

Supplementary file of “Neural Net-Enhanced Competitive Swarm Optimizer for Large-scale Multi-objective Optimization”

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1. Supplementary Figures and Tables

1.1 Figures:

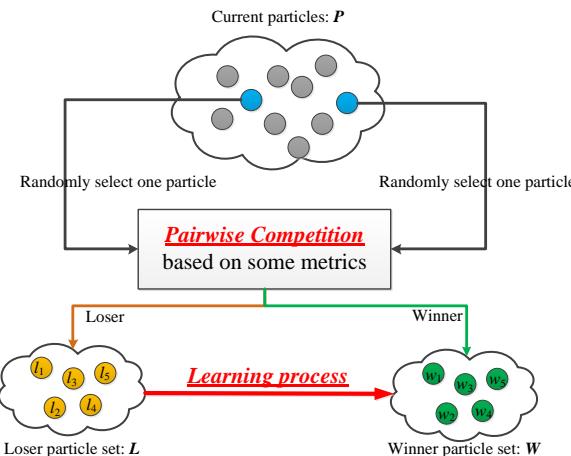
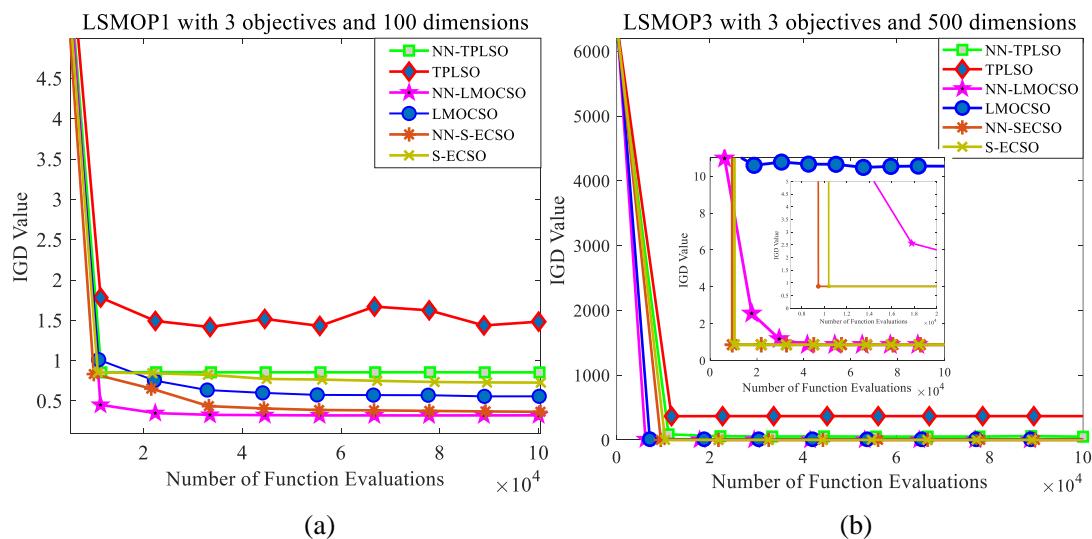


Fig. A. 1 The schematic of the pairwise competition and learning process of CSO.



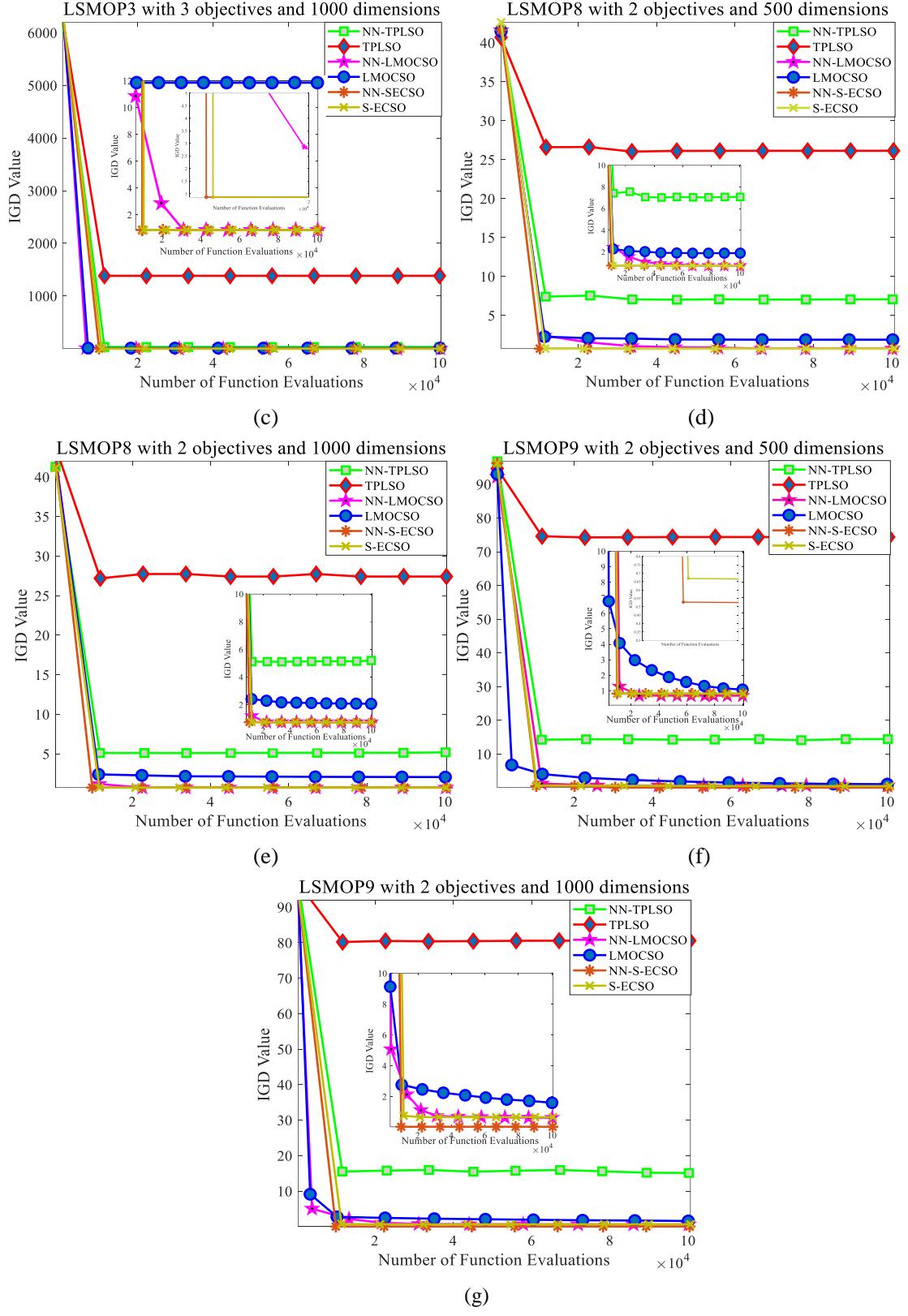


Fig. A.2. The convergence profiles of six compared algorithms on a) LSMOP1 with 3 objectives and 100 decision variables, b) LSMOP3 with 3 objectives and 500 decision variables, c) LSMOP3 with 3 objectives and 1000 decision variables, d) LSMOP8 with 2 objectives and 500 decision variables, e) LSMOP8 with 2 objectives and 1000 decision variables, f) LSMOP9 with 2 objectives and 500 decision variables, and g) LSMOP9 with 2 objectives and 1000 decision variables, respectively.

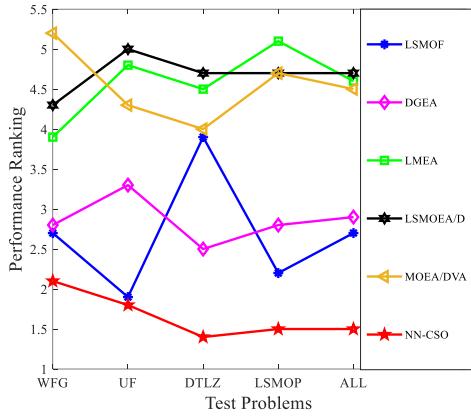


Fig. A. 3. The illustration of the average performance ranks over different test problems.

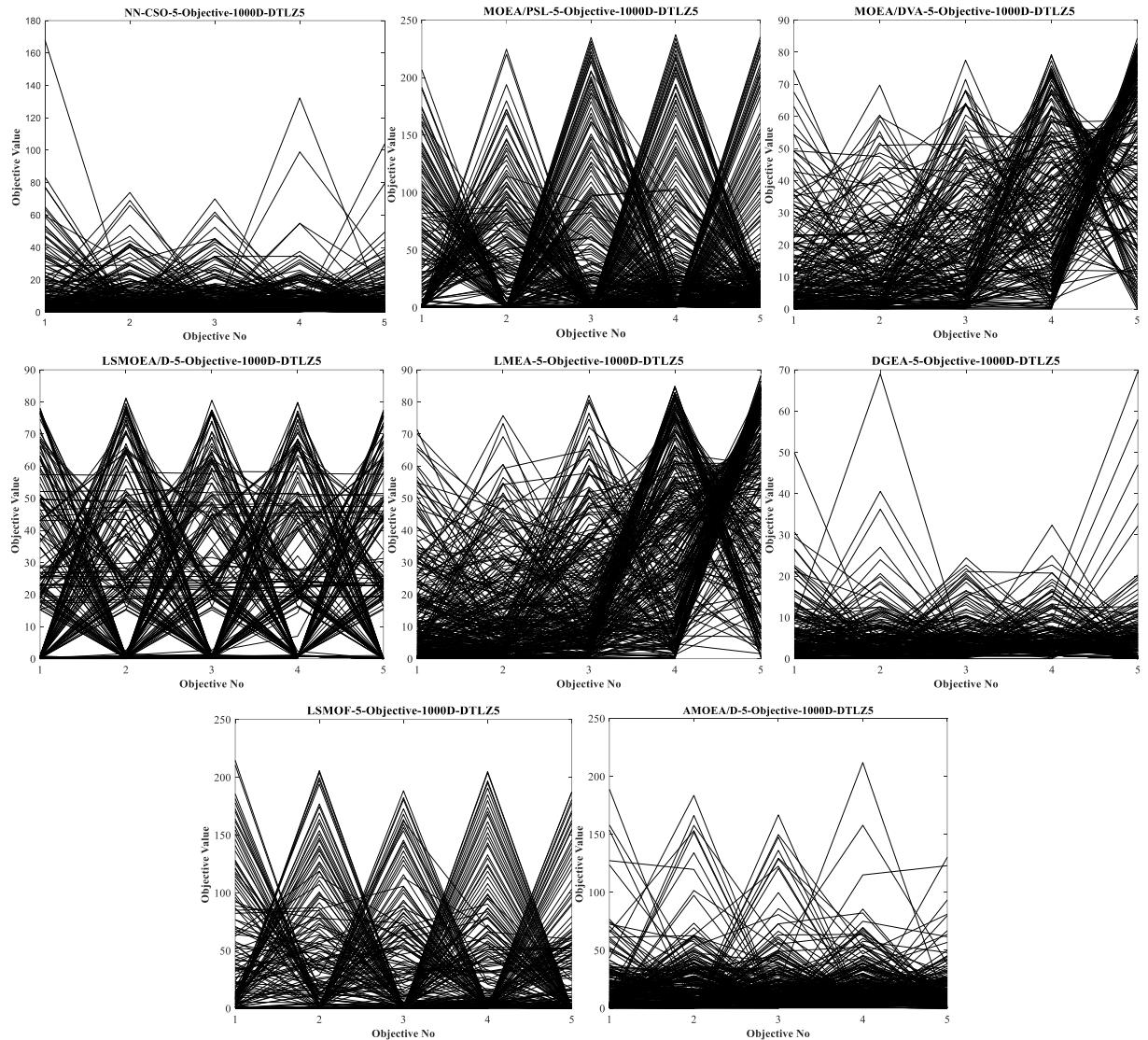


Fig. A. 4. The final population sets obtained by eight compared algorithms on 5-objective DTLZ5 with 1000 decision variables.

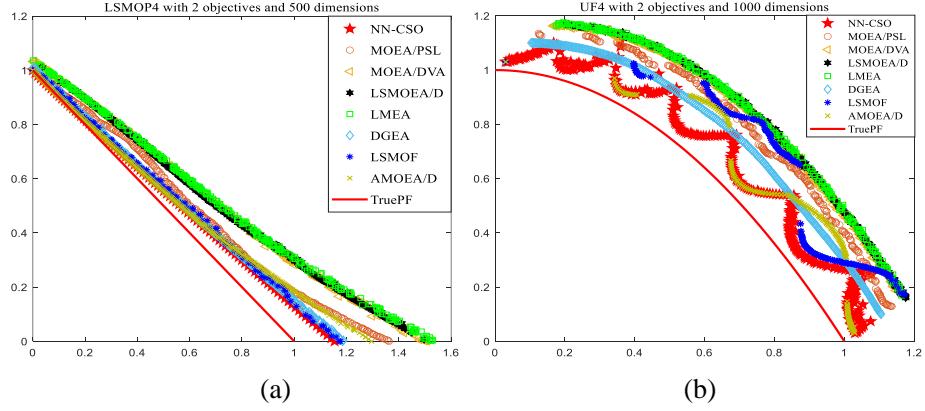


Fig. A. 5. The final population sets obtained by eight compared algorithms on a) 2-objective LSMOP4 with 500 decision variables, and b) 2-objective UF4 with 1000 decision variables.

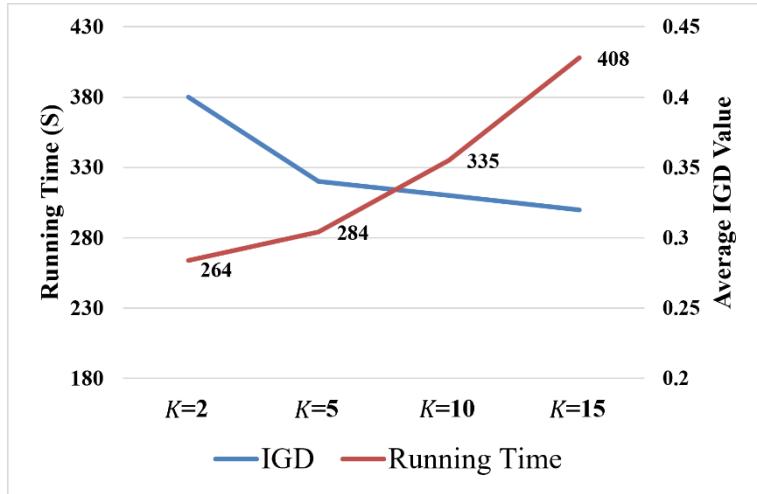


Fig. A. 6. The average IGD values and running time of NN-CSO with different values of K in solving 2-objective LSMOP1 with 1000 decision variables.

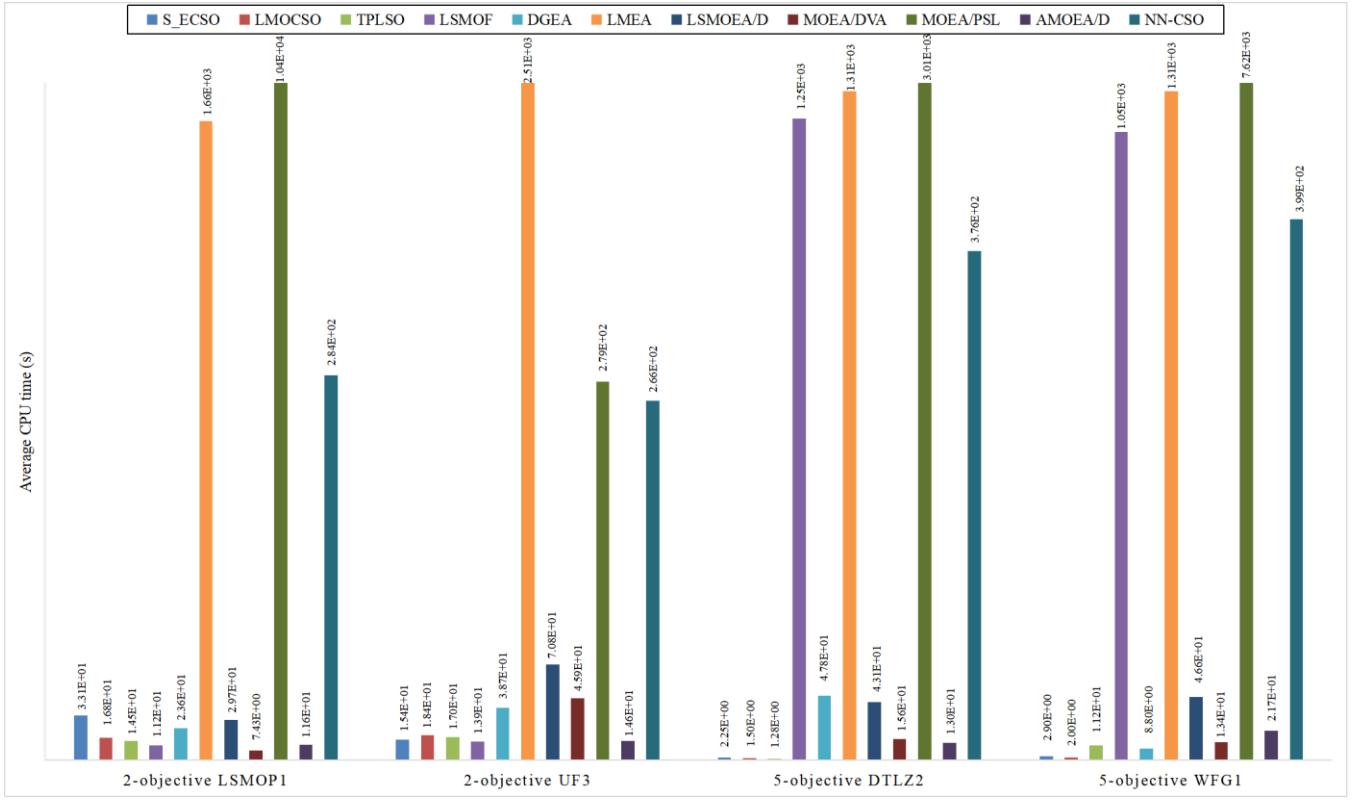


Fig. A. 7. The average CPU running times of NN-CSO and other compared algorithms on 2-objective LSMOP1, 2-objective UF3, 5-objective DTLZ2 and 5-objective WFG1 problems with 1000 decision variables.

1.2 Tables:

TABLE A. 1
SEARCH STRATEGIES AND PARAMETERS SETTINGS OF ALL THE COMPARED ALGORITHMS.

| Algorithms | Search Strategies | Parameter settings |
|------------|---|--|
| LMCSO | Proposed CSO+PM | $p_m = 1/D, n_m = 20, \alpha = 2$ |
| S_ECSO | Proposed CSO+Proposed Convex Sparse Operator | $\lambda_{initial} = 0.35, w = 0.7968, c_1 = 1.4962, c_2 = 1.4962$ |
| MOEA/DVA | Variable Analysis + DE +PM | $CR = 1.0, F = 0.5, p_m = 1/D, n_m = 20, NCA = 20, NIA = 6$ |
| LMEA | Proposed Clustering Variable Analysis + SBX +PM | $p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, nSel = 2, nPer = 4, nCor = 6$ |
| LSMOF | Problem Transformation + NSGAII + DE +PM | $CR = 1.0, F = 0.5, p_m = 1/D, n_m = 20, r = 10, SubN = 30$ |
| DGEA | Direction-guided SBX +PM | $p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, RefNo = 10$ |
| LSMOEA/D | Proposed Clustering Variable Analysis + SBX +PM | $p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, T = 0.1 \times N, nSel = 2, nPer = 4, K = 10$ |
| MOEA/PSL | Dimension Reduction + SBX +PM | $p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, epochs = 10, \eta = 0.1, momentum = 0.5$ |
| AMOEAD | AES + MOEA/D +PM | $p_c = 1.0, p_m = 1/D, n_c = 20, n_m = 20, epochs = 1, \eta = 0.1, momentum = 0, T = 10, nr = 2, type = "Tch", \delta = 0.9$ |
| NN-CSO | Neural Network Model + corresponding CSO | $K=5, E_{min} = 0.01, lr = 0.01, epochs = 20$ |

TABLE A. 2

THE IGD COMPARISON RESULTS OF EMBEDDING NN MODEL INTO THREE WELL-KNOWN CSOS ON UF1-UF10 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | S_ECSO | NN-SECSO | LMOCSO | NN-LMOCSO | TPLSO | NN-TPLSO |
|---------|---|------|-------------------------------|-----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|
| UF1 | 2 | 100 | 2.7767e-1 (6.00e-17) - | 1.5004e-1 (8.05e-3) | 4.3227e-1 (1.02e-1) - | 2.4318e-1 (1.16e-2) | 1.3293e+0 (8.16e-2) - | 5.3793e-1 (1.12e-1) |
| UF1 | 2 | 200 | 6.8069e-1 (0.00e+0) - | 2.1947e-1 (0.00e+0) | 9.3333e-1 (7.43e-2) - | 5.0663e-1 (6.26e-1) | 1.4299e+0 (8.70e-2) - | 9.1826e-1 (1.77e-1) |
| UF1 | 2 | 500 | 9.6696e-1 (1.20e-16) - | 2.4656e-1 (3.00e-17) | 1.2596e+0 (2.58e-2) - | 2.8877e-1 (4.73e-3) | 1.4901e+0 (1.72e-2) = | 1.3702e+0 (1.27e-1) |
| UF1 | 2 | 1000 | 1.1464e+0 (2.40e-16) - | 2.6651e-1 (0.00e+0) | 1.3440e+0 (1.27e-2) - | 2.9360e-1 (5.83e-3) | 1.4573e+0 (2.80e-2) - | 1.1978e+0 (8.41e-2) |
| UF2 | 2 | 100 | 1.0418e-1 (1.50e-17) + | 1.0737e-1 (3.79e-16) | 9.6931e-2 (4.29e-3) - | 8.3317e-2 (4.18e-3) | 3.5019e-1 (4.15e-3) - | 1.9961e-1 (2.78e-2) |
| UF2 | 2 | 200 | 1.2616e-1 (3.00e-17) + | 1.2745e-1 (0.00e+0) | 1.2577e-1 (3.13e-3) - | 1.1017e-1 (4.73e-2) | 3.8327e-1 (4.45e-2) - | 2.1185e-1 (3.71e-2) |
| UF2 | 2 | 500 | 1.3181e-1 (0.00e+0) - | 1.3095e-1 (0.00e+0) | 1.4446e-1 (2.31e-3) - | 9.2597e-2 (3.54e-3) | 3.8499e-1 (1.89e-2) = | 4.5739e-1 (1.37e-1) |
| UF2 | 2 | 1000 | 1.3608e-1 (0.00e+0) - | 1.3324e-1 (0.00e+0) | 1.5013e-1 (2.26e-3) - | 9.6263e-2 (4.00e-3) | 3.6869e-1 (8.11e-3) - | 2.6458e-1 (9.07e-2) |
| UF3 | 2 | 100 | 2.2227e-1 (0.00e+0) + | 2.2306e-1 (2.14e-13) | 2.3434e-1 (7.81e-3) - | 1.8399e-1 (7.77e-3) | 4.2276e-1 (7.65e-3) - | 2.3409e-1 (5.97e-3) |
| UF3 | 2 | 200 | 1.8220e-1 (3.00e-17) - | 1.7934e-1 (3.00e-17) | 2.4819e-1 (4.51e-3) - | 1.5620e-1 (3.36e-3) | 4.0538e-1 (5.93e-3) - | 1.8749e-1 (8.97e-3) |
| UF3 | 2 | 500 | 1.5452e-1 (0.00e+0) - | 1.5322e-1 (0.00e+0) | 2.9174e-1 (5.61e-3) - | 1.3442e-1 (1.11e-3) | 3.9247e-1 (3.22e-3) - | 3.8234e-1 (4.18e-3) |
| UF3 | 2 | 1000 | 1.4609e-1 (0.00e+0) - | 1.4466e-1 (3.00e-17) | 3.2107e-1 (3.19e-3) - | 1.2473e-1 (7.05e-4) | 3.9053e-1 (1.49e-3) = | 3.3499e-1 (1.44e-1) |
| UF4 | 2 | 100 | 8.8048e-2 (0.00e+0) - | 6.0168e-2 (2.26e-3) | 1.1709e-1 (3.34e-3) - | 5.8690e-2 (1.95e-4) | 5.0950e-1 (1.18e-2) - | 1.6123e-1 (1.61e-2) |
| UF4 | 2 | 200 | 1.0927e-1 (1.50e-17) - | 5.9350e-2 (7.49e-18) | 1.2692e-1 (3.46e-3) - | 5.9575e-2 (5.51e-4) | 5.2456e-1 (3.46e-2) - | 1.7091e-1 (2.06e-2) |
| UF4 | 2 | 500 | 1.2983e-1 (0.00e+0) - | 6.0084e-2 (7.49e-18) | 1.3324e-1 (1.78e-3) - | 6.1020e-2 (1.79e-3) | 5.1904e-1 (2.62e-2) = | 5.1298e-1 (5.24e-2) |
| UF4 | 2 | 1000 | 1.3462e-1 (0.00e+0) - | 6.7637e-2 (0.00e+0) | 1.3453e-1 (1.96e-3) - | 6.0001e-2 (5.24e-4) | 5.1421e-1 (2.58e-2) - | 2.0133e-1 (1.37e-2) |
| UF5 | 2 | 100 | 2.1814e+0 (4.80e-16) - | 2.0164e+0 (8.74e-3) | 2.4396e+0 (3.02e-1) - | 1.1267e+0 (1.73e-1) | 5.0672e+0 (1.11e-1) - | 3.3533e+0 (2.92e-1) |
| UF5 | 2 | 200 | 3.2064e+0 (4.80e-16) - | 2.6166e+0 (4.80e-16) | 3.1744e+0 (3.29e-1) - | 2.3209e+0 (3.11e-1) | 5.2051e+0 (1.84e-1) - | 4.1857e+0 (4.42e-1) |
| UF5 | 2 | 500 | 4.3456e+0 (0.00e+0) - | 2.8916e+0 (4.80e-16) | 4.4265e+0 (3.43e-1) - | 3.0021e+0 (6.99e-2) | 5.3495e+0 (7.11e-2) + | 5.5828e+0 (1.82e-1) |
| UF5 | 2 | 1000 | 4.7957e+0 (0.00e+0) - | 2.9851e+0 (0.00e+0) | 5.0455e+0 (2.67e-1) - | 3.0914e+0 (6.43e-2) | 5.4747e+0 (9.98e-2) - | 4.7815e+0 (4.52e-1) |
| UF6 | 2 | 100 | 1.2282e+0 (0.00e+0) - | 5.7319e-1 (4.49e-2) | 5.0983e-1 (5.26e-2) = | 5.1688e-1 (9.19e-2) | 4.7766e+0 (2.14e-1) - | 1.6452e+0 (1.87e-1) |
| UF6 | 2 | 200 | 2.7402e+0 (4.80e-16) - | 8.1212e-1 (1.20e-16) | 1.9724e+0 (1.46e-1) - | 7.1853e-1 (2.07e-1) | 5.3293e+0 (2.74e-1) - | 3.2343e+0 (1.10e+0) |
| UF6 | 2 | 500 | 3.5589e+0 (4.80e-16) - | 9.7202e-1 (1.20e-16) | 4.1239e+0 (1.69e-1) - | 1.1645e+0 (6.83e-2) | 5.5181e+0 (1.12e-1) = | 5.1312e+0 (5.26e-1) |
| UF6 | 2 | 1000 | 4.6431e+0 (0.00e+0) - | 1.0401e+0 (0.00e+0) | 5.0234e+0 (2.55e-1) - | 1.1917e+0 (4.72e-2) | 5.6845e+0 (7.38e-2) - | 5.0618e+0 (8.41e-1) |
| UF7 | 2 | 100 | 2.5015e-1 (6.00e-17) - | 1.5828e-1 (2.13e-3) | 5.2836e-1 (1.24e-1) - | 3.5681e-1 (3.58e-1) | 1.3947e+0 (7.19e-2) - | 5.0603e-1 (6.63e-2) |
| UF7 | 2 | 200 | 4.5348e-1 (0.00e+0) - | 2.2781e-1 (0.00e+0) | 9.6944e-1 (7.65e-2) - | 2.6931e-1 (1.08e-2) | 1.4383e+0 (3.89e-2) - | 8.6521e-1 (1.46e-1) |
| UF7 | 2 | 500 | 9.6546e-1 (1.20e-16) - | 2.5504e-1 (0.00e+0) | 1.3137e+0 (2.72e-2) - | 3.0180e-1 (6.16e-3) | 1.5581e+0 (9.65e-2) = | 1.4410e+0 (1.75e-1) |
| UF7 | 2 | 1000 | 1.1596e+0 (2.40e-16) - | 2.7819e-1 (0.00e+0) | 1.3950e+0 (1.68e-2) - | 3.0113e-1 (1.01e-2) | 1.5491e+0 (2.29e-2) - | 1.2384e+0 (2.59e-1) |
| UF8 | 3 | 100 | 5.4070e-1 (0.00e+0) + | 5.4091e-1 (0.00e+0) | 3.4625e-1 (1.43e-2) = | 3.4881e-1 (1.46e-2) | 7.4071e-1 (5.78e-2) - | 6.5623e-1 (3.42e-2) |
| UF8 | 3 | 200 | 5.4109e-1 (0.00e+0) - | 5.4033e-1 (1.20e-16) | 4.3478e-1 (2.54e-2) = | 4.1731e-1 (3.11e-2) | 7.5722e-1 (2.64e-2) = | 7.6013e-1 (1.04e-1) |
| UF8 | 3 | 500 | 5.4409e-1 (1.20e-16) - | 5.4188e-1 (0.00e+0) | 5.0121e-1 (1.91e-2) - | 4.8100e-1 (1.45e-2) | 7.8375e-1 (3.52e-2) = | 8.5866e-1 (1.97e-1) |
| UF8 | 3 | 1000 | 5.4619e-1 (0.00e+0) - | 5.4530e-1 (1.20e-16) | 5.2899e-1 (6.76e-3) = | 4.9542e-1 (2.93e-2) | 7.7331e-1 (3.09e-2) + | 9.7375e-1 (1.37e-1) |
| UF9 | 3 | 100 | 7.2863e-1 (1.20e-16) + | 7.3860e-1 (0.00e+0) | 5.0372e-1 (4.06e-2) = | 5.0989e-1 (4.59e-3) | 7.6222e-1 (6.08e-2) = | 7.2748e-1 (5.94e-2) |
| UF9 | 3 | 200 | 8.3139e-1 (0.00e+0) - | 7.7337e-1 (0.00e+0) | 5.8528e-1 (2.11e-2) - | 5.6101e-1 (7.41e-3) | 7.9747e-1 (3.10e-2) = | 7.6732e-1 (1.06e-1) |
| UF9 | 3 | 500 | 8.8950e-1 (0.00e+0) = | 8.8950e-1 (0.00e+0) | 6.9416e-1 (9.90e-3) - | 6.1365e-1 (1.26e-2) | 8.3073e-1 (2.33e-2) = | 8.7738e-1 (1.46e-1) |
| UF9 | 3 | 1000 | 8.8950e-1 (0.00e+0) = | 8.8950e-1 (0.00e+0) | 7.6722e-1 (1.35e-2) - | 6.6051e-1 (1.66e-2) | 8.1963e-1 (3.83e-2) + | 1.2086e+0 (3.54e-1) |
| UF10 | 3 | 100 | 5.0030e-1 (0.00e+0) + | 5.0218e-1 (9.06e-17) | 1.9738e+0 (3.04e-1) = | 1.8287e+0 (1.87e-1) | 4.2100e+0 (4.14e-1) = | 4.5354e+0 (4.63e-1) |
| UF10 | 3 | 200 | 6.9022e-1 (1.20e-16) - | 5.1564e-1 (1.20e-16) | 3.4774e+0 (4.29e-1) = | 3.1637e+0 (3.38e-1) | 4.6197e+0 (3.89e-1) = | 4.8671e+0 (3.87e-1) |
| UF10 | 3 | 500 | 5.3874e-1 (0.00e+0) + | 5.4396e-1 (1.20e-16) | 3.4774e+0 (4.29e-1) = | 3.1637e+0 (3.38e-1) | 5.0241e+0 (4.75e-1) = | 6.2307e+0 (1.25e+0) |
| UF10 | 3 | 1000 | 5.4029e-1 (0.00e+0) + | 5.4370e-1 (0.00e+0) | 4.3418e+0 (2.98e-1) - | 3.7282e+0 (2.54e-1) | 4.9915e+0 (3.54e-1) + | 8.0570e+0 (2.02e+0) |
| +/-= | | | 8/30/2 | | 0/32/8 | | 4/22/14 | |

TABLE A. 3

THE IGD COMPARISON RESULTS OF EMBEDDING NN MODEL INTO THREE WELL-KNOWN CSOS ON LSMOP1-LSMOP9 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | S_ECSO | NN-SECSO | LMOCSO | NN-LMOC SO | TPLSO | NN-TPLSO |
|---------|---|------|-------------------------------|-----------------------------|-----------------------|-----------------------------|------------------------------|----------------------------|
| LSMOP1 | 2 | 100 | 4.9281e-1 (6.00e-17) - | 2.4965e-1 (1.10e-2) | 3.9189e-1 (2.75e-2) - | 2.0217e-1 (1.04e-2) | 1.7703e+1 (2.05e+1) - | 8.3237e-1 (2.81e-1) |
| LSMOP1 | 2 | 200 | 4.7126e-1 (1.20e-16) - | 2.7370e-1 (6.00e-17) | 7.7353e-1 (4.47e-2) - | 2.8176e-1 (1.72e-2) | 4.3795e+1 (1.91e+1) - | 1.7725e+0 (7.88e-1) |
| LSMOP1 | 2 | 500 | 6.7103e-1 (1.20e-16) - | 3.2231e-1 (0.00e+0) | 1.2798e+0 (3.43e-2) - | 3.2321e-1 (1.40e-2) | 3.1437e+1 (2.81e+1) = | 2.6745e+0 (5.88e-1) |
| LSMOP1 | 2 | 1000 | 6.0144e-1 (0.00e+0) - | 3.0638e-1 (6.00e-17) | 1.4229e+0 (4.44e-2) - | 3.3104e-1 (8.72e-3) | 4.1556e+1 (1.82e+1) - | 3.4219e+0 (9.06e-1) |
| LSMOP1 | 3 | 100 | 7.2792e-1 (0.00e+0) - | 3.8855e-1 (0.00e+0) | 5.6849e-1 (4.86e-2) - | 3.2358e-1 (1.05e-2) | 1.1175e+1 (1.96e+1) - | 9.4742e-1 (2.22e-1) |
| LSMOP1 | 3 | 200 | 7.8406e-1 (1.20e-16) - | 3.6304e-1 (6.00e-17) | 9.5857e-1 (6.23e-2) - | 3.4195e-1 (9.75e-3) | 3.9253e+1 (3.20e+1) - | 2.6618e+0 (1.02e+0) |
| LSMOP1 | 3 | 500 | 7.3470e-1 (1.20e-16) - | 3.7186e-1 (6.00e-17) | 1.2326e+0 (6.20e-2) - | 3.5389e-1 (1.61e-2) | 3.8365e+1 (3.02e+1) - | 2.8171e+0 (7.07e-1) |
| LSMOP1 | 3 | 1000 | 8.1602e-1 (1.20e-16) - | 3.6947e-1 (6.00e-17) | 1.3595e+0 (4.99e-2) - | 3.7023e-1 (1.53e-2) | 2.4618e+1 (3.19e+1) = | 4.1011e+0 (5.68e-1) |
| LSMOP2 | 2 | 100 | 1.1105e-1 (1.50e-17) - | 5.0583e-2 (9.14e-4) | 1.5164e-1 (4.34e-3) - | 4.2763e-2 (1.64e-3) | 5.7959e-1 (1.14e-1) - | 1.0026e-1 (1.14e-2) |
| LSMOP2 | 2 | 200 | 5.7750e-2 (7.49e-18) - | 2.9179e-2 (0.00e+0) | 9.3398e-2 (9.33e-4) - | 2.8407e-2 (1.27e-3) | 4.5286e-1 (7.11e-2) - | 5.0742e-2 (1.37e-3) |
| LSMOP2 | 2 | 500 | 3.0162e-2 (3.75e-18) - | 1.4998e-2 (1.87e-18) | 4.2894e-2 (2.55e-4) - | 1.3729e-2 (7.39e-4) | 3.6700e-1 (1.12e-2) - | 6.0205e-2 (3.26e-3) |
| LSMOP2 | 2 | 1000 | 1.8005e-2 (3.75e-18) - | 1.0393e-2 (0.00e+0) | 2.3692e-2 (2.10e-4) - | 8.1902e-3 (2.42e-4) | 3.9549e-1 (5.98e-2) - | 4.1278e-2 (7.80e-3) |
| LSMOP2 | 3 | 100 | 2.1480e-1 (3.00e-17) - | 1.0697e-1 (1.50e-17) | 1.2877e-1 (2.73e-3) - | 8.4013e-2 (3.28e-3) | 5.5027e-1 (8.32e-2) - | 1.5674e-1 (8.57e-3) |
| LSMOP2 | 3 | 200 | 1.2266e-1 (1.50e-17) - | 8.1996e-2 (1.50e-17) | 7.9826e-2 (7.70e-4) - | 5.7013e-2 (1.60e-3) | 4.1925e-1 (2.20e-2) - | 1.1699e-1 (7.33e-3) |
| LSMOP2 | 3 | 500 | 6.7825e-2 (0.00e+0) - | 5.6603e-2 (7.49e-18) | 4.4514e-2 (3.87e-4) - | 3.8768e-2 (1.43e-3) | 4.3110e-1 (3.70e-2) = | 4.5411e-1 (7.14e-2) |
| LSMOP2 | 3 | 1000 | 5.2379e-2 (7.49e-18) - | 4.6413e-2 (7.49e-18) | 3.2330e-2 (2.89e-4) - | 2.9433e-2 (1.36e-3) | 4.3152e-1 (4.16e-2) - | 6.8964e-2 (1.61e-2) |
| LSMOP3 | 2 | 100 | 1.5105e+0 (0.00e+0) - | 1.5070e+0 (2.68e-3) | 1.0093e+1 (3.17e+0) - | 1.5170e+0 (4.71e-1) | 1.3150e+5 (8.07e+4) - | 2.8751e+0 (3.58e+0) |
| LSMOP3 | 2 | 200 | 1.5492e+0 (0.00e+0) - | 1.5447e+0 (2.40e-16) | 1.7224e+1 (2.62e+0) - | 1.9101e+0 (4.24e-1) | 1.7343e+5 (8.61e+4) - | 8.7627e+0 (1.91e+1) |
| LSMOP3 | 2 | 500 | 1.5707e+0 (0.00e+0) - | 1.5629e+0 (2.40e-16) | 2.3149e+1 (1.08e+0) - | 3.1135e+0 (1.72e+0) | 1.5923e+5 (9.51e+4) - | 1.1207e+4 (2.38e+4) |
| LSMOP3 | 2 | 1000 | 1.5762e+0 (2.40e-16) - | 1.5704e+0 (2.40e-16) | 2.7303e+1 (1.23e+0) - | 2.2104e+0 (1.65e+0) | 2.2555e+5 (4.47e+4) - | 1.2339e+4 (2.93e+4) |
| LSMOP3 | 3 | 100 | 8.6072e-1 (1.20e-16) = | 8.6072e-1 (1.20e-16) | 7.4883e+0 (6.95e-1) - | 8.5877e-1 (5.15e-3) | 8.7374e+3 (1.31e+4) - | 1.9389e+0 (2.85e+0) |
| LSMOP3 | 3 | 200 | 8.6072e-1 (1.20e-16) = | 8.6072e-1 (1.20e-16) | 9.1855e+0 (6.24e-1) - | 8.6072e-1 (1.20e-16) | 6.6958e+3 (4.81e+3) - | 4.4397e+1 (3.78e+1) |
| LSMOP3 | 3 | 500 | 8.6072e-1 (1.20e-16) = | 8.6072e-1 (1.20e-16) | 1.0876e+1 (4.73e-1) - | 8.6072e-1 (1.20e-16) | 1.2634e+4 (7.52e+3) - | 1.3144e+3 (2.39e+3) |
| LSMOP3 | 3 | 1000 | 8.6072e-1 (1.20e-16) = | 8.6072e-1 (1.20e-16) | 1.1252e+1 (2.94e-1) - | 8.6072e-1 (1.20e-16) | 3.4175e+3 (3.48e+3) - | 4.1667e+1 (3.81e+1) |
| LSMOP4 | 2 | 100 | 2.3568e-1 (0.00e+0) - | 1.5393e-1 (2.44e-3) | 1.7410e-1 (1.81e-2) - | 6.7048e-2 (2.28e-2) | 1.1937e+0 (4.80e-1) - | 2.0595e-1 (1.15e-2) |
| LSMOP4 | 2 | 200 | 1.3341e-1 (0.00e+0) - | 9.1144e-2 (1.50e-17) | 1.5665e-1 (4.21e-3) - | 8.3159e-2 (6.00e-3) | 6.2199e-1 (1.79e-1) - | 1.4837e-1 (4.30e-2) |
| LSMOP4 | 2 | 500 | 6.6433e-2 (0.00e+0) - | 4.1727e-2 (7.49e-18) | 8.8124e-2 (8.56e-4) - | 4.4418e-2 (9.30e-4) | 3.9186e-1 (2.43e-2) - | 1.0683e-1 (4.70e-3) |
| LSMOP4 | 2 | 1000 | 3.9109e-2 (0.00e+0) - | 2.3091e-2 (3.75e-18) | 5.1425e-2 (3.41e-4) - | 2.2817e-2 (5.77e-4) | 3.9892e-1 (3.37e-2) - | 6.6456e-2 (4.32e-3) |
| LSMOP4 | 3 | 100 | 4.3000e-1 (6.00e-17) - | 3.1882e-1 (0.00e+0) | 3.9018e-1 (9.52e-3) - | 2.9903e-1 (1.40e-2) | 1.0646e+0 (3.19e-1) - | 5.5828e-1 (6.62e-2) |
| LSMOP4 | 3 | 200 | 2.8344e-1 (0.00e+0) - | 2.1170e-1 (0.00e+0) | 2.6839e-1 (4.05e-3) - | 1.9584e-1 (7.70e-3) | 8.4668e-1 (2.04e-1) - | 3.6629e-1 (3.42e-2) |
| LSMOP4 | 3 | 500 | 1.5840e-1 (3.00e-17) - | 1.2228e-1 (0.00e+0) | 1.4544e-1 (7.94e-4) - | 1.0064e-1 (2.13e-3) | 5.4529e-1 (1.31e-1) = | 5.1923e-1 (7.44e-2) |
| LSMOP4 | 3 | 1000 | 1.0435e-1 (3.00e-17) - | 8.1371e-2 (0.00e+0) | 8.7226e-2 (3.58e-4) - | 6.1411e-2 (2.39e-3) | 4.1997e-1 (2.86e-2) - | 1.3990e-1 (2.31e-2) |
| LSMOP5 | 2 | 100 | 7.4209e-1 (1.20e-16) - | 7.1334e-1 (9.95e-3) | 7.6183e-1 (5.71e-2) - | 6.9839e-1 (3.87e-2) | 9.1987e+1 (4.13e+1) - | 9.3602e-1 (3.97e-1) |
| LSMOP5 | 2 | 200 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 1.9068e+0 (7.25e-2) - | 7.4209e-1 (1.20e-16) | 4.9951e+1 (5.09e+1) = | 8.9395e+0 (2.10e+0) |
| LSMOP5 | 2 | 500 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 2.7384e+0 (1.29e-1) - | 7.4209e-1 (3.92e-7) | 1.1332e+2 (1.55e+1) - | 8.8321e+0 (3.11e+0) |
| LSMOP5 | 2 | 1000 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 2.8923e+0 (7.01e-2) - | 7.4209e-1 (1.20e-16) | 1.1979e+2 (2.07e+1) - | 1.2889e+1 (5.49e+0) |
| LSMOP5 | 3 | 100 | 4.9284e-1 (6.00e-17) - | 4.1324e-1 (6.00e-17) | 8.2434e-1 (1.45e-1) - | 3.8292e-1 (3.63e-2) | 8.5442e+1 (2.08e+1) - | 1.2072e+0 (6.01e-1) |
| LSMOP5 | 3 | 200 | 5.5421e-1 (1.20e-16) - | 4.5516e-1 (0.00e+0) | 2.1603e+0 (1.33e-1) - | 4.7438e-1 (1.44e-2) | 1.0039e+2 (2.44e+1) - | 7.4014e+0 (1.95e+0) |
| LSMOP5 | 3 | 500 | 5.7303e-1 (0.00e+0) - | 4.4293e-1 (6.00e-17) | 2.7360e+0 (2.25e-1) - | 5.1560e-1 (1.36e-2) | 1.0354e+2 (1.30e+1) - | 5.8685e+0 (3.98e+0) |
| LSMOP5 | 3 | 1000 | 5.4756e-1 (0.00e+0) - | 4.6464e-1 (0.00e+0) | 2.9914e+0 (1.40e-1) - | 5.1962e-1 (4.01e-3) | 7.4732e+1 (4.12e+1) - | 1.1984e+1 (7.91e+0) |
| LSMOP6 | 2 | 100 | 2.9785e-1 (6.00e-17) - | 2.2150e-1 (2.76e-3) | 8.4682e-1 (4.27e-2) - | 7.3329e-1 (1.95e-2) | 1.4398e+5 (4.32e+4) - | 1.2153e+0 (3.36e-1) |

