0.1, 0.1, \dots].$$

42. **LIARWHD function (CUTE):**

$$f(x) = \sum_{i=1}^n 4(x_i^2 - x_1)^2 + \sum_{i=1}^n (x_i - 1)^2$$

$$x_0 = [4, 4, 4, \dots, 4]$$

43. **DIXON3DQ function (CUTE):**

$$f(x) = (x_1 - 1)^2 + \sum_{i=1}^{n-1} (x_i - x_{i+1})^2 + (x_n - 1)^2,$$

$$x_0 = [-1, -1, \dots, -1].$$

44. **COSINE function (CUTE):**

$$f(x) = \sum_{i=1}^{n-1} \cos(-0.5x_{i+1} + x_i^2),$$

$$x_0 = [1, 1, \dots, 1].$$

45. **SINE function:**

$$f(x) = \sum_{i=1}^{n-1} \sin(-0.5x_{i+1} + x_i^2),$$

$$x_0 = [1, 1, \dots, 1].$$

46. **BIGGSB1 function (CUTE):**

$$f(x) = (x_1 - 1)^2 + \sum_{i=1}^{n-1} (x_{i+1} - x_i)^2 + (1 - x_n)^2,$$

$$x_0 = [0, 0, \dots].$$

47. **Generalized Quartic function:**

$$f(x) = \sum_{i=1}^{n-1} x_i^2 + (x_{i+1} + x_i^2)^2,$$

$$x_0 = [1, 1, \dots].$$

48. **Full Hessian FH3 function:**

$$f(x) = \left(\sum_{i=1}^n x_i \right)^2 + \sum_{i=1}^n (x_i \exp(x_i) - 2x_i - x_i^2),$$

$$x_0 = [1, 1, \dots, 1].$$