| | | | | | | | | |
|--------|---|------|-------------------------------|-----------------------------|------------------------------|-----------------------------|-----------------------|----------------------------|
| LSMOP6 | 2 | 200 | 2.9550e-1 (0.00e+0) - | 2.4937e-1 (3.00e-17) | 8.6313e-1 (2.15e-2) - | 7.5911e-1 (5.40e-3) | 2.5096e+5 (8.79e+4) - | 5.0882e+2 (1.31e+3) |
| LSMOP6 | 2 | 500 | 6.6594e-1 (1.20e-16) - | 1.9458e-1 (0.00e+0) | 8.0319e-1 (9.18e-3) - | 7.5233e-1 (9.55e-4) | 3.3901e+5 (1.37e+5) - | 5.2394e+2 (1.38e+3) |
| LSMOP6 | 2 | 1000 | 1.8151e-1 (3.00e-17) + | 1.8647e-1 (0.00e+0) | 7.3024e-1 (1.13e-1) + | 7.5010e-1 (1.79e-3) | 4.2942e+5 (1.10e+5) - | 4.7739e+4 (9.42e+4) |
| LSMOP6 | 3 | 100 | 1.1164e+0 (0.00e+0) - | 7.0211e-1 (0.00e+0) | 5.8326e+0 (2.75e+0) - | 9.8301e-1 (1.86e-1) | 2.1166e+4 (4.41e+4) - | 1.4892e+0 (8.32e-3) |
| LSMOP6 | 3 | 200 | 1.2296e+0 (0.00e+0) - | 7.9934e-1 (1.20e-16) | 4.7678e+1 (1.74e+1) - | 1.2356e+0 (1.98e-3) | 3.8443e+5 (7.06e+5) = | 7.5235e+3 (6.59e+3) |
| LSMOP6 | 3 | 500 | 1.2932e+0 (0.00e+0) - | 7.9218e-1 (1.20e-16) | 1.6032e+2 (3.23e+1) - | 1.2959e+0 (3.85e-4) | 7.8085e+4 (1.95e+5) - | 2.1073e+3 (1.46e+3) |
| LSMOP6 | 3 | 1000 | 1.3137e+0 (0.00e+0) - | 9.5277e-1 (1.20e-16) | 3.2570e+2 (6.76e+1) - | 1.3168e+0 (1.48e-3) | 3.0925e+4 (5.62e+4) = | 1.9602e+4 (1.41e+4) |
| LSMOP7 | 2 | 100 | 1.4525e+0 (0.00e+0) - | 1.4456e+0 (5.78e-4) | 1.5336e+1 (2.37e+0) - | 1.4577e+0 (7.35e-4) | 3.8320e+4 (8.43e+4) - | 1.4956e+0 (9.31e-2) |
| LSMOP7 | 2 | 200 | 1.4892e+0 (2.40e-16) - | 1.4868e+0 (0.00e+0) | 1.4712e+2 (2.01e+1) - | 1.4916e+0 (5.54e-4) | 1.7010e+5 (1.70e+5) = | 6.2242e+3 (1.40e+3) |
| LSMOP7 | 2 | 500 | 1.5063e+0 (2.40e-16) - | 1.5058e+0 (0.00e+0) | 5.3070e+2 (3.89e+1) - | 1.5109e+0 (1.83e-3) | 7.1037e+4 (1.04e+5) = | 1.2130e+4 (4.38e+3) |
| LSMOP7 | 2 | 1000 | 1.5122e+0 (2.40e-16) - | 1.5114e+0 (2.40e-16) | 6.9017e+2 (3.09e+1) - | 1.5156e+0 (2.36e-3) | 4.5189e+4 (8.23e+4) = | 1.2226e+4 (5.94e+3) |
| LSMOP7 | 3 | 100 | 1.0551e+0 (0.00e+0) - | 1.0128e+0 (0.00e+0) | 1.1817e+0 (2.84e-1) = | 9.1842e-1 (9.45e-2) | 1.9666e+5 (7.81e+4) - | 1.6932e+0 (2.58e-1) |
| LSMOP7 | 3 | 200 | 9.6224e-1 (1.20e-16) - | 9.3829e-1 (0.00e+0) | 1.3861e+0 (1.08e-1) - | 1.0253e+0 (5.64e-2) | 2.0937e+5 (6.18e+4) - | 1.7604e+0 (2.98e-1) |
| LSMOP7 | 3 | 500 | 8.8607e-1 (0.00e+0) + | 9.0102e-1 (1.20e-16) | 1.1727e+0 (3.68e-2) - | 9.2035e-1 (8.90e-2) | 2.8266e+5 (6.72e+4) - | 6.9584e+4 (4.97e+4) |
| LSMOP7 | 3 | 1000 | 8.5404e-1 (0.00e+0) - | 7.5817e-1 (1.20e-16) | 1.0547e+0 (1.82e-2) - | 9.5474e-1 (2.46e-2) | 2.2596e+5 (8.99e+4) - | 2.5884e+4 (6.00e+4) |
| LSMOP8 | 2 | 100 | 7.4209e-1 (1.20e-16) - | 6.8302e-1 (4.31e-3) | 4.8960e-1 (1.33e-1) - | 2.9998e-1 (5.28e-2) | 3.7057e+1 (1.56e+1) - | 8.8840e-1 (3.39e-1) |
| LSMOP8 | 2 | 200 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 1.2261e+0 (1.30e-1) - | 6.5133e-1 (6.66e-2) | 3.9945e+1 (3.89e+0) - | 3.7061e+0 (2.18e+0) |
| LSMOP8 | 2 | 500 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 1.8998e+0 (7.52e-2) - | 7.4209e-1 (1.20e-16) | 3.7846e+1 (1.33e+1) - | 7.3759e+0 (2.41e+0) |
| LSMOP8 | 2 | 1000 | 7.4209e-1 (1.20e-16) = | 7.4209e-1 (1.20e-16) | 2.1493e+0 (6.18e-2) - | 7.4209e-1 (1.20e-16) | 3.9088e+1 (1.69e+1) - | 6.7657e+0 (1.02e+0) |
| LSMOP8 | 3 | 100 | 3.3293e-1 (6.00e-17) - | 2.1409e-1 (3.00e-17) | 6.9062e-1 (2.33e-2) - | 2.2384e-1 (2.52e-2) | 2.7022e+1 (6.19e+0) - | 6.6111e-1 (4.75e-2) |
| LSMOP8 | 3 | 200 | 3.3004e-1 (0.00e+0) - | 2.1709e-1 (0.00e+0) | 6.2168e-1 (3.77e-2) - | 1.6963e-1 (1.16e-2) | 3.9854e+1 (1.11e+1) - | 9.4899e-1 (8.25e-2) |
| LSMOP8 | 3 | 500 | 2.9704e-1 (6.00e-17) - | 1.3784e-1 (3.00e-17) | 5.4697e-1 (7.39e-3) - | 1.5592e-1 (1.80e-2) | 4.5812e+1 (1.33e+1) - | 1.9801e+1 (1.15e+1) |
| LSMOP8 | 3 | 1000 | 3.2267e-1 (0.00e+0) - | 9.8708e-2 (1.50e-17) | 5.3239e-1 (1.08e-2) - | 1.6270e-1 (3.69e-2) | 3.8762e+1 (8.61e+0) - | 3.0909e+0 (3.20e+0) |
| LSMOP9 | 2 | 100 | 8.1004e-1 (0.00e+0) = | 8.1004e-1 (0.00e+0) | 6.6243e-1 (5.98e-2) + | 8.1004e-1 (5.64e-16) | 5.4380e+1 (1.76e+1) - | 8.1140e-1 (3.59e-3) |
| LSMOP9 | 2 | 200 | 8.1004e-1 (0.00e+0) = | 8.1004e-1 (0.00e+0) | 5.2370e-1 (2.68e-2) + | 8.0603e-1 (5.30e-3) | 6.9717e+1 (1.50e+1) - | 2.7705e+0 (2.36e+0) |
| LSMOP9 | 2 | 500 | 8.1004e-1 (0.00e+0) = | 8.1004e-1 (0.00e+0) | 9.8356e-1 (6.58e-2) - | 6.6887e-1 (1.24e-1) | 8.1691e+1 (1.97e+1) - | 1.4433e+1 (7.11e+0) |
| LSMOP9 | 2 | 1000 | 6.6102e-1 (0.00e+0) - | 3.3542e-2 (0.00e+0) | 2.0274e+0 (5.77e-1) - | 6.6516e-1 (7.38e-2) | 8.9887e+1 (1.75e+1) - | 1.3884e+1 (8.31e+0) |
| LSMOP9 | 3 | 100 | 7.8445e-1 (0.00e+0) - | 6.6450e-1 (1.20e-16) | 8.7886e-1 (1.57e-1) - | 5.9295e-1 (2.15e-3) | 1.1261e+2 (1.85e+1) - | 1.5379e+0 (7.47e-6) |
| LSMOP9 | 3 | 200 | 9.2054e-1 (1.20e-16) + | 9.7553e-1 (1.20e-16) | 1.3020e+0 (2.83e-1) - | 6.7195e-1 (2.09e-1) | 1.4692e+2 (4.24e+1) - | 3.4512e+0 (4.70e+0) |
| LSMOP9 | 3 | 500 | 5.9161e-1 (0.00e+0) + | 5.9282e-1 (1.20e-16) | 1.5168e+0 (9.85e-2) - | 5.8631e-1 (1.58e-2) | 1.6372e+2 (3.73e+1) = | 1.1557e+2 (5.44e+1) |
| LSMOP9 | 3 | 1000 | 1.5379e+0 (2.40e-16) - | 5.9079e-1 (0.00e+0) | 2.0343e+1 (1.59e+1) - | 2.5451e+0 (1.34e-0) | 1.5828e+2 (3.36e+1) - | 6.4018e+1 (2.68e+1) |
| +/-= | | | 4/55/13 | | 3/68/1 | | 0/61/11 | |

TABLE A. 4

THE IGD COMPARISON RESULTS OF EMBEDDING NN MODEL INTO THREE WELL-KNOWN CSOs ON DTLZ1-DTLZ7 TEST PROBLEMS WITH 5-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | S_ECSO | NN-SECSO | LMOCSO | NN-LMOCOSO | TPLSO | NN-TPLSO |
|---------|----|------|-------------------------------|-----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|
| DTLZ1 | 5 | 100 | 5.8154e+2 (0.00e+0) - | 1.4012e-1 (1.11e-2) | 3.1214e+2 (4.18e+1) - | 1.6925e+2 (1.38e+2) | 2.0757e+3 (6.70e+2) - | 8.7038e+2 (6.55e+2) |
| DTLZ1 | 5 | 200 | 1.3259e+3 (2.46e-13) - | 6.7617e+0 (0.00e+0) | 6.9953e+2 (2.32e+1) - | 2.6128e+2 (2.57e+2) | 4.8962e+3 (3.89e+2) - | 2.9406e+3 (6.30e+2) |
| DTLZ1 | 5 | 500 | 3.5849e+3 (0.00e+0) - | 2.0963e-1 (0.00e+0) | 1.5820e+3 (3.07e+2) - | 1.2046e+2 (2.56e+2) | 1.2181e+4 (1.76e+3) - | 9.0397e+3 (1.71e+3) |
| DTLZ1 | 5 | 1000 | 8.8038e+3 (0.00e+0) - | 8.8037e+3 (1.96e-12) | 8.3434e+3 (7.54e+2) - | 2.2002e+2 (2.22e+2) | 2.5198e+4 (2.80e+3) - | 1.9425e+4 (2.92e+3) |
| DTLZ1 | 8 | 100 | 5.6534e+2 (0.00e+0) - | 3.3784e-1 (6.00e-17) | 2.8892e+2 (6.51e+1) = | 2.4699e+2 (6.08e+1) | 1.7860e+3 (2.54e+2) - | 1.0650e+3 (6.04e+2) |
| DTLZ1 | 8 | 200 | 1.2723e+3 (2.46e-13) - | 6.8328e-1 (0.00e+0) | 6.6358e+2 (1.06e+2) - | 4.6851e+2 (1.64e+2) | 4.2642e+3 (5.89e+2) - | 3.2013e+3 (5.92e+2) |
| DTLZ1 | 8 | 500 | 3.7356e+3 (0.00e+0) - | 1.6196e+3 (2.46e-13) | 1.6431e+3 (2.92e+2) - | 4.2218e+2 (6.81e+2) | 1.1408e+4 (9.41e+2) - | 9.3994e+3 (1.32e+3) |
| DTLZ1 | 8 | 1000 | 8.7711e+3 (0.00e+0) - | 6.7373e+2 (1.23e-13) | 7.5354e+3 (1.04e+3) - | 6.8877e+2 (8.48e+2) | 2.1743e+4 (1.99e+3) = | 1.9462e+4 (1.39e+3) |
| DTLZ1 | 10 | 100 | 5.9543e+2 (1.23e-13) - | 8.2911e-1 (1.20e-16) | 2.7020e+2 (2.78e+1) = | 1.9673e+2 (1.55e+2) | 1.8150e+3 (2.78e+2) - | 1.2936e+3 (2.60e+2) |
| DTLZ1 | 10 | 200 | 1.3472e+3 (2.46e-13) - | 2.7250e-1 (0.00e+0) | 6.6286e+2 (9.88e+1) = | 5.3201e+2 (1.79e+2) | 4.2835e+3 (6.08e+2) - | 3.1887e+3 (4.27e+2) |
| DTLZ1 | 10 | 500 | 3.7054e+3 (0.00e+0) - | 8.1397e+2 (1.23e-13) | 1.6630e+3 (2.18e+2) - | 2.7571e+2 (2.80e+2) | 1.0735e+4 (6.69e+2) - | 8.5541e+3 (8.22e+2) |
| DTLZ1 | 10 | 1000 | 8.7596e+3 (1.96e-12) - | 8.6852e+3 (0.00e+0) | 8.1627e+3 (4.59e+2) - | 3.2814e+2 (5.18e+2) | 2.1856e+4 (1.78e+3) - | 1.8671e+4 (2.00e+3) |
| DTLZ2 | 5 | 100 | 1.4944e+1 (0.00e+0) - | 1.4850e+1 (1.92e-15) | 4.3847e-1 (2.35e-2) + | 4.9801e-1 (4.04e-2) | 9.6434e-1 (1.67e-1) - | 7.7497e-1 (4.76e-2) |
| DTLZ2 | 5 | 200 | 3.8588e+1 (0.00e+0) - | 3.8335e+1 (7.67e-15) | 7.9854e-1 (4.73e-2) - | 5.6523e-1 (6.63e-2) | 1.2328e+0 (3.85e-1) = | 2.5003e+0 (1.47e+0) |
| DTLZ2 | 5 | 500 | 1.1255e+2 (0.00e+0) + | 1.1312e+2 (1.53e-14) | 1.7491e+0 (1.20e-1) - | 6.9030e-1 (6.45e-2) | 8.4612e+0 (1.22e+1) = | 5.4578e+0 (3.14e+0) |
| DTLZ2 | 5 | 1000 | 2.4770e+2 (3.07e-14) + | 2.4804e+2 (3.07e-14) | 4.3532e+0 (5.67e-1) - | 8.2565e-1 (3.53e-2) | 5.8078e+0 (4.48e+0) + | 1.5449e+1 (1.26e+1) |
| DTLZ2 | 8 | 100 | 1.4953e+1 (1.92e-15) + | 1.4997e+1 (0.00e+0) | 6.7127e-1 (3.58e-2) + | 8.8452e-1 (3.41e-2) | 1.2248e+0 (1.42e-1) = | 1.1350e+0 (3.36e-1) |
| DTLZ2 | 8 | 200 | 3.8265e+1 (0.00e+0) + | 3.9396e+1 (0.00e+0) | 1.0435e+0 (7.38e-2) = | 1.0250e+0 (2.93e-2) | 1.6763e+0 (6.35e-1) + | 3.3744e+0 (1.16e+0) |
| DTLZ2 | 8 | 500 | 1.2229e+2 (1.53e-14) - | 1.2202e+2 (1.53e-14) | 2.3982e+0 (4.02e-1) - | 9.8507e-1 (4.22e-2) | 2.7410e+0 (2.10e+0) = | 6.3136e+0 (3.89e+0) |
| DTLZ2 | 8 | 1000 | 2.4696e+2 (6.14e-14) + | 2.4737e+2 (3.07e-14) | 4.3099e+0 (8.91e-1) - | 9.8649e-1 (2.51e-2) | 3.3436e+0 (1.05e+0) + | 1.3724e+1 (6.86e+0) |
| DTLZ2 | 10 | 100 | 1.5021e+1 (1.92e-15) + | 1.5449e+1 (1.92e-15) | 8.5911e-1 (3.99e-2) + | 9.9078e-1 (2.74e-2) | 1.6303e+0 (4.79e-1) - | 1.2585e+0 (6.48e-1) |
| DTLZ2 | 10 | 200 | 3.8730e+1 (0.00e+0) - | 3.8363e+1 (0.00e+0) | 1.1109e+0 (3.02e-2) = | 1.0680e+0 (5.82e-2) | 2.3249e+0 (2.01e+0) + | 4.0251e+0 (1.22e+0) |
| DTLZ2 | 10 | 500 | 1.2187e+2 (3.07e-14) - | 1.2164e+2 (1.53e-14) | 1.8366e+0 (8.08e-2) - | 1.0921e+0 (9.10e-2) | 4.0002e+0 (4.42e+0) = | 6.9432e+0 (3.39e+0) |
| DTLZ2 | 10 | 1000 | 2.4679e+2 (0.00e+0) - | 2.4664e+2 (0.00e+0) | 3.8430e+0 (3.89e-1) - | 1.0579e+0 (3.91e-2) | 3.9745e+0 (1.14e+0) + | 2.0856e+1 (1.03e+1) |
| DTLZ3 | 5 | 100 | 2.1744e+3 (4.91e-13) + | 2.1837e+3 (0.00e+0) | 1.1884e+3 (7.79e+1) - | 7.6616e+2 (4.86e+2) | 7.7218e+3 (7.04e+2) - | 2.2614e+3 (1.57e+3) |
| DTLZ3 | 5 | 200 | 4.7016e+3 (9.82e-13) + | 4.7073e+3 (0.00e+0) | 2.6380e+3 (1.00e+2) - | 7.4980e+2 (1.01e+3) | 1.7398e+4 (7.79e+2) - | 7.7793e+3 (1.70e+3) |
| DTLZ3 | 5 | 500 | 1.2192e+4 (1.96e-12) + | 1.2238e+4 (1.96e-12) | 6.2067e+3 (7.05e+2) - | 3.8409e+2 (6.12e+2) | 4.8685e+4 (1.71e+3) - | 2.1380e+4 (7.25e+3) |
| DTLZ3 | 5 | 1000 | 2.4877e+4 (3.93e-12) - | 2.4862e+4 (3.93e-12) | 2.5336e+4 (1.54e+2) - | 1.3701e+3 (1.40e+3) | 9.6755e+4 (2.56e+3) - | 5.8277e+4 (9.49e+3) |
| DTLZ3 | 8 | 100 | 2.1127e+3 (0.00e+0) + | 2.1588e+3 (4.91e-13) | 1.2838e+3 (1.08e+2) = | 1.0390e+3 (2.46e+2) | 7.5174e+3 (6.51e+2) - | 2.3580e+3 (6.20e+1) |
| DTLZ3 | 8 | 200 | 4.6247e+3 (0.00e+0) - | 4.5528e+3 (9.82e-13) | 2.6434e+3 (2.63e+2) - | 1.6571e+3 (8.85e+2) | 1.7467e+4 (6.67e+2) - | 7.8124e+3 (1.68e+3) |
| DTLZ3 | 8 | 500 | 1.2276e+4 (0.00e+0) + | 1.2286e+4 (1.96e-12) | 1.2368e+4 (6.58e+1) - | 4.8984e+2 (4.86e+2) | 4.6905e+4 (1.06e+3) - | 2.5616e+4 (1.23e+4) |
| DTLZ3 | 8 | 1000 | 2.4796e+4 (0.00e+0) + | 2.4799e+4 (0.00e+0) | 2.4050e+4 (2.82e+3) - | 4.2066e+2 (4.91e+2) | 9.8128e+4 (3.25e+3) - | 4.7449e+4 (1.78e+4) |
| DTLZ3 | 10 | 100 | 2.0363e+3 (4.91e-13) + | 2.0732e+3 (4.91e-13) | 1.2000e+3 (2.80e+2) = | 1.1943e+3 (1.02e+2) | 7.5317e+3 (6.93e+2) - | 2.1444e+3 (1.56e+3) |
| DTLZ3 | 10 | 200 | 4.5890e+3 (9.82e-13) + | 4.6107e+3 (9.82e-13) | 2.7406e+3 (3.82e+2) = | 1.8951e+3 (1.32e+3) | 1.7645e+4 (1.13e+3) - | 6.5672e+3 (1.01e+3) |
| DTLZ3 | 10 | 500 | 1.2229e+4 (1.96e-12) + | 1.2236e+4 (0.00e+0) | 1.2339e+4 (8.17e+1) - | 1.0827e+3 (1.58e+3) | 4.6846e+4 (2.42e+3) - | 1.9983e+4 (5.54e+3) |
| DTLZ3 | 10 | 1000 | 2.4744e+4 (3.93e-12) - | 2.4740e+4 (3.93e-12) | 2.4199e+4 (1.23e+3) - | 2.2712e+3 (1.98e+3) | 9.9585e+4 (2.39e+3) - | 4.0912e+4 (9.52e+3) |
| DTLZ4 | 5 | 100 | 7.9337e-1 (1.20e-16) - | 4.1048e-1 (1.97e-2) | 6.7391e-1 (2.03e-1) = | 9.0123e-1 (2.29e-1) | 2.4689e+0 (8.30e-1) - | 1.2446e+0 (1.12e-1) |
| DTLZ4 | 5 | 200 | 2.1390e+0 (0.00e+0) - | 4.9910e-1 (6.00e-17) | 1.3057e+0 (3.38e-1) = | 1.1041e+0 (7.73e-3) | 5.6322e+0 (3.91e+0) - | 1.8214e+0 (3.51e-1) |
| DTLZ4 | 5 | 500 | 5.7025e+0 (9.59e-16) - | 9.1238e-1 (2.40e-16) | 3.6440e+0 (4.96e-1) - | 1.1081e+0 (7.96e-7) | 8.5718e+0 (6.42e+0) = | 4.0822e+0 (1.72e+0) |
| DTLZ4 | 5 | 1000 | 1.8210e+1 (3.84e-15) - | 1.1088e+0 (0.00e+0) | 9.6230e+0 (1.32e+0) - | 1.2318e+0 (3.14e-2) | 1.5048e+1 (3.20e+0) - | 8.4090e+0 (3.69e+0) |
| DTLZ4 | 8 | 100 | 2.9257e+0 (0.00e+0) - | 2.3141e+0 (0.00e+0) | 9.0120e-1 (6.96e-2) + | 1.1920e+0 (1.04e-2) | 2.3009e+0 (4.53e-1) - | 1.4614e+0 (2.48e-1) |
| DTLZ4 | 8 | 200 | 2.8234e+0 (0.00e+0) - | 1.2140e+0 (0.00e+0) | 1.6314e+0 (1.56e-1) - | 1.2133e+0 (2.39e-3) | 3.8470e+0 (2.58e+0) = | 2.7884e+0 (9.23e-1) |

| | | | | | | | | |
|-------|----|---------|-------------------------------|-----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|
| DTLZ4 | 8 | 500 | 5.4576e+0 (9.59e-16) + | 6.8211e+0 (9.59e-16) | 4.5056e+0 (5.83e-1) - | 1.3757e+0 (7.06e-2) | 9.9425e+0 (4.50e+0) = | 5.5812e+0 (2.31e+0) |
| DTLZ4 | 8 | 1000 | 1.8206e+1 (0.00e+0) - | 1.2148e+0 (0.00e+0) | 9.6390e+0 (1.10e+0) - | 1.3439e+0 (3.91e-2) | 1.1482e+1 (7.99e+0) = | 1.0308e+1 (6.26e+0) |
| DTLZ4 | 10 | 100 | 1.8208e+0 (2.40e-16) + | 4.3507e+0 (0.00e+0) | 1.0375e+0 (8.82e-2) + | 1.2250e+0 (1.20e-2) | 2.2130e+0 (6.22e-1) - | 1.4207e+0 (9.99e-2) |
| DTLZ4 | 10 | 200 | 1.0311e+1 (0.00e+0) - | 6.0934e+0 (9.59e-16) | 1.6510e+0 (1.31e-1) - | 1.3963e+0 (1.14e-1) | 5.4886e+0 (2.50e+0) - | 2.9568e+0 (7.87e-1) |
| DTLZ4 | 10 | 500 | 4.2916e+0 (9.59e-16) - | 1.2437e+0 (0.00e+0) | 4.1124e+0 (3.23e-1) - | 1.3750e+0 (8.46e-2) | 1.1174e+1 (6.53e+0) = | 4.9468e+0 (2.04e+0) |
| DTLZ4 | 10 | 1000 | 2.0021e+1 (0.00e+0) - | 1.3142e+0 (2.40e-16) | 8.8109e+0 (1.07e+0) - | 1.3390e+0 (6.47e-2) | 2.2685e+1 (1.39e+1) - | 8.9945e+0 (3.60e+0) |
| DTLZ5 | 5 | 100 | 3.6554e-1 (6.00e-17) - | 1.7817e-1 (9.22e-2) | 3.9857e-1 (4.40e-2) - | 3.1277e-1 (1.93e-2) | 1.2414e+0 (4.36e-1) - | 4.6998e-1 (1.85e-1) |
| DTLZ5 | 5 | 200 | 3.1222e-1 (0.00e+0) - | 1.8848e-1 (0.00e+0) | 7.7006e-1 (1.13e-1) - | 3.5304e-1 (2.71e-2) | 1.7007e+0 (1.90e+0) = | 2.4190e+0 (1.20e+0) |
| DTLZ5 | 5 | 500 | 7.9092e-2 (0.00e+0) + | 8.6882e-2 (1.50e-17) | 1.8086e+0 (1.07e-1) - | 3.7765e-1 (2.68e-2) | 3.4259e+0 (4.88e+0) + | 7.0683e+0 (3.26e+0) |
| DTLZ5 | 5 | 1000 | 5.8581e+0 (0.00e+0) - | 1.2528e-1 (0.00e+0) | 4.8741e+0 (7.95e-1) - | 4.8973e-1 (3.81e-2) | 7.6654e+0 (1.10e+1) = | 9.7319e+0 (4.63e+0) |
| DTLZ5 | 8 | 100 | 1.0314e+0 (0.00e+0) - | 3.6309e-1 (6.00e-17) | 4.8647e-1 (7.84e-2) - | 3.1610e-1 (2.27e-2) | 1.5430e+0 (1.10e+0) = | 5.8315e-1 (2.55e-1) |
| DTLZ5 | 8 | 200 | 5.5003e-1 (0.00e+0) - | 2.7692e-1 (0.00e+0) | 8.6025e-1 (1.96e-1) - | 3.7485e-1 (1.02e-2) | 1.7493e+0 (1.62e+0) = | 2.2607e+0 (1.26e+0) |
| DTLZ5 | 8 | 500 | 4.9556e-1 (6.00e-17) + | 3.0600e+0 (4.80e-16) | 2.4553e+0 (2.18e-1) - | 3.9319e-1 (2.00e-2) | 2.4104e+0 (1.35e+0) + | 6.8778e+0 (3.65e+0) |
| DTLZ5 | 8 | 1000 | 1.7749e+1 (0.00e+0) - | 3.8405e+0 (0.00e+0) | 3.9433e+0 (5.84e-1) - | 4.4120e-1 (5.98e-2) | 1.0514e+1 (1.38e+1) = | 1.4867e+1 (6.86e+0) |
| DTLZ5 | 10 | 100 | 4.8513e+0 (0.00e+0) - | 2.5213e+0 (0.00e+0) | 3.5665e-1 (1.80e-1) = | 3.3800e-1 (4.47e-2) | 1.9053e+0 (1.06e+0) = | 1.2038e+0 (5.39e-1) |
| DTLZ5 | 10 | 200 | 2.0110e+1 (3.84e-15) - | 4.0218e+0 (0.00e+0) | 8.4073e-1 (1.44e-1) - | 4.5488e-1 (3.23e-2) | 1.9851e+0 (1.51e+0) = | 2.5073e+0 (8.63e-1) |
| DTLZ5 | 10 | 500 | 4.7319e+0 (9.59e-16) - | 9.6563e-1 (1.20e-16) | 2.5040e+0 (3.71e-1) - | 5.1257e-1 (7.28e-2) | 2.7328e+0 (1.68e+0) = | 5.2946e+0 (2.74e+0) |
| DTLZ5 | 10 | 1000 | 3.8172e+0 (0.00e+0) - | 7.9785e-1 (1.20e-16) | 4.3453e+0 (5.12e-1) - | 5.0542e-1 (5.40e-2) | 6.8548e+0 (8.74e+0) = | 1.2591e+1 (4.78e+0) |
| DTLZ6 | 5 | 100 | 1.1599e+0 (0.00e+0) - | 1.1067e+0 (0.00e+0) | 2.7917e+1 (6.28e+0) - | 1.1439e+0 (1.24e-1) | 8.8161e+1 (1.61e-1) - | 2.2209e+1 (2.66e+1) |
| DTLZ6 | 5 | 200 | 1.1964e+0 (0.00e+0) - | 1.0484e+0 (0.00e+0) | 7.0379e+1 (9.75e+0) - | 7.4977e+0 (1.30e+1) | 1.8065e+2 (1.43e+0) - | 1.0154e+2 (1.75e+1) |
| DTLZ6 | 5 | 500 | 1.2964e+0 (2.40e-16) - | 1.2043e+0 (0.00e+0) | 2.1585e+2 (6.25e+0) - | 1.2555e+2 (6.86e+1) | 4.6042e+2 (1.23e+0) - | 3.1040e+2 (4.97e+1) |
| DTLZ6 | 5 | 1000 | 1.2964e+0 (0.00e+0) - | 1.2964e+0 (2.40e-16) | 4.8198e+2 (1.18e+1) = | 4.4290e+2 (5.97e+1) | 9.2429e+2 (3.56e+0) - | 6.3197e+2 (7.11e+1) |
| DTLZ6 | 8 | 100 | 1.7992e+0 (2.40e-16) - | 1.7353e+0 (0.00e+0) | 3.3768e+1 (3.27e+0) - | 1.4865e+0 (1.14e-1) | 8.4960e+1 (2.13e-1) - | 2.8806e+1 (2.14e+1) |
| DTLZ6 | 8 | 200 | 2.1004e+0 (0.00e+0) - | 1.9384e+0 (2.40e-16) | 7.2958e+1 (4.81e+0) - | 5.5756e+0 (9.93e+0) | 1.7817e+2 (5.79e-1) - | 8.9864e+1 (2.83e+1) |
| DTLZ6 | 8 | 500 | 2.0245e+0 (0.00e+0) - | 1.9312e+0 (0.00e+0) | 2.3351e+2 (6.68e+0) - | 1.8481e+2 (8.36e+1) | 4.5777e+2 (7.50e-1) - | 2.7142e+2 (3.46e+1) |
| DTLZ6 | 8 | 1000 | 2.0245e+0 (4.80e-16) + | 2.0245e+0 (0.00e+0) | 4.8364e+2 (1.28e+1) = | 4.6411e+2 (2.03e+1) | 9.2237e+2 (8.82e-1) - | 5.2713e+2 (9.38e+1) |
| DTLZ6 | 10 | 100 | 2.5196e+0 (4.80e-16) - | 2.4278e+0 (0.00e+0) | 3.1211e+1 (3.14e+0) - | 1.8316e+0 (1.90e-1) | 8.3236e+1 (2.78e-1) - | 1.3775e+1 (1.64e+1) |
| DTLZ6 | 10 | 200 | 2.1578e+0 (0.00e+0) + | 3.0000e+0 (0.00e+0) | 7.5626e+1 (3.16e+0) - | 3.4666e+0 (2.95e+0) | 1.7566e+2 (7.63e-1) - | 9.8957e+1 (2.28e+1) |
| DTLZ6 | 10 | 500 | 2.2783e+0 (0.00e+0) + | 2.4365e+0 (0.00e+0) | 2.2663e+2 (5.84e+0) = | 1.9093e+2 (8.34e+1) | 4.5522e+2 (9.73e-1) - | 2.7026e+2 (3.21e+1) |
| DTLZ6 | 10 | 1000 | 2.4365e+0 (4.80e-16) - | 2.4365e+0 (0.00e+0) | 4.7349e+2 (7.49e+0) = | 4.7408e+2 (1.61e+1) | 9.1740e+2 (4.75e+0) - | 6.0092e+2 (7.90e+1) |
| DTLZ7 | 5 | 100 | 3.9318e-1 (6.00e-17) - | 3.6743e-1 (1.60e-3) | 1.0579e+0 (2.93e-1) - | 5.2470e-1 (4.62e-3) | 2.1597e+1 (3.14e-1) - | 3.0007e+0 (6.44e-4) |
| DTLZ7 | 5 | 200 | 4.0986e-1 (0.00e+0) - | 3.6101e-1 (6.00e-17) | 5.9248e+0 (2.61e+0) - | 5.2269e-1 (9.85e-3) | 2.2745e+1 (2.44e-1) - | 1.0267e+1 (2.06e+0) |
| DTLZ7 | 5 | 500 | 4.0213e-1 (0.00e+0) - | 3.9909e-1 (6.00e-17) | 1.3412e+1 (2.21e+0) - | 5.3577e-1 (5.48e-2) | 2.3657e+1 (3.92e-1) - | 1.5187e+1 (3.80e+0) |
| DTLZ7 | 5 | 1000 | 1.3057e+0 (0.00e+0) + | 1.6914e+0 (2.40e-16) | 1.8375e+1 (3.99e-1) - | 1.0133e+0 (1.57e-1) | 2.3364e+1 (4.82e-1) - | 1.8834e+1 (1.43e+0) |
| DTLZ7 | 8 | 100 | 8.7559e-1 (1.20e-16) - | 8.3839e-1 (1.20e-16) | 3.3232e+0 (1.86e+0) - | 1.6240e+0 (2.70e-2) | 3.6314e+1 (9.38e-1) - | 5.3263e+0 (5.65e-4) |
| DTLZ7 | 8 | 200 | 8.8937e-1 (1.20e-16) - | 8.4415e-1 (1.20e-16) | 6.0767e+0 (5.21e+0) - | 1.7672e+0 (4.05e-1) | 3.6591e+1 (3.74e-1) - | 2.3250e+1 (4.17e+0) |
| DTLZ7 | 8 | 500 | 2.4096e+0 (4.80e-16) + | 2.5429e+0 (0.00e+0) | 3.0442e+1 (3.32e+0) - | 1.9336e+0 (3.03e-1) | 3.8006e+1 (3.88e-1) - | 2.8340e+1 (5.24e+0) |
| DTLZ7 | 8 | 1000 | 2.6884e+0 (4.80e-16) + | 3.7687e+0 (4.80e-16) | 3.1414e+1 (1.07e+0) - | 3.3249e+0 (7.49e-1) | 3.8454e+1 (3.39e-1) - | 3.1184e+1 (2.83e+0) |
| DTLZ7 | 10 | 100 | 1.2942e+0 (0.00e+0) - | 1.2233e+0 (0.00e+0) | 1.7905e+0 (1.83e-1) + | 2.5731e+0 (7.75e-1) | 4.5337e+1 (1.43e+0) - | 6.5225e+0 (2.54e-2) |
| DTLZ7 | 10 | 200 | 1.2552e+0 (2.40e-16) - | 1.2006e+0 (2.40e-16) | 1.9084e+0 (1.58e-1) = | 1.9409e+0 (2.96e-1) | 4.6610e+1 (5.96e-1) - | 2.3685e+1 (8.46e+0) |
| DTLZ7 | 10 | 500 | 4.3329e+0 (9.59e-16) - | 3.3804e+0 (0.00e+0) | 3.5226e+1 (1.04e+0) - | 2.6103e+0 (7.30e-1) | 4.7504e+1 (8.55e-1) - | 3.5197e+1 (4.22e+0) |
| DTLZ7 | 10 | 1000 | 3.0398e+0 (0.00e+0) + | 4.7455e+0 (0.00e+0) | 3.5821e+1 (2.54e+0) - | 3.1208e+0 (1.39e+0) | 4.8093e+1 (3.71e-1) - | 3.9525e+1 (2.31e+0) |
| +/-= | | 26/58/0 | | 6/62/16 | | 7/57/20 | | |

TABLE A. 5

THE IGD COMPARISON RESULTS OF EMBEDDING NN MODEL INTO THREE WELL-KNOWN CSOs ON WFG1-WFG9 TEST PROBLEMS WITH 5-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | S_ECSO | NN-SECSO | LMOCSO | NN-LMOCOS | TPLSO | NN-TPLSO |
|---------|----|------|------------------------------|-----------------------------|------------------------------|----------------------------|-----------------------|----------------------------|
| WFG1 | 5 | 100 | 2.2982e+0 (4.80e-16) - | 2.2392e+0 (2.35e-2) | 1.9695e+0 (3.30e-2) + | 2.0110e+0 (2.93e-2) = | 3.0838e+0 (5.99e-1) - | 2.3281e+0 (3.90e-2) |
| WFG1 | 5 | 200 | 2.3441e+0 (6.03e-5) - | 2.2442e+0 (5.45e-2) | 2.0480e+0 (4.78e-2) = | 2.0071e+0 (1.28e-2) | 3.3023e+0 (1.26e+0) - | 2.5644e+0 (1.45e-1) |
| WFG1 | 5 | 500 | 2.3500e+0 (0.00e+0) - | 2.1083e+0 (0.00e+0) | 2.0314e+0 (3.14e-2) = | 2.0096e+0 (2.30e-2) | 2.8578e+0 (1.22e-1) - | 2.5445e+0 (1.77e-1) |
| WFG1 | 5 | 1000 | 2.3985e+0 (0.00e+0) - | 2.3846e+0 (4.80e-16) | 2.2087e+0 (4.20e-2) = | 2.1607e+0 (3.70e-2) | 2.8758e+0 (7.74e-2) - | 2.7675e+0 (7.18e-2) |
| WFG1 | 8 | 100 | 2.9082e+0 (4.80e-16) - | 2.7536e+0 (4.80e-16) | 2.6186e+0 (2.99e-2) + | 2.6508e+0 (2.50e-2) | 4.3975e+0 (2.64e+0) - | 2.9254e+0 (6.82e-2) |
| WFG1 | 8 | 200 | 2.8779e+0 (4.80e-16) - | 2.7804e+0 (4.80e-16) | 2.6507e+0 (2.54e-2) = | 2.6401e+0 (2.00e-2) | 3.4364e+0 (1.18e-1) - | 3.1399e+0 (7.95e-2) |
| WFG1 | 8 | 500 | 2.9969e+0 (0.00e+0) - | 2.9591e+0 (7.68e-2) | 2.6710e+0 (2.84e-2) = | 2.6538e+0 (3.33e-2) | 3.4044e+0 (4.84e-2) - | 3.2649e+0 (6.15e-2) |
| WFG1 | 8 | 1000 | 2.9914e+0 (4.80e-16) - | 2.9206e+0 (4.80e-16) | 2.7933e+0 (3.22e-2) = | 2.8140e+0 (5.60e-2) | 3.3829e+0 (5.23e-2) - | 3.2004e+0 (7.83e-2) |
| WFG1 | 10 | 100 | 3.3333e+0 (5.47e-2) - | 3.1430e+0 (0.00e+0) | 3.0162e+0 (2.55e-2) = | 3.0278e+0 (2.83e-2) | 3.6545e+0 (4.19e-2) - | 3.3157e+0 (6.20e-2) |
| WFG1 | 10 | 200 | 3.3437e+0 (0.00e+0) - | 3.2303e+0 (0.00e+0) | 3.0698e+0 (2.70e-2) = | 3.0462e+0 (2.01e-2) | 3.6761e+0 (9.75e-2) - | 3.4590e+0 (5.70e-2) |
| WFG1 | 10 | 500 | 3.3242e+0 (4.80e-16) - | 3.2406e+0 (4.80e-16) | 3.0783e+0 (3.36e-2) = | 3.0566e+0 (2.62e-2) | 3.6512e+0 (5.81e-2) - | 3.5284e+0 (8.78e-2) |
| WFG1 | 10 | 1000 | 3.3303e+0 (0.00e+0) - | 3.2923e+0 (9.59e-16) | 3.2273e+0 (3.62e-2) = | 3.1995e+0 (4.98e-2) | 3.6315e+0 (7.99e-2) - | 3.5110e+0 (8.25e-2) |
| WFG2 | 5 | 100 | 1.2471e+0 (0.00e+0) - | 6.9406e-1 (1.59e-2) | 5.2601e-1 (2.05e-2) = | 5.0634e-1 (1.48e-2) | 4.4484e+0 (1.98e+0) - | 1.6161e+0 (2.38e-1) |
| WFG2 | 5 | 200 | 1.3469e+0 (2.40e-16) - | 7.0951e-1 (1.20e-16) | 5.9276e-1 (2.37e-2) - | 5.5282e-1 (1.92e-2) | 7.1982e+0 (2.37e+0) - | 1.4324e+0 (2.58e-1) |
| WFG2 | 5 | 500 | 1.3787e+0 (0.00e+0) - | 8.3332e-1 (0.00e+0) | 6.5085e-1 (1.89e-2) - | 5.7927e-1 (1.76e-2) | 5.9764e+0 (2.49e+0) - | 1.5391e+0 (3.26e-1) |
| WFG2 | 5 | 1000 | 1.3821e+0 (2.40e-16) - | 1.1949e+0 (2.40e-16) | 7.6442e-1 (2.33e-2) - | 7.2980e-1 (2.70e-2) | 4.9653e+0 (1.78e+0) - | 1.3747e+0 (1.98e-1) |
| WFG2 | 8 | 101 | 2.0775e+0 (0.00e+0) - | 1.4912e+0 (0.00e+0) | 1.3257e+0 (4.02e-2) - | 1.1968e+0 (2.06e-2) | 1.0817e+1 (3.41e+0) - | 2.3578e+0 (3.18e-1) |
| WFG2 | 8 | 201 | 2.1289e+0 (4.80e-16) - | 1.2313e+0 (0.00e+0) | 1.3467e+0 (8.16e-2) - | 1.2357e+0 (2.93e-2) | 1.0409e+1 (3.10e+0) - | 2.1125e+0 (3.16e-1) |
| WFG2 | 8 | 501 | 2.2819e+0 (0.00e+0) - | 2.0552e+0 (0.00e+0) | 1.4102e+0 (4.59e-2) - | 1.2865e+0 (3.89e-2) | 8.7587e+0 (3.47e+0) - | 2.6990e+0 (5.57e-1) |
| WFG2 | 8 | 1001 | 2.1172e+0 (0.00e+0) - | 2.0078e+0 (0.00e+0) | 1.5680e+0 (1.05e-1) - | 1.3762e+0 (4.31e-2) | 8.8071e+0 (2.79e+0) - | 2.7136e+0 (4.11e-1) |
| WFG2 | 10 | 101 | 2.5336e+0 (0.00e+0) - | 1.7268e+0 (2.40e-16) | 1.4481e+0 (6.87e-2) = | 1.4342e+0 (4.64e-2) | 1.4641e+1 (4.17e+0) - | 2.9027e+0 (3.52e-1) |
| WFG2 | 10 | 201 | 2.5875e+0 (4.80e-16) - | 2.1155e+0 (4.80e-16) | 1.5226e+0 (6.77e-2) = | 1.4897e+0 (6.34e-2) | 1.4073e+1 (5.55e+0) - | 3.1718e+0 (6.40e-1) |
| WFG2 | 10 | 501 | 2.7132e+0 (4.80e-16) - | 2.2817e+0 (0.00e+0) | 1.6409e+0 (7.04e-2) = | 1.5601e+0 (8.69e-2) | 1.1299e+1 (5.84e+0) - | 3.3966e+0 (8.81e-1) |
| WFG2 | 10 | 1001 | 2.7439e+0 (0.00e+0) - | 2.3443e+0 (0.00e+0) | 1.9789e+0 (1.71e-1) - | 1.7821e+0 (1.27e-1) | 1.0130e+1 (4.81e+0) - | 3.5339e+0 (9.22e-1) |
| WFG3 | 5 | 100 | 1.2720e+0 (2.40e-16) - | 6.4761e-1 (1.64e-2) | 8.5789e-1 (4.08e-2) - | 5.9375e-1 (3.14e-2) | 3.0118e+0 (2.15e-1) - | 9.3995e-1 (8.16e-2) |
| WFG3 | 5 | 200 | 1.2843e+0 (0.00e+0) - | 6.4929e-1 (0.00e+0) | 9.1730e-1 (5.78e-2) - | 6.3256e-1 (4.62e-2) | 3.0774e+0 (3.36e-1) - | 8.9353e-1 (8.79e-2) |
| WFG3 | 5 | 500 | 1.2550e+0 (2.40e-16) - | 6.2183e-1 (0.00e+0) | 1.0334e+0 (9.02e-2) - | 6.8104e-1 (9.27e-2) | 3.0437e+0 (2.53e-1) - | 9.5294e-1 (6.75e-2) |
| WFG3 | 5 | 1000 | 1.3470e+0 (0.00e+0) - | 7.4661e-1 (1.20e-16) | 1.2626e+0 (5.67e-2) - | 9.2953e-1 (3.72e-2) | 2.2713e+0 (3.68e-1) - | 9.8579e-1 (1.73e-1) |
| WFG3 | 8 | 101 | 1.9041e+0 (0.00e+0) - | 1.3779e+0 (0.00e+0) | 3.8600e+0 (2.58e+0) = | 2.2319e+0 (5.89e-2) | 5.0300e+0 (6.63e-1) - | 1.4144e+0 (2.32e-1) |
| WFG3 | 8 | 201 | 1.8244e+0 (4.80e-16) - | 1.2483e+0 (2.40e-16) | 3.3553e+0 (2.27e+0) - | 2.1652e+0 (1.93e-1) | 5.0500e+0 (4.18e-1) - | 1.1898e+0 (1.46e-1) |
| WFG3 | 8 | 501 | 1.7334e+0 (0.00e+0) - | 1.2984e+0 (2.40e-16) | 3.4533e+0 (2.38e+0) - | 2.0726e+0 (1.50e-1) | 4.0465e+0 (2.22e-1) - | 1.2518e+0 (9.89e-2) |
| WFG3 | 8 | 1001 | 1.7921e+0 (0.00e+0) - | 1.2187e+0 (0.00e+0) | 3.6361e+0 (2.40e+0) = | 2.5123e+0 (6.40e-2) | 4.1822e+0 (1.07e+0) - | 1.2778e+0 (1.65e-1) |
| WFG3 | 10 | 101 | 2.4063e+0 (0.00e+0) - | 1.8621e+0 (0.00e+0) | 3.3679e+0 (1.34e-1) - | 3.0854e+0 (1.81e-1) | 6.0816e+0 (6.08e-1) - | 1.4911e+0 (1.50e-1) |
| WFG3 | 10 | 201 | 2.2400e+0 (0.00e+0) - | 1.5018e+0 (2.40e-16) | 3.3341e+0 (1.61e-1) = | 3.0089e+0 (3.13e-1) | 6.4149e+0 (1.06e+0) - | 1.4254e+0 (1.60e-1) |
| WFG3 | 10 | 501 | 2.1088e+0 (0.00e+0) - | 1.5580e+0 (2.40e-16) | 3.3644e+0 (4.62e-1) - | 2.8836e+0 (2.04e-1) | 5.7684e+0 (7.54e-1) - | 1.4509e+0 (1.40e-1) |
| WFG3 | 10 | 1001 | 2.1572e+0 (0.00e+0) - | 1.6784e+0 (4.80e-16) | 3.3933e+0 (4.13e-1) = | 3.0806e+0 (1.78e-1) | 5.7701e+0 (8.10e-1) - | 1.3761e+0 (1.80e-1) |
| WFG4 | 5 | 100 | 1.3524e+0 (2.40e-16) - | 1.2656e+0 (8.80e-3) | 1.0531e+0 (5.51e-3) = | 1.0561e+0 (5.97e-3) | 5.5063e+0 (4.37e-1) - | 2.2349e+0 (1.38e-1) |
| WFG4 | 5 | 200 | 1.3417e+0 (2.40e-16) - | 1.2869e+0 (0.00e+0) | 1.0594e+0 (6.66e-3) = | 1.0542e+0 (6.35e-3) | 5.4732e+0 (4.58e-1) - | 2.1364e+0 (5.05e-1) |
| WFG4 | 5 | 500 | 1.3669e+0 (2.40e-16) - | 1.2408e+0 (0.00e+0) | 1.0642e+0 (6.50e-3) = | 1.1859e+0 (3.20e-1) | 5.6420e+0 (7.35e-1) - | 2.1003e+0 (2.84e-1) |
| WFG4 | 5 | 1000 | 1.4032e+0 (0.00e+0) - | 1.3214e+0 (2.40e-16) | 1.1268e+0 (1.08e-2) = | 1.1353e+0 (1.69e-2) | 4.8420e+0 (3.16e-1) - | 2.2417e+0 (2.83e-1) |
| WFG4 | 8 | 100 | 3.3713e+0 (0.00e+0) + | 3.4394e+0 (4.80e-16) | 3.1809e+0 (3.53e-2) = | 3.1920e+0 (3.04e-2) | 1.1666e+1 (7.40e-1) - | 5.1018e+0 (3.41e-1) |
| WFG4 | 8 | 200 | 3.4035e+0 (9.59e-16) - | 3.3751e+0 (4.80e-16) | 3.1995e+0 (3.76e-2) = | 3.2079e+0 (2.39e-2) | 1.1952e+1 (1.31e+0) - | 4.6585e+0 (4.49e-1) |

| | | | | | | | | |
|------|----|------|-------------------------------|-----------------------------|------------------------------|----------------------------|------------------------------|----------------------------|
| WFG4 | 8 | 500 | 3.4025e+0 (9.59e-16) + | 3.4769e+0 (4.80e-16) | 3.2094e+0 (1.55e-2) - | 3.1822e+0 (1.84e-2) | 9.7661e+0 (4.87e-1) - | 5.3885e+0 (6.24e-1) |
| WFG4 | 8 | 1000 | 3.3879e+0 (4.80e-16) + | 3.4073e+0 (4.80e-16) | 3.2899e+0 (6.89e-2) = | 3.2678e+0 (4.27e-2) | 1.0135e+1 (1.01e+0) - | 5.9105e+0 (1.14e+0) |
| WFG4 | 10 | 100 | 4.9528e+0 (9.59e-16) + | 5.0841e+0 (0.00e+0) | 4.8867e+0 (2.23e-1) = | 4.7190e+0 (1.23e-1) | 1.5224e+1 (1.34e+0) - | 7.0807e+0 (5.52e-1) |
| WFG4 | 10 | 200 | 4.9020e+0 (0.00e+0) + | 5.0509e+0 (9.59e-16) | 4.7849e+0 (8.82e-2) - | 4.6203e+0 (9.04e-2) | 1.5768e+1 (1.29e+0) - | 6.5846e+0 (6.38e-1) |
| WFG4 | 10 | 500 | 4.9659e+0 (9.59e-16) - | 4.9038e+0 (9.59e-16) | 4.9058e+0 (1.99e-1) - | 4.6596e+0 (9.84e-2) | 1.4520e+1 (7.15e-1) - | 7.3433e+0 (9.10e-1) |
| WFG4 | 10 | 1000 | 5.0287e+0 (9.59e-16) - | 4.9405e+0 (9.59e-16) | 4.6017e+0 (4.82e-2) - | 4.5209e+0 (3.49e-2) | 1.3830e+1 (1.58e+0) - | 7.4552e+0 (1.47e+0) |
| WFG5 | 5 | 100 | 1.3247e+0 (0.00e+0) - | 1.2748e+0 (1.91e-2) | 1.0137e+0 (2.18e-3) = | 1.0132e+0 (1.34e-3) | 5.8071e+0 (6.96e-1) - | 1.9285e+0 (1.16e-1) |
| WFG5 | 5 | 200 | 1.3034e+0 (2.40e-16) - | 1.2519e+0 (2.40e-16) | 1.0143e+0 (3.30e-3) = | 1.0150e+0 (3.04e-3) | 6.2578e+0 (1.13e+0) - | 1.6836e+0 (1.57e-1) |
| WFG5 | 5 | 500 | 1.2811e+0 (0.00e+0) - | 1.2338e+0 (0.00e+0) | 1.0137e+0 (3.24e-3) = | 1.0134e+0 (3.75e-3) | 1.7102e+0 (4.77e-2) = | 1.7267e+0 (9.86e-2) |
| WFG5 | 5 | 1000 | 1.3782e+0 (2.40e-16) + | 1.3897e+0 (2.40e-16) | 1.1240e+0 (1.50e-2) = | 1.1103e+0 (1.31e-2) | 3.8753e+0 (6.19e-1) - | 1.9894e+0 (3.01e-1) |
| WFG5 | 8 | 100 | 3.7182e+0 (0.00e+0) - | 3.6865e+0 (4.80e-16) | 2.9906e+0 (2.37e-2) + | 3.0526e+0 (4.36e-2) | 1.1272e+1 (1.56e+0) - | 4.1708e+0 (1.98e-1) |
| WFG5 | 8 | 200 | 3.8461e+0 (9.59e-16) - | 3.8040e+0 (0.00e+0) | 3.0403e+0 (4.69e-2) = | 3.0415e+0 (4.23e-2) | 1.0554e+1 (1.14e+0) - | 4.3292e+0 (1.86e-1) |
| WFG5 | 8 | 500 | 4.3595e+0 (0.00e+0) - | 4.0549e+0 (0.00e+0) | 3.0819e+0 (6.57e-2) = | 3.0802e+0 (7.22e-2) | 7.4106e+0 (3.52e-1) - | 4.8696e+0 (9.57e-1) |
| WFG5 | 8 | 1000 | 4.2952e+0 (9.59e-16) - | 4.0921e+0 (9.59e-16) | 3.4914e+0 (6.11e-2) = | 3.4457e+0 (2.78e-2) | 6.8596e+0 (5.23e-1) - | 4.5208e+0 (4.41e-1) |
| WFG5 | 10 | 100 | 5.4438e+0 (9.59e-16) - | 5.2635e+0 (0.00e+0) | 4.3653e+0 (6.10e-2) = | 4.3701e+0 (5.38e-2) | 1.2195e+1 (1.52e+0) - | 5.9483e+0 (4.40e-1) |
| WFG5 | 10 | 200 | 5.6043e+0 (9.59e-16) - | 5.5215e+0 (9.59e-16) | 4.3604e+0 (4.31e-2) = | 4.4166e+0 (6.79e-2) | 1.4423e+1 (2.19e+0) - | 6.0945e+0 (5.04e-1) |
| WFG5 | 10 | 500 | 6.0519e+0 (0.00e+0) - | 5.8067e+0 (9.59e-16) | 4.4110e+0 (5.74e-2) + | 4.5010e+0 (3.98e-2) | 9.0437e+0 (8.24e-1) - | 6.2460e+0 (6.75e-1) |
| WFG5 | 10 | 1000 | 6.6456e+0 (9.59e-16) - | 5.7111e+0 (9.59e-16) | 4.9757e+0 (7.17e-2) = | 4.9927e+0 (7.12e-2) | 8.8401e+0 (7.02e-1) - | 6.1808e+0 (5.71e-1) |
| WFG6 | 5 | 100 | 1.3949e+0 (2.40e-16) - | 1.2561e+0 (1.39e-2) | 1.0590e+0 (5.38e-3) = | 1.0606e+0 (8.55e-3) | 5.1134e+0 (5.34e-1) - | 2.1218e+0 (1.97e-1) |
| WFG6 | 5 | 200 | 1.5283e+0 (2.40e-16) - | 1.3221e+0 (2.40e-16) | 1.0622e+0 (8.95e-3) = | 1.0734e+0 (2.12e-2) | 5.1664e+0 (5.63e-1) - | 2.1936e+0 (2.69e-1) |
| WFG6 | 5 | 500 | 1.5921e+0 (2.40e-16) - | 1.4532e+0 (2.40e-16) | 1.0700e+0 (9.28e-3) = | 1.0849e+0 (2.12e-2) | 5.1900e+0 (5.16e-1) - | 2.2328e+0 (2.25e-1) |
| WFG6 | 5 | 1000 | 2.3031e+0 (4.80e-16) - | 1.9136e+0 (0.00e+0) | 1.5838e+0 (4.95e-2) - | 1.3864e+0 (3.03e-2) | 5.1336e+0 (5.13e-1) - | 2.4301e+0 (2.53e-1) |
| WFG6 | 8 | 100 | 3.4417e+0 (0.00e+0) - | 3.4178e+0 (0.00e+0) | 3.2835e+0 (6.52e-2) - | 3.1393e+0 (8.91e-2) | 1.0507e+1 (1.29e+0) - | 5.3815e+0 (7.58e-1) |
| WFG6 | 8 | 200 | 3.5345e+0 (4.80e-16) - | 3.4770e+0 (4.80e-16) | 3.2915e+0 (8.21e-2) - | 3.1595e+0 (8.56e-2) | 1.0699e+1 (5.81e-1) - | 5.2236e+0 (3.20e-1) |
| WFG6 | 8 | 500 | 5.8389e+0 (0.00e+0) - | 4.8228e+0 (0.00e+0) | 3.2844e+0 (5.53e-2) - | 3.1892e+0 (5.75e-2) | 9.7830e+0 (7.64e-1) - | 5.9913e+0 (5.62e-1) |
| WFG6 | 8 | 1000 | 5.6952e+0 (9.59e-16) + | 6.1921e+0 (9.59e-16) | 3.8969e+0 (2.62e-1) - | 3.4520e+0 (6.52e-2) | 1.0189e+1 (4.48e-1) - | 5.9202e+0 (4.67e-1) |
| WFG6 | 10 | 100 | 5.1302e+0 (9.59e-16) - | 5.0566e+0 (9.59e-16) | 4.7055e+0 (7.04e-2) = | 4.6680e+0 (1.04e-1) | 1.3622e+1 (6.36e-1) - | 7.4573e+0 (9.42e-1) |
| WFG6 | 10 | 200 | 5.2255e+0 (0.00e+0) + | 5.4755e+0 (0.00e+0) | 4.7835e+0 (1.79e-1) - | 4.5751e+0 (7.01e-2) | 1.3626e+1 (8.04e-1) - | 7.2712e+0 (7.01e-1) |
| WFG6 | 10 | 500 | 7.7139e+0 (0.00e+0) - | 7.5884e+0 (0.00e+0) | 4.6370e+0 (8.79e-2) = | 4.6990e+0 (1.56e-1) | 1.3859e+1 (4.78e-1) - | 8.4610e+0 (8.94e-1) |
| WFG6 | 10 | 1000 | 7.9653e+0 (0.00e+0) - | 7.0262e+0 (9.59e-16) | 5.1286e+0 (2.79e-1) = | 4.9120e+0 (2.16e-1) | 1.2832e+1 (7.03e-1) - | 8.6881e+0 (9.20e-1) |
| WFG7 | 5 | 100 | 1.6056e+0 (2.40e-16) - | 1.4011e+0 (1.93e-2) | 1.1449e+0 (8.91e-3) - | 1.1053e+0 (6.00e-3) | 5.8770e+0 (9.26e-1) - | 2.9833e+0 (5.53e-1) |
| WFG7 | 5 | 200 | 1.5735e+0 (2.40e-16) - | 1.4429e+0 (0.00e+0) | 1.1635e+0 (7.17e-3) - | 1.1238e+0 (7.95e-3) | 5.9621e+0 (8.06e-1) - | 2.2336e+0 (3.75e-1) |
| WFG7 | 5 | 500 | 1.5707e+0 (0.00e+0) - | 1.4779e+0 (0.00e+0) | 1.1861e+0 (1.80e-2) - | 1.1375e+0 (6.22e-3) | 5.4560e+0 (7.88e-1) - | 2.0865e+0 (1.90e-1) |
| WFG7 | 5 | 1000 | 1.6496e+0 (2.40e-16) + | 1.6779e+0 (0.00e+0) | 1.2868e+0 (8.89e-3) - | 1.2482e+0 (2.09e-2) | 4.8687e+0 (3.97e-1) - | 2.3755e+0 (3.88e-1) |
| WFG7 | 8 | 100 | 3.5595e+0 (4.80e-16) - | 3.5590e+0 (0.00e+0) | 3.1562e+0 (1.82e-2) - | 3.1192e+0 (2.66e-2) | 1.0940e+1 (1.27e+0) - | 8.1203e+0 (9.27e-1) |
| WFG7 | 8 | 200 | 3.5733e+0 (4.80e-16) - | 3.5559e+0 (9.59e-16) | 3.1903e+0 (2.65e-2) = | 3.1565e+0 (2.86e-2) | 1.1167e+1 (1.41e+0) - | 6.3015e+0 (8.06e-1) |
| WFG7 | 8 | 500 | 3.7430e+0 (0.00e+0) + | 3.9220e+0 (0.00e+0) | 3.2262e+0 (4.25e-2) - | 3.1208e+0 (1.84e-2) | 1.0276e+1 (5.37e-1) - | 6.1287e+0 (9.27e-1) |
| WFG7 | 8 | 1000 | 3.7269e+0 (9.59e-16) - | 3.6756e+0 (4.80e-16) | 3.5538e+0 (9.22e-2) - | 3.3300e+0 (4.05e-2) | 1.0652e+1 (8.79e-1) - | 5.6400e+0 (5.20e-1) |
| WFG7 | 10 | 100 | 5.0882e+0 (0.00e+0) + | 5.1056e+0 (9.59e-16) | 4.5082e+0 (4.46e-2) = | 4.4828e+0 (4.43e-2) | 1.4561e+1 (9.70e-1) - | 1.0775e+1 (9.08e-1) |
| WFG7 | 10 | 200 | 5.1090e+0 (0.00e+0) - | 5.0699e+0 (0.00e+0) | 4.5069e+0 (4.02e-2) = | 4.4663e+0 (5.14e-2) | 1.4092e+1 (1.43e+0) - | 8.7651e+0 (1.13e+0) |
| WFG7 | 10 | 500 | 5.3986e+0 (0.00e+0) + | 5.7015e+0 (9.59e-16) | 5.0244e+0 (5.36e-1) - | 4.4638e+0 (1.18e-1) | 1.4045e+1 (1.43e+0) - | 8.3921e+0 (9.71e-1) |
| WFG7 | 10 | 1000 | 5.4265e+0 (0.00e+0) - | 5.3593e+0 (0.00e+0) | 4.9586e+0 (2.37e-1) - | 4.6457e+0 (1.11e-1) | 1.3724e+1 (7.63e-1) - | 8.5385e+0 (7.44e-1) |
| WFG8 | 5 | 100 | 1.5997e+0 (2.40e-16) - | 1.4255e+0 (2.40e-2) | 1.1548e+0 (1.59e-2) = | 1.1426e+0 (4.87e-3) | 5.3538e+0 (6.49e-1) - | 2.4988e+0 (1.54e-1) |
| WFG8 | 5 | 200 | 1.6791e+0 (2.40e-16) - | 1.4210e+0 (2.40e-16) | 1.1848e+0 (1.77e-2) = | 1.1737e+0 (1.07e-2) | 5.2804e+0 (3.40e-1) - | 2.2028e+0 (2.91e-1) |
| WFG8 | 5 | 500 | 1.7322e+0 (2.40e-16) - | 1.6305e+0 (2.40e-16) | 1.2109e+0 (2.01e-2) - | 1.1718e+0 (1.33e-2) | 5.3421e+0 (6.32e-1) - | 2.3871e+0 (3.14e-1) |

| | | | | | | | | |
|------|----|---------|-------------------------------|-----------------------------|------------------------------|----------------------------|-----------------------|----------------------------|
| WFG8 | 5 | 1000 | 2.2099e+0 (0.00e+0) + | 2.2671e+0 (0.00e+0) | 1.3328e+0 (4.49e-2) = | 1.3015e+0 (1.09e-2) | 4.8314e+0 (4.06e-1) - | 2.1983e+0 (1.76e-1) |
| WFG8 | 8 | 100 | 3.7693e+0 (0.00e+0) - | 3.6733e+0 (4.80e-16) | 3.2325e+0 (5.31e-2) = | 3.2508e+0 (6.18e-2) | 1.0840e+1 (5.66e-1) - | 5.5627e+0 (2.29e-1) |
| WFG8 | 8 | 200 | 3.9034e+0 (4.80e-16) + | 3.9079e+0 (0.00e+0) | 3.2252e+0 (1.33e-2) = | 3.2326e+0 (2.47e-2) | 1.0089e+1 (6.22e-1) - | 5.7691e+0 (6.91e-1) |
| WFG8 | 8 | 500 | 6.6102e+0 (0.00e+0) - | 6.2815e+0 (9.59e-16) | 3.2526e+0 (2.44e-2) - | 3.1741e+0 (4.80e-3) | 1.0015e+1 (1.11e+0) - | 5.8039e+0 (7.42e-1) |
| WFG8 | 8 | 1000 | 6.5402e+0 (9.59e-16) - | 5.3579e+0 (9.59e-16) | 3.5711e+0 (6.99e-2) - | 3.4078e+0 (3.16e-2) | 1.0676e+1 (4.83e-1) - | 6.1945e+0 (4.52e-1) |
| WFG8 | 10 | 100 | 5.2256e+0 (0.00e+0) - | 5.1787e+0 (9.59e-16) | 4.5533e+0 (5.26e-2) = | 4.6268e+0 (9.97e-2) | 1.3944e+1 (9.85e-1) - | 7.3616e+0 (4.19e-1) |
| WFG8 | 10 | 200 | 5.5224e+0 (9.59e-16) - | 5.4163e+0 (0.00e+0) | 4.5744e+0 (8.73e-2) = | 4.5396e+0 (8.20e-2) | 1.3703e+1 (8.28e-1) - | 7.6362e+0 (7.20e-1) |
| WFG8 | 10 | 500 | 8.8712e+0 (0.00e+0) + | 9.0618e+0 (0.00e+0) | 4.9886e+0 (2.29e-1) - | 4.7277e+0 (5.74e-2) | 1.3217e+1 (1.13e+0) - | 8.2270e+0 (8.96e-1) |
| WFG8 | 10 | 1000 | 8.3122e+0 (1.92e-15) + | 8.4577e+0 (1.92e-15) | 4.9095e+0 (1.75e-1) - | 4.7367e+0 (1.34e-1) | 1.3909e+1 (5.95e-1) - | 9.6980e+0 (1.51e+0) |
| WFG9 | 5 | 100 | 1.6479e+0 (4.80e-16) - | 1.2327e+0 (5.46e-3) | 1.0465e+0 (4.62e-3) = | 1.0434e+0 (9.91e-3) | 6.1724e+0 (8.77e-1) - | 1.7790e+0 (2.02e-1) |
| WFG9 | 5 | 200 | 1.5864e+0 (2.40e-16) - | 1.1969e+0 (0.00e+0) | 1.0518e+0 (1.21e-2) = | 1.0619e+0 (9.93e-3) | 5.8348e+0 (1.25e+0) - | 1.7197e+0 (2.13e-1) |
| WFG9 | 5 | 500 | 1.4773e+0 (0.00e+0) - | 1.2040e+0 (0.00e+0) | 1.0707e+0 (1.88e-2) = | 1.0759e+0 (1.61e-2) | 5.9941e+0 (8.87e-1) - | 1.8112e+0 (3.89e-1) |
| WFG9 | 5 | 1000 | 1.7663e+0 (0.00e+0) - | 1.3882e+0 (0.00e+0) | 1.2258e+0 (3.23e-2) - | 1.1851e+0 (1.98e-2) | 3.6332e+0 (8.31e-1) - | 1.7219e+0 (2.06e-1) |
| WFG9 | 8 | 100 | 4.2186e+0 (0.00e+0) - | 3.4774e+0 (0.00e+0) | 3.0530e+0 (3.95e-2) = | 3.0253e+0 (2.74e-2) | 1.1311e+1 (1.79e+0) - | 5.9506e+0 (1.12e+0) |
| WFG9 | 8 | 200 | 4.3916e+0 (0.00e+0) - | 3.5301e+0 (4.80e-16) | 3.0553e+0 (3.35e-2) = | 3.0798e+0 (3.05e-2) | 1.1414e+1 (2.34e+0) - | 4.2765e+0 (2.05e-1) |
| WFG9 | 8 | 500 | 4.8454e+0 (0.00e+0) - | 3.9756e+0 (9.59e-16) | 3.1083e+0 (6.30e-2) = | 3.0605e+0 (3.92e-2) | 7.0927e+0 (6.13e-1) - | 4.2020e+0 (2.51e-1) |
| WFG9 | 8 | 1000 | 4.8297e+0 (0.00e+0) - | 3.9591e+0 (0.00e+0) | 3.6744e+0 (8.79e-2) - | 3.4628e+0 (6.34e-2) | 6.7029e+0 (5.93e-1) - | 4.0383e+0 (2.66e-1) |
| WFG9 | 10 | 100 | 5.8096e+0 (0.00e+0) - | 4.9432e+0 (0.00e+0) | 4.4941e+0 (1.34e-1) + | 4.6532e+0 (4.89e-2) | 1.3715e+1 (2.32e+0) - | 6.1342e+0 (4.82e-1) |
| WFG9 | 10 | 200 | 6.0558e+0 (9.59e-16) - | 5.0416e+0 (0.00e+0) | 4.5941e+0 (5.51e-2) = | 4.6372e+0 (7.13e-2) | 1.0972e+1 (1.85e+0) - | 6.5802e+0 (8.35e-1) |
| WFG9 | 10 | 500 | 7.0047e+0 (0.00e+0) - | 6.2363e+0 (0.00e+0) | 4.8974e+0 (1.89e-1) = | 5.0515e+0 (8.17e-2) | 8.6738e+0 (6.90e-1) - | 5.6362e+0 (6.06e-1) |
| WFG9 | 10 | 1000 | 7.1895e+0 (9.59e-16) - | 5.7497e+0 (9.59e-16) | 4.8908e+0 (1.54e-1) = | 4.9860e+0 (1.42e-1) | 8.4672e+0 (6.53e-1) - | 6.5027e+0 (8.18e-1) |
| +/-= | | 16/92/0 | | | 5/42/61 | | 0/107/1 | |

TABLE A. 6

THE IGD COMPARISON RESULTS OF SIX COMPARED ALGORITHMS ON UF1-UF10 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | LSMOf | DGEA | LMEA | LSMOEAD | MOEADVA | NN-CSO | |
|---------|---|----------|------------------------------|-----------------------|------------------------------|---------------------|---------------------|----------------------------|--|
| UF1 | 2 | 100 | 1.4349e-1 (2.13e-2) + | 7.1944e-1 (1.67e-1) - | 4.1409e-2 (1.43e-3) + | 1.31e+00(1.31e-01)- | 3.94e-01(2.00e-02)- | 2.4318e-1 (1.16e-2) | |
| UF1 | 2 | 200 | 2.0901e-1 (4.27e-2) + | 1.1972e+0 (9.62e-2) - | 1.8699e+0 (6.12e-2) - | 1.57e+00(1.04e-01)- | 1.15e+00(4.23e-02)- | 5.0663e-1 (6.26e-1) | |
| UF1 | 2 | 500 | 3.0578e-1 (5.88e-2) = | 9.6395e-1 (5.93e-1) - | 2.0674e+0 (3.36e-2) - | 1.87e+00(6.01e-02)- | 1.77e+00(4.86e-02)- | 2.8877e-1 (4.73e-3) | |
| UF1 | 2 | 1000 | 3.2827e-1 (2.12e-2) - | 5.3782e-1 (4.32e-1) - | 2.1304e+0 (2.13e-2) - | 2.08e+00(4.44e-02)- | 2.01e+00(5.53e-02)- | 2.9360e-1 (5.83e-3) | |
| UF2 | 2 | 100 | 1.9456e-1 (6.95e-2) - | 1.8207e-1 (1.96e-2) - | 1.7251e-2 (3.17e-4) + | 4.84e-01(6.64e-02)- | 1.96e-01(1.02e-02)- | 8.3317e-2 (4.18e-3) | |
| UF2 | 2 | 200 | 2.4282e-1 (4.76e-2) - | 2.2943e-1 (2.35e-2) - | 8.5254e-1 (2.45e-2) - | 7.15e-01(3.62e-02)- | 5.46e-01(9.97e-03)- | 1.1017e-1 (4.73e-2) | |
| UF2 | 2 | 500 | 3.2271e-1 (2.78e-2) - | 2.8149e-1 (2.81e-2) - | 8.9856e-1 (7.61e-3) - | 7.98e-01(3.47e-02)- | 8.04e-01(1.08e-02)- | 9.2597e-2 (3.54e-3) | |
| UF2 | 2 | 1000 | 3.8262e-1 (4.01e-2) - | 3.0738e-1 (1.25e-2) - | 9.3439e-1 (1.18e-2) - | 9.09e-01(1.22e-02)- | 8.89e-01(1.13e-02)- | 9.6263e-2 (4.00e-3) | |
| UF3 | 2 | 100 | 2.3127e-1 (8.73e-3) - | 2.8003e-1 (4.83e-2) - | 1.4085e-1 (2.57e-3) + | 7.41e-01(6.46e-02)- | 3.64e-01(1.19e-02)- | 1.8399e-1 (7.77e-3) | |
| UF3 | 2 | 200 | 2.1555e-1 (4.79e-3) - | 3.6099e-1 (1.66e-2) - | 1.0422e+0 (2.22e-2) - | 8.69e-01(2.99e-02)- | 6.96e-01(1.64e-02)- | 1.5620e-1 (3.36e-3) | |
| UF3 | 2 | 500 | 2.0555e-1 (3.28e-3) - | 3.8754e-1 (1.12e-1) - | 1.0891e+0 (1.67e-2) - | 9.22e-01(1.93e-02)- | 9.60e-01(8.22e-03)- | 1.3442e-1 (1.11e-3) | |
| UF3 | 2 | 1000 | 2.0280e-1 (1.63e-3) - | 3.7934e-1 (1.61e-1) - | 1.1058e+0 (1.03e-2) - | 1.04e+00(7.73e-03)- | 1.05e+00(1.10e-02)- | 1.2473e-1 (7.05e-4) | |
| UF4 | 2 | 100 | 9.8790e-2 (2.67e-2) - | 1.2687e-1 (4.67e-3) - | 4.2089e-2 (1.62e-4) + | 1.87e-01(2.40e-03)- | 9.73e-02(9.85e-04)- | 5.8690e-2 (1.95e-4) | |
| UF4 | 2 | 200 | 1.1356e-1 (2.62e-2) - | 1.2584e-1 (1.22e-2) - | 2.1385e-1 (8.14e-4) - | 2.07e-01(1.87e-03)- | 1.68e-01(1.02e-03)- | 5.9575e-2 (5.51e-4) | |
| UF4 | 2 | 500 | 1.3919e-1 (1.18e-2) - | 1.2766e-1 (1.26e-2) - | 2.1987e-1 (6.29e-4) - | 2.16e-01(1.26e-03)- | 2.03e-01(6.11e-04)- | 6.1020e-2 (1.79e-3) | |
| UF4 | 2 | 1000 | 1.3437e-1 (2.70e-2) - | 1.3508e-1 (7.68e-4) - | 2.2269e-1 (1.21e-3) - | 2.22e-01(1.68e-03)- | 2.16e-01(4.86e-04)- | 6.0001e-2 (5.24e-4) | |
| UF5 | 2 | 100 | 9.6521e-1 (9.79e-2) = | 2.5211e+0 (4.43e-1) - | 8.4887e-1 (5.47e-2) + | 4.94e+00(2.83e-01)- | 2.39e+00(8.37e-02)- | 1.1267e+0 (1.73e-1) | |
| UF5 | 2 | 200 | 1.5900e+0 (5.07e-1) + | 4.0524e+0 (4.69e-1) - | 6.4982e+0 (1.20e-1) - | 5.72e+00(1.54e-01)- | 4.83e+00(6.79e-02)- | 2.3209e+0 (3.11e-1) | |
| UF5 | 2 | 500 | 2.1960e+0 (2.17e-1) + | 4.9939e+0 (4.28e-1) - | 6.9829e+0 (1.03e-1) - | 6.47e+00(1.30e-01)- | 6.35e+00(7.92e-02)- | 3.0021e+0 (6.99e-2) | |
| UF5 | 2 | 1000 | 2.9378e+0 (2.78e-1) = | 5.7137e+0 (1.24e-1) - | 7.1961e+0 (5.16e-2) - | 6.98e+00(3.35e-02)- | 6.89e+00(9.13e-02)- | 3.0914e+0 (6.43e-2) | |
| UF6 | 2 | 100 | 4.1538e-1 (1.37e-1) = | 2.2169e+0 (2.20e-1) - | 2.4367e-1 (4.03e-3) + | 5.03e+00(5.84e-01)- | 1.61e+00(1.71e-01)- | 5.1688e-1 (9.19e-2) | |
| UF6 | 2 | 200 | 5.0481e-1 (1.96e-1) = | 4.0059e+0 (3.64e-1) - | 7.8753e+0 (2.32e-1) - | 6.71e+00(2.56e-01)- | 4.76e+00(1.31e-01)- | 7.1853e-1 (2.07e-1) | |
| UF6 | 2 | 500 | 6.6943e-1 (1.07e-1) + | 5.2685e+0 (2.68e-1) - | 8.2628e+0 (2.05e-1) - | 7.41e+00(3.53e-01)- | 7.34e+00(1.22e-01)- | 1.1645e+0 (6.83e-2) | |
| UF6 | 2 | 1000 | 1.0601e+0 (1.49e-1) = | 5.9626e+0 (1.76e-1) - | 8.5635e+0 (1.51e-1) - | 8.45e+00(2.19e-01)- | 8.21e+00(1.12e-01)- | 1.1917e+0 (4.72e-2) | |
| UF7 | 2 | 100 | 1.7185e-1 (1.33e-1) = | 7.8848e-1 (1.73e-1) - | 8.5529e-2 (2.49e-2) + | 1.13e+00(1.08e-01)- | 4.81e-01(2.08e-02)- | 3.5681e-1 (3.58e-1) | |
| UF7 | 2 | 200 | 2.0807e-1 (1.39e-1) = | 1.1637e+0 (1.14e-1) - | 1.9279e+0 (5.58e-2) - | 1.63e+00(1.11e-01)- | 1.23e+00(3.06e-02)- | 2.6931e-1 (1.08e-2) | |
| UF7 | 2 | 500 | 2.6120e-1 (1.12e-1) = | 1.2694e+0 (4.09e-1) - | 2.0973e+0 (2.16e-2) - | 1.94e+00(7.82e-02)- | 1.86e+00(3.51e-02)- | 3.0180e-1 (6.16e-3) | |
| UF7 | 2 | 1000 | 3.3575e-1 (1.23e-1) = | 4.8469e-1 (1.89e-1) - | 2.1994e+0 (1.59e-2) - | 2.14e+00(2.53e-02)- | 2.07e+00(1.21e-02)- | 3.0113e-1 (1.01e-2) | |
| UF8 | 3 | 100 | 4.7656e-1 (2.16e-2) - | 6.7429e-1 (1.14e-1) - | 1.7226e-1 (9.98e-3) + | 2.18e+00(3.15e-01)- | 9.89e-01(2.56e-02)- | 3.4881e-1 (1.46e-2) | |
| UF8 | 3 | 200 | 5.2538e-1 (1.04e-2) - | 8.6434e-1 (1.06e-1) - | 3.9916e+0 (1.13e-1) - | 2.86e+00(2.14e-01)- | 2.56e+00(9.12e-02)- | 4.1731e-1 (3.11e-2) | |
| UF8 | 3 | 500 | 5.6558e-1 (2.27e-2) - | 1.0051e+0 (1.95e-1) - | 4.2399e+0 (6.80e-2) - | 3.41e+00(1.78e-01)- | 3.69e+00(1.11e-01)- | 4.8100e-1 (1.45e-2) | |
| UF8 | 3 | 1000 | 6.0969e-1 (2.39e-2) - | 1.1445e+0 (1.60e-1) - | 4.3248e+0 (4.30e-2) - | 3.78e+00(5.65e-02)- | 4.03e+00(8.57e-02)- | 4.9542e-1 (2.93e-2) | |
| UF9 | 3 | 100 | 4.9519e-1 (5.29e-3) + | 7.4916e-1 (5.04e-2) - | 1.9022e-1 (1.55e-2) + | 2.06e+00(4.90e-01)- | 1.07e+00(4.79e-02)- | 5.0989e-1 (4.59e-3) | |
| UF9 | 3 | 200 | 5.2126e-1 (8.09e-3) + | 1.0372e+0 (8.93e-2) - | 4.1095e+0 (7.27e-2) - | 3.22e+00(2.44e-01)- | 2.72e+00(7.62e-02)- | 5.6101e-1 (7.41e-3) | |
| UF9 | 3 | 500 | 5.6199e-1 (1.01e-2) + | 1.2599e+0 (8.19e-2) - | 4.3692e+0 (5.69e-2) - | 3.53e+00(8.93e-02)- | 3.88e+00(7.08e-02)- | 6.1365e-1 (1.26e-2) | |
| UF9 | 3 | 1000 | 5.8510e-1 (1.35e-2) + | 1.3848e+0 (1.41e-1) - | 4.4708e+0 (5.28e-2) - | 3.97e+00(5.35e-02)- | 4.28e+00(7.65e-02)- | 6.6051e-1 (1.66e-2) | |
| UF10 | 3 | 100 | 1.2671e+0 (3.66e-1) + | 4.1683e+0 (5.02e-1) - | 1.2158e+0 (6.49e-2) + | 1.23e+01(8.71e-01)- | 6.27e+00(3.64e-01)- | 1.8287e+0 (1.87e-1) | |
| UF10 | 3 | 200 | 1.0936e+0 (1.27e-1) + | 6.1673e+0 (3.71e-1) - | 1.9659e+1 (5.73e-1) - | 1.57e+01(1.23e+00)- | 1.36e+01(4.01e-01)- | 2.4275e+0 (1.72e-1) | |
| UF10 | 3 | 500 | 1.9335e+0 (3.55e-1) + | 7.4275e+0 (1.35e+0) - | 2.0398e+1 (2.63e-1) - | 1.74e+01(3.25e-01)- | 1.82e+01(2.62e-01)- | 3.1637e+0 (3.38e-1) | |
| UF10 | 3 | 1000 | 2.7519e+0 (3.56e-1) + | 8.8886e+0 (1.32e+0) - | 2.0772e+1 (1.97e-1) - | 1.89e+01(3.04e-01)- | 1.98e+01(3.45e-01)- | 3.7282e+0 (2.54e-1) | |
| +/-= | | 13/17/10 | | 0/40/0 | | 10/30/0 | | 0/40/0 | |

TABLE A. 7

THE IGD RESULTS OF SIX COMPARED ALGORITHMS ON LSMOP1-LSMOP9 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | LSMOF | DGEA | LMEA | LSMOEAD | MOEADVA | NN-CSO |
|---------|----|------|------------------------------|------------------------------|------------------------------|-----------------------|------------------------------|----------------------------|
| LSMOP1 | 2 | 100 | 5.2434e-1 (2.78e-2) - | 1.0276e+0 (1.33e-1) - | 9.3143e-1 (2.02e+0) - | 3.23e+00(1.00e+00)- | 1.60e+00(2.47e-01)- | 2.0217e-1 (1.04e-2) |
| LSMOP1 | 2 | 200 | 5.8204e-1 (2.43e-2) - | 5.1114e-1 (4.78e-1) - | 9.4374e+0 (6.25e-1) - | 6.43e+00(5.00e-01)- | 4.48e+00(3.38e-01)- | 2.8176e-1 (1.72e-2) |
| LSMOP1 | 2 | 500 | 5.7182e-1 (2.55e-2) - | 4.0520e-1 (1.45e-1) = | 1.0626e+1 (2.48e-1) - | 8.94e+00(7.03e-01)- | 8.91e+00(2.87e-01)- | 3.2321e-1 (1.40e-2) |
| LSMOP1 | 2 | 1000 | 6.5147e-1 (6.49e-3) - | 6.0693e-1 (3.39e-1) - | 1.0852e+1 (1.31e-1) - | 9.97e+00(2.74e-01)- | 1.02e+01(2.38e-01)- | 3.3104e-1 (8.72e-3) |
| LSMOP1 | 3 | 100 | 5.4935e-1 (3.68e-2) - | 7.0046e-1 (3.28e-1) - | 1.5137e-1 (9.02e-3) + | 2.57e+00(1.14e+00)- | 1.71e+00(3.37e-01)- | 3.2358e-1 (1.05e-2) |
| LSMOP1 | 3 | 200 | 5.8156e-1 (3.11e-2) - | 6.2812e-1 (1.35e-1) - | 9.5172e+0 (1.58e+0) - | 6.14e+00(1.01e+00)- | 4.20e+00(6.32e-01)- | 3.4195e-1 (9.75e-3) |
| LSMOP1 | 3 | 500 | 6.2146e-1 (1.48e-2) - | 7.5292e-1 (8.13e-2) - | 1.0810e+1 (1.89e-1) - | 9.29e+00(4.26e-01)- | 9.17e+00(3.30e-01)- | 3.5389e-1 (1.61e-2) |
| LSMOP1 | 3 | 1000 | 6.3154e-1 (4.75e-3) - | 8.3988e-1 (1.17e-1) - | 1.1146e+1 (3.20e-1) - | 1.04e+01(4.45e-01)- | 1.04e+01(3.16e-01)- | 3.7023e-1 (1.53e-2) |
| LSMOP1 | 5 | 100 | 8.4391e-1 (2.99e-2) - | 5.7402e-1 (1.20e-1) = | 1.5847e+0 (1.66e+0) = | 9.1440e-01(9.75e-01)= | 1.0443e+0 (1.32e-1) - | 5.4001e-1 (4.78e-2) |
| LSMOP1 | 5 | 200 | 8.7518e-1 (1.45e-2) - | 6.9508e-1 (1.21e-1) = | 8.5487e+0 (1.68e+0) - | 2.7381e+00(1.30e+00)- | 7.9890e-1 (8.05e-2) - | 6.7819e-1 (7.03e-2) |
| LSMOP1 | 5 | 500 | 9.1054e-1 (2.04e-2) - | 8.8718e-1 (8.67e-2) = | 9.4461e+0 (7.11e-1) - | 4.1678e+00(1.68e+00)- | 2.9245e-1 (1.24e-2) + | 8.2544e-1 (6.64e-2) |
| LSMOP1 | 5 | 1000 | 9.3108e-1 (1.17e-2) = | 8.2080e-1 (1.03e-1) = | 1.0488e+1 (3.04e-1) - | 7.8703e+00(1.23e+00)- | 1.7642e-1 (5.29e-3) + | 8.7563e-1 (5.58e-2) |
| LSMOP1 | 8 | 100 | 1.0018e+0 (1.22e-2) - | 6.3967e-1 (1.11e-1) = | 1.0361e+0 (1.79e+0) - | 1.4577e+0 (7.08e-1) - | 1.2331e+0 (1.68e-1) - | 5.8057e-1 (5.93e-2) |
| LSMOP1 | 8 | 200 | 1.0004e+0 (7.66e-3) - | 8.9870e-1 (1.23e-1) - | 7.0552e+0 (3.76e-1) - | 3.1231e+00(1.67e+00)- | 5.7361e+0 (9.56e-1) - | 6.6402e-1 (1.61e-2) |
| LSMOP1 | 8 | 500 | 3.0273e+0 (2.09e+0) - | 2.3683e+0 (1.44e+0) - | 8.9952e+0 (5.25e-1) - | 9.7721e+00(5.07e-01)- | 9.0974e+0 (2.37e-1) - | 1.2379e+0 (7.37e-2) |
| LSMOP1 | 8 | 1000 | 4.4094e+0 (2.36e+0) - | 2.7553e+0 (1.62e+0) = | 9.3171e+0 (7.44e-1) - | 9.5953e+00(3.84e-01)- | 9.4381e+0 (3.47e-1) - | 1.2725e+0 (1.43e-1) |
| LSMOP1 | 10 | 100 | 1.0239e+0 (1.07e-3) - | 6.6120e-1 (7.13e-2) = | 9.8774e-1 (1.61e+0) - | 1.9970e+0 (9.67e-1) - | 1.7079e+0 (2.01e-1) - | 6.3258e-1 (2.84e-2) |
| LSMOP1 | 10 | 200 | 1.0185e+0 (2.74e-3) - | 8.7728e-1 (1.52e-1) = | 7.1366e+0 (1.07e+0) - | 1.9532e+00(6.79e-01)- | 1.2386e+0 (7.40e-2) - | 7.6043e-1 (8.47e-2) |
| LSMOP1 | 10 | 500 | 3.4143e+0 (1.50e+0) - | 1.1382e+0 (7.65e-2) = | 9.8227e+0 (6.85e-1) - | 9.7994e+00(6.80e-01)- | 6.2678e-1 (4.66e-2) + | 1.2403e+0 (4.48e-1) |
| LSMOP1 | 10 | 1000 | 4.2072e+0 (2.59e+0) - | 1.1200e+0 (4.98e-2) + | 9.9487e+0 (5.58e-1) - | 9.8644e+00(4.93e-01)- | 4.1980e-1 (3.28e-2) + | 1.2816e+0 (1.35e-1) |
| LSMOP2 | 2 | 100 | 1.2782e-1 (2.11e-3) - | 1.1459e-1 (5.88e-2) - | 1.6610e-1 (7.07e-2) - | 2.49e-01(6.52e-03)- | 2.32e-01(2.50e-03)- | 4.2763e-2 (1.64e-3) |
| LSMOP2 | 2 | 200 | 6.9542e-2 (8.63e-4) - | 3.2251e-2 (4.32e-3) = | 1.5826e-1 (4.28e-4) - | 1.54e-01(1.68e-03)- | 1.54e-01(3.67e-04)- | 2.8407e-2 (1.27e-3) |
| LSMOP2 | 2 | 500 | 2.5522e-2 (6.09e-4) - | 1.4876e-2 (1.53e-3) = | 7.2703e-2 (1.23e-4) - | 7.42e-02(1.10e-03)- | 7.25e-02(6.98e-05)- | 1.3729e-2 (7.39e-4) |
| LSMOP2 | 2 | 1000 | 1.8810e-2 (1.68e-3) - | 9.4701e-3 (2.75e-3) = | 3.9351e-2 (2.96e-5) - | 4.10e-02(1.27e-03)- | 3.92e-02(4.36e-05)- | 8.1902e-3 (2.42e-4) |
| LSMOP2 | 3 | 100 | 1.9669e-1 (6.12e-3) - | 1.3203e-1 (1.27e-2) - | 1.5132e-1 (5.27e-2) - | 1.98e-01(2.64e-03)- | 1.73e-01(1.14e-03)- | 8.4013e-2 (3.28e-3) |
| LSMOP2 | 3 | 200 | 1.2274e-1 (1.76e-3) - | 8.5131e-2 (8.53e-3) - | 1.1904e-1 (3.69e-3) - | 1.18e-01(2.41e-03)- | 1.16e-01(2.25e-04)- | 5.7013e-2 (1.60e-3) |
| LSMOP2 | 3 | 500 | 6.5749e-2 (1.30e-3) - | 4.9981e-2 (1.01e-3) - | 6.2559e-2 (7.46e-4) - | 6.48e-02(4.52e-03)- | 6.23e-02(7.87e-04)- | 3.8768e-2 (1.43e-3) |
| LSMOP2 | 3 | 1000 | 4.6604e-2 (9.35e-4) - | 3.4575e-2 (4.42e-4) - | 4.4478e-2 (1.61e-3) - | 5.53e-02(3.84e-03)- | 4.43e-02(6.69e-04)- | 2.9433e-2 (1.36e-3) |
| LSMOP2 | 5 | 100 | 4.1326e-1 (4.79e-3) - | 2.8696e-1 (1.24e-2) - | 1.8572e-1 (1.10e-2) + | 2.4257e-01(2.08e-02)= | 2.8445e-1 (7.73e-3) - | 2.5799e-1 (8.31e-3) |
| LSMOP2 | 5 | 200 | 2.7168e-1 (6.59e-3) - | 2.1704e-1 (4.81e-3) - | 2.7344e-1 (1.00e-2) - | 2.2343e-01(9.81e-03)- | 2.2141e-1 (7.57e-3) - | 2.0205e-1 (1.70e-3) |
| LSMOP2 | 5 | 500 | 1.7319e-1 (2.55e-3) - | 1.4673e-1 (1.04e-3) - | 1.8788e-1 (8.87e-3) - | 1.5244e-01(6.68e-03)- | 1.7802e-1 (5.35e-3) - | 1.4269e-1 (9.84e-4) |
| LSMOP2 | 5 | 1000 | 1.4946e-1 (4.38e-3) - | 1.2241e-1 (7.45e-4) = | 1.6528e-1 (7.67e-3) - | 1.2737e-01(5.62e-03)= | 1.5682e-1 (7.21e-3) - | 1.2193e-1 (3.36e-4) |
| LSMOP2 | 8 | 100 | 7.3256e-1 (2.24e-2) - | 3.7921e-1 (1.72e-2) - | 5.8608e-1 (1.52e-1) - | 3.7506e-1 (3.29e-2) - | 5.1256e-1 (2.91e-2) - | 3.4709e-1 (1.02e-2) |
| LSMOP2 | 8 | 200 | 4.7562e-1 (1.28e-2) - | 3.3664e-1 (2.76e-2) - | 5.0182e-1 (5.01e-2) - | 3.7355e-01(1.14e-01)- | 5.3344e-1 (3.67e-2) - | 2.6358e-1 (4.25e-3) |
| LSMOP2 | 8 | 500 | 2.8783e-1 (3.72e-3) - | 3.6776e-1 (1.93e-2) - | 3.9310e-1 (2.31e-2) - | 4.4821e-01(1.99e-02)- | 3.8123e-1 (1.40e-2) - | 1.9823e-1 (3.22e-3) |
| LSMOP2 | 8 | 1000 | 2.4016e-1 (2.95e-3) - | 3.2281e-1 (7.53e-3) - | 3.2649e-1 (1.27e-2) - | 3.9985e-01(2.10e-02)- | 3.2842e-1 (9.05e-3) - | 1.7017e-1 (4.45e-3) |
| LSMOP2 | 10 | 100 | 8.0793e-1 (2.38e-2) - | 4.1601e-1 (1.06e-2) + | 5.2517e-1 (1.09e-1) - | 4.5151e-1 (1.42e-1) - | 6.2839e-1 (4.12e-2) - | 4.3314e-1 (9.88e-3) |
| LSMOP2 | 10 | 200 | 5.6479e-1 (2.62e-2) - | 3.5816e-1 (2.77e-2) = | 6.4012e-1 (8.07e-2) - | 4.4870e-01(1.32e-01)= | 5.4764e-1 (2.76e-2) - | 3.5728e-1 (4.56e-3) |
| LSMOP2 | 10 | 500 | 3.3882e-1 (1.11e-2) - | 3.6993e-1 (6.06e-2) - | 5.1262e-1 (2.47e-2) - | 5.0962e-01(2.51e-02)- | 4.7482e-1 (3.11e-2) - | 2.9527e-1 (1.28e-2) |
| LSMOP2 | 10 | 1000 | 2.8308e-1 (4.74e-3) - | 3.5204e-1 (3.02e-2) - | 4.3758e-1 (2.16e-2) - | 4.4317e-01(1.54e-02)- | 4.2947e-1 (1.75e-2) - | 2.4892e-1 (1.55e-2) |
| LSMOP3 | 2 | 100 | 1.2990e+0 (3.09e-1) = | 1.6189e+1 (1.06e+1) - | 1.0879e+1 (6.20e+0) - | 8.11e+00(4.03e+00)- | 8.68e+01(1.03e+02)- | 1.5170e+0 (4.71e-1) |
| LSMOP3 | 2 | 200 | 1.4800e+0 (1.45e-1) + | 6.8561e+0 (9.08e+0) = | 2.7296e+2 (5.40e+2) - | 1.59e+01(2.02e+00)- | 4.46e+02(4.47e+02)- | 1.9101e+0 (4.24e-1) |
| LSMOP3 | 2 | 500 | 1.5641e+0 (1.45e-3) + | 1.5688e+0 (3.80e-3) + | 5.4285e+2 (5.01e+2) - | 2.73e+01(3.75e+00)- | 5.82e+02(8.04e+02)- | 3.1135e+0 (1.72e+0) |

| | | | | | | | | |
|--------|----|------|-------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------------|
| LSMOP3 | 2 | 1000 | 1.5737e+0 (3.30e-4) + | 3.0592e+0 (3.93e+0) - | 6.4795e+2 (3.41e+2) - | 3.67e+01(2.78e+00)- | 5.03e+02(3.48e+02)- | 2.2104e+0 (1.65e+0) |
| LSMOP3 | 3 | 100 | 8.0353e-1 (3.98e-2) + | 3.0014e+0 (3.76e+0) = | 3.3598e+0 (3.31e+0) - | 5.85e+00(1.61e+00)- | 2.27e+01(1.19e+01)- | 8.5877e-1 (5.15e-3) |
| LSMOP3 | 3 | 200 | 8.5053e-1 (1.55e-2) + | 1.6402e+0 (2.11e+0) = | 9.3608e+1 (1.12e+2) - | 1.09e+01(1.08e+00)- | 8.71e+01(4.66e+01)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 3 | 500 | 8.6024e-1 (1.16e-3) + | 2.5496e+0 (2.43e+0) = | 2.4494e+2 (1.98e+2) - | 1.44e+01(1.49e+00)- | 1.12e+02(8.63e+01)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 3 | 1000 | 8.6068e-1 (3.55e-5) = | 1.6874e+0 (2.19e+0) = | 1.5274e+2 (1.36e+2) - | 3.43e+01(3.88e+01)- | 1.62e+02(7.66e+01)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 5 | 100 | 9.5879e-1 (1.02e-4) = | 9.4325e-1 (1.40e-2) = | 1.0331e+1 (1.52e+1) - | 4.5231e+00(4.54e+00)= | 7.1951e+1 (2.58e+1) - | 9.4960e-1 (1.59e-2) |
| LSMOP3 | 5 | 200 | 9.5883e-1 (1.20e-16) = | 1.5986e+0 (1.62e+0) = | 7.9172e+2 (7.39e+2) - | 9.1801e+00(5.10e+00)- | 1.8284e+1 (6.77e+0) - | 9.5883e-1 (1.20e-16) |
| LSMOP3 | 5 | 500 | 9.5883e-1 (1.20e-16) = | 4.0807e+0 (3.67e+0) = | 6.3137e+2 (4.21e+2) - | 8.1959e+00(4.67e+00)= | 5.5274e+0 (2.25e+0) = | 4.2096e+0 (4.07e+0) |
| LSMOP3 | 5 | 1000 | 9.5883e-1 (1.20e-16) = | 7.8266e+0 (3.04e+0) = | 1.0326e+3 (4.97e+2) - | 1.3865e+03(1.77e+03)- | 2.5719e+0 (6.92e-1) = | 4.9524e+0 (3.87e+0) |
| LSMOP3 | 8 | 100 | 1.0163e+0 (5.30e-3) - | 9.2066e-1 (2.93e-2) = | 1.3896e+0 (1.16e+0) - | 9.9606e-1 (1.33e-1) - | 1.8292e+0 (9.66e-1) - | 9.3540e-1 (1.82e-2) |
| LSMOP3 | 8 | 200 | 1.0805e+0 (1.64e-1) + | 8.7076e+0 (3.19e+0) - | 9.3515e+2 (3.13e+2) - | 2.4217e+03(1.72e+03)- | 9.7931e+2 (3.15e+2) - | 5.0341e+0 (1.09e+0) |
| LSMOP3 | 8 | 500 | 4.4373e+0 (7.29e+0) + | 2.2089e+1 (1.26e+1) - | 2.2865e+3 (1.56e+3) - | 4.4062e+03(1.83e+03)- | 1.9835e+3 (1.08e+3) - | 9.4167e+0 (1.11e+0) |
| LSMOP3 | 8 | 1000 | 1.9634e+0 (1.82e-1) + | 2.9716e+1 (2.04e+1) - | 3.0103e+3 (2.51e+3) - | 6.2107e+03(3.06e+03)- | 2.3668e+3 (1.53e+3) - | 1.2758e+1 (4.89e+0) |
| LSMOP3 | 10 | 100 | 8.9948e-1 (2.69e-2) = | 7.6456e-1 (1.42e-1) = | 7.9495e+0 (1.31e+1) - | 2.5621e+0 (2.62e+0) - | 9.4664e+0 (1.85e+0) - | 7.3819e-1 (1.37e-1) |
| LSMOP3 | 10 | 200 | 9.7504e-1 (2.15e-2) - | 1.1121e+0 (4.16e-1) - | 1.2357e+3 (6.04e+2) - | 2.9365e+02(5.61e+02)- | 3.0893e+1 (2.16e+1) - | 9.4073e-1 (6.37e-3) |
| LSMOP3 | 10 | 500 | 2.4256e+0 (1.26e+0) + | 1.4604e+1 (2.43e+0) + | 3.7202e+3 (2.20e+3) - | 4.5626e+03(1.81e+03)- | 1.4075e+1 (6.27e+0) = | 2.0659e+1 (3.62e+0) |
| LSMOP3 | 10 | 1000 | 1.1221e+1 (1.66e+1) = | 1.4116e+1 (1.02e+0) = | 4.8977e+3 (3.39e+3) - | 6.2262e+03(3.03e+03)- | 4.8980e+0 (9.25e-1) + | 1.3028e+1 (7.65e+0) |
| LSMOP4 | 2 | 100 | 2.4029e-1 (9.78e-3) - | 1.6057e-1 (6.98e-2) - | 2.0848e-1 (5.84e-2) - | 3.21e-01(1.25e-02)- | 2.77e-01(9.47e-03)- | 6.7048e-2 (2.28e-2) |
| LSMOP4 | 2 | 200 | 1.8305e-1 (7.91e-3) - | 9.7774e-2 (9.81e-3) - | 2.5457e-1 (6.96e-3) - | 2.38e-01(6.06e-03)- | 2.08e-01(1.48e-03)- | 8.3159e-2 (6.00e-3) |
| LSMOP4 | 2 | 500 | 5.4837e-2 (1.90e-3) - | 5.1832e-2 (3.84e-3) - | 1.3447e-1 (2.29e-4) - | 1.32e-01(2.31e-03)- | 1.28e-01(5.56e-04)- | 4.4418e-2 (9.30e-4) |
| LSMOP4 | 2 | 1000 | 5.4126e-2 (2.86e-3) - | 2.5523e-2 (1.84e-3) - | 7.6720e-2 (1.17e-4) - | 7.87e-02(9.55e-04)- | 7.52e-02(1.58e-04)- | 2.2817e-2 (5.77e-4) |
| LSMOP4 | 3 | 100 | 3.4603e-1 (9.23e-3) - | 4.1558e-1 (3.48e-2) - | 2.8138e-1 (1.08e-1) + | 5.17e-01(8.23e-03)- | 4.52e-01(7.80e-03)- | 2.9903e-1 (1.40e-2) |
| LSMOP4 | 3 | 200 | 3.0142e-1 (3.60e-3) - | 2.5086e-1 (2.29e-2) - | 3.8077e-1 (3.74e-3) - | 3.65e-01(8.04e-03)- | 3.25e-01(3.56e-03)- | 1.9584e-1 (7.70e-3) |
| LSMOP4 | 3 | 500 | 1.9019e-1 (5.11e-3) - | 1.3596e-1 (1.53e-2) - | 2.0293e-1 (1.47e-3) - | 1.99e-01(3.44e-03)- | 1.94e-01(9.78e-04)- | 1.0064e-1 (2.13e-3) |
| LSMOP4 | 3 | 1000 | 1.1693e-1 (1.40e-3) - | 8.7320e-2 (1.03e-2) - | 1.1774e-1 (8.44e-4) - | 1.22e-01(3.02e-03)- | 1.16e-01(8.38e-04)- | 6.1411e-2 (2.39e-3) |
| LSMOP4 | 5 | 100 | 5.5496e-1 (1.27e-2) - | 5.0657e-1 (1.17e-2) - | 4.2194e-1 (6.50e-2) + | 3.5990e-01(7.13e-02)+ | 5.8801e-1 (8.15e-2) - | 4.6034e-1 (9.30e-3) |
| LSMOP4 | 5 | 200 | 4.5327e-1 (1.05e-2) - | 3.8109e-1 (1.37e-2) - | 5.8234e-1 (6.79e-2) - | 3.8039e-01(1.06e-02)- | 4.0323e-1 (1.80e-2) - | 3.5466e-1 (7.19e-3) |
| LSMOP4 | 5 | 500 | 3.1169e-1 (6.82e-3) - | 2.5735e-1 (4.44e-3) - | 3.6289e-1 (2.19e-2) - | 2.7376e-01(9.78e-03)- | 2.1570e-1 (9.33e-3) + | 2.3945e-1 (2.52e-3) |
| LSMOP4 | 5 | 1000 | 2.3191e-1 (7.03e-3) - | 1.9147e-1 (1.23e-3) - | 2.5751e-1 (1.01e-2) - | 2.0577e-01(1.09e-02)- | 1.7108e-1 (4.98e-3) + | 1.8216e-1 (9.38e-4) |
| LSMOP4 | 8 | 100 | 7.7269e-1 (4.70e-2) - | 5.3138e-1 (4.88e-2) - | 5.9957e-1 (1.15e-1) - | 5.0126e-1 (1.54e-1) - | 6.1345e-1 (2.11e-2) - | 4.8784e-1 (1.23e-2) |
| LSMOP4 | 8 | 200 | 5.6444e-1 (2.80e-2) - | 4.5075e-1 (3.63e-2) - | 6.0535e-1 (5.77e-2) - | 3.8225e-01(3.12e-02)- | 5.7457e-1 (1.43e-2) - | 3.5284e-1 (2.72e-3) |
| LSMOP4 | 8 | 500 | 3.4943e-1 (1.02e-2) - | 3.9803e-1 (1.07e-2) - | 4.0086e-1 (1.55e-2) - | 4.5321e-01(1.70e-02)- | 4.0358e-1 (2.25e-2) - | 2.5310e-1 (6.78e-3) |
| LSMOP4 | 8 | 1000 | 2.8141e-1 (5.50e-3) - | 3.3452e-1 (1.09e-2) - | 3.3137e-1 (6.69e-3) - | 3.8561e-01(2.09e-02)- | 3.3156e-1 (1.47e-2) - | 1.9668e-1 (2.24e-3) |
| LSMOP4 | 10 | 100 | 8.0126e-1 (4.72e-2) - | 6.2662e-1 (6.84e-2) - | 6.3125e-1 (9.56e-2) - | 6.4887e-1 (6.27e-2) - | 6.7972e-1 (2.78e-2) - | 5.4561e-1 (2.30e-2) |
| LSMOP4 | 10 | 200 | 5.9544e-1 (3.25e-2) - | 4.9146e-1 (6.40e-2) = | 7.1798e-1 (6.67e-2) - | 5.3461e-01(3.08e-02)- | 5.6462e-1 (2.85e-2) - | 4.4464e-1 (8.34e-3) |
| LSMOP4 | 10 | 500 | 3.9652e-1 (1.30e-2) - | 4.3095e-1 (3.73e-2) - | 5.1127e-1 (1.32e-2) - | 4.9892e-01(1.99e-02)- | 4.0317e-1 (9.53e-3) - | 3.4588e-1 (2.59e-2) |
| LSMOP4 | 10 | 1000 | 3.2573e-1 (7.01e-3) - | 4.0357e-1 (2.28e-2) - | 4.2769e-1 (2.29e-2) - | 4.2460e-01(2.10e-02)- | 3.7350e-1 (1.28e-2) - | 2.8738e-1 (1.35e-2) |
| LSMOP5 | 2 | 100 | 7.4209e-1 (1.20e-16) - | 2.6902e+0 (7.46e-1) - | 7.1328e-1 (3.14e-1) = | 1.07e+01(2.28e+00)- | 4.25e+00(4.52e-01)- | 6.9839e-1 (3.87e-2) |
| LSMOP5 | 2 | 200 | 7.4209e-1 (1.20e-16) = | 4.3081e+0 (5.08e-1) - | 2.0729e+1 (8.98e-1) - | 1.80e+01(1.60e+00)- | 1.43e+01(6.23e-01)- | 7.4209e-1 (1.20e-16) |
| LSMOP5 | 2 | 500 | 7.4209e-1 (1.20e-16) = | 4.8163e+0 (1.62e+0) - | 2.2524e+1 (3.18e-1) - | 2.07e+01(1.02e+00)- | 2.03e+01(4.68e-01)- | 7.4209e-1 (3.92e-7) |
| LSMOP5 | 2 | 1000 | 7.4209e-1 (1.20e-16) = | 6.0120e+0 (1.23e+0) - | 2.3329e+1 (5.07e-1) - | 2.30e+01(5.63e-01)- | 2.23e+01(3.26e-01)- | 7.4209e-1 (1.20e-16) |
| LSMOP5 | 3 | 100 | 5.2308e-1 (4.86e-2) - | 7.4872e-1 (6.52e-1) = | 2.9568e+0 (4.32e+0) - | 5.74e+00(2.67e+00)- | 2.76e+00(2.83e-01)- | 3.8292e-1 (3.63e-2) |
| LSMOP5 | 3 | 200 | 5.5295e-1 (1.79e-2) - | 9.6924e-1 (5.99e-1) = | 1.5598e+1 (1.94e+0) - | 1.12e+01(8.93e-01)- | 1.11e+01(1.08e+00)- | 4.7438e-1 (1.44e-2) |
| LSMOP5 | 3 | 500 | 5.5594e-1 (1.29e-2) - | 1.3695e+0 (6.89e-1) - | 1.8997e+1 (7.26e-1) - | 1.50e+01(6.31e-01)- | 1.62e+01(5.09e-01)- | 5.1560e-1 (1.36e-2) |
| LSMOP5 | 3 | 1000 | 5.6684e-1 (4.52e-2) - | 1.5791e+0 (5.95e-1) - | 1.9511e+1 (2.78e-1) - | 1.81e+01(7.50e-01)- | 1.82e+01(1.08e+00)- | 5.1962e-1 (4.01e-3) |

| | | | | | | | | |
|--------|----|------|------------------------------|------------------------------|-----------------------|-----------------------|------------------------------|----------------------------|
| LSMOP5 | 5 | 100 | 4.7949e-1 (4.56e-2) = | 5.3847e-1 (3.08e-1) = | 7.4345e-1 (3.93e-1) = | 8.0976e-01(4.45e-02)- | 1.1668e+0 (1.78e-1) - | 5.2997e-1 (3.04e-1) |
| LSMOP5 | 5 | 200 | 4.8905e-1 (3.41e-2) - | 4.4157e-1 (1.81e-1) = | 9.7330e+0 (1.78e+0) - | 2.0170e+00(1.60e+00)- | 1.1473e+0 (7.77e-2) - | 3.2849e-1 (1.30e-2) |
| LSMOP5 | 5 | 500 | 4.3685e-1 (3.43e-2) - | 3.9849e-1 (9.54e-2) - | 1.5111e+1 (1.07e+0) - | 6.4238e+00(2.77e+00)- | 6.9832e-1 (9.47e-3) - | 3.3887e-1 (7.04e-3) |
| LSMOP5 | 5 | 1000 | 4.4164e-1 (4.18e-2) - | 5.1753e-1 (1.47e-1) - | 1.6287e+1 (7.10e-1) - | 1.1011e+01(1.32e+00)- | 3.5667e-1 (3.41e-3) - | 3.4478e-1 (1.01e-2) |
| LSMOP5 | 8 | 100 | 1.2139e+0 (0.00e+0) - | 1.1028e+0 (1.33e-1) - | 3.2703e+0 (6.02e+0) - | 2.4254e+0 (2.00e+0) - | 1.3589e+0 (7.26e-2) - | 7.7934e-1 (2.20e-1) |
| LSMOP5 | 8 | 200 | 1.2195e+0 (0.00e+0) - | 2.3152e+0 (7.05e-1) - | 5.9409e+0 (2.07e+0) - | 8.8977e+00(2.05e+00)- | 6.0302e+0 (1.95e+0) - | 1.1120e+0 (8.64e-2) |
| LSMOP5 | 8 | 500 | 1.3932e+1 (5.65e+0) - | 6.7151e+0 (3.56e+0) - | 1.0631e+1 (2.43e+0) - | 1.2419e+01(7.47e-01)- | 1.2111e+1 (5.39e-1) - | 2.0608e+0 (4.04e-1) |
| LSMOP5 | 8 | 1000 | 1.5033e+1 (5.59e+0) - | 9.8621e+0 (4.41e+0) - | 1.3774e+1 (9.14e-1) - | 1.4667e+01(9.95e-01)- | 1.3843e+1 (5.01e-1) - | 1.9488e+0 (1.50e-1) |
| LSMOP5 | 10 | 100 | 1.2276e+0 (3.74e-2) - | 8.0290e-1 (3.21e-1) = | 2.0210e+0 (2.20e+0) - | 5.4084e+0 (1.47e+0) - | 2.2248e+0 (3.82e-1) - | 7.7738e-1 (1.52e-1) |
| LSMOP5 | 10 | 200 | 1.2417e+0 (0.00e+0) - | 1.4819e+0 (4.53e-1) - | 1.5417e+1 (7.34e+0) - | 9.4801e+00(2.45e+00)- | 1.9344e+0 (2.52e-1) - | 9.0794e-1 (1.97e-1) |
| LSMOP5 | 10 | 500 | 1.6254e+1 (2.28e+0) - | 2.6234e+0 (8.58e-1) - | 1.4815e+1 (7.00e-1) - | 1.4741e+01(9.05e-01)- | 1.1981e+0 (1.20e-2) + | 1.7131e+0 (1.45e-1) |
| LSMOP5 | 10 | 1000 | 1.1585e+1 (5.90e+0) - | 1.9143e+0 (1.91e-1) = | 1.5377e+1 (2.69e-1) - | 1.5332e+01(3.82e-01)- | 7.9091e-1 (5.36e-3) + | 1.7416e+0 (9.40e-2) |
| LSMOP6 | 2 | 100 | 4.2468e-1 (3.48e-3) + | 7.7717e-1 (1.58e-1) = | 1.0696e+0 (1.04e-1) - | 1.02e+00(0.25e-02)- | 7.75e+01(8.16e+01)- | 7.3329e-1 (1.95e-2) |
| LSMOP6 | 2 | 200 | 3.5745e-1 (1.17e-3) + | 7.6302e-1 (4.60e-2) = | 5.6211e+2 (8.82e+2) - | 7.48e-01(9.16e-02)+ | 1.69e+02(1.48e+02)- | 7.5911e-1 (5.40e-3) |
| LSMOP6 | 2 | 500 | 3.2024e-1 (3.82e-4) + | 7.4190e-1 (4.20e-2) = | 6.1881e+2 (3.54e+2) - | 5.67e-01(5.61e-02)+ | 7.61e+02(5.59e+02)- | 7.5233e-1 (9.55e-4) |
| LSMOP6 | 2 | 1000 | 3.1227e-1 (1.86e-4) + | 6.8193e-1 (1.64e-1) = | 1.2429e+3 (1.48e+3) - | 5.66e-01(1.44e-01)= | 1.32e+03(9.13e+02)- | 7.5010e-1 (1.79e-3) |
| LSMOP6 | 3 | 100 | 1.0566e+0 (6.74e-3) = | 2.6482e+1 (2.88e+1) - | 2.3786e+3 (6.25e+3) - | 3.20e+03(2.46e+03)- | 7.45e+02(3.50e+02)- | 9.8301e-1 (1.86e-1) |
| LSMOP6 | 3 | 200 | 1.0920e+0 (1.93e-1) + | 1.4590e+1 (2.66e+1) = | 2.3290e+4 (1.06e+4) - | 1.26e+04(3.91e+03)- | 1.34e+04(2.21e+03)- | 1.2356e+0 (1.98e-3) |
| LSMOP6 | 3 | 500 | 1.2533e+0 (8.20e-2) + | 7.8582e+1 (1.16e+2) - | 2.9819e+4 (4.93e+3) - | 1.82e+04(4.24e+03)- | 2.61e+04(2.47e+03)- | 1.2959e+0 (3.85e-4) |
| LSMOP6 | 3 | 1000 | 1.1505e+0 (2.69e-1) + | 1.0522e+2 (1.34e+2) = | 3.5801e+4 (4.01e+3) - | 2.22e+04(1.97e+03)- | 3.28e+04(5.31e+03)- | 1.3168e+0 (1.48e-3) |
| LSMOP6 | 5 | 100 | 7.6951e-1 (4.18e-2) - | 6.6529e-1 (2.23e-2) - | 8.8858e-1 (1.70e-1) - | 7.0474e-01(6.43e-03)- | 1.2981e+0 (3.72e-1) - | 5.9515e-1 (1.92e-2) |
| LSMOP6 | 5 | 200 | 1.0465e+0 (9.57e-2) = | 1.0588e+0 (2.37e-1) = | 4.2034e+3 (1.25e+3) - | 2.1817e+02(3.50e+02)- | 1.7839e+1 (1.12e+1) - | 9.9017e-1 (1.00e-1) |
| LSMOP6 | 5 | 500 | 1.2105e+0 (8.22e-2) = | 1.4324e+0 (3.58e-1) = | 1.6027e+4 (1.78e+3) - | 5.0104e+02(7.25e+02)- | 1.7339e+1 (6.02e+0) - | 1.2606e+0 (1.37e-1) |
| LSMOP6 | 5 | 1000 | 1.1886e+0 (9.16e-2) = | 2.0017e+0 (9.57e-1) = | 2.0993e+4 (5.70e+3) - | 3.6413e+03(3.07e+03)- | 8.4323e+0 (1.41e+0) - | 1.2842e+0 (1.51e-1) |
| LSMOP6 | 8 | 100 | 1.1242e+0 (6.39e-2) = | 8.9326e-1 (3.01e-1) = | 1.6222e+0 (3.54e-1) - | 1.5361e+0 (6.37e-1) - | 3.4461e+0 (1.98e+0) - | 8.9782e-1 (3.41e-1) |
| LSMOP6 | 8 | 200 | 1.5751e+0 (1.40e-2) - | 1.8325e+0 (1.44e-1) - | 1.2206e+2 (1.31e+2) - | 2.1663e+00(7.36e-01)- | 1.0960e+2 (1.46e+2) - | 1.1391e+0 (1.28e-1) |
| LSMOP6 | 8 | 500 | 1.3891e+0 (1.15e-1) = | 1.4288e+1 (3.20e+1) = | 2.3134e+2 (1.80e+2) - | 6.2001e+02(7.20e+02)- | 2.9353e+2 (2.16e+2) - | 1.3731e+0 (2.87e-2) |
| LSMOP6 | 8 | 1000 | 1.4176e+0 (1.88e-1) = | 1.5799e+0 (2.94e-1) = | 1.4785e+2 (2.12e+2) - | 1.4383e+03(1.04e+03)- | 2.1718e+2 (1.90e+2) - | 1.3527e+0 (3.66e-2) |
| LSMOP6 | 10 | 100 | 1.2105e+0 (5.32e-2) = | 9.2906e-1 (4.64e-1) = | 2.4613e+0 (1.02e+0) - | 2.6435e+0 (5.57e-1) - | 5.5320e+0 (1.76e+0) - | 1.1114e+0 (2.57e-1) |
| LSMOP6 | 10 | 200 | 1.5908e+0 (1.23e-2) - | 1.2766e+0 (1.81e-1) = | 5.1095e+2 (6.20e+2) - | 1.9314e+00(3.10e-01)- | 2.1304e+1 (1.28e+1) - | 1.2913e+0 (1.29e-1) |
| LSMOP6 | 10 | 500 | 1.4200e+0 (1.36e-1) = | 1.3497e+0 (9.93e-4) = | 5.4226e+2 (3.72e+2) - | 4.9755e+02(3.82e+02)- | 2.6495e+0 (1.15e+0) - | 1.3515e+0 (1.38e-2) |
| LSMOP6 | 10 | 1000 | 1.4182e+0 (6.02e-2) - | 1.2760e+0 (6.89e-5) + | 1.0345e+3 (1.04e+3) - | 5.4283e+02(4.61e+02)- | 1.4847e+0 (2.90e-2) - | 1.3027e+0 (1.64e-2) |
| LSMOP7 | 2 | 100 | 1.4601e+0 (3.82e-4) - | 2.0901e+2 (8.97e+1) - | 1.7924e+1 (2.63e+0) - | 2.51e+04(1.13e+04)- | 4.39e+03(7.99e+02)- | 1.4577e+0 (7.35e-4) |
| LSMOP7 | 2 | 200 | 1.4904e+0 (8.53e-4) + | 2.2437e+3 (5.95e+2) - | 6.7514e+4 (4.80e+3) - | 4.69e+04(8.56e+03)- | 4.03e+04(4.71e+03)- | 1.4916e+0 (5.54e-4) |
| LSMOP7 | 2 | 500 | 1.5023e+0 (1.28e-3) + | 5.7882e+3 (9.36e+2) - | 7.8612e+4 (3.07e+3) - | 6.83e+04(4.42e+03)- | 6.43e+04(3.32e+03)- | 1.5109e+0 (1.83e-3) |
| LSMOP7 | 2 | 1000 | 1.5144e+0 (8.89e-4) = | 6.0164e+3 (1.52e+3) - | 8.3559e+4 (1.62e+3) - | 7.98e+04(3.18e+03)- | 7.78e+04(2.38e+03)- | 1.5156e+0 (2.36e-3) |
| LSMOP7 | 3 | 100 | 9.0510e-1 (6.12e-2) = | 1.1212e+0 (1.59e-1) - | 3.5550e+0 (6.29e-1) - | 1.59e+00(2.24e-01)- | 1.04e+02(7.83e+01)- | 9.1842e-1 (9.45e-2) |
| LSMOP7 | 3 | 200 | 9.2707e-1 (2.45e-2) + | 1.0764e+0 (1.19e-1) = | 3.6173e+2 (3.31e+2) - | 1.65e+00(1.02e-01)- | 5.46e+02(5.41e+02)- | 1.0253e+0 (5.64e-2) |
| LSMOP7 | 3 | 500 | 9.2434e-1 (3.65e-2) = | 9.4830e-1 (9.07e-2) = | 7.2343e+2 (5.35e+2) - | 1.11e+00(4.92e-02)- | 1.08e+03(1.10e+03)- | 9.2035e-1 (8.90e-2) |
| LSMOP7 | 3 | 1000 | 8.9570e-1 (4.64e-2) = | 9.1924e-1 (1.00e-1) = | 6.6750e+2 (9.02e+2) - | 9.49e-01(1.17e-01)= | 1.38e+03(9.88e+02)- | 9.5474e-1 (2.46e-2) |
| LSMOP7 | 5 | 100 | 9.8945e-1 (4.10e-2) = | 1.2472e+0 (4.82e-1) = | 6.3719e+0 (2.68e+0) - | 7.7267e-01(4.75e-02)+ | 6.3802e+1 (4.55e+1) - | 1.0319e+0 (4.90e-2) |
| LSMOP7 | 5 | 200 | 1.1313e+0 (7.63e-2) = | 1.1902e+0 (1.92e-1) = | 5.9998e+2 (5.03e+2) - | 1.0538e+00(4.90e-01)= | 2.5227e+1 (3.02e+1) - | 1.2105e+0 (1.38e-1) |
| LSMOP7 | 5 | 500 | 1.3451e+0 (6.42e-2) - | 1.0777e+0 (6.95e-2) + | 1.1700e+3 (1.77e+3) - | 2.0015e+00(7.24e-01)= | 2.1888e+0 (7.28e-1) - | 1.2076e+0 (8.47e-2) |
| LSMOP7 | 5 | 1000 | 1.1985e+0 (6.06e-2) = | 1.0367e+0 (5.80e-2) + | 7.2440e+2 (5.46e+2) - | 1.7621e+00(5.06e-02)- | 1.0556e+0 (4.53e-2) + | 1.1337e+0 (2.98e-2) |
| LSMOP7 | 8 | 100 | 1.1702e+0 (1.93e-2) - | 9.0980e-1 (2.20e-2) = | 1.3945e+1 (3.38e+1) - | 9.2918e-1 (2.40e-2) - | 4.1118e+0 (3.21e+0) - | 8.8881e-1 (2.77e-2) |

| | | | | | | | | |
|--------|----|------|------------------------------|------------------------------|-----------------------|-----------------------|------------------------------|-----------------------------|
| LSMOP7 | 8 | 200 | 1.8648e+0 (4.39e-2) - | 2.8786e+1 (4.03e+1) = | 2.3833e+3 (1.80e+3) - | 1.5543e+03(1.63e+03)- | 2.0747e+3 (5.01e+2) - | 1.6179e+0 (1.55e-1) |
| LSMOP7 | 8 | 500 | 9.4577e+3 (2.45e+4) - | 4.3861e+3 (3.61e+3) = | 9.2739e+3 (1.46e+3) - | 1.3536e+04(3.12e+03)- | 9.1862e+3 (1.54e+3) - | 2.4863e+1 (3.93e+1) |
| LSMOP7 | 8 | 1000 | 1.6708e+4 (3.18e+4) = | 8.1420e+3 (5.22e+3) - | 1.4034e+4 (1.44e+3) - | 1.4555e+04(1.02e+03)- | 1.4728e+4 (1.82e+3) - | 2.5745e+2 (2.40e+2) |
| LSMOP7 | 10 | 100 | 1.5978e+0 (8.02e-3) - | 1.4612e+0 (8.66e-1) = | 4.0721e+1 (9.99e+1) - | 6.8344e+2 (6.22e+2) - | 2.5463e+1 (2.02e+1) - | 9.7143e-1 (1.01e-1) |
| LSMOP7 | 10 | 200 | 1.8547e+0 (3.95e-4) - | 1.3013e+0 (3.13e-1) = | 1.0937e+4 (2.06e+3) - | 7.1220e+03(1.98e+03)- | 1.3074e+2 (5.99e+1) - | 1.3870e+0 (4.99e-1) |
| LSMOP7 | 10 | 500 | 3.8319e+4 (6.54e+4) = | 1.5152e+2 (1.12e+2) = | 1.7341e+4 (1.18e+3) - | 2.0376e+04(2.26e+03)- | 5.0761e+1 (1.09e+1) + | 1.4840e+2 (3.46e+1) |
| LSMOP7 | 10 | 1000 | 4.7656e+4 (5.89e+4) - | 3.6424e+1 (5.64e+0) + | 1.8823e+4 (2.16e+3) - | 1.7964e+04(2.02e+03)- | 1.4611e+1 (2.06e+0) + | 5.0758e+1 (1.82e+1) |
| LSMOP8 | 2 | 100 | 7.4209e-1 (1.20e-16) - | 1.5785e+0 (6.76e-1) - | 3.4014e-1 (2.13e-2) = | 1.41e+01(1.40e+00)- | 3.27e+00(5.00e-01)- | 2.9998e-1 (5.28e-2) |
| LSMOP8 | 2 | 200 | 7.4209e-1 (1.20e-16) - | 3.2966e+0 (6.47e-1) - | 1.7439e+1 (5.36e-1) - | 1.68e+01(3.20e-01)- | 1.27e+01(3.64e-01)- | 6.5133e-1 (6.66e-2) |
| LSMOP8 | 2 | 500 | 7.4209e-1 (1.20e-16) = | 4.5203e+0 (4.47e-1) - | 1.9130e+1 (4.74e-1) - | 1.85e+01(5.05e-01)- | 1.72e+01(4.16e-01)- | 7.4209e-1 (1.20e-16) |
| LSMOP8 | 2 | 1000 | 7.4209e-1 (1.20e-16) = | 4.1292e+0 (1.51e+0) - | 1.9957e+1 (4.21e-1) - | 1.96e+01(3.58e-01)- | 1.89e+01(3.99e-01)- | 7.4209e-1 (1.20e-16) |
| LSMOP8 | 3 | 100 | 3.7046e-1 (2.24e-2) - | 6.5854e-1 (1.67e-1) - | 3.4703e-1 (6.89e-2) - | 6.77e-01(2.49e-02)- | 7.46e-01(5.22e-02)- | 2.2384e-1 (2.52e-2) |
| LSMOP8 | 3 | 200 | 4.0454e-1 (6.88e-2) - | 3.5548e-1 (1.68e-1) - | 7.0342e-1 (3.39e-2) - | 6.82e-01(4.72e-02)- | 7.25e-01(6.49e-02)- | 1.6963e-1 (1.16e-2) |
| LSMOP8 | 3 | 500 | 4.0422e-1 (5.94e-2) - | 3.4096e-1 (1.66e-1) - | 6.5173e-1 (2.50e-2) - | 6.44e-01(6.84e-02)- | 6.45e-01(4.53e-02)- | 1.5592e-1 (1.80e-2) |
| LSMOP8 | 3 | 1000 | 4.6143e-1 (2.65e-2) - | 4.1178e-1 (1.67e-1) - | 6.3326e-1 (1.95e-2) - | 5.97e-01(1.69e-02)- | 6.23e-01(2.37e-02)- | 1.6270e-1 (3.69e-2) |
| LSMOP8 | 5 | 100 | 4.3481e-1 (4.32e-2) = | 8.0802e-1 (2.56e-1) = | 6.4777e-1 (4.05e-1) = | 7.4144e-01(1.04e-02)= | 8.9428e-1 (4.24e-2) = | 5.9321e-1 (3.06e-1) |
| LSMOP8 | 5 | 200 | 4.0322e-1 (3.53e-2) = | 6.4341e-1 (3.23e-1) = | 1.2305e+0 (1.14e-1) - | 7.6864e-01(3.75e-02)= | 8.1908e-1 (3.25e-2) = | 5.2508e-1 (3.21e-1) |
| LSMOP8 | 5 | 500 | 7.9127e-1 (1.95e-1) = | 4.8401e-1 (2.75e-1) = | 1.0206e+0 (4.93e-2) - | 8.8375e-01(4.27e-02)= | 4.8300e-1 (5.36e-3) = | 5.1970e-1 (2.88e-1) |
| LSMOP8 | 5 | 1000 | 9.2262e-1 (3.69e-2) = | 7.0690e-1 (1.34e-1) = | 9.4934e-1 (6.31e-2) = | 8.2539e-01(2.65e-02)= | 2.8924e-1 (5.54e-3) + | 6.7233e-1 (3.37e-1) |
| LSMOP8 | 8 | 100 | 1.1390e+0 (7.03e-2) - | 8.6982e-1 (1.24e-1) - | 9.7179e-1 (7.14e-1) - | 2.3777e+0 (1.28e+0) - | 1.2531e+0 (8.75e-2) - | 7.5927e-1 (1.26e-1) |
| LSMOP8 | 8 | 200 | 1.1710e+0 (6.52e-2) - | 1.6593e+0 (5.70e-1) - | 5.6583e+0 (8.96e-1) - | 4.5394e+00(1.55e+00)- | 4.6761e+0 (6.52e-1) - | 9.9455e-1 (7.08e-2) |
| LSMOP8 | 8 | 500 | 1.1964e+1 (2.26e+0) - | 5.3136e+0 (7.36e-1) - | 7.5617e+0 (3.87e-1) - | 7.7833e+00(1.18e+00)- | 6.5959e+0 (9.66e-1) - | 1.8196e+0 (1.35e-1) |
| LSMOP8 | 8 | 1000 | 8.5804e+0 (3.29e+0) - | 6.6792e+0 (2.53e+0) - | 8.6241e+0 (5.36e-1) - | 9.4397e+00(4.67e-01)- | 8.3328e+0 (3.85e-1) - | 1.6755e+0 (9.05e-2) |
| LSMOP8 | 10 | 100 | 1.2199e+0 (4.12e-2) - | 7.6800e-1 (2.08e-1) = | 1.8223e+0 (2.39e+0) - | 4.4824e+0 (1.05e+0) - | 1.4936e+0 (1.96e-1) - | 8.6846e-1 (8.60e-2) |
| LSMOP8 | 10 | 200 | 1.2417e+0 (0.00e+0) - | 9.6695e-1 (7.88e-2) = | 9.1160e+0 (9.81e-1) - | 8.2854e+00(1.13e+00)- | 1.6112e+0 (1.47e-1) - | 9.3794e-1 (2.23e-1) |
| LSMOP8 | 10 | 500 | 9.6523e+0 (2.69e+0) - | 3.2149e+0 (7.55e-1) - | 1.0095e+1 (6.17e-1) - | 9.5969e+00(5.66e-01)- | 9.9156e-1 (1.35e-2) + | 1.7015e+0 (1.86e-1) |
| LSMOP8 | 10 | 1000 | 1.0716e+1 (5.32e+0) - | 2.0034e+0 (2.69e-1) - | 9.9192e+0 (5.31e-1) - | 1.0412e+01(2.34e-01)- | 7.1346e-1 (1.15e-2) + | 1.6369e+0 (6.87e-2) |
| LSMOP9 | 2 | 100 | 8.1004e-1 (0.00e+0) - | 1.9235e+0 (7.44e-1) - | 8.9923e+0 (7.60e+0) - | 7.31e+00(2.01e+00)- | 6.93e+00(1.20e+00)- | 8.1004e-1 (5.64e-16) |
| LSMOP9 | 2 | 200 | 8.1004e-1 (0.00e+0) = | 3.3653e+0 (1.45e+0) - | 3.9236e+1 (8.92e+0) - | 2.13e+01(6.71e+00)- | 1.76e+01(2.19e+00)- | 8.0603e-1 (5.30e-3) |
| LSMOP9 | 2 | 500 | 8.0895e-1 (6.01e-4) - | 8.9924e+0 (1.10e+0) - | 5.4906e+1 (2.24e+0) - | 2.68e+01(3.99e+00)- | 4.31e+01(2.80e+00)- | 6.6887e-1 (1.24e-1) |
| LSMOP9 | 2 | 1000 | 8.0627e-1 (2.24e-4) - | 1.0527e+1 (1.66e+0) - | 5.7790e+1 (1.26e+0) - | 4.00e+01(3.89e+00)- | 5.37e+01(1.02e+00)- | 6.6516e-1 (7.38e-2) |
| LSMOP9 | 3 | 100 | 1.5379e+0 (2.40e-16) - | 5.1136e+0 (1.12e+0) - | 1.2102e+0 (4.61e-2) - | 3.42e+01(7.38e+00)- | 1.86e+01(2.00e+00)- | 5.9295e-1 (2.15e-3) |
| LSMOP9 | 3 | 200 | 1.4817e+0 (1.49e-1) - | 9.5105e+0 (3.61e+0) - | 1.0982e+2 (2.49e+1) - | 6.21e+01(8.12e+00)- | 4.72e+01(2.87e+00)- | 6.7195e-1 (2.09e-1) |
| LSMOP9 | 3 | 500 | 1.3691e+0 (2.10e-1) - | 3.0712e+1 (5.40e+0) - | 1.2961e+2 (1.89e+0) - | 7.95e+01(6.92e+00)- | 1.06e+02(6.02e+00)- | 5.8631e-1 (1.58e-2) |
| LSMOP9 | 3 | 1000 | 1.1446e+0 (1.87e-4) = | 3.7763e+1 (1.26e+1) - | 1.4238e+2 (3.48e+0) - | 9.72e+01(4.24e+00)- | 1.32e+02(2.12e+00)- | 2.5451e+0 (1.34e+0) |
| LSMOP9 | 5 | 100 | 3.0005e+0 (0.00e+0) - | 1.0219e+1 (4.40e+0) - | 3.9824e+1 (5.84e+1) - | 1.2429e+02(2.95e+01)- | 3.6769e+1 (2.53e+0) - | 9.2390e-1 (7.70e-2) |
| LSMOP9 | 5 | 200 | 2.9921e+0 (2.23e-2) - | 1.0066e+1 (1.86e+0) - | 2.5936e+2 (3.82e+1) - | 1.9650e+02(3.65e+01)- | 2.5815e+1 (3.25e+0) - | 9.0629e-1 (6.71e-2) |
| LSMOP9 | 5 | 500 | 3.0005e+0 (0.00e+0) - | 3.2261e+1 (1.45e+1) - | 3.3148e+2 (1.67e+1) - | 1.7447e+02(1.59e+01)- | 5.7116e+0 (6.72e-1) - | 9.5179e-1 (1.73e-1) |
| LSMOP9 | 5 | 1000 | 3.0005e+0 (0.00e+0) - | 7.1005e+1 (4.11e+0) - | 3.5304e+2 (6.11e+0) - | 2.1663e+02(9.51e+00)- | 1.0244e+0 (1.10e-1) - | 9.3546e-1 (2.02e-1) |
| LSMOP9 | 8 | 100 | 5.3249e+0 (2.32e-3) - | 1.9854e+1 (1.13e+1) - | 1.8399e+2 (2.52e+2) - | 3.6463e+2 (6.09e+1) - | 1.7637e+2 (1.00e+1) - | 3.2921e+0 (2.17e+0) |
| LSMOP9 | 8 | 200 | 5.1165e+0 (7.90e-4) - | 1.0359e+2 (5.95e+1) - | 5.5963e+2 (3.93e+1) - | 4.8838e+02(6.93e+01)- | 4.7346e+2 (1.88e+1) - | 2.4936e+0 (1.21e+0) |
| LSMOP9 | 8 | 500 | 5.1275e+0 (9.48e-3) - | 3.5602e+2 (2.21e+1) - | 7.1233e+2 (7.37e+0) - | 7.3359e+02(2.63e+01)- | 7.0473e+2 (3.64e+1) - | 3.9986e+0 (2.51e+0) |
| LSMOP9 | 8 | 1000 | 5.1234e+0 (6.73e-3) - | 3.2290e+2 (2.62e+1) - | 7.4199e+2 (1.51e+1) - | 7.7083e+02(3.21e+01)- | 7.4961e+2 (1.11e+1) - | 3.2940e+0 (2.01e+0) |
| LSMOP9 | 10 | 100 | 6.4484e+0 (1.81e-1) - | 4.4410e+1 (1.08e+1) - | 3.7283e+2 (5.05e+2) - | 7.9518e+2 (1.76e+2) - | 3.6307e+2 (4.54e+1) - | 2.2616e+0 (7.04e-1) |
| LSMOP9 | 10 | 200 | 6.5321e+0 (0.00e+0) = | 1.0385e+2 (1.21e+1) - | 1.1856e+3 (6.18e+1) - | 9.0904e+02(6.09e+01)- | 2.3155e+2 (2.18e+1) - | 4.4422e+0 (2.40e+0) |

| | | | | | | | | |
|--------|----|------|------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|---------------------|
| LSMOP9 | 10 | 500 | 6.5872e+0 (8.03e-2) = | 4.6934e+2 (5.71e+1) - | 1.1463e+3 (7.53e+1) - | 1.1797e+03(4.52e+01)- | 5.6726e+1 (3.61e+0) - | 9.6554e+0 (5.41e+0) |
| LSMOP9 | 10 | 1000 | 6.5525e+0 (1.47e-2) = | 4.9535e+2 (6.58e+1) - | 1.1996e+3 (3.88e+1) - | 1.2022e+03(2.96e+01)- | 1.7237e+1 (2.33e-1) - | 7.1615e+0 (4.73e+0) |
| +/-= | | | 20/118/42 | 8/106/66 | 4/170/6 | 4/162/14 | 15/159/6 | |

TABLE A. 8

THE IGD RESULTS OF SIX COMPARED ALGORITHMS ON DTLZ1-DTLZ7 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | LSMOF | DGEA | LMEA | LSMOEA/D | MOEADVA | NN-CSO |
|---------|----|------|------------------------------|-----------------------|------------------------------|-----------------------|------------------------------|----------------------------|
| DTLZ1 | 2 | 100 | 1.2349e+3 (4.85e+0) - | 7.6342e+2 (1.61e+2) = | 4.2556e+1 (2.17e+0) + | 1.5997e+03(1.98e+02)- | 9.9615e+2 (4.62e+1) - | 5.3793e+2 (2.23e+2) |
| DTLZ1 | 2 | 200 | 2.4707e+3 (3.99e+1) - | 1.5905e+3 (4.04e+2) - | 6.8312e+3 (1.58e+2) - | 4.6682e+03(1.97e+02)- | 1.8906e+3 (7.58e+1) - | 1.0141e+3 (2.19e+2) |
| DTLZ1 | 2 | 500 | 6.2328e+3 (2.47e-1) - | 4.2750e+3 (3.06e+2) - | 1.7825e+4 (2.43e+2) - | 1.5927e+04(5.43e+02)- | 2.1093e+3 (4.27e+1) + | 2.7736e+3 (8.35e+2) |
| DTLZ1 | 2 | 1000 | 1.2399e+4 (2.10e+2) - | 7.0568e+3 (3.01e+3) = | 3.6653e+4 (2.17e+2) - | 3.5843e+04(5.74e+02)- | 2.1902e+3 (5.48e+1) + | 5.7686e+3 (1.47e+3) |
| DTLZ1 | 3 | 100 | 1.8349e-2 (1.34e-3) + | 3.7094e+2 (2.42e+2) = | 3.3048e+1 (1.70e+0) + | 1.2401e+03(6.89e+01)- | 8.3055e+2 (5.71e+1) - | 3.7321e+2 (7.74e+1) |
| DTLZ1 | 3 | 200 | 1.9542e-2 (2.33e-3) + | 7.9119e+2 (4.66e+2) = | 5.6681e+3 (1.11e+2) - | 4.0675e+03(2.65e+02)- | 1.6152e+3 (3.84e+1) - | 7.5949e+2 (6.39e+1) |
| DTLZ1 | 3 | 500 | 2.0664e-2 (1.61e-3) + | 1.4915e+3 (6.03e+2) = | 1.4825e+4 (2.55e+2) - | 1.3502e+04(5.05e+02)- | 1.7772e+3 (4.04e+1) = | 2.1264e+3 (6.16e+2) |
| DTLZ1 | 3 | 1000 | 2.0328e-2 (4.71e-3) + | 4.9175e+3 (2.85e+3) = | 3.0213e+4 (3.39e+2) - | 2.9282e+04(7.37e+02)- | 1.8420e+3 (4.88e+1) + | 4.2642e+3 (4.30e+2) |
| DTLZ1 | 5 | 100 | 1.1497e+2 (3.04e+2) + | 2.5896e+2 (4.77e+1) = | 2.5706e+1 (1.25e+0) = | 1.29e+03(1.23e+02)- | 5.86e+02(4.02e+01)- | 1.6925e+2 (1.38e+2) |
| DTLZ1 | 5 | 200 | 1.3726e+2 (3.63e+2) + | 6.2035e+2 (2.47e+2) - | 4.6919e+3 (1.78e+2) - | 3.71e+03(6.11e+01)- | 3.08e+03(1.75e+02)- | 2.6128e+2 (2.57e+2) |
| DTLZ1 | 5 | 500 | 7.0610e-2 (1.68e-3) + | 9.9795e+2 (3.68e+2) - | 1.1943e+4 (3.13e+2) - | 1.11e+04(3.23e+02)- | 1.09e+04(2.61e+02)- | 1.2046e+2 (2.56e+2) |
| DTLZ1 | 5 | 1000 | 6.7920e+3 (3.58e+3) - | 3.3512e+3 (9.18e+2) - | 2.4636e+4 (4.20e+2) - | 2.40e+04(3.51e+02)- | 2.33e+04(3.29e+02)- | 2.2002e+2 (2.22e+2) |
| DTLZ1 | 8 | 100 | 7.6648e+2 (2.53e+2) - | 2.7663e+2 (3.61e+1) = | 2.1388e+1 (1.66e+0) + | 1.07e+03(1.20e+02)- | 5.88e+02(3.53e+01)- | 2.4699e+2 (6.08e+1) |
| DTLZ1 | 8 | 200 | 1.2699e+3 (4.24e+2) - | 5.3954e+2 (2.06e+2) = | 4.3433e+3 (2.03e+2) - | 3.08e+03(2.05e+02)- | 3.01e+03(1.49e+02)- | 4.6851e+2 (1.64e+2) |
| DTLZ1 | 8 | 500 | 4.7818e+3 (1.92e+3) - | 1.8236e+3 (3.20e+2) - | 1.0927e+4 (5.73e+2) - | 9.19e+03(4.00e+02)- | 9.74e+03(3.56e+02)- | 4.2218e+2 (6.81e+2) |
| DTLZ1 | 8 | 1000 | 8.7278e+3 (5.06e+3) - | 3.2942e+3 (1.03e+3) - | 2.1955e+4 (1.22e+3) - | 2.00e+04(5.40e+02)- | 2.13e+04(8.95e+02)- | 6.8877e+2 (8.48e+2) |
| DTLZ1 | 10 | 100 | 7.9116e+2 (2.01e+2) - | 2.9306e+2 (8.04e+1) = | 1.9581e+1 (1.29e+0) + | 1.23e+03(1.89e+02)- | 6.00e+02(2.79e+01)- | 1.9673e+2 (1.55e+2) |
| DTLZ1 | 10 | 200 | 1.8619e+3 (4.19e+2) - | 6.2382e+2 (2.07e+2) = | 4.0241e+3 (1.97e+2) - | 3.50e+03(1.15e+02)- | 3.02e+03(2.42e+02)- | 5.3201e+2 (1.79e+2) |
| DTLZ1 | 10 | 500 | 4.0741e+3 (1.12e+3) - | 1.7280e+3 (2.46e+2) - | 1.0735e+4 (7.04e+2) - | 9.81e+03(4.77e+02)- | 9.99e+03(2.63e+02)- | 2.7571e+2 (2.80e+2) |
| DTLZ1 | 10 | 1000 | 1.0145e+4 (3.67e+3) - | 3.4907e+3 (9.03e+2) - | 2.1843e+4 (1.18e+3) - | 1.91e+04(8.19e+02)- | 2.06e+04(8.66e+02)- | 3.2814e+2 (5.18e+2) |
| DTLZ2 | 2 | 100 | 4.2806e+0 (2.12e-1) - | 3.1493e-1 (4.05e-2) - | 2.5887e-3 (7.09e-5) + | 2.6609e+00(5.08e-01)- | 1.5733e+0 (1.00e-1) - | 7.9524e-2 (1.00e-2) |
| DTLZ2 | 2 | 200 | 8.9595e+0 (1.61e+0) - | 1.3810e+0 (2.51e-1) - | 1.3741e+1 (4.76e-1) - | 9.1270e+00(6.57e-01)- | 2.2408e+0 (1.04e-1) - | 1.9177e-1 (2.86e-2) |
| DTLZ2 | 2 | 500 | 2.5889e+1 (1.52e+0) - | 5.6270e+0 (1.05e+0) - | 3.6733e+1 (7.15e-1) - | 3.0979e+01(1.31e+00)- | 1.5612e+0 (1.74e-2) - | 5.7716e-1 (5.73e-2) |
| DTLZ2 | 2 | 1000 | 5.5267e+1 (1.88e+0) - | 1.2186e+1 (1.46e+0) - | 7.6886e+1 (4.76e-1) - | 7.3467e+01(2.17e+00)- | 9.5973e-1 (1.31e-2) + | 1.1890e+0 (1.12e-1) |
| DTLZ2 | 3 | 100 | 6.1902e-2 (3.23e-2) + | 6.9371e-1 (1.43e-1) - | 3.3667e-2 (1.04e-3) + | 2.9094e+00(4.42e-01)- | 1.5818e+0 (8.96e-2) - | 1.9668e-1 (1.64e-2) |
| DTLZ2 | 3 | 200 | 1.1760e-1 (1.73e-1) + | 1.7259e+0 (2.56e-1) - | 1.3874e+1 (6.02e-1) - | 1.0137e+01(5.99e-01)- | 2.3487e+0 (3.95e-2) - | 3.7337e-1 (4.58e-2) |
| DTLZ2 | 3 | 500 | 1.0605e+0 (1.74e+0) = | 4.3788e+0 (3.97e-1) - | 3.6809e+1 (7.84e-1) - | 3.3556e+01(7.59e-01)- | 1.6008e+0 (3.38e-2) - | 9.0447e-1 (5.55e-2) |
| DTLZ2 | 3 | 1000 | 6.1187e+0 (1.07e+1) = | 9.3625e+0 (2.32e+0) - | 7.6285e+1 (8.77e-1) - | 7.4534e+01(1.43e+00)- | 9.9234e-1 (1.28e-2) + | 1.5976e+0 (1.43e-1) |
| DTLZ2 | 5 | 100 | 2.5195e+0 (5.24e-1) - | 7.5579e-1 (6.46e-2) - | 1.5239e-1 (2.62e-3) + | 3.40e+00(2.53e-01)- | 1.36e+00(6.10e-02)- | 4.9801e-1 (4.04e-2) |
| DTLZ2 | 5 | 200 | 8.4418e+0 (1.40e+0) - | 1.3947e+0 (1.76e-1) - | 1.3755e+1 (3.68e-1) - | 1.13e+01(7.43e-01)- | 7.77e+00(3.11e-01)- | 5.6523e-1 (6.63e-2) |
| DTLZ2 | 5 | 500 | 3.4105e+1 (2.11e+0) - | 2.9162e+0 (1.30e-1) - | 3.6973e+1 (4.10e-1) - | 3.28e+01(1.25e+00)- | 3.18e+01(4.62e-01)- | 6.9030e-1 (6.45e-2) |
| DTLZ2 | 5 | 1000 | 5.8958e+1 (1.37e+0) - | 5.4007e+0 (5.61e-1) - | 7.6754e+1 (6.81e-1) - | 7.47e+01(1.03e+00)- | 7.23e+01(4.52e-01)- | 8.2565e-1 (3.53e-2) |
| DTLZ2 | 8 | 100 | 1.5534e+1 (1.73e+0) - | 1.0453e+0 (8.57e-2) - | 3.3266e-1 (6.29e-3) + | 5.15e+00(2.42e-01)- | 1.70e+00(3.43e-02)- | 8.8452e-1 (3.41e-2) |
| DTLZ2 | 8 | 200 | 2.8831e+1 (5.08e+0) - | 1.4586e+0 (1.35e-1) - | 1.3718e+1 (3.71e-1) - | 1.32e+01(4.94e-01)- | 8.68e+00(9.29e-02)- | 1.0250e+0 (2.93e-2) |
| DTLZ2 | 8 | 500 | 4.3349e+1 (7.83e+0) - | 3.0779e+0 (3.62e-1) - | 3.6929e+1 (4.70e-1) - | 3.49e+01(5.79e-01)- | 3.22e+01(3.00e-01)- | 9.8507e-1 (4.22e-2) |
| DTLZ2 | 8 | 1000 | 7.8487e+1 (9.76e+0) - | 5.8028e+0 (6.06e-1) - | 7.6851e+1 (7.09e-1) - | 7.55e+01(1.57e+00)- | 7.23e+01(9.43e-01)- | 9.8649e-1 (2.51e-2) |
| DTLZ2 | 10 | 100 | 1.0879e+1 (3.04e+0) - | 1.1251e+0 (1.02e-1) - | 4.1071e-1 (7.33e-3) + | 5.30e+00(3.15e-01)- | 1.88e+00(7.37e-02)- | 9.9078e-1 (2.74e-2) |
| DTLZ2 | 10 | 200 | 2.7987e+1 (6.08e+0) - | 1.5628e+0 (1.20e-1) - | 1.3964e+1 (2.71e-1) - | 1.29e+01(3.34e-01)- | 9.04e+00(2.31e-01)- | 1.0680e+0 (5.82e-2) |
| DTLZ2 | 10 | 500 | 7.7268e+1 (1.60e+1) - | 3.1548e+0 (3.94e-1) - | 3.6814e+1 (4.76e-1) - | 3.51e+01(8.82e-01)- | 3.27e+01(4.95e-01)- | 1.0921e+0 (9.10e-2) |
| DTLZ2 | 10 | 1000 | 8.0609e+1 (1.57e+1) - | 5.2500e+0 (7.49e-1) - | 7.6309e+1 (7.61e-1) - | 7.48e+01(2.23e+00)- | 7.32e+01(8.43e-01)- | 1.0579e+0 (3.91e-2) |
| DTLZ3 | 2 | 100 | 2.4741e+3 (3.49e-2) - | 1.3890e+3 (1.07e+3) = | 1.2191e+2 (8.37e+0) + | 4.3348e+03(5.47e+02)- | 2.6728e+3 (7.81e+1) - | 1.3287e+3 (4.97e+2) |
| DTLZ3 | 2 | 200 | 4.9552e+3 (3.15e+1) - | 3.3969e+3 (1.57e+3) = | 1.8603e+4 (3.55e+2) - | 1.2911e+04(4.98e+02)- | 5.0521e+3 (1.39e+2) - | 3.0668e+3 (9.45e+2) |
| DTLZ3 | 2 | 500 | 1.2470e+4 (9.88e-2) - | 6.2963e+3 (4.79e+3) = | 4.9345e+4 (3.19e+2) - | 4.3324e+04(1.08e+03)- | 5.8008e+3 (1.29e+2) = | 5.8953e+3 (8.19e+2) |

| | | | | | | | | |
|-------|----|------|------------------------------|------------------------------|------------------------------|-----------------------|------------------------------|----------------------------|
| DTLZ3 | 2 | 1000 | 2.4959e+4 (8.17e+0) - | 1.5593e+4 (1.12e+4) = | 1.0212e+5 (4.34e+2) - | 9.9355e+04(7.94e+02)- | 6.1409e+3 (6.17e+1) + | 1.3700e+4 (3.68e+3) |
| DTLZ3 | 3 | 100 | 4.2772e-2 (2.04e-3) + | 1.0549e+3 (6.00e+2) = | 1.1713e+2 (4.52e+0) + | 4.3677e+03(3.35e+02)- | 2.5659e+3 (1.28e+2) - | 1.2512e+3 (2.07e+2) |
| DTLZ3 | 3 | 200 | 4.3266e-2 (2.16e-3) + | 2.5202e+3 (1.76e+3) = | 1.8595e+4 (3.02e+2) - | 1.4243e+04(5.68e+02)- | 5.1140e+3 (1.78e+2) - | 2.4816e+3 (3.06e+2) |
| DTLZ3 | 3 | 500 | 4.4824e-2 (3.09e-3) + | 5.5132e+3 (3.66e+3) = | 4.9240e+4 (7.48e+2) - | 4.6231e+04(7.46e+02)- | 5.7265e+3 (1.21e+2) + | 6.4010e+3 (4.86e+2) |
| DTLZ3 | 3 | 1000 | 5.0918e-2 (7.22e-3) + | 8.6391e+3 (8.58e+3) = | 1.0106e+5 (1.31e+3) - | 9.8866e+04(1.20e+03)- | 6.1573e+3 (6.71e+1) + | 1.3679e+4 (1.34e+3) |
| DTLZ3 | 5 | 100 | 1.8340e+2 (3.48e+2) = | 7.3817e+2 (3.49e+2) = | 1.1859e+2 (5.83e+0) + | 5.18e+03(3.32e+02)- | 2.14e+03(6.62e+01)- | 7.6616e+2 (4.86e+2) |
| DTLZ3 | 5 | 200 | 1.5020e+2 (2.25e+2) = | 1.8645e+3 (8.82e+2) - | 1.8035e+4 (4.30e+2) - | 1.57e+04(4.74e+02)- | 1.20e+04(3.07e+02)- | 7.4980e+2 (1.01e+3) |
| DTLZ3 | 5 | 500 | 1.9466e+3 (1.29e+3) - | 5.4544e+3 (1.73e+3) - | 4.8987e+4 (5.30e+2) - | 4.52e+04(6.85e+02)- | 4.36e+04(8.96e+02)- | 3.8409e+2 (6.12e+2) |
| DTLZ3 | 5 | 1000 | 2.8187e+3 (3.41e+3) = | 4.8999e+3 (3.21e+3) - | 1.0173e+5 (6.12e+2) - | 9.98e+04(1.01e+03)- | 9.66e+04(1.43e+03)- | 1.3701e+3 (1.40e+3) |
| DTLZ3 | 8 | 100 | 2.2487e+3 (8.34e+1) - | 9.5022e+2 (2.77e+2) = | 1.1129e+2 (2.33e+0) + | 6.55e+03(2.34e+02)- | 2.23e+03(1.04e+02)- | 1.0390e+3 (2.46e+2) |
| DTLZ3 | 8 | 200 | 4.5414e+3 (5.51e+2) - | 2.3074e+3 (5.84e+2) = | 1.7966e+4 (5.95e+2) - | 1.71e+04(5.25e+02)- | 1.22e+04(3.79e+02)- | 1.6571e+3 (8.85e+2) |
| DTLZ3 | 8 | 500 | 2.2166e+4 (4.29e+3) - | 3.9971e+3 (1.35e+3) - | 4.8903e+4 (2.33e+2) - | 4.70e+04(7.14e+02)- | 4.41e+04(2.63e+02)- | 4.8984e+2 (4.86e+2) |
| DTLZ3 | 8 | 1000 | 3.3338e+4 (1.18e+4) - | 6.9528e+3 (2.72e+3) - | 1.0096e+5 (4.51e+2) - | 9.91e+04(1.61e+03)- | 9.69e+04(3.98e+02)- | 4.2066e+2 (4.91e+2) |
| DTLZ3 | 10 | 100 | 2.2578e+3 (3.76e+1) - | 8.6595e+2 (3.67e+2) + | 1.0981e+2 (6.42e+0) + | 7.26e+03(5.02e+02)- | 2.27e+03(7.73e+01)- | 1.1943e+3 (1.02e+2) |
| DTLZ3 | 10 | 200 | 4.6720e+3 (9.61e+1) - | 1.7969e+3 (5.34e+2) = | 1.7782e+4 (5.03e+2) - | 1.75e+04(6.37e+02)- | 1.29e+04(2.79e+02)- | 1.8951e+3 (1.32e+3) |
| DTLZ3 | 10 | 500 | 1.9228e+4 (5.55e+3) - | 3.6291e+3 (2.35e+3) = | 4.8659e+4 (6.02e+2) - | 4.72e+04(7.25e+02)- | 4.43e+04(8.55e+02)- | 1.0827e+3 (1.58e+3) |
| DTLZ3 | 10 | 1000 | 3.5243e+4 (8.84e+3) - | 9.2376e+3 (2.46e+3) - | 1.0119e+5 (7.53e+2) - | 1.00e+05(9.48e+02)- | 9.71e+04(6.77e+02)- | 2.2712e+3 (1.98e+3) |
| DTLZ4 | 2 | 100 | 1.6918e-3 (3.29e-5) + | 4.1605e-1 (7.04e-2) - | 8.3809e-2 (5.32e-2) + | 3.1463e+00(7.14e-01)- | 1.8925e+0 (7.29e-2) - | 2.1880e-1 (2.81e-2) |
| DTLZ4 | 2 | 200 | 1.7391e-3 (1.82e-5) + | 1.7832e+0 (4.20e-1) - | 1.4173e+1 (3.05e-1) - | 1.0465e+01(1.06e+00)- | 2.5168e+0 (1.68e-1) - | 8.0161e-1 (5.73e-2) |
| DTLZ4 | 2 | 500 | 1.7545e-3 (4.44e-5) + | 7.0232e+0 (1.28e+0) - | 3.7448e+1 (4.59e-1) - | 3.1680e+01(2.29e+00)- | 1.7939e+0 (4.30e-2) + | 2.5251e+0 (3.29e-1) |
| DTLZ4 | 2 | 1000 | 1.7475e-3 (7.10e-5) + | 1.3245e+1 (2.76e+0) - | 7.7344e+1 (6.59e-1) - | 7.0443e+01(2.85e+00)- | 1.0433e+0 (3.42e-2) + | 5.4437e+0 (9.45e-1) |
| DTLZ4 | 3 | 100 | 1.2908e-1 (6.86e-2) + | 9.1177e-1 (1.66e-1) = | 2.3597e-1 (6.19e-2) + | 2.7868e+00(4.75e-01)- | 2.0176e+0 (6.26e-2) - | 9.7413e-1 (1.95e-1) |
| DTLZ4 | 3 | 200 | 7.8632e-1 (7.53e-1) + | 2.3675e+0 (5.66e-1) = | 1.3931e+1 (4.42e-1) - | 1.0349e+01(7.04e-01)- | 2.6988e+0 (1.66e-1) - | 2.1691e+0 (1.65e-1) |
| DTLZ4 | 3 | 500 | 2.7687e+0 (2.41e+0) = | 7.0979e+0 (9.99e-1) - | 3.7423e+1 (2.99e-1) - | 3.2815e+01(1.01e+00)- | 1.9109e+0 (5.01e-2) + | 4.8555e+0 (1.03e+0) |
| DTLZ4 | 3 | 1000 | 1.2429e+1 (1.21e+1) = | 1.3360e+1 (5.40e+0) - | 7.7072e+1 (1.16e+0) - | 7.4900e+01(9.50e-01)- | 1.1860e+0 (2.81e-2) + | 7.6875e+0 (1.52e+0) |
| DTLZ4 | 5 | 100 | 4.9134e+0 (4.57e+0) - | 1.2706e+0 (2.23e-1) - | 3.6263e-1 (6.39e-2) + | 3.84e+00(6.15e-01)- | 1.74e+00(6.32e-02)- | 9.0123e-1 (2.29e-1) |
| DTLZ4 | 5 | 200 | 1.8012e+1 (9.31e+0) - | 3.0288e+0 (6.44e-1) - | 1.4137e+1 (2.62e-1) - | 1.14e+01(6.52e-01)- | 8.26e+00(1.60e-01)- | 1.1041e+0 (7.73e-3) |
| DTLZ4 | 5 | 500 | 3.7679e+1 (1.14e+1) - | 6.4330e+0 (1.02e+0) - | 3.7057e+1 (5.04e-1) - | 3.29e+01(1.50e+00)- | 3.17e+01(3.02e-01)- | 1.1081e+0 (7.96e-7) |
| DTLZ4 | 5 | 1000 | 7.8601e+1 (1.89e+1) - | 1.1546e+1 (1.50e+0) - | 7.6785e+1 (6.78e-1) - | 7.25e+01(2.60e+00)- | 7.17e+01(9.77e-01)- | 1.2318e+0 (3.14e-2) |
| DTLZ4 | 8 | 100 | 1.5614e+1 (4.17e+0) - | 1.7410e+0 (1.38e-1) - | 4.1005e-1 (3.00e-2) + | 3.80e+00(4.16e-01)- | 1.95e+00(6.19e-02)- | 1.1920e+0 (1.04e-2) |
| DTLZ4 | 8 | 200 | 2.4207e+1 (9.43e+0) - | 2.4999e+0 (2.32e-1) - | 1.4198e+1 (2.24e-1) - | 1.17e+01(8.22e-01)- | 8.69e+00(2.65e-01)- | 1.2133e+0 (2.39e-3) |
| DTLZ4 | 8 | 500 | 4.9721e+1 (1.82e+1) - | 5.3502e+0 (7.39e-1) - | 3.7395e+1 (2.14e-1) - | 2.98e+01(2.81e+00)- | 3.25e+01(3.75e-01)- | 1.3757e+0 (7.06e-2) |
| DTLZ4 | 8 | 1000 | 1.0893e+2 (3.19e+1) - | 1.1142e+1 (1.34e+0) - | 7.6936e+1 (6.45e-1) - | 7.27e+01(2.41e+00)- | 7.22e+01(1.01e+00)- | 1.3439e+0 (3.91e-2) |
| DTLZ4 | 10 | 100 | 1.1826e+1 (3.63e+0) - | 1.6901e+0 (1.19e-1) - | 4.4223e-1 (2.56e-2) + | 4.81e+00(3.17e-01)- | 2.04e+00(9.21e-02)- | 1.2250e+0 (1.20e-2) |
| DTLZ4 | 10 | 200 | 3.5112e+1 (1.00e+1) - | 2.5033e+0 (2.76e-1) - | 1.3884e+1 (2.61e-1) - | 1.20e+01(3.26e-01)- | 9.19e+00(4.56e-01)- | 1.3963e+0 (1.14e-1) |
| DTLZ4 | 10 | 500 | 5.5392e+1 (1.32e+1) - | 4.7595e+0 (5.90e-1) - | 3.6967e+1 (7.91e-1) - | 3.17e+01(2.06e+00)- | 3.28e+01(1.08e+00)- | 1.3750e+0 (8.46e-2) |
| DTLZ4 | 10 | 1000 | 1.2165e+2 (3.24e+1) - | 8.6497e+0 (1.31e+0) - | 7.6268e+1 (1.26e+0) - | 7.06e+01(1.76e+00)- | 7.29e+01(8.85e-01)- | 1.3390e+0 (6.47e-2) |
| DTLZ5 | 2 | 100 | 3.2314e+0 (1.09e+0) - | 2.7977e-1 (6.03e-2) - | 2.6731e-3 (1.67e-4) + | 2.6314e+00(2.51e-01)- | 1.5693e+0 (7.20e-2) - | 8.3136e-2 (9.22e-3) |
| DTLZ5 | 2 | 200 | 8.1286e+0 (2.48e+0) - | 1.5779e+0 (3.45e-1) - | 1.4063e+1 (2.81e-1) - | 9.0868e+00(6.50e-01)- | 2.2795e+0 (8.34e-2) - | 1.8608e-1 (1.68e-2) |
| DTLZ5 | 2 | 500 | 2.3415e+1 (3.57e+0) - | 4.9765e+0 (6.99e-1) - | 3.7148e+1 (4.46e-1) - | 3.1304e+01(1.45e+00)- | 1.5374e+0 (6.52e-2) - | 6.0724e-1 (6.90e-2) |
| DTLZ5 | 2 | 1000 | 5.4182e+1 (2.35e+0) - | 1.1628e+1 (2.31e+0) - | 7.6443e+1 (8.90e-1) - | 7.3437e+01(1.25e+00)- | 9.6059e-1 (1.72e-2) + | 1.1779e+0 (9.17e-2) |
| DTLZ5 | 3 | 100 | 7.3087e-3 (5.56e-4) + | 6.0672e-1 (1.29e-1) - | 2.4536e-3 (1.36e-4) + | 2.8770e+00(4.32e-01)- | 1.5290e+0 (6.58e-2) - | 2.9437e-1 (2.36e-2) |
| DTLZ5 | 3 | 200 | 4.9454e-3 (1.12e-3) + | 1.7339e+0 (4.20e-1) - | 1.3816e+1 (3.29e-1) - | 9.4126e+00(7.23e-01)- | 2.3136e+0 (1.00e-1) - | 4.8664e-1 (3.20e-2) |
| DTLZ5 | 3 | 500 | 4.6623e-3 (2.84e-3) + | 3.8922e+0 (4.08e-1) - | 3.6940e+1 (1.09e+0) - | 3.3531e+01(1.09e+00)- | 1.5727e+0 (4.47e-2) - | 9.2839e-1 (6.35e-2) |
| DTLZ5 | 3 | 1000 | 3.1579e-3 (5.23e-4) + | 9.1561e+0 (1.16e+0) - | 7.6801e+1 (7.51e-1) - | 7.4247e+01(7.41e-01)- | 9.6771e-1 (1.99e-2) + | 1.6843e+0 (1.71e-1) |

| | | | | | | | | |
|-------|----|------|-------------------------------|------------------------------|------------------------------|-----------------------|------------------------------|----------------------------|
| DTLZ5 | 5 | 100 | 3.6219e+0 (4.06e+0) - | 6.4306e-1 (1.76e-1) - | 2.2639e-3 (2.73e-4) + | 3.31e+00(2.16e-01)- | 1.52e+00(6.84e-02)- | 3.1277e-1 (1.93e-2) |
| DTLZ5 | 5 | 200 | 1.6472e+1 (8.87e-1) - | 1.3186e+0 (1.12e-1) - | 1.3699e+1 (3.23e-1) - | 1.06e+01(3.84e-01)- | 8.02e+00(3.02e-01)- | 3.5304e-1 (2.71e-2) |
| DTLZ5 | 5 | 500 | 4.3189e+1 (7.79e+0) - | 3.0608e+0 (7.14e-1) - | 3.6622e+1 (9.68e-1) - | 3.16e+01(7.65e-01)- | 3.16e+01(5.73e-01)- | 3.7765e-1 (2.68e-2) |
| DTLZ5 | 5 | 1000 | 4.8752e+1 (1.86e+1) - | 5.6973e+0 (8.12e-1) - | 7.6366e+1 (7.25e-1) - | 7.52e+01(7.70e-01)- | 7.20e+01(6.17e-01)- | 4.8973e-1 (3.81e-2) |
| DTLZ5 | 8 | 100 | 7.0726e+0 (4.26e+0) - | 7.5440e-1 (4.71e-2) - | 2.1206e-3 (2.29e-4) + | 4.98e+00(2.14e-01)- | 2.60e+00(2.75e-01)- | 3.1610e-1 (2.27e-2) |
| DTLZ5 | 8 | 200 | 1.8188e+1 (6.86e+0) - | 1.4012e+0 (1.99e-1) - | 1.3461e+1 (2.30e-1) - | 1.24e+01(4.81e-01)- | 8.60e+00(3.32e-01)- | 3.7485e-1 (1.02e-2) |
| DTLZ5 | 8 | 500 | 4.2608e+1 (8.24e+0) - | 3.4005e+0 (8.95e-1) - | 3.6734e+1 (4.83e-1) - | 3.40e+01(7.53e-01)- | 3.17e+01(5.93e-01)- | 3.9319e-1 (2.00e-2) |
| DTLZ5 | 8 | 1000 | 8.2719e+1 (7.14e+0) - | 5.5787e+0 (7.57e-1) - | 7.6290e+1 (1.35e+0) - | 7.37e+01(1.53e+00)- | 7.20e+01(7.44e-01)- | 4.4120e-1 (5.98e-2) |
| DTLZ5 | 10 | 100 | 8.1365e+0 (3.74e+0) - | 7.5612e-1 (1.23e-1) - | 2.2727e-3 (1.01e-4) + | 4.95e+00(3.91e-01)- | 3.58e+00(2.81e-01)- | 3.3800e-1 (4.47e-2) |
| DTLZ5 | 10 | 200 | 2.4451e+1 (4.58e+0) - | 1.3333e+0 (1.94e-1) - | 1.3440e+1 (2.08e-1) - | 1.28e+01(2.39e-01)- | 9.53e+00(3.17e-01)- | 4.5488e-1 (3.23e-2) |
| DTLZ5 | 10 | 500 | 4.9461e+1 (9.08e+0) - | 2.9058e+0 (5.62e-1) - | 3.6599e+1 (4.98e-1) - | 3.55e+01(1.09e+00)- | 3.26e+01(4.58e-01)- | 5.1257e-1 (7.28e-2) |
| DTLZ5 | 10 | 1000 | 9.8967e+1 (1.27e+1) - | 5.6669e+0 (7.90e-1) - | 7.5841e+1 (9.52e-1) - | 7.47e+01(1.47e+00)- | 7.24e+01(5.85e-01)- | 5.0542e-1 (5.40e-2) |
| DTLZ6 | 2 | 100 | 9.3769e-1 (7.79e-2) + | 2.4976e+1 (6.65e+0) = | 1.2893e+1 (1.40e+0) + | 4.1027e+01(2.92e+00)- | 6.4646e+1 (1.00e+0) - | 2.0551e+1 (6.02e+0) |
| DTLZ6 | 2 | 200 | 9.6098e-1 (6.89e-2) + | 7.4807e+1 (6.78e+0) - | 1.7676e+2 (6.36e-1) - | 1.3275e+02(1.36e+00)- | 1.5616e+2 (6.38e-1) - | 5.4776e+1 (9.58e+0) |
| DTLZ6 | 2 | 500 | 9.6912e-1 (5.59e-2) + | 2.3136e+2 (6.27e+0) - | 4.4787e+2 (1.21e+0) - | 4.2833e+02(1.34e+00)- | 3.6688e+2 (5.05e-1) - | 1.2901e+2 (3.16e+1) |
| DTLZ6 | 2 | 1000 | 9.9590e-1 (1.08e-2) + | 4.8794e+2 (1.02e+1) - | 9.0025e+2 (8.11e-1) - | 8.9444e+02(2.21e+00)- | 6.9392e+2 (8.14e-1) - | 3.0210e+2 (5.79e+1) |
| DTLZ6 | 3 | 100 | 7.3206e-1 (1.32e-5) + | 3.7446e+1 (1.02e+1) - | 1.5187e+1 (5.18e-1) + | 5.3528e+01(3.01e+00)- | 6.3693e+1 (1.53e+0) - | 3.1633e+1 (3.50e+0) |
| DTLZ6 | 3 | 200 | 1.9550e-3 (6.72e-5) + | 8.5303e+1 (5.35e+0) - | 1.7609e+2 (4.61e-1) - | 1.5539e+02(2.76e+00)- | 1.5607e+2 (7.57e-1) - | 7.4758e+1 (6.53e+0) |
| DTLZ6 | 3 | 500 | 7.3206e-1 (1.60e-5) + | 2.3113e+2 (1.53e+1) - | 4.4671e+2 (1.26e+0) - | 4.3618e+02(2.93e+00)- | 3.6617e+2 (5.97e-1) - | 1.9931e+2 (1.93e+1) |
| DTLZ6 | 3 | 1000 | 7.3206e-1 (4.60e-6) + | 4.6028e+2 (4.07e+1) = | 8.9950e+2 (7.79e-1) - | 8.9451e+02(1.88e+00)- | 6.9180e+2 (1.34e+0) - | 4.1347e+2 (7.43e+1) |
| DTLZ6 | 5 | 100 | 1.4736e+0 (2.40e-16) - | 3.5759e+1 (3.62e+0) - | 1.4926e+1 (1.46e+0) - | 6.36e+01(2.03e+00)- | 6.22e+01(9.56e-01)- | 1.1439e+0 (1.24e-1) |
| DTLZ6 | 5 | 200 | 1.4736e+0 (2.40e-16) = | 8.1987e+1 (2.41e+0) - | 1.7419e+2 (5.39e-1) - | 1.63e+02(1.41e+00)- | 1.66e+02(5.18e-01)- | 7.4977e+0 (1.30e+1) |
| DTLZ6 | 5 | 500 | 1.4736e+0 (2.40e-16) + | 1.9447e+2 (5.82e+1) = | 4.4469e+2 (6.98e-1) - | 4.35e+02(1.30e+00)- | 4.38e+02(1.40e+00)- | 1.2555e+2 (6.86e+1) |
| DTLZ6 | 5 | 1000 | 3.7603e+2 (4.81e+1) = | 4.4896e+2 (4.74e+1) = | 8.9684e+2 (8.10e-1) - | 8.96e+02(2.32e+00)- | 8.93e+02(8.69e-01)- | 4.4290e+2 (5.97e+1) |
| DTLZ6 | 8 | 100 | 2.1272e+0 (0.00e+0) - | 3.3755e+1 (4.40e+0) - | 1.4692e+1 (1.10e+0) - | 7.76e+01(8.83e-01)- | 6.03e+01(7.93e-01)- | 1.4865e+0 (1.14e-1) |
| DTLZ6 | 8 | 200 | 2.1272e+0 (0.00e+0) = | 6.3658e+1 (2.19e+1) - | 1.7102e+2 (2.85e-1) - | 1.70e+02(1.27e+00)- | 1.65e+02(4.12e-01)- | 5.5756e+0 (9.93e+0) |
| DTLZ6 | 8 | 500 | 3.2506e+2 (4.02e+1) - | 2.0427e+2 (4.41e+1) = | 4.4098e+2 (1.11e+0) - | 4.41e+02(1.55e+00)- | 4.37e+02(1.01e+00)- | 1.8481e+2 (8.36e+1) |
| DTLZ6 | 8 | 1000 | 7.0539e+2 (4.32e+1) - | 4.2547e+2 (1.08e+2) = | 8.9404e+2 (1.31e+0) - | 8.95e+02(1.37e+00)- | 8.91e+02(7.62e-01)- | 4.6411e+2 (2.03e+1) |
| DTLZ6 | 10 | 100 | 2.5196e+0 (4.80e-16) - | 3.1060e+1 (9.14e+0) - | 1.4724e+1 (1.30e+0) - | 7.83e+01(1.44e+00)- | 5.94e+01(1.31e+00)- | 1.8316e+0 (1.90e-1) |
| DTLZ6 | 10 | 200 | 2.5196e+0 (4.80e-16) = | 6.5655e+1 (2.30e+1) - | 1.6929e+2 (5.42e-1) - | 1.70e+02(9.47e-01)- | 1.63e+02(8.71e-01)- | 3.4666e+0 (2.95e+0) |
| DTLZ6 | 10 | 500 | 3.3167e+2 (6.82e+1) - | 2.0063e+2 (4.95e+1) = | 4.4033e+2 (6.54e-1) - | 4.40e+02(9.75e-01)- | 4.36e+02(7.84e-01)- | 1.9093e+2 (8.34e+1) |
| DTLZ6 | 10 | 1000 | 5.9334e+2 (1.00e+2) - | 4.1390e+2 (8.39e+1) = | 8.9164e+2 (8.28e-1) - | 8.92e+02(2.31e+00)- | 8.90e+02(6.03e-01)- | 4.7408e+2 (1.61e+1) |
| DTLZ7 | 2 | 100 | 4.4230e-1 (8.83e-6) - | 2.4861e+0 (4.10e-1) - | 4.8408e-3 (1.41e-4) + | 3.1482e+00(3.46e-01)- | 2.4978e+0 (1.37e-1) - | 9.4690e-2 (1.32e-1) |
| DTLZ7 | 2 | 200 | 4.4231e-1 (1.43e-5) - | 4.6972e+0 (3.49e-1) - | 7.2163e+0 (1.97e-1) - | 5.1442e+00(1.20e-01)- | 2.0394e+0 (5.68e-2) - | 2.4954e-1 (2.18e-1) |
| DTLZ7 | 2 | 500 | 4.6254e-1 (2.80e-2) = | 6.2072e+0 (2.46e-1) - | 7.4919e+0 (7.40e-2) - | 6.5427e+00(1.60e-01)- | 8.5387e-1 (1.24e-2) - | 3.3772e-1 (1.65e-1) |
| DTLZ7 | 2 | 1000 | 5.2485e-1 (6.16e-2) = | 6.9155e+0 (2.16e-1) - | 7.7141e+0 (8.84e-2) - | 7.3678e+00(1.21e-01)- | 4.8027e-1 (8.40e-3) = | 6.3712e-1 (4.44e-1) |
| DTLZ7 | 3 | 100 | 6.8827e-1 (2.85e-1) = | 5.2889e+0 (6.59e-1) - | 3.7472e-2 (1.53e-3) + | 3.6927e+00(3.21e-01)- | 3.6841e+0 (1.42e-1) - | 1.1238e+0 (1.22e+0) |
| DTLZ7 | 3 | 200 | 7.9613e-1 (4.27e-4) = | 7.9145e+0 (5.48e-1) - | 1.0887e+1 (2.50e-1) - | 6.5164e+00(3.14e-01)- | 2.8494e+0 (2.39e-1) - | 2.2019e+0 (2.21e+0) |
| DTLZ7 | 3 | 500 | 7.9671e-1 (7.74e-4) = | 9.2322e+0 (2.33e-1) - | 1.1068e+1 (2.44e-1) - | 7.7673e+00(1.88e-01)- | 1.0213e+0 (1.54e-2) = | 3.8856e+0 (3.38e+0) |
| DTLZ7 | 3 | 1000 | 8.0662e-1 (4.34e-1) + | 1.0019e+1 (3.52e-1) = | 1.1298e+1 (1.68e-1) - | 9.6356e+00(7.64e-02)= | 5.2029e-1 (7.00e-3) + | 8.3253e+0 (2.63e+0) |
| DTLZ7 | 5 | 100 | 1.3658e+0 (2.87e-1) - | 1.8749e+0 (1.21e+0) - | 2.3730e-1 (3.82e-3) + | 8.69e+00(1.02e+00)- | 4.71e+00(7.49e-01)- | 5.2470e-1 (4.62e-3) |
| DTLZ7 | 5 | 200 | 1.5643e+0 (2.11e-1) - | 3.8662e+0 (3.93e+0) - | 1.8254e+1 (5.64e-1) - | 1.29e+01(9.34e-01)- | 1.19e+01(6.18e-01)- | 5.2269e-1 (9.85e-3) |
| DTLZ7 | 5 | 500 | 2.5696e+0 (7.36e-1) - | 5.6080e+0 (5.60e+0) - | 1.8809e+1 (4.07e-1) - | 1.32e+01(4.59e-01)- | 1.62e+01(4.10e-01)- | 5.3577e-1 (5.48e-2) |
| DTLZ7 | 5 | 1000 | 7.4045e-1 (3.83e-1) = | 5.8051e+0 (5.94e+0) - | 1.9379e+1 (3.64e-1) - | 1.65e+01(2.41e-01)- | 1.78e+01(1.55e-01)- | 1.0133e+0 (1.57e-1) |
| DTLZ7 | 8 | 100 | 7.2877e-1 (2.09e-2) + | 3.4521e+0 (2.03e+0) - | 6.3318e-1 (7.23e-3) + | 1.85e+01(3.06e+00)- | 1.00e+01(8.05e-01)- | 1.6240e+0 (2.70e-2) |

| | | | | | | | | |
|-------|----|------|-------------------------|-------------------------|------------------------------|-----------------------|-----------------------|----------------------------|
| DTLZ7 | 8 | 200 | $3.9158e+0 (1.91e+0) -$ | $7.5607e+0 (4.26e+0) -$ | $3.0851e+1 (7.47e-1) -$ | $2.43e+01(1.28e+00)-$ | $2.19e+01(3.67e-01)-$ | 1.7672e+0 (4.05e-1) |
| DTLZ7 | 8 | 500 | $3.6563e+0 (1.22e+0) -$ | $6.7727e+0 (5.50e+0) -$ | $3.1385e+1 (6.88e-1) -$ | $2.37e+01(6.83e-01)-$ | $2.84e+01(1.07e+00)-$ | 1.9336e+0 (3.03e-1) |
| DTLZ7 | 8 | 1000 | $4.3311e+0 (7.06e-1) =$ | $4.4140e+0 (2.89e+0) =$ | $3.1812e+1 (7.22e-1) -$ | $2.75e+01(7.45e-01)-$ | $3.05e+01(4.30e-01)-$ | 3.3249e+0 (7.49e-1) |
| DTLZ7 | 10 | 100 | $1.0466e+0 (5.41e-2) +$ | $2.8808e+0 (1.78e+0) =$ | 8.8268e-1 (1.63e-2) + | $2.70e+01(3.58e+00)-$ | $1.37e+01(1.17e+00)-$ | $2.5731e+0 (7.75e-1)$ |
| DTLZ7 | 10 | 200 | $6.5043e+0 (6.69e-2) -$ | $5.5423e+0 (5.07e+0) -$ | $3.9233e+1 (5.90e-1) -$ | $3.27e+01(9.63e-01)-$ | $2.86e+01(9.05e-01)-$ | 1.9409e+0 (2.96e-1) |
| DTLZ7 | 10 | 500 | $6.5031e+0 (8.92e-2) -$ | $9.1824e+0 (3.42e+0) -$ | $3.9643e+1 (1.06e+0) -$ | $3.12e+01(1.76e+00)-$ | $3.68e+01(8.30e-01)-$ | 2.6103e+0 (7.30e-1) |
| DTLZ7 | 10 | 1000 | $6.3154e+0 (3.51e-1) -$ | $5.8587e+0 (3.34e+0) =$ | $3.9957e+1 (4.43e-1) -$ | $3.35e+01(6.20e-01)-$ | $3.82e+01(8.22e-01)-$ | 3.1208e+0 (1.39e+0) |
| +/-= | | | 58/99/23 | 31/107/42 | 43/125/12 | 16/152/12 | 11/167/2 | |

TABLE A. 9

THE IGD RESULTS OF SIX COMPARED ALGORITHMS ON WFG1-WFG9 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | LSMOF | DGEA | LMEA | LSMOEA/D | MOEADVA | NN-CSO |
|---------|----|------|------------------------------|------------------------------|------------------------------|------------------------------|-----------------------|----------------------------|
| WFG1 | 2 | 100 | 1.1678e+0 (1.55e-1) + | 1.3687e+0 (1.91e-2) = | 1.6456e+0 (3.34e-2) - | 1.0921e+00(2.01e-02)+ | 1.9633e+0 (5.95e-2) - | 1.3861e+0 (1.73e-2) |
| WFG1 | 2 | 200 | 1.3720e+0 (8.37e-2) = | 1.4102e+0 (1.17e-2) = | 1.9602e+0 (5.53e-2) - | 1.2650e+00(3.55e-03)+ | 1.9441e+0 (6.79e-2) - | 1.3920e+0 (2.54e-2) |
| WFG1 | 2 | 500 | 1.4704e+0 (6.63e-2) - | 1.4427e+0 (4.53e-2) - | 1.9677e+0 (6.46e-2) - | 1.3020e+00(1.31e-02)+ | 1.9386e+0 (8.00e-2) - | 1.3805e+0 (2.37e-2) |
| WFG1 | 2 | 1000 | 1.5428e+0 (9.19e-2) - | 1.4221e+0 (4.67e-2) = | 1.9798e+0 (7.26e-2) - | 1.3007e+00(8.33e-03)+ | 1.9761e+0 (4.02e-2) - | 1.3864e+0 (2.13e-2) |
| WFG1 | 3 | 100 | 1.3360e+0 (2.69e-2) + | 1.5591e+0 (2.75e-2) + | 2.0915e+0 (7.63e-2) - | 1.2658e+00(5.25e-02)+ | 2.3136e+0 (5.54e-2) - | 1.5872e+0 (1.67e-2) |
| WFG1 | 3 | 200 | 1.4158e+0 (9.91e-2) + | 1.5705e+0 (1.42e-2) = | 2.3323e+0 (5.31e-2) - | 1.4681e+00(9.62e-03)+ | 2.3316e+0 (4.61e-2) - | 1.5829e+0 (7.51e-3) |
| WFG1 | 3 | 500 | 1.4739e+0 (4.73e-2) + | 1.5646e+0 (1.65e-2) + | 2.3659e+0 (6.30e-2) - | 1.5109e+00(2.22e-03)+ | 2.2927e+0 (3.95e-2) - | 1.5991e+0 (9.23e-3) |
| WFG1 | 3 | 1000 | 1.4970e+0 (3.53e-3) + | 1.5628e+0 (2.63e-2) = | 2.2800e+0 (7.20e-2) - | 1.5157e+00(1.84e-03)+ | 2.3322e+0 (6.89e-2) - | 1.5903e+0 (1.19e-2) |
| WFG1 | 5 | 100 | 1.9291e+0 (3.10e-2) + | 1.9930e+0 (1.21e-2) = | 2.2781e+0 (3.42e-2) - | 1.82e+00(2.83e-02)+ | 2.67e+00(2.52e-02)- | 2.0110e+0 (2.93e-2) |
| WFG1 | 5 | 200 | 1.9688e+0 (3.09e-2) = | 1.9953e+0 (1.53e-2) = | 2.6638e+0 (2.30e-2) - | 1.94e+00(3.60e-02)+ | 2.69e+00(6.56e-02)- | 2.0071e+0 (1.28e-2) |
| WFG1 | 5 | 500 | 1.9842e+0 (3.08e-2) = | 2.0023e+0 (2.99e-2) = | 2.6664e+0 (2.57e-2) - | 1.95e+00(6.07e-03)+ | 2.69e+00(4.09e-02)- | 2.0096e+0 (2.30e-2) |
| WFG1 | 5 | 1000 | 2.0519e+0 (2.27e-2) + | 2.0284e+0 (5.26e-2) + | 2.6844e+0 (1.68e-2) - | 2.02e+00(6.67e-02)+ | 2.70e+00(3.85e-02)- | 2.1607e+0 (3.70e-2) |
| WFG1 | 8 | 100 | 2.5595e+0 (3.53e-2) + | 2.6353e+0 (5.35e-2) = | 2.6111e+0 (4.51e-2) = | 2.62e+00(5.33e-02)= | 3.13e+00(3.50e-02)- | 2.6508e+0 (2.50e-2) |
| WFG1 | 8 | 200 | 2.6018e+0 (3.22e-2) + | 2.6403e+0 (3.35e-2) = | 3.1475e+0 (3.49e-2) - | 2.68e+00(2.74e-02)- | 3.14e+00(3.38e-02)- | 2.6401e+0 (2.00e-2) |
| WFG1 | 8 | 500 | 2.5989e+0 (2.93e-2) + | 2.6423e+0 (3.95e-2) = | 3.1545e+0 (2.81e-2) - | 2.64e+00(3.41e-02)= | 3.15e+00(3.77e-02)- | 2.6538e+0 (3.33e-2) |
| WFG1 | 8 | 1000 | 2.6643e+0 (1.24e-2) + | 2.6420e+0 (2.91e-2) + | 3.1406e+0 (3.59e-2) - | 2.68e+00(1.71e-02)+ | 3.17e+00(2.63e-02)- | 2.8140e+0 (5.60e-2) |
| WFG1 | 10 | 100 | 2.9181e+0 (5.67e-2) + | 3.0555e+0 (3.45e-2) = | 2.8314e+0 (3.83e-2) + | 3.12e+00(2.01e-02)- | 3.43e+00(3.26e-02)- | 3.0278e+0 (2.83e-2) |
| WFG1 | 10 | 200 | 2.9684e+0 (2.75e-2) + | 3.0696e+0 (4.88e-2) = | 3.4513e+0 (2.00e-2) - | 3.14e+00(2.44e-02)- | 3.43e+00(1.59e-02)- | 3.0462e+0 (2.01e-2) |
| WFG1 | 10 | 500 | 2.9584e+0 (2.16e-2) + | 3.0810e+0 (2.58e-2) = | 3.4359e+0 (3.16e-2) - | 3.03e+00(2.49e-02)= | 3.44e+00(2.51e-02)- | 3.0566e+0 (2.62e-2) |
| WFG1 | 10 | 1000 | 3.0400e+0 (1.98e-2) + | 3.0471e+0 (2.39e-2) + | 3.4415e+0 (1.13e-2) - | 3.11e+00(3.17e-02)+ | 3.45e+00(4.40e-02)- | 3.1995e+0 (4.98e-2) |
| WFG2 | 2 | 101 | 6.9732e-2 (7.50e-3) + | 2.6457e-1 (2.52e-2) - | 4.0165e-2 (1.00e-2) + | 3.5781e-01(3.89e-02)- | 3.8045e-1 (5.93e-3) - | 1.6965e-1 (5.99e-3) |
| WFG2 | 2 | 201 | 1.0893e-1 (1.14e-2) + | 3.0223e-1 (1.12e-2) - | 6.4423e-1 (8.01e-3) - | 4.9811e-01(1.95e-02)- | 3.6399e-1 (4.28e-3) - | 1.8455e-1 (1.00e-2) |
| WFG2 | 2 | 501 | 1.6837e-1 (9.18e-3) + | 3.0650e-1 (7.95e-3) - | 6.5874e-1 (1.84e-2) - | 6.1112e-01(7.74e-03)- | 3.1928e-1 (1.80e-3) - | 1.8244e-1 (7.91e-3) |
| WFG2 | 2 | 1001 | 2.1845e-1 (1.39e-2) - | 3.3191e-1 (1.66e-2) - | 6.5648e-1 (4.85e-3) - | 6.4038e-01(6.40e-03)- | 2.9547e-1 (1.86e-3) - | 1.7151e-1 (1.05e-2) |
| WFG2 | 3 | 100 | 1.4227e-1 (2.01e-2) + | 4.0032e-1 (1.71e-2) - | 1.9674e-1 (3.78e-2) + | 4.9430e-01(2.35e-02)- | 5.8621e-1 (6.99e-3) - | 2.7215e-1 (1.11e-2) |
| WFG2 | 3 | 200 | 1.6110e-1 (3.21e-2) + | 4.2995e-1 (6.87e-3) - | 9.1558e-1 (6.93e-2) - | 6.2030e-01(2.45e-02)- | 5.6074e-1 (4.85e-3) - | 2.8162e-1 (1.20e-2) |
| WFG2 | 3 | 500 | 1.6462e-1 (3.29e-2) + | 4.3625e-1 (2.29e-2) - | 9.1904e-1 (6.47e-2) - | 7.5245e-01(7.16e-03)- | 5.0552e-1 (2.66e-3) - | 3.0717e-1 (1.69e-2) |
| WFG2 | 3 | 1000 | 1.6608e-1 (4.32e-2) + | 4.3990e-1 (2.38e-2) - | 9.3226e-1 (8.00e-2) - | 7.9565e-01(7.77e-03)- | 4.7817e-1 (2.66e-3) - | 3.2326e-1 (1.45e-2) |
| WFG2 | 5 | 100 | 7.2004e-1 (4.27e-2) - | 7.0386e-1 (4.56e-2) - | 4.9042e-1 (6.91e-2) = | 9.30e-01(2.96e-02)- | 1.50e+00(1.42e-02)- | 5.0634e-1 (1.48e-2) |
| WFG2 | 5 | 200 | 7.1690e-1 (4.43e-2) - | 6.7882e-1 (3.22e-2) - | 1.5203e+0 (1.36e-1) - | 1.00e+00(5.28e-02)- | 1.65e+00(9.31e-03)- | 5.5282e-1 (1.92e-2) |
| WFG2 | 5 | 500 | 7.0608e-1 (5.14e-2) - | 7.2178e-1 (3.79e-2) - | 1.5083e+0 (1.50e-1) - | 1.02e+00(2.64e-02)- | 1.77e+00(1.10e-02)- | 5.7927e-1 (1.76e-2) |
| WFG2 | 5 | 1000 | 7.2294e-1 (5.84e-2) = | 7.3557e-1 (3.10e-2) = | 1.6005e+0 (2.26e-1) - | 1.09e+00(1.15e-02)- | 1.81e+00(9.25e-03)- | 7.2980e-1 (2.70e-2) |
| WFG2 | 8 | 101 | 1.3389e+0 (4.44e-2) - | 1.3577e+0 (6.06e-2) - | 8.7857e-1 (7.82e-2) + | 1.85e+00(8.10e-02)- | 2.58e+00(5.09e-01)- | 1.1968e+0 (2.06e-2) |
| WFG2 | 8 | 201 | 1.3827e+0 (4.78e-2) - | 1.3888e+0 (5.73e-2) - | 2.8956e+0 (3.27e-1) - | 1.80e+00(2.56e-02)- | 2.68e+00(3.24e-01)- | 1.2357e+0 (2.93e-2) |
| WFG2 | 8 | 501 | 1.3538e+0 (9.63e-2) = | 1.4160e+0 (6.18e-2) - | 2.8752e+0 (3.24e-1) - | 1.60e+00(3.71e-02)- | 2.94e+00(3.21e-01)- | 1.2865e+0 (3.89e-2) |
| WFG2 | 8 | 1001 | 1.7758e+0 (1.12e-1) - | 1.4767e+0 (7.64e-2) - | 3.1004e+0 (5.11e-1) - | 1.73e+00(6.98e-02)- | 2.95e+00(5.54e-01)- | 1.3762e+0 (4.31e-2) |
| WFG2 | 10 | 101 | 1.5688e+0 (5.03e-2) - | 1.6010e+0 (6.39e-2) - | 1.0946e+0 (5.54e-2) + | 2.23e+00(9.18e-02)- | 3.87e+00(8.53e-01)- | 1.4342e+0 (4.64e-2) |
| WFG2 | 10 | 201 | 1.5787e+0 (8.50e-2) = | 1.6287e+0 (9.47e-2) - | 3.9159e+0 (7.13e-1) - | 2.21e+00(3.72e-02)- | 3.62e+00(8.27e-01)- | 1.4897e+0 (6.34e-2) |
| WFG2 | 10 | 501 | 1.6132e+0 (8.40e-2) = | 1.7349e+0 (7.99e-2) - | 3.9291e+0 (8.27e-1) - | 1.89e+00(5.11e-02)- | 3.73e+00(1.06e+00)- | 1.5601e+0 (8.69e-2) |
| WFG2 | 10 | 1001 | 2.3242e+0 (6.64e-2) - | 1.7967e+0 (9.25e-2) = | 3.8247e+0 (5.61e-1) - | 1.97e+00(3.58e-02)- | 3.77e+00(5.78e-01)- | 1.7821e+0 (1.27e-1) |
| WFG3 | 2 | 101 | 4.7854e-1 (8.72e-2) - | 2.2921e-1 (1.64e-2) - | 2.0968e-2 (7.95e-3) + | 4.5347e-01(1.02e-02)- | 4.0938e-1 (2.74e-3) - | 1.2736e-1 (7.83e-3) |
| WFG3 | 2 | 201 | 4.6571e-1 (9.10e-2) - | 3.0369e-1 (1.32e-2) - | 6.9674e-1 (6.26e-3) - | 5.8763e-01(3.56e-02)- | 4.0235e-1 (3.22e-3) - | 1.3611e-1 (8.30e-3) |

| | | | | | | | | |
|------|----|------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|----------------------------|
| WFG3 | 2 | 501 | 5.3124e-1 (6.24e-2) - | 3.6446e-1 (1.59e-2) - | 7.1917e-1 (2.88e-3) - | 7.0231e-01(1.27e-02)- | 3.5569e-1 (1.29e-3) - | 1.3523e-1 (6.16e-3) |
| WFG3 | 2 | 1001 | 5.5735e-1 (2.58e-2) - | 3.7766e-1 (1.41e-2) - | 7.2776e-1 (2.22e-3) - | 7.1459e-01(4.64e-03)- | 3.3377e-1 (1.12e-3) - | 1.3520e-1 (1.02e-2) |
| WFG3 | 3 | 100 | 6.6396e-2 (6.97e-3) + | 4.5237e-1 (1.43e-2) - | 3.3186e-2 (1.90e-2) + | 5.2117e-01(2.12e-02)- | 5.2966e-1 (8.48e-3) - | 3.2416e-1 (1.59e-2) |
| WFG3 | 3 | 200 | 5.6766e-2 (7.21e-3) + | 4.5786e-1 (1.76e-2) - | 8.4972e-1 (5.61e-3) - | 6.8602e-01(3.14e-02)- | 5.1357e-1 (5.11e-3) - | 3.4552e-1 (1.73e-2) |
| WFG3 | 3 | 500 | 5.8669e-2 (4.36e-3) + | 5.1266e-1 (2.66e-2) - | 8.6402e-1 (3.11e-3) - | 8.0894e-01(1.32e-02)- | 4.5646e-1 (3.80e-3) - | 3.7091e-1 (2.00e-2) |
| WFG3 | 3 | 1000 | 5.5218e-2 (5.56e-3) + | 4.9589e-1 (2.14e-2) - | 8.7545e-1 (6.97e-3) - | 8.5512e-01(1.13e-02)- | 4.3212e-1 (4.10e-3) - | 3.6457e-1 (7.98e-3) |
| WFG3 | 5 | 100 | 4.9955e-1 (6.78e-2) + | 1.0588e+0 (9.54e-2) - | 4.5176e-2 (1.83e-2) + | 1.12e+00(5.27e-02)- | 8.01e-01(3.18e-02)- | 5.9375e-1 (3.14e-2) |
| WFG3 | 5 | 200 | 4.5540e-1 (4.26e-2) + | 1.1358e+0 (8.27e-2) - | 1.1396e+0 (1.42e-2) - | 1.29e+00(2.90e-02)- | 9.70e-01(1.25e-02)- | 6.3256e-1 (4.62e-2) |
| WFG3 | 5 | 500 | 4.5469e-1 (6.40e-2) + | 1.1323e+0 (1.09e-1) - | 1.1448e+0 (1.62e-2) - | 1.34e+00(1.79e-02)- | 1.10e+00(1.95e-02)- | 6.8104e-1 (9.27e-2) |
| WFG3 | 5 | 1000 | 4.7415e-1 (3.30e-2) + | 1.1435e+0 (1.24e-1) - | 1.1586e+0 (1.06e-2) - | 1.37e+00(1.97e-02)- | 1.15e+00(1.95e-02)- | 9.2953e-1 (3.72e-2) |
| WFG3 | 8 | 101 | 7.4297e-1 (1.06e-1) + | 2.7119e+0 (3.61e-1) - | 1.1668e-1 (3.46e-2) + | 4.05e+00(2.64e-01)- | 1.24e+00(3.47e-02)+ | 2.2319e+0 (5.89e-2) |
| WFG3 | 8 | 201 | 7.0496e-1 (8.21e-2) + | 2.5675e+0 (2.33e-1) - | 1.5756e+0 (2.33e-2) + | 3.46e+00(1.39e+00)- | 1.45e+00(2.56e-02)+ | 2.1652e+0 (1.93e-1) |
| WFG3 | 8 | 501 | 7.1337e-1 (1.37e-1) + | 2.7859e+0 (1.94e-1) - | 1.6133e+0 (1.64e-2) + | 2.68e+00(2.20e-01)- | 1.56e+00(2.51e-02)+ | 2.0726e+0 (1.50e-1) |
| WFG3 | 8 | 1001 | 7.0464e-1 (2.63e-2) + | 2.7294e+0 (2.15e-1) - | 1.6110e+0 (1.13e-2) + | 3.27e+00(9.74e-01)= | 1.60e+00(2.06e-02)+ | 2.5123e+0 (6.40e-2) |
| WFG3 | 10 | 101 | 8.9822e-1 (1.56e-1) + | 3.5447e+0 (1.11e-1) - | 1.5583e-1 (4.10e-2) + | 5.42e+00(5.50e-01)- | 1.53e+00(3.85e-02)+ | 3.0854e+0 (1.81e-1) |
| WFG3 | 10 | 201 | 9.9375e-1 (1.39e-1) + | 3.6409e+0 (6.59e-2) - | 1.8282e+0 (2.86e-2) + | 3.55e+00(6.02e-01)= | 1.73e+00(1.52e-02)+ | 3.0089e+0 (3.13e-1) |
| WFG3 | 10 | 501 | 8.2383e-1 (1.81e-1) + | 3.7490e+0 (3.62e-1) - | 1.8529e+0 (1.57e-2) + | 3.27e+00(1.67e-01)- | 1.81e+00(2.30e-02)+ | 2.8836e+0 (2.04e-1) |
| WFG3 | 10 | 1001 | 8.2345e-1 (4.38e-2) + | 3.6395e+0 (1.35e-1) - | 1.8591e+0 (3.12e-2) + | 3.20e+00(3.56e-01)= | 1.84e+00(2.86e-02)+ | 3.0806e+0 (1.78e-1) |
| WFG4 | 2 | 100 | 8.1975e-2 (6.51e-3) + | 1.5748e-1 (1.45e-2) - | 1.3592e-2 (1.45e-3) + | 2.3701e-01(2.72e-02)- | 1.6958e-1 (6.25e-3) - | 1.2645e-1 (3.86e-3) |
| WFG4 | 2 | 200 | 1.1090e-1 (7.88e-3) + | 1.8559e-1 (1.68e-2) - | 4.2674e-1 (9.31e-3) - | 3.3025e-01(5.53e-03)- | 1.4267e-1 (1.48e-3) - | 1.2845e-1 (2.49e-3) |
| WFG4 | 2 | 500 | 1.4773e-1 (1.09e-2) - | 1.9873e-1 (1.65e-2) - | 4.4467e-1 (9.68e-3) - | 4.1711e-01(8.61e-03)- | 7.6919e-2 (6.00e-4) + | 1.3101e-1 (3.24e-3) |
| WFG4 | 2 | 1000 | 1.7527e-1 (1.21e-2) - | 2.0119e-1 (1.18e-2) - | 4.4565e-1 (9.43e-3) - | 4.3495e-01(5.71e-03)- | 4.6838e-2 (1.88e-4) + | 1.2881e-1 (3.76e-3) |
| WFG4 | 3 | 100 | 1.7992e-1 (1.90e-2) + | 2.8349e-1 (9.27e-3) - | 1.6767e-1 (1.84e-2) + | 3.5401e-01(6.28e-03)- | 3.9717e-1 (2.29e-3) - | 2.3064e-1 (8.49e-3) |
| WFG4 | 3 | 200 | 1.8165e-1 (1.84e-2) + | 2.8781e-1 (1.78e-2) - | 6.7476e-1 (5.34e-2) - | 4.5146e-01(1.49e-02)- | 3.6719e-1 (4.39e-4) - | 2.3747e-1 (6.72e-3) |
| WFG4 | 3 | 500 | 1.7099e-1 (1.02e-2) + | 2.9505e-1 (2.15e-2) - | 6.9475e-1 (3.26e-2) - | 4.9295e-01(7.97e-03)- | 3.0959e-1 (3.65e-4) - | 2.4558e-1 (9.02e-3) |
| WFG4 | 3 | 1000 | 1.8129e-1 (2.81e-2) + | 3.0451e-1 (2.03e-2) - | 7.2253e-1 (5.69e-2) - | 5.1648e-01(2.39e-03)- | 2.9007e-1 (1.33e-4) - | 2.4896e-1 (5.19e-3) |
| WFG4 | 5 | 100 | 1.1544e+0 (3.40e-2) - | 1.0864e+0 (1.54e-2) - | 1.0447e+0 (3.36e-2) = | 1.57e+00(2.43e-01)- | 2.04e+00(5.21e-03)- | 1.0561e+0 (5.97e-3) |
| WFG4 | 5 | 200 | 1.1503e+0 (3.15e-2) - | 1.0925e+0 (2.87e-2) - | 2.3214e+0 (1.55e-1) - | 1.36e+00(2.37e-01)- | 2.14e+00(3.58e-03)- | 1.0542e+0 (6.35e-3) |
| WFG4 | 5 | 500 | 1.1411e+0 (2.93e-2) + | 1.0889e+0 (1.88e-2) + | 2.2466e+0 (1.05e-1) - | 1.11e+00(4.26e-03)+ | 2.22e+00(2.14e-03)- | 1.1859e+0 (3.20e-1) |
| WFG4 | 5 | 1000 | 1.3826e+0 (1.12e-1) - | 1.1110e+0 (2.40e-2) = | 2.2897e+0 (2.18e-1) - | 1.13e+00(7.03e-03)= | 2.24e+00(2.81e-03)- | 1.1353e+0 (1.69e-2) |
| WFG4 | 8 | 100 | 3.1955e+0 (5.35e-2) = | 3.2748e+0 (3.92e-2) - | 3.3879e+0 (1.02e-1) - | 6.51e+00(1.66e-01)- | 6.37e+00(4.49e-01)- | 3.1920e+0 (3.04e-2) |
| WFG4 | 8 | 200 | 3.1488e+0 (4.97e-2) + | 3.2702e+0 (5.94e-2) = | 6.3943e+0 (2.02e-1) - | 5.89e+00(4.43e-01)- | 6.56e+00(5.12e-01)- | 3.2079e+0 (2.39e-2) |
| WFG4 | 8 | 500 | 3.1083e+0 (4.07e-2) + | 3.2783e+0 (4.61e-2) - | 6.3456e+0 (3.61e-1) - | 3.17e+00(9.27e-02)= | 6.53e+00(2.53e-01)- | 3.1822e+0 (1.84e-2) |
| WFG4 | 8 | 1000 | 3.4265e+0 (2.60e-2) - | 3.2670e+0 (4.19e-2) = | 6.4654e+0 (2.51e-1) - | 3.25e+00(1.07e-01)= | 6.52e+00(2.56e-01)- | 3.2678e+0 (4.27e-2) |
| WFG4 | 10 | 100 | 4.4760e+0 (5.21e-2) + | 4.8601e+0 (2.78e-1) = | 5.0176e+0 (1.72e-1) - | 9.12e+00(5.17e-01)- | 9.22e+00(4.77e-01)- | 4.7190e+0 (1.23e-1) |
| WFG4 | 10 | 200 | 4.5049e+0 (4.17e-2) + | 4.9364e+0 (2.43e-1) - | 9.1449e+0 (3.66e-1) - | 8.86e+00(1.75e-02)- | 9.32e+00(3.75e-01)- | 4.6203e+0 (9.04e-2) |
| WFG4 | 10 | 500 | 4.4680e+0 (1.73e-2) + | 4.7044e+0 (1.28e-1) = | 9.4019e+0 (4.45e-1) - | 4.87e+00(3.34e-01)= | 9.82e+00(3.50e-01)- | 4.6596e+0 (9.84e-2) |
| WFG4 | 10 | 1000 | 4.7276e+0 (5.49e-2) - | 4.9576e+0 (2.02e-1) - | 9.4977e+0 (4.05e-1) - | 4.97e+00(5.20e-01)- | 9.57e+00(3.62e-01)- | 4.5209e+0 (3.49e-2) |
| WFG5 | 2 | 100 | 7.3934e-2 (3.92e-3) = | 6.2991e-2 (5.49e-4) + | 6.8397e-2 (1.56e-4) = | 3.3638e-01(3.75e-02)- | 2.6234e-1 (4.70e-3) - | 6.9319e-2 (2.45e-3) |
| WFG5 | 2 | 200 | 9.2215e-2 (2.19e-2) - | 6.4091e-2 (1.51e-3) + | 6.3181e-1 (3.67e-3) - | 4.9023e-01(1.25e-02)- | 2.7593e-1 (2.35e-3) - | 7.0663e-2 (3.27e-3) |
| WFG5 | 2 | 500 | 1.3528e-1 (9.80e-2) - | 6.4019e-2 (9.46e-4) + | 6.5055e-1 (3.39e-3) - | 6.2660e-01(6.08e-03)- | 1.7162e-1 (7.75e-4) - | 7.0263e-2 (2.36e-3) |
| WFG5 | 2 | 1000 | 1.2411e-1 (9.96e-2) - | 6.3156e-2 (1.42e-3) + | 6.5645e-1 (2.49e-3) - | 6.4619e-01(3.85e-03)- | 1.2348e-1 (1.89e-4) - | 6.8693e-2 (3.12e-3) |
| WFG5 | 3 | 100 | 1.9870e-1 (1.48e-2) - | 1.6381e-1 (3.00e-3) = | 1.6234e-1 (3.30e-3) = | 4.5789e-01(1.46e-02)- | 3.7477e-1 (3.15e-3) - | 1.6114e-1 (6.18e-3) |
| WFG5 | 3 | 200 | 2.1307e-1 (1.25e-2) - | 1.6862e-1 (5.59e-3) - | 8.0670e-1 (5.53e-3) - | 6.1343e-01(1.16e-02)- | 3.8088e-1 (1.07e-3) - | 1.6242e-1 (3.87e-3) |
| WFG5 | 3 | 500 | 2.2132e-1 (1.69e-2) - | 1.6828e-1 (7.25e-3) = | 8.1086e-1 (7.16e-3) - | 7.0518e-01(5.34e-03)- | 2.5970e-1 (3.06e-4) - | 1.6664e-1 (6.54e-3) |

| | | | | | | | | |
|------|----|------|------------------------------|------------------------------|------------------------------|-----------------------|-----------------------|----------------------------|
| WFG5 | 3 | 1000 | 2.1717e-1 (1.42e-2) - | 1.5840e-1 (4.05e-3) + | 8.1903e-1 (1.09e-2) - | 7.4634e-01(7.23e-03)- | 2.1254e-1 (6.07e-5) - | 1.6605e-1 (6.94e-3) |
| WFG5 | 5 | 100 | 1.0803e+0 (2.84e-2) - | 1.0234e+0 (8.93e-3) = | 8.9900e-1 (2.52e-2) + | 1.74e+00(5.85e-02)- | 1.38e+00(1.83e-03)- | 1.0132e+0 (1.34e-3) |
| WFG5 | 5 | 200 | 1.0869e+0 (2.77e-2) - | 1.0207e+0 (6.49e-3) = | 1.7718e+0 (3.64e-2) - | 1.55e+00(1.23e-01)- | 1.60e+00(1.78e-03)- | 1.0150e+0 (3.04e-3) |
| WFG5 | 5 | 500 | 1.0894e+0 (1.49e-2) - | 1.0245e+0 (8.28e-3) - | 1.6836e+0 (4.74e-2) - | 1.23e+00(9.06e-03)- | 1.73e+00(2.89e-03)- | 1.0134e+0 (3.75e-3) |
| WFG5 | 5 | 1000 | 1.4280e+0 (2.54e-2) - | 1.0320e+0 (1.11e-2) + | 1.7096e+0 (4.29e-2) - | 1.29e+00(5.67e-03)- | 1.77e+00(1.83e-03)- | 1.1103e+0 (1.31e-2) |
| WFG5 | 8 | 100 | 3.2055e+0 (4.78e-2) - | 3.2119e+0 (6.86e-2) - | 2.8456e+0 (6.54e-2) + | 6.33e+00(1.35e-01)- | 4.41e+00(1.76e-01)- | 3.0526e+0 (4.36e-2) |
| WFG5 | 8 | 200 | 3.1942e+0 (5.94e-2) - | 3.2138e+0 (7.91e-2) - | 4.8150e+0 (2.01e-1) - | 5.20e+00(5.13e-01)- | 4.68e+00(7.43e-02)- | 3.0415e+0 (4.23e-2) |
| WFG5 | 8 | 500 | 3.1744e+0 (8.06e-2) - | 3.2694e+0 (6.00e-2) - | 4.8878e+0 (1.78e-1) - | 3.51e+00(8.32e-02)- | 4.85e+00(1.04e-01)- | 3.0802e+0 (7.22e-2) |
| WFG5 | 8 | 1000 | 3.5853e+0 (7.07e-2) - | 3.2548e+0 (7.29e-2) + | 4.7315e+0 (1.19e-1) - | 3.63e+00(1.54e-01)- | 4.93e+00(1.53e-01)- | 3.4457e+0 (2.78e-2) |
| WFG5 | 10 | 100 | 4.5114e+0 (7.47e-2) - | 4.4297e+0 (4.75e-2) = | 4.2530e+0 (8.58e-2) + | 8.77e+00(2.05e-01)- | 6.85e+00(4.37e-01)- | 4.3701e+0 (5.38e-2) |
| WFG5 | 10 | 200 | 4.5559e+0 (5.55e-2) - | 4.4751e+0 (7.71e-2) = | 7.3586e+0 (2.17e-1) - | 8.77e+00(2.41e-01)- | 6.77e+00(2.33e-01)- | 4.4166e+0 (6.79e-2) |
| WFG5 | 10 | 500 | 4.5190e+0 (3.63e-2) = | 4.5288e+0 (5.31e-2) = | 7.1815e+0 (2.38e-1) - | 5.04e+00(1.25e-01)- | 7.09e+00(3.49e-01)- | 4.5010e+0 (3.98e-2) |
| WFG5 | 10 | 1000 | 4.7529e+0 (6.23e-2) + | 4.4961e+0 (6.20e-2) + | 7.2211e+0 (3.72e-1) - | 5.60e+00(4.22e-01)- | 7.29e+00(3.77e-01)- | 4.9927e+0 (7.12e-2) |
| WFG6 | 2 | 100 | 2.1165e-1 (1.96e-1) - | 2.6008e-2 (2.11e-4) + | 1.4964e-2 (7.62e-4) + | 4.3829e-01(5.06e-02)- | 4.3623e-1 (6.77e-3) - | 2.9661e-2 (2.43e-3) |
| WFG6 | 2 | 200 | 2.4231e-1 (2.05e-1) - | 1.4739e-2 (1.04e-3) + | 7.9412e-1 (7.84e-3) - | 6.5159e-01(2.78e-02)- | 3.1660e-1 (2.15e-3) - | 1.7915e-2 (1.39e-3) |
| WFG6 | 2 | 500 | 2.5021e-1 (1.38e-1) - | 8.7398e-3 (7.29e-4) + | 8.1116e-1 (5.93e-3) - | 7.7632e-01(1.60e-02)- | 1.6141e-1 (5.92e-4) - | 1.2482e-2 (3.05e-3) |
| WFG6 | 2 | 1000 | 2.6461e-1 (1.94e-1) - | 6.1965e-3 (6.72e-4) + | 8.2023e-1 (4.27e-3) - | 8.0380e-01(4.31e-03)- | 7.9706e-1 (2.54e-3) - | 1.2221e-2 (4.94e-3) |
| WFG6 | 3 | 100 | 2.2301e-1 (1.12e-2) - | 1.4336e-1 (1.13e-2) = | 1.3186e-1 (2.90e-3) + | 6.0709e-01(4.40e-02)- | 5.9441e-1 (5.65e-3) - | 1.4004e-1 (5.11e-3) |
| WFG6 | 3 | 200 | 2.2580e-1 (1.16e-2) - | 1.4200e-1 (7.00e-3) - | 9.9911e-1 (6.63e-3) - | 7.9035e-01(3.48e-02)- | 4.3142e-1 (3.48e-3) - | 1.3283e-1 (3.45e-3) |
| WFG6 | 3 | 500 | 2.2096e-1 (7.61e-3) = | 1.4144e-1 (1.12e-2) + | 1.0036e+0 (1.77e-2) - | 8.7094e-01(1.32e-02)- | 2.4406e-1 (8.47e-4) = | 1.9857e-1 (5.50e-2) |
| WFG6 | 3 | 1000 | 2.2459e-1 (1.13e-2) - | 1.3825e-1 (6.72e-3) = | 1.0075e+0 (9.30e-3) - | 9.3143e-01(8.38e-03)- | 8.5110e-1 (3.00e-1) - | 1.7362e-1 (4.00e-2) |
| WFG6 | 5 | 100 | 1.3081e+0 (6.68e-2) - | 1.0469e+0 (3.10e-3) + | 1.0444e+0 (4.33e-1) + | 1.79e+00(9.21e-02)- | 1.54e+00(8.20e-03)- | 1.0606e+0 (8.55e-3) |
| WFG6 | 5 | 200 | 1.3855e+0 (1.39e-1) - | 1.0489e+0 (3.15e-3) + | 1.9770e+0 (1.00e-1) - | 1.69e+00(1.24e-01)- | 1.76e+00(3.89e-03)- | 1.0734e+0 (2.12e-2) |
| WFG6 | 5 | 500 | 1.3940e+0 (1.21e-1) - | 1.0665e+0 (1.36e-2) = | 1.9568e+0 (7.85e-2) - | 1.35e+00(9.75e-03)- | 1.92e+00(2.29e-03)- | 1.0849e+0 (2.12e-2) |
| WFG6 | 5 | 1000 | 1.5316e+0 (3.88e-2) - | 1.0937e+0 (5.92e-2) + | 1.9484e+0 (5.08e-2) - | 1.45e+00(5.28e-03)- | 1.97e+00(2.85e-03)- | 1.3864e+0 (3.03e-2) |
| WFG6 | 8 | 100 | 3.3584e+0 (4.07e-2) - | 3.2711e+0 (9.66e-2) - | 3.1754e+0 (8.25e-1) - | 6.19e+00(2.62e-01)- | 4.86e+00(1.91e-01)- | 3.1393e+0 (8.91e-2) |
| WFG6 | 8 | 200 | 3.4323e+0 (9.24e-2) - | 3.2673e+0 (8.02e-2) - | 5.1725e+0 (1.00e-1) - | 5.85e+00(2.19e-01)- | 5.14e+00(2.33e-01)- | 3.1595e+0 (8.56e-2) |
| WFG6 | 8 | 500 | 3.3613e+0 (9.05e-2) - | 3.2802e+0 (1.10e-1) = | 5.0684e+0 (1.71e-1) - | 3.65e+00(1.33e-01)- | 5.23e+00(1.53e-01)- | 3.1892e+0 (5.75e-2) |
| WFG6 | 8 | 1000 | 3.5150e+0 (3.98e-2) = | 3.3133e+0 (1.52e-1) = | 5.0740e+0 (1.94e-1) - | 3.99e+00(3.52e-01)- | 5.25e+00(3.03e-01)- | 3.4520e+0 (6.52e-2) |
| WFG6 | 10 | 100 | 4.7129e+0 (3.21e-2) = | 5.3170e+0 (2.82e-1) - | 4.6036e+0 (1.10e+0) + | 8.84e+00(4.15e-01)- | 7.25e+00(3.48e-01)- | 4.6680e+0 (1.04e-1) |
| WFG6 | 10 | 200 | 4.6830e+0 (5.77e-2) - | 5.1439e+0 (2.76e-1) - | 7.6980e+0 (2.40e-1) - | 8.51e+00(1.26e-01)- | 7.57e+00(1.88e-01)- | 4.5751e+0 (7.01e-2) |
| WFG6 | 10 | 500 | 4.6160e+0 (8.03e-2) = | 5.2729e+0 (2.91e-1) - | 7.4397e+0 (3.57e-1) - | 5.25e+00(1.81e-01)- | 7.46e+00(2.34e-01)- | 4.6990e+0 (1.56e-1) |
| WFG6 | 10 | 1000 | 4.7522e+0 (5.74e-2) = | 5.1477e+0 (3.02e-1) = | 7.5965e+0 (2.19e-1) - | 5.83e+00(6.29e-01)- | 7.66e+00(4.22e-01)- | 4.9120e+0 (2.16e-1) |
| WFG7 | 2 | 100 | 1.1268e-1 (1.84e-2) = | 1.9790e-1 (2.52e-2) - | 2.1475e-1 (1.54e-1) = | 3.2455e-01(2.97e-02)- | 5.5515e-1 (4.94e-3) - | 1.2382e-1 (9.87e-3) |
| WFG7 | 2 | 200 | 1.7501e-1 (3.72e-2) - | 2.6653e-1 (1.26e-2) - | 1.8680e-1 (1.23e-1) = | 5.0455e-01(3.70e-02)- | 5.8100e-1 (3.75e-3) - | 1.2664e-1 (7.82e-3) |
| WFG7 | 2 | 500 | 2.7585e-1 (4.65e-2) - | 2.9440e-1 (1.01e-2) - | 6.0346e-1 (3.63e-3) - | 5.9928e-01(5.36e-03)- | 6.0068e-1 (4.47e-3) - | 1.2925e-1 (5.48e-3) |
| WFG7 | 2 | 1000 | 3.6751e-1 (2.55e-2) - | 3.0071e-1 (8.47e-3) - | 6.0858e-1 (2.92e-3) - | 6.1453e-01(2.71e-03)- | 6.0989e-1 (1.41e-3) - | 1.2301e-1 (4.64e-3) |
| WFG7 | 3 | 100 | 2.1669e-1 (2.55e-2) + | 3.7946e-1 (1.58e-2) - | 4.1947e-1 (1.54e-1) = | 5.2943e-01(2.68e-02)- | 7.4183e-1 (1.01e-2) - | 2.9567e-1 (1.73e-2) |
| WFG7 | 3 | 200 | 2.4318e-1 (2.61e-2) + | 4.1495e-1 (1.69e-2) - | 2.3048e-1 (1.02e-1) = | 6.4295e-01(1.41e-02)- | 7.7042e-1 (3.22e-2) - | 3.0577e-1 (9.44e-3) |
| WFG7 | 3 | 500 | 2.7504e-1 (6.71e-2) = | 4.2218e-1 (1.47e-2) - | 7.7741e-1 (1.58e-2) - | 6.8855e-01(1.09e-02)- | 7.7940e-1 (1.37e-2) - | 3.3910e-1 (2.23e-2) |
| WFG7 | 3 | 1000 | 2.9466e-1 (4.63e-2) = | 4.2575e-1 (1.36e-2) - | 7.7430e-1 (9.31e-3) - | 7.1065e-01(5.64e-03)- | 7.6883e-1 (7.63e-3) - | 3.4150e-1 (1.39e-2) |
| WFG7 | 5 | 100 | 1.3319e+0 (3.66e-2) - | 1.1701e+0 (2.18e-2) - | 9.9774e-1 (2.42e-2) + | 1.72e+00(9.61e-02)- | 1.92e+00(7.95e-02)- | 1.1053e+0 (6.00e-3) |
| WFG7 | 5 | 200 | 1.3825e+0 (3.58e-2) - | 1.1956e+0 (2.68e-2) - | 1.0462e+0 (1.19e-1) = | 1.52e+00(1.10e-01)- | 1.96e+00(1.17e-01)- | 1.1238e+0 (7.95e-3) |
| WFG7 | 5 | 500 | 1.3570e+0 (6.58e-2) - | 1.2154e+0 (3.28e-2) - | 1.7977e+0 (5.26e-2) - | 1.23e+00(1.23e-02)- | 1.88e+00(1.23e-01)- | 1.1375e+0 (6.22e-3) |
| WFG7 | 5 | 1000 | 1.4342e+0 (3.96e-2) - | 1.2010e+0 (1.63e-2) + | 1.8060e+0 (4.72e-2) - | 1.27e+00(8.13e-03)= | 1.89e+00(6.97e-02)- | 1.2482e+0 (2.09e-2) |

| | | | | | | | | |
|------|----|------|------------------------------|------------------------------|------------------------------|-----------------------|------------------------------|----------------------------|
| WFG7 | 8 | 100 | 3.4150e+0 (6.79e-2) - | 3.3449e+0 (6.10e-2) - | 2.7696e+0 (2.96e-2) + | 6.36e+00(1.14e-01)- | 5.21e+00(2.50e-01)- | 3.1192e+0 (2.66e-2) |
| WFG7 | 8 | 200 | 3.4214e+0 (4.81e-2) - | 3.3702e+0 (1.21e-1) - | 3.0032e+0 (2.26e-1) + | 5.15e+00(5.10e-01)- | 5.36e+00(2.12e-01)- | 3.1565e+0 (2.86e-2) |
| WFG7 | 8 | 500 | 3.3915e+0 (5.57e-2) - | 3.3855e+0 (9.57e-2) - | 5.1216e+0 (3.23e-1) - | 3.32e+00(1.21e-01)- | 5.47e+00(4.65e-01)- | 3.1208e+0 (1.84e-2) |
| WFG7 | 8 | 1000 | 3.6628e+0 (4.27e-2) - | 3.3500e+0 (7.47e-2) = | 5.1437e+0 (2.09e-1) - | 3.41e+00(1.59e-01)= | 5.24e+00(3.45e-01)- | 3.3300e+0 (4.05e-2) |
| WFG7 | 10 | 100 | 4.6902e+0 (5.64e-2) - | 4.6593e+0 (8.82e-2) - | 4.0682e+0 (2.71e-2) + | 8.90e+00(1.03e-01)- | 7.79e+00(2.25e-01)- | 4.4828e+0 (4.43e-2) |
| WFG7 | 10 | 200 | 4.7015e+0 (3.89e-2) - | 4.6155e+0 (7.84e-2) - | 4.4273e+0 (8.26e-1) + | 8.75e+00(6.02e-02)- | 7.72e+00(3.08e-01)- | 4.4663e+0 (5.14e-2) |
| WFG7 | 10 | 500 | 4.8597e+0 (5.45e-2) - | 4.6306e+0 (7.47e-2) - | 7.6659e+0 (3.60e-1) - | 5.22e+00(3.25e-01)- | 7.79e+00(4.61e-01)- | 4.4638e+0 (1.18e-1) |
| WFG7 | 10 | 1000 | 4.9074e+0 (2.59e-2) - | 4.6271e+0 (5.81e-2) = | 7.5940e+0 (3.29e-1) - | 5.16e+00(2.59e-01)- | 7.59e+00(3.90e-01)- | 4.6457e+0 (1.11e-1) |
| WFG8 | 2 | 100 | 2.0751e-1 (3.46e-2) = | 2.7475e-1 (1.98e-2) - | 7.8763e-2 (7.23e-3) + | 3.3003e-01(3.41e-02)- | 3.4009e-1 (4.03e-3) - | 2.3974e-1 (9.48e-3) |
| WFG8 | 2 | 200 | 3.0443e-1 (6.43e-2) = | 3.0402e-1 (1.28e-2) - | 8.3219e-2 (4.92e-3) + | 4.6861e-01(1.88e-02)- | 2.6944e-1 (2.31e-3) - | 2.4560e-1 (1.27e-2) |
| WFG8 | 2 | 500 | 3.4228e-1 (7.46e-2) - | 3.1548e-1 (8.41e-3) - | 6.1957e-1 (4.49e-3) - | 5.9128e-01(8.12e-03)- | 2.0523e-1 (1.77e-3) - | 1.7036e-1 (1.43e-2) |
| WFG8 | 2 | 1000 | 3.5088e-1 (4.01e-2) - | 3.1596e-1 (6.50e-3) - | 6.2186e-1 (4.83e-3) - | 6.0930e-01(5.79e-03)- | 5.9196e-1 (2.13e-3) - | 1.3687e-1 (4.02e-3) |
| WFG8 | 3 | 100 | 2.6494e-1 (1.27e-2) + | 4.4024e-1 (2.62e-2) - | 1.8765e-1 (5.81e-3) + | 4.6936e-01(1.52e-02)- | 4.7365e-1 (9.06e-3) - | 3.7263e-1 (7.64e-3) |
| WFG8 | 3 | 200 | 2.9358e-1 (2.30e-2) + | 4.3033e-1 (1.63e-2) - | 1.8719e-1 (3.72e-3) + | 5.9450e-01(1.67e-02)- | 3.6924e-1 (3.49e-3) = | 3.7016e-1 (7.34e-3) |
| WFG8 | 3 | 500 | 3.4474e-1 (7.40e-3) + | 4.4636e-1 (2.38e-2) - | 8.1780e-1 (1.35e-2) - | 6.7758e-01(1.13e-02)- | 2.8915e-1 (1.04e-3) + | 3.7377e-1 (2.37e-3) |
| WFG8 | 3 | 1000 | 3.5251e-1 (2.33e-2) = | 4.3422e-1 (9.92e-3) - | 8.0641e-1 (1.14e-2) - | 7.1403e-01(9.83e-03)- | 7.3526e-1 (2.73e-3) - | 3.5338e-1 (1.43e-2) |
| WFG8 | 5 | 100 | 1.3416e+0 (1.31e-1) - | 1.2868e+0 (2.95e-2) - | 9.3434e-1 (3.51e-2) + | 1.63e+00(1.06e-01)- | 1.47e+00(2.37e-02)- | 1.1426e+0 (4.87e-3) |
| WFG8 | 5 | 200 | 1.4029e+0 (9.56e-2) - | 1.3144e+0 (4.28e-2) - | 9.3390e-1 (2.24e-2) + | 1.48e+00(1.54e-01)- | 1.59e+00(4.49e-03)- | 1.1737e+0 (1.07e-2) |
| WFG8 | 5 | 500 | 1.3775e+0 (9.21e-2) - | 1.3209e+0 (3.74e-2) - | 1.8146e+0 (7.09e-2) - | 1.19e+00(4.28e-03)- | 1.70e+00(1.34e-03)- | 1.1718e+0 (1.33e-2) |
| WFG8 | 5 | 1000 | 1.4756e+0 (4.70e-2) - | 1.3264e+0 (2.49e-2) = | 1.7838e+0 (6.38e-2) - | 1.26e+00(7.23e-03)+ | 1.75e+00(4.10e-03)- | 1.3015e+0 (1.09e-2) |
| WFG8 | 8 | 100 | 3.5321e+0 (8.31e-2) - | 3.5241e+0 (5.74e-2) - | 3.0249e+0 (7.55e-2) + | 5.74e+00(3.16e-01)- | 4.84e+00(1.96e-01)- | 3.2508e+0 (6.18e-2) |
| WFG8 | 8 | 200 | 3.5376e+0 (4.58e-2) - | 3.5387e+0 (5.61e-2) - | 2.9303e+0 (5.42e-2) + | 4.97e+00(3.61e-01)- | 4.90e+00(2.49e-01)- | 3.2326e+0 (2.47e-2) |
| WFG8 | 8 | 500 | 3.4980e+0 (4.55e-2) - | 3.4983e+0 (6.15e-2) - | 4.9783e+0 (2.20e-1) - | 3.34e+00(1.47e-01)- | 4.93e+00(1.76e-01)- | 3.1741e+0 (4.80e-3) |
| WFG8 | 8 | 1000 | 3.7044e+0 (6.76e-2) - | 3.6276e+0 (6.76e-2) - | 5.0685e+0 (1.42e-1) - | 3.77e+00(4.03e-01)- | 4.99e+00(2.27e-01)- | 3.4078e+0 (3.16e-2) |
| WFG8 | 10 | 100 | 4.7673e+0 (7.71e-2) - | 4.8883e+0 (9.77e-2) - | 4.6523e+0 (3.45e-1) = | 8.48e+00(1.30e-01)- | 7.06e+00(3.27e-01)- | 4.6268e+0 (9.97e-2) |
| WFG8 | 10 | 200 | 4.7844e+0 (4.77e-2) - | 4.8874e+0 (1.06e-1) - | 4.4099e+0 (9.09e-2) + | 8.31e+00(1.20e-01)- | 6.98e+00(2.50e-01)- | 4.5396e+0 (8.20e-2) |
| WFG8 | 10 | 500 | 4.9328e+0 (7.63e-2) - | 4.9298e+0 (1.04e-1) - | 7.1791e+0 (2.23e-1) - | 5.22e+00(1.12e-01)- | 7.32e+00(3.00e-01)- | 4.7277e+0 (5.74e-2) |
| WFG8 | 10 | 1000 | 4.9314e+0 (4.50e-2) - | 4.9420e+0 (1.31e-1) - | 7.3746e+0 (2.93e-1) - | 5.85e+00(5.53e-01)- | 7.43e+00(4.49e-01)- | 4.7367e+0 (1.34e-1) |
| WFG9 | 2 | 100 | 9.9117e-2 (5.82e-2) = | 5.4427e-2 (4.72e-2) = | 2.7280e-1 (3.06e-1) = | 5.0021e-01(5.48e-02)- | 7.3824e-1 (1.37e-2) - | 7.4102e-2 (1.01e-2) |
| WFG9 | 2 | 200 | 1.3694e-1 (2.88e-2) - | 1.2449e-1 (1.02e-1) = | 5.7994e-1 (2.28e-1) - | 6.8179e-01(4.33e-02)- | 8.0266e-1 (8.33e-3) - | 6.0157e-2 (3.15e-3) |
| WFG9 | 2 | 500 | 1.6613e-1 (9.41e-3) - | 3.6303e-2 (6.71e-2) + | 8.2596e-1 (5.75e-3) - | 7.9047e-01(2.30e-02)- | 8.0332e-1 (4.52e-3) - | 5.1020e-2 (4.95e-3) |
| WFG9 | 2 | 1000 | 1.7332e-1 (5.84e-3) - | 1.1125e-2 (8.85e-3) + | 8.3191e-1 (4.99e-3) - | 8.4449e-01(2.80e-02)- | 8.3240e-1 (6.58e-3) - | 4.0541e-2 (5.70e-3) |
| WFG9 | 3 | 100 | 2.8723e-1 (1.54e-2) + | 5.1263e-1 (4.13e-2) - | 2.2639e-1 (7.61e-3) + | 6.2189e-01(6.20e-02)- | 1.0280e+0 (1.03e-2) - | 3.3069e-1 (1.89e-2) |
| WFG9 | 3 | 200 | 3.4497e-1 (3.14e-1) - | 2.1524e-1 (8.27e-2) = | 6.8293e-1 (1.77e-1) - | 8.2465e-01(4.21e-02)- | 1.0519e+0 (1.85e-2) - | 1.8597e-1 (1.67e-2) |
| WFG9 | 3 | 500 | 2.3982e-1 (3.78e-2) - | 2.9266e-1 (6.64e-2) - | 1.0691e+0 (1.56e-2) - | 9.2446e-01(2.05e-02)- | 1.0400e+0 (1.31e-2) - | 1.7455e-1 (1.27e-2) |
| WFG9 | 3 | 1000 | 2.1776e-1 (2.38e-2) - | 2.4530e-1 (9.80e-2) = | 1.0488e+0 (1.55e-2) - | 9.6699e-01(1.70e-02)- | 1.0531e+0 (1.16e-2) - | 1.7183e-1 (1.09e-2) |
| WFG9 | 5 | 100 | 1.5651e+0 (1.14e-1) - | 1.0642e+0 (1.45e-2) - | 1.1252e+0 (3.31e-2) - | 1.87e+00(1.42e-01)- | 2.19e+00(3.47e-02)- | 1.0434e+0 (9.91e-3) |
| WFG9 | 5 | 200 | 1.6543e+0 (1.13e-1) - | 1.0816e+0 (1.42e-2) - | 1.3763e+0 (9.56e-2) - | 1.86e+00(1.05e-01)- | 2.28e+00(1.15e-01)- | 1.0619e+0 (9.93e-3) |
| WFG9 | 5 | 500 | 1.5836e+0 (5.70e-2) - | 1.0763e+0 (1.77e-2) = | 2.0897e+0 (7.93e-2) - | 1.51e+00(1.38e-01)- | 2.21e+00(8.79e-02)- | 1.0759e+0 (1.61e-2) |
| WFG9 | 5 | 1000 | 1.4285e+0 (2.62e-2) - | 1.0950e+0 (2.53e-2) + | 2.1192e+0 (5.97e-2) - | 1.53e+00(5.66e-02)- | 2.13e+00(8.97e-02)- | 1.1851e+0 (1.98e-2) |
| WFG9 | 8 | 100 | 3.8603e+0 (1.32e-1) - | 3.2312e+0 (9.56e-2) - | 2.9300e+0 (2.37e-2) + | 6.15e+00(2.40e-01)- | 6.42e+00(6.23e-01)- | 3.0253e+0 (2.74e-2) |
| WFG9 | 8 | 200 | 3.8345e+0 (1.58e-1) - | 3.1980e+0 (5.08e-2) - | 3.2271e+0 (2.54e-1) - | 6.05e+00(1.85e-01)- | 5.42e+00(1.67e-01)- | 3.0798e+0 (3.05e-2) |
| WFG9 | 8 | 500 | 3.8467e+0 (5.48e-2) - | 3.2045e+0 (3.81e-2) - | 5.3753e+0 (1.69e-1) - | 4.08e+00(6.09e-01)- | 5.48e+00(2.06e-01)- | 3.0605e+0 (3.92e-2) |
| WFG9 | 8 | 1000 | 3.6433e+0 (7.76e-2) - | 3.2825e+0 (9.76e-2) + | 5.3122e+0 (1.49e-1) - | 4.09e+00(5.24e-01)- | 5.24e+00(1.67e-01)- | 3.4628e+0 (6.34e-2) |
| WFG9 | 10 | 100 | 5.1494e+0 (8.12e-2) - | 4.5019e+0 (1.05e-1) + | 4.1263e+0 (3.09e-2) + | 8.32e+00(6.42e-01)- | 7.54e+00(2.43e-01)- | 4.6532e+0 (4.89e-2) |

| | | | | | | | | |
|------|----|------|-----------------------|------------------------------|------------------------------|---------------------|---------------------|---------------------|
| WFG9 | 10 | 200 | 5.0573e+0 (1.38e-1) - | 4.5220e+0 (5.92e-2) + | 4.2430e+0 (2.52e-2) + | 8.57e+00(1.35e-01)- | 7.85e+00(4.98e-01)- | 4.6372e+0 (7.13e-2) |
| WFG9 | 10 | 500 | 4.9280e+0 (9.57e-2) + | 4.5500e+0 (9.32e-2) + | 7.7311e+0 (2.11e-1) - | 7.11e+00(1.47e+00)- | 7.73e+00(1.84e-01)- | 5.0515e+0 (8.17e-2) |
| WFG9 | 10 | 1000 | 4.9003e+0 (8.31e-2) = | 4.5806e+0 (7.10e-2) + | 7.6145e+0 (2.60e-1) - | 5.56e+00(4.71e-01)- | 7.82e+00(3.98e-01)- | 4.9860e+0 (1.42e-1) |
| +/-= | | | 58/99/23 | | 31/107/42 | | 43/125/12 | |
| | | | | | | | 16/152/12 | |
| | | | | | | | 11/167/2 | |

TABLE A. 10

THE IGD COMPARISON RESULTS OF THREE MBEAS ON UF1-UF10 TEST PROBLEMS WITH 2-3 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | MOEA/PSL | AMOEAD | NN-CSO |
|---------|---|------|------------------------------|-------------------------------|----------------------------|
| UF1 | 2 | 100 | 1.2709e-1 (1.40e-2) + | 3.1438e-01(3.77e-02)- | 2.4318e-1 (1.16e-2) |
| UF1 | 2 | 200 | 3.5689e-1 (1.60e-1) = | 3.4578e-01(4.15e-02) + | 5.0663e-1 (6.26e-1) |
| UF1 | 2 | 500 | 8.0389e-1 (2.00e-1) - | 3.8061e-01(2.34e-02)- | 2.8877e-1 (4.73e-3) |
| UF1 | 2 | 1000 | 1.1247e+0 (7.92e-2) - | 3.7534e-01(2.54e-02)- | 2.9360e-1 (5.83e-3) |
| UF2 | 2 | 100 | 1.1203e-1 (5.53e-3) - | 1.6544e-01(2.63e-02)- | 8.3317e-2 (4.18e-3) |
| UF2 | 2 | 200 | 1.2227e-1 (4.97e-3) - | 1.8545e-01(1.36e-02)- | 1.1017e-1 (4.73e-2) |
| UF2 | 2 | 500 | 1.3049e-1 (2.35e-3) - | 1.9848e-01(1.16e-02)- | 9.2597e-2 (3.54e-3) |
| UF2 | 2 | 1000 | 1.3068e-1 (8.96e-4) - | 1.8905e-01(2.34e-02)- | 9.6263e-2 (4.00e-3) |
| UF3 | 2 | 100 | 3.8867e-1 (2.29e-1) - | 2.8318e-01(1.21e-02)- | 1.8399e-1 (7.77e-3) |
| UF3 | 2 | 200 | 3.1091e-1 (2.34e-1) - | 2.4829e-01(9.52e-03)- | 1.5620e-1 (3.36e-3) |
| UF3 | 2 | 500 | 3.2411e-1 (9.66e-2) - | 2.3143e-01(8.62e-03)- | 1.3442e-1 (1.11e-3) |
| UF3 | 2 | 1000 | 3.5107e-1 (6.89e-2) - | 2.2904e-01(2.46e-02)- | 1.2473e-1 (7.05e-4) |
| UF4 | 2 | 100 | 9.6710e-2 (4.39e-3) - | 8.6899e-02(2.92e-03)- | 5.8690e-2 (1.95e-4) |
| UF4 | 2 | 200 | 1.3724e-1 (1.08e-2) - | 9.1129e-02(1.33e-03)- | 5.9575e-2 (5.51e-4) |
| UF4 | 2 | 500 | 1.8416e-1 (5.67e-3) - | 9.4354e-02(1.19e-03)- | 6.1020e-2 (1.79e-3) |
| UF4 | 2 | 1000 | 1.8519e-1 (1.41e-2) - | 9.5332e-02(8.21e-04)- | 6.0001e-2 (5.24e-4) |
| UF5 | 2 | 100 | 7.7277e-1 (3.08e-1) = | 2.8931e+00(1.17e-01)- | 1.1267e+0 (1.73e-1) |
| UF5 | 2 | 200 | 1.8020e+0 (4.34e-1) + | 3.1123e+00(1.50e-01)- | 2.3209e+0 (3.11e-1) |
| UF5 | 2 | 500 | 2.9519e+0 (3.78e-1) = | 3.2946e+00(1.07e-01)- | 3.0021e+0 (6.99e-2) |
| UF5 | 2 | 1000 | 3.8439e+0 (4.62e-1) - | 3.3477e+00(2.96e-02)- | 3.0914e+0 (6.43e-2) |
| UF6 | 2 | 100 | 3.2826e-1 (8.01e-2) + | 1.2935e+00(1.63e-01)- | 5.1688e-1 (9.19e-2) |
| UF6 | 2 | 200 | 1.0656e+0 (4.29e-1) = | 1.4244e+00(1.63e-01)- | 7.1853e-1 (2.07e-1) |
| UF6 | 2 | 500 | 2.6600e+0 (4.09e-1) - | 1.4822e+00(2.48e-01)- | 1.1645e+0 (6.83e-2) |
| UF6 | 2 | 1000 | 3.8872e+0 (5.10e-1) - | 1.4090e+00(9.69e-02)- | 1.1917e+0 (4.72e-2) |
| UF7 | 2 | 100 | 9.0371e-2 (3.56e-2) + | 4.7047e-01(2.65e-02)- | 3.5681e-1 (3.58e-1) |
| UF7 | 2 | 200 | 2.5102e-1 (7.42e-2) = | 5.0605e-01(1.27e-02)- | 2.6931e-1 (1.08e-2) |
| UF7 | 2 | 500 | 6.4630e-1 (9.15e-2) - | 5.1601e-01(5.89e-03)- | 3.0180e-1 (6.16e-3) |
| UF7 | 2 | 1000 | 9.2322e-1 (6.37e-2) - | 5.2132e-01(9.43e-03)- | 3.0113e-1 (1.01e-2) |
| UF8 | 3 | 100 | 2.5888e-1 (5.53e-3) + | 5.8996e-01(3.41e-02)- | 3.4881e-1 (1.46e-2) |
| UF8 | 3 | 200 | 2.4945e-1 (3.11e-3) + | 6.0723e-01(3.00e-02)- | 4.1731e-1 (3.11e-2) |
| UF8 | 3 | 500 | 2.7351e-1 (1.86e-2) + | 6.3433e-01(3.60e-02)- | 4.8100e-1 (1.45e-2) |
| UF8 | 3 | 1000 | 4.7051e-1 (1.74e-2) = | 6.3763e-01(2.97e-02)- | 4.9542e-1 (2.93e-2) |
| UF9 | 3 | 100 | 7.1581e-1 (1.63e-1) - | 6.5109e-01(4.31e-02)- | 5.0989e-1 (4.59e-3) |
| UF9 | 3 | 200 | 6.7679e-1 (9.77e-2) - | 6.7016e-01(4.35e-02)- | 5.6101e-1 (7.41e-3) |
| UF9 | 3 | 500 | 8.0453e-1 (1.06e-1) - | 6.7160e-01(1.00e-02)- | 6.1365e-1 (1.26e-2) |
| UF9 | 3 | 1000 | 8.7062e-1 (4.99e-2) - | 7.5041e-01(3.46e-02)- | 6.6051e-1 (1.66e-2) |
| UF10 | 3 | 100 | 3.1995e-1 (1.46e-2) + | 3.3368e+00(5.73e-01)- | 1.8287e+0 (1.87e-1) |
| UF10 | 3 | 200 | 2.9300e-1 (8.79e-3) + | 3.8627e+00(4.33e-01)- | 2.4275e+0 (1.72e-1) |
| UF10 | 3 | 500 | 2.7886e-1 (9.92e-3) + | 3.7178e+00(6.11e-02)- | 3.1637e+0 (3.38e-1) |
| UF10 | 3 | 1000 | 2.4254e-1 (4.71e-3) + | 3.8734e+00(2.20e-01)= | 3.7282e+0 (2.54e-1) |
| +/-/= | | | 11/23/6 | 1/38/1 | |

TABLE A. 11

THE IGD COMPARISON RESULTS OF THREE MBEAS ON LSMOP1-LSMOP9 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | MOEA/PSL | AMOEA/D | NN-CSO |
|---------|----|------|------------------------------|--------------------------------|----------------------------|
| LSMOP1 | 2 | 100 | 2.9582e-1 (1.11e-2) - | 2.9094e-01(2.00e-02)- | 2.0217e-1 (1.04e-2) |
| LSMOP1 | 2 | 200 | 2.9363e-1 (7.84e-3) = | 3.2456e-01(2.21e-02)- | 2.8176e-1 (1.72e-2) |
| LSMOP1 | 2 | 500 | 4.5701e-1 (1.93e-1) = | 3.3695e-01(4.87e-03)- | 3.2321e-1 (1.40e-2) |
| LSMOP1 | 2 | 1000 | 1.1970e+0 (6.10e-1) - | 3.4331e-01(6.56e-03)- | 3.3104e-1 (8.72e-3) |
| LSMOP1 | 3 | 100 | 2.7519e-1 (9.53e-2) + | 3.5425e-01(3.50e-02)= | 3.2358e-1 (1.05e-2) |
| LSMOP1 | 3 | 200 | 5.3214e-1 (2.71e-1) - | 4.3490e-01(1.78e-02)- | 3.4195e-1 (9.75e-3) |
| LSMOP1 | 3 | 500 | 1.2140e+0 (8.21e-1) - | 4.7801e-01(6.52e-02)- | 3.5389e-1 (1.61e-2) |
| LSMOP1 | 3 | 1000 | 1.0723e+0 (5.60e-1) - | 4.7109e-01(1.06e-02)- | 3.7023e-1 (1.53e-2) |
| LSMOP1 | 5 | 100 | 8.5612e-1 (6.67e-2) - | 3.2082e-01(1.46e-02)+ | 5.4001e-1 (4.78e-2) |
| LSMOP1 | 5 | 200 | 9.5883e-1 (1.20e-16) - | 4.7501e-01(4.96e-02)+ | 6.7819e-1 (7.03e-2) |
| LSMOP1 | 5 | 500 | 9.5883e-1 (1.20e-16) - | 6.6987e-01(1.03e-01)+ | 8.2544e-1 (6.64e-2) |
| LSMOP1 | 5 | 1000 | 3.7352e+0 (3.15e+0) - | 6.0594e-01(3.24e-02)+ | 8.7563e-1 (5.58e-2) |
| LSMOP1 | 8 | 100 | 9.9913e-1 (3.41e-2) - | 4.8196e-01 (4.94e-02) + | 5.8057e-1 (5.93e-2) |
| LSMOP1 | 8 | 200 | 1.0327e+0 (2.40e-16) - | 7.3081e-01(3.65e-02)- | 6.6402e-1 (1.61e-2) |
| LSMOP1 | 8 | 500 | 2.0598e+0 (1.84e+0) = | 8.1374e-01(1.68e-01)+ | 1.2379e+0 (7.37e-2) |
| LSMOP1 | 8 | 1000 | 3.4025e+0 (3.20e+0) = | 8.1963e-01(1.43e-01)+ | 1.2725e+0 (1.43e-1) |
| LSMOP1 | 10 | 100 | 1.0071e+0 (2.72e-2) - | 5.4592e-01 (3.23e-02) + | 6.3258e-1 (2.84e-2) |
| LSMOP1 | 10 | 200 | 1.0167e+0 (1.38e-2) - | 6.0806e-01(3.52e-02)+ | 7.6043e-1 (8.47e-2) |
| LSMOP1 | 10 | 500 | 7.2037e+0 (6.01e+0) = | 7.8426e-01(1.11e-01)+ | 1.2403e+0 (4.48e-1) |
| LSMOP1 | 10 | 1000 | 7.0600e+0 (7.40e+0) = | 7.5907e-01(1.16e-02)+ | 1.2816e+0 (1.35e-1) |
| LSMOP2 | 2 | 100 | 1.2479e-1 (2.02e-3) - | 4.3184e-02(3.04e-03)= | 4.2763e-2 (1.64e-3) |
| LSMOP2 | 2 | 200 | 7.1067e-2 (1.22e-3) - | 2.4810e-02(2.64e-03)+ | 2.8407e-2 (1.27e-3) |
| LSMOP2 | 2 | 500 | 3.3297e-2 (8.06e-3) - | 1.2075e-02(4.67e-04)+ | 1.3729e-2 (7.39e-4) |
| LSMOP2 | 2 | 1000 | 1.7062e-2 (4.30e-3) - | 6.7946e-03(4.23e-04)+ | 8.1902e-3 (2.42e-4) |
| LSMOP2 | 3 | 100 | 2.0131e-1 (4.71e-3) - | 7.0854e-02(2.85e-03)+ | 8.4013e-2 (3.28e-3) |
| LSMOP2 | 3 | 200 | 1.2051e-1 (2.96e-3) - | 5.5983e-02(2.22e-03)= | 5.7013e-2 (1.60e-3) |
| LSMOP2 | 3 | 500 | 6.0650e-2 (9.43e-4) - | 3.5935e-02(1.69e-03)+ | 3.8768e-2 (1.43e-3) |
| LSMOP2 | 3 | 1000 | 4.2521e-2 (1.05e-3) - | 2.8446e-02(5.89e-04)= | 2.9433e-2 (1.36e-3) |
| LSMOP2 | 5 | 100 | 4.1553e-1 (1.49e-2) - | 1.6908e-01(3.18e-03)+ | 2.5799e-1 (8.31e-3) |
| LSMOP2 | 5 | 200 | 2.5936e-1 (6.66e-3) - | 1.4366e-01(1.92e-03)+ | 2.0205e-1 (1.70e-3) |
| LSMOP2 | 5 | 500 | 1.6660e-1 (4.99e-3) - | 1.1605e-01(1.67e-03)+ | 1.4269e-1 (9.84e-4) |
| LSMOP2 | 5 | 1000 | 1.4727e-1 (3.18e-3) - | 1.0653e-01(1.33e-03)+ | 1.2193e-1 (3.36e-4) |
| LSMOP2 | 8 | 100 | 7.6158e-1 (3.56e-2) - | 3.6724e-01 (3.41e-02) - | 3.4709e-1 (1.02e-2) |
| LSMOP2 | 8 | 200 | 4.7250e-1 (1.33e-2) - | 3.2450e-01(2.97e-02)- | 2.6358e-1 (4.25e-3) |
| LSMOP2 | 8 | 500 | 2.4124e-1 (3.07e-3) - | 3.0939e-01(3.10e-02)- | 1.9823e-1 (3.22e-3) |
| LSMOP2 | 8 | 1000 | 1.9970e-1 (3.72e-3) - | 3.1317e-01(2.90e-02)- | 1.7017e-1 (4.45e-3) |
| LSMOP2 | 10 | 100 | 8.5270e-1 (5.39e-2) - | 4.5409e-01 (6.42e-02) - | 4.3314e-1 (9.88e-3) |
| LSMOP2 | 10 | 200 | 5.9423e-1 (7.66e-3) - | 4.3590e-01(4.92e-02)- | 3.5728e-1 (4.56e-3) |
| LSMOP2 | 10 | 500 | 3.3311e-1 (7.96e-3) - | 4.2177e-01(3.45e-02)- | 2.9527e-1 (1.28e-2) |
| LSMOP2 | 10 | 1000 | 2.8094e-1 (6.53e-3) - | 3.9732e-01(3.04e-02)- | 2.4892e-1 (1.55e-2) |
| LSMOP3 | 2 | 100 | 6.6670e-1 (1.14e-2) + | 1.4572e+00(1.15e-03)= | 1.5170e+0 (4.71e-1) |
| LSMOP3 | 2 | 200 | 3.0502e+0 (4.78e+0) = | 1.5232e+00(2.38e-03)+ | 1.9101e+0 (4.24e-1) |

| | | | | | |
|--------|----|------|------------------------------|--------------------------------|-----------------------------|
| LSMOP3 | 2 | 500 | 8.8387e+0 (9.17e+0) = | 1.5658e+00(2.80e-04)+ | 3.1135e+0 (1.72e+0) |
| LSMOP3 | 2 | 1000 | 5.7176e+1 (1.09e+2) - | 1.5793e+00(9.34e-06)+ | 2.2104e+0 (1.65e+0) |
| LSMOP3 | 3 | 100 | 9.8643e-1 (3.67e-1) = | 8.6067e-01(1.30e-04)- | 8.5877e-1 (5.15e-3) |
| LSMOP3 | 3 | 200 | 8.6072e-1 (1.20e-16) = | 8.6072e-01(1.20e-16)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 3 | 500 | 2.6913e+0 (3.72e+0) = | 8.6072e-01(1.20e-16)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 3 | 1000 | 4.5815e+0 (4.19e+0) = | 8.6072e-01(1.20e-16)- | 8.6072e-1 (1.20e-16) |
| LSMOP3 | 5 | 100 | 9.5883e-1 (1.20e-16) = | 6.8040e-01(2.90e-02)+ | 9.4960e-1 (1.59e-2) |
| LSMOP3 | 5 | 200 | 9.5883e-1 (1.20e-16) = | 9.5987e-01(8.65e-03)- | 9.5883e-1 (1.20e-16) |
| LSMOP3 | 5 | 500 | 9.5883e-1 (1.20e-16) = | 9.5129e-01(1.41e-02)+ | 4.2096e+0 (4.07e+0) |
| LSMOP3 | 5 | 1000 | 3.6559e+0 (4.26e+0) = | 9.5660e-01(0.00e+00)+ | 4.9524e+0 (3.87e+0) |
| LSMOP3 | 8 | 100 | 1.0183e+0 (3.06e-5) - | 6.1433e-01 (8.92e-02) + | 9.3540e-1 (1.82e-2) |
| LSMOP3 | 8 | 200 | 1.4723e+0 (1.08e-2) + | 6.3535e-01(1.55e-02)+ | 5.0341e+0 (1.09e+0) |
| LSMOP3 | 8 | 500 | 1.1975e+1 (1.28e+1) = | 1.5680e+00(3.31e-03)+ | 9.4167e+0 (1.11e+0) |
| LSMOP3 | 8 | 1000 | 2.1848e+1 (1.52e+1) = | 3.6960e+01(1.84e+01)- | 1.2758e+1 (4.89e+0) |
| LSMOP3 | 10 | 100 | 8.9687e-1 (8.16e-2) - | 9.3988e-01 (2.05e-2) - | 7.3819e-1 (1.37e-1) |
| LSMOP3 | 10 | 200 | 1.0228e+0 (1.37e-3) - | 1.0054e+00(1.01e-02)- | 9.4073e-1 (6.37e-3) |
| LSMOP3 | 10 | 500 | 1.9586e+1 (1.79e+1) = | 1.8013e+00(2.09e-03)+ | 2.0659e+1 (3.62e+0) |
| LSMOP3 | 10 | 1000 | 2.3382e+1 (1.68e+1) = | 3.8939e+01(1.36e+01)- | 1.3028e+1 (7.65e+0) |
| LSMOP4 | 2 | 100 | 2.2679e-1 (1.26e-2) - | 1.3002e-01(8.85e-03)- | 6.7048e-2 (2.28e-2) |
| LSMOP4 | 2 | 200 | 1.4341e-1 (5.40e-3) - | 9.2449e-02(6.05e-03)- | 8.3159e-2 (6.00e-3) |
| LSMOP4 | 2 | 500 | 7.4994e-2 (1.99e-3) - | 5.3733e-02(2.03e-03)- | 4.4418e-2 (9.30e-4) |
| LSMOP4 | 2 | 1000 | 4.8117e-2 (7.53e-4) - | 3.1687e-02(1.92e-03)- | 2.2817e-2 (5.77e-4) |
| LSMOP4 | 3 | 100 | 3.2875e-1 (8.66e-3) - | 3.1354e-01(1.60e-02)= | 2.9903e-1 (1.40e-2) |
| LSMOP4 | 3 | 200 | 3.0549e-1 (6.38e-3) - | 2.1212e-01(4.36e-03)- | 1.9584e-1 (7.70e-3) |
| LSMOP4 | 3 | 500 | 1.7168e-1 (4.66e-3) - | 1.1486e-01(2.30e-03)- | 1.0064e-1 (2.13e-3) |
| LSMOP4 | 3 | 1000 | 9.3075e-2 (1.10e-3) - | 6.9296e-02(1.05e-03)- | 6.1411e-2 (2.39e-3) |
| LSMOP4 | 5 | 100 | 5.6624e-1 (1.59e-2) - | 3.9466e-01(4.48e-03)+ | 4.6034e-1 (9.30e-3) |
| LSMOP4 | 5 | 200 | 4.7168e-1 (1.38e-2) - | 3.5179e-01(1.75e-02)= | 3.5466e-1 (7.19e-3) |
| LSMOP4 | 5 | 500 | 3.1431e-1 (2.77e-3) - | 2.3165e-01(6.47e-03)= | 2.3945e-1 (2.52e-3) |
| LSMOP4 | 5 | 1000 | 2.2760e-1 (6.74e-3) - | 1.6872e-01(4.21e-03)+ | 1.8216e-1 (9.38e-4) |
| LSMOP4 | 8 | 100 | 7.6079e-1 (5.38e-2) - | 4.9274e-01 (8.24e-02) - | 4.8784e-1 (1.23e-2) |
| LSMOP4 | 8 | 200 | 5.0794e-1 (8.99e-3) - | 3.7503e-01(3.01e-02)= | 3.5284e-1 (2.72e-3) |
| LSMOP4 | 8 | 500 | 3.1136e-1 (1.17e-2) - | 3.3262e-01(3.06e-02)- | 2.5310e-1 (6.78e-3) |
| LSMOP4 | 8 | 1000 | 2.4255e-1 (3.73e-3) - | 3.1801e-01(2.38e-02)- | 1.9668e-1 (2.24e-3) |
| LSMOP4 | 10 | 100 | 8.4564e-1 (6.93e-2) - | 5.3427e-01 (7.24e-02) = | 5.4561e-1 (2.30e-2) |
| LSMOP4 | 10 | 200 | 6.2401e-1 (4.17e-2) - | 3.9784e-01(5.41e-02)= | 4.4464e-1 (8.34e-3) |
| LSMOP4 | 10 | 500 | 4.2994e-1 (1.62e-2) - | 4.3142e-01(3.94e-02)- | 3.4588e-1 (2.59e-2) |
| LSMOP4 | 10 | 1000 | 3.2949e-1 (8.29e-3) - | 3.9211e-01(3.46e-02)- | 2.8738e-1 (1.35e-2) |
| LSMOP5 | 2 | 100 | 3.3601e-1 (1.64e-2) + | 7.4191e-01(4.68e-04)- | 6.9839e-1 (3.87e-2) |
| LSMOP5 | 2 | 200 | 3.5097e-1 (7.03e-2) + | 7.4209e-01(0.00e+00)+ | 7.4209e-1 (1.20e-16) |
| LSMOP5 | 2 | 500 | 9.6382e-1 (3.81e-1) = | 7.4209e-01(0.00e+00)+ | 7.4209e-1 (3.92e-7) |
| LSMOP5 | 2 | 1000 | 1.8068e+0 (1.65e+0) = | 7.4209e-01(0.00e+00)+ | 7.4209e-1 (1.20e-16) |
| LSMOP5 | 3 | 100 | 3.5687e-1 (8.80e-2) = | 5.4189e-01(5.19e-05)- | 3.8292e-1 (3.63e-2) |
| LSMOP5 | 3 | 200 | 4.1873e-1 (1.28e-1) = | 5.4192e-01(5.36e-05)- | 4.7438e-1 (1.44e-2) |
| LSMOP5 | 3 | 500 | 7.8801e-1 (4.63e-1) = | 5.4195e-01(1.27e-05)- | 5.1560e-1 (1.36e-2) |

| | | | | | |
|--------|----|------|------------------------------|-------------------------------|----------------------------|
| LSMOP5 | 3 | 1000 | 1.4174e+0 (1.05e+0) - | 5.4191e-01(4.35e-05)- | 5.1962e-1 (4.01e-3) |
| LSMOP5 | 5 | 100 | 5.0602e-1 (3.96e-2) = | 2.6447e-01(1.55e-03)+ | 5.2997e-1 (3.04e-1) |
| LSMOP5 | 5 | 200 | 5.1366e-1 (2.32e-2) - | 3.6148e-01(2.23e-02)- | 3.2849e-1 (1.30e-2) |
| LSMOP5 | 5 | 500 | 4.9990e-1 (2.03e-2) - | 4.0800e-01(5.44e-04)- | 3.3887e-1 (7.04e-3) |
| LSMOP5 | 5 | 1000 | 5.3226e-1 (1.03e-1) - | 4.0840e-01(3.38e-04)- | 3.4478e-1 (1.01e-2) |
| LSMOP5 | 8 | 100 | 7.6013e-1 (5.53e-2) = | 4.5293e-01(1.21e-02) + | 7.7934e-1 (2.20e-1) |
| LSMOP5 | 8 | 200 | 5.7026e-1 (3.99e-2) + | 4.1431e-01(1.10e-02)+ | 1.1120e+0 (8.64e-2) |
| LSMOP5 | 8 | 500 | 1.0477e+0 (1.32e-1) + | 5.1235e-01(4.34e-02)+ | 2.0608e+0 (4.04e-1) |
| LSMOP5 | 8 | 1000 | 1.0792e+0 (1.27e-1) + | 5.4188e-01(5.33e-02)+ | 1.9488e+0 (1.50e-1) |
| LSMOP5 | 10 | 100 | 1.1088e+0 (1.28e-1) - | 4.7892e-01(1.28e-02) + | 7.7738e-1 (1.52e-1) |
| LSMOP5 | 10 | 200 | 1.2417e+0 (0.00e+0) - | 4.8368e-01(1.87e-02)+ | 9.0794e-1 (1.97e-1) |
| LSMOP5 | 10 | 500 | 1.2417e+0 (0.00e+0) + | 6.0333e-01(4.01e-02)+ | 1.7131e+0 (1.45e-1) |
| LSMOP5 | 10 | 1000 | 1.6696e+0 (8.95e-1) = | 5.9637e-01(5.05e-02)+ | 1.7416e+0 (9.40e-2) |
| LSMOP6 | 2 | 100 | 7.4848e-1 (8.80e-2) = | 7.1384e-01(4.87e-02)= | 7.3329e-1 (1.95e-2) |
| LSMOP6 | 2 | 200 | 7.1130e-1 (1.38e-1) = | 6.9806e-01(1.01e-02)+ | 7.5911e-1 (5.40e-3) |
| LSMOP6 | 2 | 500 | 7.5438e-1 (3.38e-1) - | 6.8505e-01(6.71e-03)+ | 7.5233e-1 (9.55e-4) |
| LSMOP6 | 2 | 1000 | 5.9762e-1 (1.43e-1) = | 6.7784e-01(2.29e-03)+ | 7.5010e-1 (1.79e-3) |
| LSMOP6 | 3 | 100 | 1.1254e+0 (3.80e-3) - | 9.2584e-01(1.48e-03)= | 9.8301e-1 (1.86e-1) |
| LSMOP6 | 3 | 200 | 1.2344e+0 (5.76e-4) = | 1.1354e+00(7.67e-06)+ | 1.2356e+0 (1.98e-3) |
| LSMOP6 | 3 | 500 | 4.3442e+1 (1.12e+2) = | 1.2555e+00(5.37e-05)+ | 1.2959e+0 (3.85e-4) |
| LSMOP6 | 3 | 1000 | 1.0696e+2 (1.97e+2) = | 1.3360e+00(1.08e-01)- | 1.3168e+0 (1.48e-3) |
| LSMOP6 | 5 | 100 | 6.3494e-1 (5.25e-2) = | 6.3392e-01(2.19e-02)- | 5.9515e-1 (1.92e-2) |
| LSMOP6 | 5 | 200 | 1.0934e+0 (1.47e-1) = | 9.1548e-01(3.67e-02)= | 9.9017e-1 (1.00e-1) |
| LSMOP6 | 5 | 500 | 1.2159e+0 (5.69e-2) = | 1.6119e+00(1.23e-01)- | 1.2606e+0 (1.37e-1) |
| LSMOP6 | 5 | 1000 | 1.3234e+0 (8.99e-2) = | 1.4780e+00(2.53e-02)- | 1.2842e+0 (1.51e-1) |
| LSMOP6 | 8 | 100 | 8.7986e-1 (1.09e-1) = | 9.5032e-01 (1.32e-02) - | 8.9782e-1 (3.41e-1) |
| LSMOP6 | 8 | 200 | 7.8729e-1 (1.74e-2) + | 1.0271e+00(3.04e-02)+ | 1.1391e+0 (1.28e-1) |
| LSMOP6 | 8 | 500 | 1.5638e+0 (3.09e-1) = | 1.4241e+00(4.91e-02)- | 1.3731e+0 (2.87e-2) |
| LSMOP6 | 8 | 1000 | 1.5813e+0 (1.98e-1) - | 1.5259e+00(1.43e-01)- | 1.3527e+0 (3.66e-2) |
| LSMOP6 | 10 | 100 | 1.1023e+0 (3.30e-2) = | 1.0152e+00 (3.26e-01)= | 1.1114e+0 (2.57e-1) |
| LSMOP6 | 10 | 200 | 1.3363e+0 (2.50e-1) = | 1.0848e-01(3.53e-02)+ | 1.2913e+0 (1.29e-1) |
| LSMOP6 | 10 | 500 | 1.5168e+0 (1.32e-1) - | 1.4712e+00(1.25e-01)- | 1.3515e+0 (1.38e-2) |
| LSMOP6 | 10 | 1000 | 1.5305e+0 (4.17e-2) - | 1.3397e+00(2.67e-02)- | 1.3027e+0 (1.64e-2) |
| LSMOP7 | 2 | 100 | 1.4585e+0 (6.06e-3) - | 3.3151e+01(8.38e+01)- | 1.4577e+0 (7.35e-4) |
| LSMOP7 | 2 | 200 | 6.4950e+0 (7.99e+0) - | 6.1417e+01(1.59e+02)- | 1.4916e+0 (5.54e-4) |
| LSMOP7 | 2 | 500 | 2.0008e+2 (2.93e+2) - | 8.4822e+01(2.20e+02)- | 1.5109e+0 (1.83e-3) |
| LSMOP7 | 2 | 1000 | 2.0901e+3 (1.45e+3) - | 1.5137e+00(1.45e-05)+ | 1.5156e+0 (2.36e-3) |
| LSMOP7 | 3 | 100 | 1.0631e+0 (1.68e-1) = | 1.2577e+00(9.48e-03)- | 9.1842e-1 (9.45e-2) |
| LSMOP7 | 3 | 200 | 1.1152e+0 (1.13e-1) = | 1.1316e+00(1.52e-02)- | 1.0253e+0 (5.64e-2) |
| LSMOP7 | 3 | 500 | 1.0161e+0 (1.21e-1) = | 9.6223e-01(9.07e-03)= | 9.2035e-1 (8.90e-2) |
| LSMOP7 | 3 | 1000 | 1.0779e+0 (2.86e-1) = | 8.9385e-01(6.00e-03)+ | 9.5474e-1 (2.46e-2) |
| LSMOP7 | 5 | 100 | 1.1237e+0 (1.41e-1) = | 1.2724e+00(2.13e-04)- | 1.0319e+0 (4.90e-2) |
| LSMOP7 | 5 | 200 | 1.2444e+0 (3.12e-2) = | 1.3841e+00(2.74e-02)- | 1.2105e+0 (1.38e-1) |
| LSMOP7 | 5 | 500 | 1.3071e+0 (1.20e-1) = | 1.3726e+00(6.20e-02)- | 1.2076e+0 (8.47e-2) |
| LSMOP7 | 5 | 1000 | 1.2607e+0 (9.44e-2) - | 1.2540e+00(5.02e-02)- | 1.1337e+0 (2.98e-2) |

| | | | | | |
|--------|----|------|------------------------------|--------------------------------|-----------------------------|
| LSMOP7 | 8 | 100 | 9.5606e-1 (2.72e-2) - | 8.7210e-01 (3.22e-02) = | 8.8881e-1 (2.77e-2) |
| LSMOP7 | 8 | 200 | 1.1049e+0 (2.67e-2) + | 1.1500e+00(4.91e-01)+ | 1.6179e+0 (1.55e-1) |
| LSMOP7 | 8 | 500 | 1.5382e+0 (2.32e-1) + | 1.2929e+00(9.00e-02) + | 2.4863e+1 (3.93e+1) |
| LSMOP7 | 8 | 1000 | 1.6936e+0 (1.84e-1) + | 1.4272e+00(1.03e-01) + | 2.5745e+2 (2.40e+2) |
| LSMOP7 | 10 | 100 | 9.8536e-1 (6.65e-2) = | 9.1646e-01 (2.33e-02) = | 9.7143e-1 (1.01e-1) |
| LSMOP7 | 10 | 200 | 1.5226e+0 (3.27e-1) = | 9.6176e-01(2.44e-02) + | 1.3870e+0 (4.99e-1) |
| LSMOP7 | 10 | 500 | 1.7086e+0 (1.52e-1) + | 1.2983e+00(4.62e-02) + | 1.4840e+2 (3.46e+1) |
| LSMOP7 | 10 | 1000 | 4.5767e+3 (1.19e+4) = | 1.5006e+00(6.50e-02) + | 5.0758e+1 (1.82e+1) |
| LSMOP8 | 2 | 100 | 3.4141e-1 (2.44e-3) - | 7.0176e-01(4.81e-02)- | 2.9998e-1 (5.28e-2) |
| LSMOP8 | 2 | 200 | 3.3716e-1 (2.97e-3) + | 7.4209e-01(0.00e+00)- | 6.5133e-1 (6.66e-2) |
| LSMOP8 | 2 | 500 | 6.2642e-1 (7.36e-2) + | 7.4209e-01(0.00e+00)+ | 7.4209e-1 (1.20e-16) |
| LSMOP8 | 2 | 1000 | 1.7660e+0 (9.30e-1) - | 7.4136e-01(1.93e-03) + | 7.4209e-1 (1.20e-16) |
| LSMOP8 | 3 | 100 | 3.5624e-1 (2.91e-2) - | 1.6280e-01(8.90e-02) + | 2.2384e-1 (2.52e-2) |
| LSMOP8 | 3 | 200 | 3.2780e-1 (4.76e-2) - | 2.0737e-01(6.58e-02)= | 1.6963e-1 (1.16e-2) |
| LSMOP8 | 3 | 500 | 2.8134e-1 (8.18e-2) - | 1.9925e-01(5.17e-02)= | 1.5592e-1 (1.80e-2) |
| LSMOP8 | 3 | 1000 | 3.8197e-1 (1.11e-1) - | 2.1174e-01(2.40e-02)- | 1.6270e-1 (3.69e-2) |
| LSMOP8 | 5 | 100 | 4.2601e-1 (1.07e-2) = | 2.4372e-01(1.39e-02) + | 5.9321e-1 (3.06e-1) |
| LSMOP8 | 5 | 200 | 4.1919e-1 (2.26e-2) = | 3.2529e-01(1.08e-02) = | 5.2508e-1 (3.21e-1) |
| LSMOP8 | 5 | 500 | 4.1844e-1 (1.51e-2) = | 3.0177e-01(1.01e-02) + | 5.1970e-1 (2.88e-1) |
| LSMOP8 | 5 | 1000 | 4.1248e-1 (2.95e-2) = | 2.9404e-01(6.46e-03) + | 6.7233e-1 (3.37e-1) |
| LSMOP8 | 8 | 100 | 7.7818e-1 (7.99e-2) = | 3.9022e-01 (6.43e-03) + | 7.5927e-1 (1.26e-1) |
| LSMOP8 | 8 | 200 | 4.9423e-1 (1.37e-2) + | 3.9529e-01(7.54e-03) + | 9.9455e-1 (7.08e-2) |
| LSMOP8 | 8 | 500 | 1.8822e+0 (2.56e+0) - | 4.6483e-01(4.44e-02) + | 1.8196e+0 (1.35e-1) |
| LSMOP8 | 8 | 1000 | 1.7537e+0 (1.34e+0) = | 4.9764e-01(4.60e-02) + | 1.6755e+0 (9.05e-2) |
| LSMOP8 | 10 | 100 | 1.0159e+0 (1.52e-1) = | 4.5602e-01 (8.23e-02) + | 8.6846e-1 (8.60e-2) |
| LSMOP8 | 10 | 200 | 1.2188e+0 (4.11e-2) - | 4.6565e-01(5.50e-03) + | 9.3794e-1 (2.23e-1) |
| LSMOP8 | 10 | 500 | 1.2417e+0 (0.00e+0) + | 5.1540e-01(3.64e-02) + | 1.7015e+0 (1.86e-1) |
| LSMOP8 | 10 | 1000 | 1.2245e+0 (4.56e-2) + | 5.4290e-01(3.90e-02) + | 1.6369e+0 (6.87e-2) |
| LSMOP9 | 2 | 100 | 8.1004e-1 (0.00e+0) - | 8.3300e-01(0.00e+00)- | 8.1004e-1 (5.64e-16) |
| LSMOP9 | 2 | 200 | 8.1336e-1 (1.18e-1) = | 8.1584e-01(1.20e-16)- | 8.0603e-1 (5.30e-3) |
| LSMOP9 | 2 | 500 | 8.9836e-1 (2.34e-1) - | 8.1098e-01(1.20e-16)- | 6.6887e-1 (1.24e-1) |
| LSMOP9 | 2 | 1000 | 8.1004e-1 (0.00e+0) - | 8.1030e-01(0.00e+00)- | 6.6516e-1 (7.38e-2) |
| LSMOP9 | 3 | 100 | 1.5300e+0 (2.09e-2) - | 1.1869e+00(5.24e-01)- | 5.9295e-1 (2.15e-3) |
| LSMOP9 | 3 | 200 | 1.5379e+0 (2.53e-10) - | 1.4193e+00(3.60e-01)- | 6.7195e-1 (2.09e-1) |
| LSMOP9 | 3 | 500 | 1.4566e+0 (4.94e-2) - | 1.4971e+00(8.14e-02)- | 5.8631e-1 (1.58e-2) |
| LSMOP9 | 3 | 1000 | 3.3903e+0 (5.28e+0) = | 1.5350e+00(9.63e-03) = | 2.5451e+0 (1.34e+0) |
| LSMOP9 | 5 | 100 | 2.9697e+0 (7.90e-2) - | 2.5005e+00(1.19e+00)- | 9.2390e-1 (7.70e-2) |
| LSMOP9 | 5 | 200 | 2.9955e+0 (8.01e-3) - | 2.5357e+00(6.70e-01)- | 9.0629e-1 (6.71e-2) |
| LSMOP9 | 5 | 500 | 2.7334e+0 (3.55e-1) - | 2.8306e+00(4.84e-01)- | 9.5179e-1 (1.73e-1) |
| LSMOP9 | 5 | 1000 | 8.0796e+0 (1.40e+1) - | 2.9638e+00(8.20e-02)- | 9.3546e-1 (2.02e-1) |
| LSMOP9 | 8 | 100 | 5.2880e+0 (9.78e-2) - | 2.4131e+01 (5.29e-01) - | 3.2921e+0 (2.17e+0) |
| LSMOP9 | 8 | 200 | 5.1038e+0 (1.82e-2) - | 1.0550e+01(8.55e-01)- | 2.4936e+0 (1.21e+0) |
| LSMOP9 | 8 | 500 | 2.8441e+1 (6.20e+1) = | 6.0372e+00(1.51e-01)- | 3.9986e+0 (2.51e+0) |
| LSMOP9 | 8 | 1000 | 1.7785e+2 (1.63e+2) - | 5.1322e+00(4.73e-01)- | 3.2940e+0 (2.01e+0) |
| LSMOP9 | 10 | 100 | 6.3944e+0 (2.86e-1) - | 4.0891e+01 (5.54e-01) - | 2.2616e+0 (7.04e-1) |

| | | | | | |
|--------|----|------|-----------------------|------------------------------|----------------------------|
| LSMOP9 | 10 | 200 | 6.5110e+0 (5.48e-2) = | 2.8588e+01(6.62e-01)- | 4.4422e+0 (2.40e+0) |
| LSMOP9 | 10 | 500 | 1.4217e+1 (2.17e+1) = | 8.1759e+00(7.42e-01)= | 9.6554e+0 (5.41e+0) |
| LSMOP9 | 10 | 1000 | 7.2247e+1 (1.28e+2) = | 3.0315e+01(3.55e+0)- | 7.1615e+0 (4.73e+0) |
| +/-/= | | | 19/96/65 | 73/84/23 | |

TABLE A. 12

THE IGD COMPARISON RESULTS OF THREE MBEAS ON DTLZ1-DTLZ7 TEST PROBLEMS WITH 2-10 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | MOEA/PSL | AMOEAD | NN-CSO |
|---------|----|------|------------------------------|------------------------------|----------------------------|
| DTLZ1 | 2 | 100 | 4.9452e+2 (4.71e+1) = | 6.9551e+02(5.37e+01)= | 5.3793e+2 (2.23e+2) |
| DTLZ1 | 2 | 200 | 1.4470e+3 (8.33e+1) - | 1.5341e+03(4.04e+01)- | 1.0141e+3 (2.19e+2) |
| DTLZ1 | 2 | 500 | 4.1530e+3 (9.70e+1) - | 3.8707e+03(8.19e+01)- | 2.7736e+3 (8.35e+2) |
| DTLZ1 | 2 | 1000 | 8.6408e+3 (1.59e+2) - | 7.9529e+03(5.42e+02)- | 5.7686e+3 (1.47e+3) |
| DTLZ1 | 3 | 100 | 7.0205e+2 (4.44e+0) - | 5.4639e+02(3.84e+01)- | 3.7321e+2 (7.74e+1) |
| DTLZ1 | 3 | 200 | 1.4302e+3 (7.02e+0) - | 1.2142e+03(1.24e+02)- | 7.5949e+2 (6.39e+1) |
| DTLZ1 | 3 | 500 | 3.6550e+3 (2.01e+1) - | 3.2095e+03(2.02e+02)- | 2.1264e+3 (6.16e+2) |
| DTLZ1 | 3 | 1000 | 7.3421e+3 (5.71e+1) - | 6.3517e+03(4.10e+02)- | 4.2642e+3 (4.30e+2) |
| DTLZ1 | 5 | 100 | 7.2856e+2 (1.16e+2) - | 4.4253e+02(3.66e+01)- | 1.6925e+2 (1.38e+2) |
| DTLZ1 | 5 | 200 | 1.5155e+3 (1.78e+2) - | 9.7879e+02(5.22e+01)- | 2.6128e+2 (2.57e+2) |
| DTLZ1 | 5 | 500 | 3.9613e+3 (5.35e+2) - | 2.5888e+03(2.86e+02)- | 1.2046e+2 (2.56e+2) |
| DTLZ1 | 5 | 1000 | 7.0760e+3 (4.45e+2) - | 5.2562e+03(5.95e+02)- | 2.2002e+2 (2.22e+2) |
| DTLZ1 | 8 | 100 | 1.0651e+3 (2.01e+2) - | 3.7153e+02(4.77e+01)- | 2.4699e+2 (6.08e+1) |
| DTLZ1 | 8 | 200 | 2.3936e+3 (8.38e+0) - | 8.3303e+02(7.78e+01)- | 4.6851e+2 (1.64e+2) |
| DTLZ1 | 8 | 500 | 4.3716e+3 (1.30e+3) - | 2.1452e+03(2.38e+02)- | 4.2218e+2 (6.81e+2) |
| DTLZ1 | 8 | 1000 | 8.8377e+3 (3.34e+3) - | 4.6588e+03(4.68e+02)- | 6.8877e+2 (8.48e+2) |
| DTLZ1 | 10 | 100 | 1.1141e+3 (8.11e+0) - | 5.5770e+02(6.26e+01)- | 1.9673e+2 (1.55e+2) |
| DTLZ1 | 10 | 200 | 2.0345e+3 (4.19e+2) - | 1.2635e+03(1.42e+02)- | 5.3201e+2 (1.79e+2) |
| DTLZ1 | 10 | 500 | 4.7056e+3 (1.03e+3) - | 3.2867e+03(2.64e+02)- | 2.7571e+2 (2.80e+2) |
| DTLZ1 | 10 | 1000 | 8.7259e+3 (2.22e+3) - | 6.8853e+03(4.82e+02)- | 3.2814e+2 (5.18e+2) |
| DTLZ2 | 2 | 100 | 9.1083e-3 (2.63e-3) + | 1.5422e-01(9.19e-03)- | 7.9524e-2 (1.00e-2) |
| DTLZ2 | 2 | 200 | 1.8132e-1 (6.65e-2) = | 2.5846e-01(1.99e-02)- | 1.9177e-1 (2.86e-2) |
| DTLZ2 | 2 | 500 | 5.8848e+0 (1.78e+0) - | 4.7510e-01(2.12e-02)+ | 5.7716e-1 (5.73e-2) |
| DTLZ2 | 2 | 1000 | 7.0643e+0 (1.59e+0) - | 7.1036e-01(3.94e-02)+ | 1.1890e+0 (1.12e-1) |
| DTLZ2 | 3 | 100 | 6.8307e-2 (1.82e-3) + | 3.1118e-01(3.43e-02)- | 1.9668e-1 (1.64e-2) |
| DTLZ2 | 3 | 200 | 2.5303e-1 (7.51e-2) + | 4.8618e-01(2.82e-02)- | 3.7337e-1 (4.58e-2) |
| DTLZ2 | 3 | 500 | 4.4493e+0 (9.25e-1) - | 7.8005e-01(1.22e-01)= | 9.0447e-1 (5.55e-2) |
| DTLZ2 | 3 | 1000 | 8.4162e+0 (2.68e+0) - | 1.2174e+00(1.37e-01)+ | 1.5976e+0 (1.43e-1) |
| DTLZ2 | 5 | 100 | 1.7650e+0 (3.56e-1) - | 7.0225e-01(3.43e-02)- | 4.9801e-1 (4.04e-2) |
| DTLZ2 | 5 | 200 | 9.8608e+0 (1.25e+0) - | 1.0013e+00(1.57e-01)- | 5.6523e-1 (6.63e-2) |
| DTLZ2 | 5 | 500 | 1.2971e+1 (1.09e+0) - | 1.6527e+00(3.63e-01)- | 6.9030e-1 (6.45e-2) |
| DTLZ2 | 5 | 1000 | 4.5996e+0 (5.02e-1) - | 3.3971e+00(5.99e-01)- | 8.2565e-1 (3.53e-2) |
| DTLZ2 | 8 | 100 | 1.3662e+1 (9.75e-1) - | 1.0194e+00(4.18e-02)- | 8.8452e-1 (3.41e-2) |
| DTLZ2 | 8 | 200 | 2.7553e+1 (3.46e+0) - | 1.4215e+00(1.56e-01)- | 1.0250e+0 (2.93e-2) |
| DTLZ2 | 8 | 500 | 5.9495e+1 (1.48e+1) - | 2.1628e+00(7.79e-01)- | 9.8507e-1 (4.22e-2) |
| DTLZ2 | 8 | 1000 | 9.6193e+1 (3.39e+1) - | 3.9883e+00(1.50e+00)- | 9.8649e-1 (2.51e-2) |
| DTLZ2 | 10 | 100 | 1.4908e+1 (6.50e-1) - | 1.1938e+00(1.20e-01)- | 9.9078e-1 (2.74e-2) |
| DTLZ2 | 10 | 200 | 2.9448e+1 (2.48e+0) - | 1.7872e+00(3.97e-01)- | 1.0680e+0 (5.82e-2) |
| DTLZ2 | 10 | 500 | 6.5537e+1 (1.17e+1) - | 3.4608e+00(4.91e-01)- | 1.0921e+0 (9.10e-2) |
| DTLZ2 | 10 | 1000 | 1.4289e+2 (6.90e+0) - | 6.8488e+00(1.45e+00)- | 1.0579e+0 (3.91e-2) |
| DTLZ3 | 2 | 100 | 1.2317e+3 (8.36e+1) = | 2.0330e+03(9.53e+01)- | 1.3287e+3 (4.97e+2) |
| DTLZ3 | 2 | 200 | 3.8443e+3 (2.24e+2) = | 4.2208e+03(1.15e+02)- | 3.0668e+3 (9.45e+2) |

| | | | | | |
|-------|----|------|------------------------------|-------------------------------|----------------------------|
| DTLZ3 | 2 | 500 | 1.1482e+4 (2.85e+2) - | 1.0846e+04(5.39e+02)- | 5.8953e+3 (8.19e+2) |
| DTLZ3 | 2 | 1000 | 2.3903e+4 (5.83e+2) - | 2.1843e+04(1.78e+03)- | 1.3700e+4 (3.68e+3) |
| DTLZ3 | 3 | 100 | 2.2510e+3 (3.27e+1) - | 1.6377e+03(2.47e+02)- | 1.2512e+3 (2.07e+2) |
| DTLZ3 | 3 | 200 | 4.8020e+3 (1.45e+1) - | 3.8947e+03(2.90e+02)- | 2.4816e+3 (3.06e+2) |
| DTLZ3 | 3 | 500 | 1.2318e+4 (2.33e+1) - | 1.0682e+04(6.16e+02)- | 6.4010e+3 (4.86e+2) |
| DTLZ3 | 3 | 1000 | 2.4809e+4 (4.00e+1) - | 1.9983e+04(9.95e+02)- | 1.3679e+4 (1.34e+3) |
| DTLZ3 | 5 | 100 | 2.3237e+3 (1.51e+1) - | 1.7029e+03(1.27e+02)- | 7.6616e+2 (4.86e+2) |
| DTLZ3 | 5 | 200 | 4.8417e+3 (1.62e+1) - | 3.5750e+03(2.67e+02)- | 7.4980e+2 (1.01e+3) |
| DTLZ3 | 5 | 500 | 1.2352e+4 (1.25e+1) - | 9.2075e+03(7.85e+02)- | 3.8409e+2 (6.12e+2) |
| DTLZ3 | 5 | 1000 | 2.4802e+4 (2.25e+1) - | 2.0143e+04(1.73e+03)- | 1.3701e+3 (1.40e+3) |
| DTLZ3 | 8 | 100 | 2.2822e+3 (1.41e+1) - | 1.6884e+03(6.59e+01)- | 1.0390e+3 (2.46e+2) |
| DTLZ3 | 8 | 200 | 4.7776e+3 (1.61e+1) - | 3.7491e+03(1.17e+02)- | 1.6571e+3 (8.85e+2) |
| DTLZ3 | 8 | 500 | 1.2294e+4 (2.06e+1) - | 9.9074e+03(5.30e+02)- | 4.8984e+2 (4.86e+2) |
| DTLZ3 | 8 | 1000 | 2.4976e+4 (2.70e+2) - | 1.9655e+04(1.54e+03)- | 4.2066e+2 (4.91e+2) |
| DTLZ3 | 10 | 100 | 2.2446e+3 (1.10e+1) - | 2.0504e+03(1.25e+02)- | 1.1943e+3 (1.02e+2) |
| DTLZ3 | 10 | 200 | 4.7401e+3 (1.12e+1) - | 4.9530e+03(1.43e+02)- | 1.8951e+3 (1.32e+3) |
| DTLZ3 | 10 | 500 | 1.2425e+4 (4.28e+2) - | 1.3176e+04(3.14e+02)- | 1.0827e+3 (1.58e+3) |
| DTLZ3 | 10 | 1000 | 2.4763e+4 (1.75e+1) - | 2.7440e+04(1.08e+03)- | 2.2712e+3 (1.98e+3) |
| DTLZ4 | 2 | 100 | 1.1478e-1 (2.79e-1) + | 7.9286e-01(1.01e-02)- | 2.1880e-1 (2.81e-2) |
| DTLZ4 | 2 | 200 | 6.0132e-1 (5.04e-1) = | 8.6221e-01(3.38e-02)- | 8.0161e-1 (5.73e-2) |
| DTLZ4 | 2 | 500 | 5.8059e+0 (1.90e+0) - | 1.1057e+00(8.84e-02) + | 2.5251e+0 (3.29e-1) |
| DTLZ4 | 2 | 1000 | 7.0333e+0 (1.54e+0) = | 1.5635e+00(1.78e-01) + | 5.4437e+0 (9.45e-1) |
| DTLZ4 | 3 | 100 | 6.9196e-2 (4.19e-3) + | 9.9473e-01(1.74e-02)= | 9.7413e-1 (1.95e-1) |
| DTLZ4 | 3 | 200 | 2.1556e-1 (2.86e-2) + | 1.0660e+00(2.71e-02)+ | 2.1691e+0 (1.65e-1) |
| DTLZ4 | 3 | 500 | 4.4686e+0 (2.07e+0) = | 1.4035e+00(1.10e-01) + | 4.8555e+0 (1.03e+0) |
| DTLZ4 | 3 | 1000 | 9.4844e+0 (2.79e+0) = | 1.8117e+00(3.05e-01) + | 7.6875e+0 (1.52e+0) |
| DTLZ4 | 5 | 100 | 1.5329e+0 (5.92e-1) = | 1.1696e+00(3.13e-02)- | 9.0123e-1 (2.29e-1) |
| DTLZ4 | 5 | 200 | 7.3735e+0 (1.41e+0) - | 1.3135e+00(1.15e-01)- | 1.1041e+0 (7.73e-3) |
| DTLZ4 | 5 | 500 | 1.2205e+1 (2.01e+0) - | 1.4930e+00(2.03e-01)- | 1.1081e+0 (7.96e-7) |
| DTLZ4 | 5 | 1000 | 1.0211e+1 (2.09e+0) - | 2.7637e+00(6.27e-01)- | 1.2318e+0 (3.14e-2) |
| DTLZ4 | 8 | 100 | 1.0653e+1 (1.41e+0) - | 1.3483e+00(9.12e-02)- | 1.1920e+0 (1.04e-2) |
| DTLZ4 | 8 | 200 | 2.2867e+1 (2.61e+0) - | 1.5047e+00(2.35e-01)- | 1.2133e+0 (2.39e-3) |
| DTLZ4 | 8 | 500 | 2.5836e+1 (6.51e+0) - | 2.0397e+00(6.61e-01)- | 1.3757e+0 (7.06e-2) |
| DTLZ4 | 8 | 1000 | 6.6311e+1 (3.84e+1) - | 3.6938e+00(1.55e+00)- | 1.3439e+0 (3.91e-2) |
| DTLZ4 | 10 | 100 | 1.3200e+1 (1.31e+0) - | 1.5892e+00(2.10e-01)- | 1.2250e+0 (1.20e-2) |
| DTLZ4 | 10 | 200 | 2.7421e+1 (3.52e+0) - | 1.9333e+00(3.91e-01)- | 1.3963e+0 (1.14e-1) |
| DTLZ4 | 10 | 500 | 3.9763e+1 (1.47e+1) - | 4.0322e+00(2.02e+00)- | 1.3750e+0 (8.46e-2) |
| DTLZ4 | 10 | 1000 | 7.4709e+1 (3.69e+1) - | 6.7995e+00(3.01e+00)- | 1.3390e+0 (6.47e-2) |
| DTLZ5 | 2 | 100 | 8.9707e-3 (2.75e-3) + | 1.4512e-01(8.60e-03)- | 8.3136e-2 (9.22e-3) |
| DTLZ5 | 2 | 200 | 5.7317e-1 (1.99e-1) - | 2.5496e-01(1.30e-02)- | 1.8608e-1 (1.68e-2) |
| DTLZ5 | 2 | 500 | 7.0648e+0 (2.05e+0) - | 4.7348e-01(3.29e-02) + | 6.0724e-1 (6.90e-2) |
| DTLZ5 | 2 | 1000 | 7.5447e+0 (8.92e-1) - | 7.4041e-01(2.61e-02) + | 1.1779e+0 (9.17e-2) |
| DTLZ5 | 3 | 100 | 1.1921e-2 (1.47e-3) + | 2.3542e-01(4.29e-02) + | 2.9437e-1 (2.36e-2) |
| DTLZ5 | 3 | 200 | 1.5536e-1 (1.02e-1) + | 4.2015e-01(6.81e-02)+ | 4.8664e-1 (3.20e-2) |
| DTLZ5 | 3 | 500 | 4.5808e+0 (1.21e+0) - | 7.5291e-01(1.81e-01) = | 9.2839e-1 (6.35e-2) |

| | | | | | |
|-------|----|------|------------------------------|------------------------------|----------------------------|
| DTLZ5 | 3 | 1000 | 6.6934e+0 (1.34e+0) - | 1.3876e+00(2.58e-01)+ | 1.6843e+0 (1.71e-1) |
| DTLZ5 | 5 | 100 | 4.9192e+0 (3.56e-1) - | 4.5117e-01(1.58e-01)= | 3.1277e-1 (1.93e-2) |
| DTLZ5 | 5 | 200 | 1.1055e+1 (1.27e+0) - | 7.3997e-01(2.25e-01)- | 3.5304e-1 (2.71e-2) |
| DTLZ5 | 5 | 500 | 2.5985e+1 (3.57e+0) - | 1.7117e+00(3.55e-01)- | 3.7765e-1 (2.68e-2) |
| DTLZ5 | 5 | 1000 | 3.4502e+1 (5.82e+0) - | 3.2755e+00(7.47e-01)- | 4.8973e-1 (3.81e-2) |
| DTLZ5 | 8 | 100 | 1.2341e+1 (2.08e+0) - | 6.8692e-01(2.30e-01)- | 3.1610e-1 (2.27e-2) |
| DTLZ5 | 8 | 200 | 2.8370e+1 (2.44e+0) - | 1.1053e+00(3.51e-01)- | 3.7485e-1 (1.02e-2) |
| DTLZ5 | 8 | 500 | 6.1112e+1 (1.73e+1) - | 2.6759e+00(5.45e-01)- | 3.9319e-1 (2.00e-2) |
| DTLZ5 | 8 | 1000 | 1.2943e+2 (2.29e+1) - | 3.8000e+00(9.69e-01)- | 4.4120e-1 (5.98e-2) |
| DTLZ5 | 10 | 100 | 1.2204e+1 (1.80e+0) - | 1.0511e+00(2.70e-01)- | 3.3800e-1 (4.47e-2) |
| DTLZ5 | 10 | 200 | 2.8411e+1 (3.25e+0) - | 1.5554e+00(3.71e-01)- | 4.5488e-1 (3.23e-2) |
| DTLZ5 | 10 | 500 | 7.1164e+1 (8.47e+0) - | 3.5867e+00(1.01e+00)- | 5.1257e-1 (7.28e-2) |
| DTLZ5 | 10 | 1000 | 1.3384e+2 (2.48e+1) - | 5.1221e+00(2.34e+00)- | 5.0542e-1 (5.40e-2) |
| DTLZ6 | 2 | 100 | 4.1425e-1 (7.34e-5) + | 1.3187e-03(1.05e-06)+ | 2.0551e+1 (6.02e+0) |
| DTLZ6 | 2 | 200 | 4.1422e-1 (8.17e-6) + | 1.3188e-03(9.68e-07)+ | 5.4776e+1 (9.58e+0) |
| DTLZ6 | 2 | 500 | 4.1422e-1 (2.22e-6) + | 1.0719e-01(2.80e-01)+ | 1.2901e+2 (3.16e+1) |
| DTLZ6 | 2 | 1000 | 4.1423e-1 (2.32e-5) + | 1.0719e-01(2.80e-01)+ | 3.0210e+2 (5.79e+1) |
| DTLZ6 | 3 | 100 | 7.3207e-1 (4.44e-5) + | 2.0085e-02(6.54e-04)+ | 3.1633e+1 (3.50e+0) |
| DTLZ6 | 3 | 200 | 1.7311e-3 (3.86e-5) + | 2.0369e-02(3.97e-04)+ | 7.4758e+1 (6.53e+0) |
| DTLZ6 | 3 | 500 | 7.3206e-1 (6.36e-6) + | 2.0313e-02(7.21e-04)+ | 1.9931e+2 (1.93e+1) |
| DTLZ6 | 3 | 1000 | 7.3205e-1 (3.66e-6) + | 1.9571e-02(9.27e-04)+ | 4.1347e+2 (7.43e+1) |
| DTLZ6 | 5 | 100 | 1.2681e+0 (8.73e-1) = | 5.3456e-02(4.66e-03)+ | 1.1439e+0 (1.24e-1) |
| DTLZ6 | 5 | 200 | 1.5408e+0 (9.32e-1) = | 5.2170e-02(3.19e-03)+ | 7.4977e+0 (1.30e+1) |
| DTLZ6 | 5 | 500 | 1.2014e+1 (1.49e+1) + | 5.3763e-02(1.73e-03)+ | 1.2555e+2 (6.86e+1) |
| DTLZ6 | 5 | 1000 | 3.3020e+0 (2.26e+0) + | 1.4052e-01(2.33e-01)+ | 4.4290e+2 (5.97e+1) |
| DTLZ6 | 8 | 100 | 2.6796e+1 (8.72e+0) - | 9.4780e-02(4.60e-03)+ | 1.4865e+0 (1.14e-1) |
| DTLZ6 | 8 | 200 | 5.9047e+1 (1.81e+1) - | 9.4046e-02(5.23e-03)+ | 5.5756e+0 (9.93e+0) |
| DTLZ6 | 8 | 500 | 1.4237e+2 (5.48e+1) = | 9.4737e-02(3.73e-03)+ | 1.8481e+2 (8.36e+1) |
| DTLZ6 | 8 | 1000 | 3.1340e+2 (1.63e+2) + | 8.6028e-02(7.19e-03)+ | 4.6411e+2 (2.03e+1) |
| DTLZ6 | 10 | 100 | 3.2701e+1 (7.34e+0) - | 8.4353e-01(3.75e-01)+ | 1.8316e+0 (1.90e-1) |
| DTLZ6 | 10 | 200 | 7.8389e+1 (6.98e+0) - | 1.4679e+00(7.65e-01)+ | 3.4666e+0 (2.95e+0) |
| DTLZ6 | 10 | 500 | 1.8170e+2 (4.52e+1) = | 6.4159e+00(4.90e+00)+ | 1.9093e+2 (8.34e+1) |
| DTLZ6 | 10 | 1000 | 4.2400e+2 (1.38e+1) + | 1.3364e+01(1.01e+01)+ | 4.7408e+2 (1.61e+1) |
| DTLZ7 | 2 | 100 | 1.7000e-3 (6.11e-5) + | 2.1219e-03(1.85e-05)+ | 9.4690e-2 (1.32e-1) |
| DTLZ7 | 2 | 200 | 1.6650e-3 (2.57e-5) + | 2.1210e-03(1.54e-05)+ | 2.4954e-1 (2.18e-1) |
| DTLZ7 | 2 | 500 | 1.6951e-3 (2.20e-5) + | 2.1237e-03(1.95e-05)+ | 3.3772e-1 (1.65e-1) |
| DTLZ7 | 2 | 1000 | 1.7094e-3 (3.17e-5) + | 2.1281e-03(2.88e-05)+ | 6.3712e-1 (4.44e-1) |
| DTLZ7 | 3 | 100 | 4.2005e-2 (9.18e-4) + | 5.7391e-02(5.67e-04)+ | 1.1238e+0 (1.22e+0) |
| DTLZ7 | 3 | 200 | 4.3711e-2 (1.02e-3) + | 5.7832e-02(1.49e-03)+ | 2.2019e+0 (2.21e+0) |
| DTLZ7 | 3 | 500 | 4.5009e-2 (1.57e-3) + | 5.8036e-02(1.18e-03)+ | 3.8856e+0 (3.38e+0) |
| DTLZ7 | 3 | 1000 | 4.6727e-2 (1.97e-3) + | 5.6467e-02(1.71e-03)+ | 8.3253e+0 (2.63e+0) |
| DTLZ7 | 5 | 100 | 3.0846e-1 (1.02e-2) + | 6.6965e-01(4.94e-01)- | 5.2470e-1 (4.62e-3) |
| DTLZ7 | 5 | 200 | 3.1596e-1 (7.79e-3) + | 4.8310e-01(1.97e-02)+ | 5.2269e-1 (9.85e-3) |
| DTLZ7 | 5 | 500 | 3.1750e-1 (1.15e-2) + | 5.4412e-01(1.55e-01)= | 5.3577e-1 (5.48e-2) |
| DTLZ7 | 5 | 1000 | 2.8680e-1 (6.01e-3) + | 8.6825e-01(4.54e-01)= | 1.0133e+0 (1.57e-1) |

| | | | | | |
|-------|----|------|------------------------------|-----------------------|---------------------|
| DTLZ7 | 8 | 100 | 8.2068e-1 (1.45e-2) + | 1.4371e+00(5.72e-01)+ | 1.6240e+0 (2.70e-2) |
| DTLZ7 | 8 | 200 | 8.2253e-1 (4.03e-3) + | 1.7506e+00(9.77e-01)= | 1.7672e+0 (4.05e-1) |
| DTLZ7 | 8 | 500 | 8.0712e-1 (3.63e-2) + | 1.8283e+00(1.35e+00)+ | 1.9336e+0 (3.03e-1) |
| DTLZ7 | 8 | 1000 | 9.0229e-1 (7.11e-2) + | 1.9210e+00(1.20e+00)= | 3.3249e+0 (7.49e-1) |
| DTLZ7 | 10 | 100 | 1.1458e+0 (2.49e-2) + | 3.5572e+00(7.61e-01)- | 2.5731e+0 (7.75e-1) |
| DTLZ7 | 10 | 200 | 1.1578e+0 (1.50e-2) + | 3.5443e+00(1.26e+00)- | 1.9409e+0 (2.96e-1) |
| DTLZ7 | 10 | 500 | 1.8062e+0 (1.74e+0) + | 3.2224e+00(9.83e-01)= | 2.6103e+0 (7.30e-1) |
| DTLZ7 | 10 | 1000 | 1.1753e+0 (5.73e-2) + | 2.7656e+00(9.35e-01)= | 3.1208e+0 (1.39e+0) |
| +/-= | | | 41/86/13 | 44/85/11 | |

TABLE A. 13

THE IGD COMPARISON OF RESULTS OF THREE MBEAS ON WFG1-WFG9 TEST PROBLEMS WITH 2-20 OBJECTIVES AND 100-1000 DECISION VARIABLES.

| Problem | M | D | MOEA/PSL | AMOEAD | NN-CSO |
|---------|----|------|------------------------------|------------------------------|----------------------------|
| WFG1 | 2 | 100 | 5.6487e-1 (2.57e-2) + | 1.6980e+00(3.53e-02)- | 1.3861e+0 (1.73e-2) |
| WFG1 | 2 | 200 | 8.1189e-1 (1.45e-2) + | 1.6976e+00(3.23e-02)- | 1.3920e+0 (2.54e-2) |
| WFG1 | 2 | 500 | 1.0850e+0 (3.78e-3) + | 1.7081e+00(3.26e-02)- | 1.3805e+0 (2.37e-2) |
| WFG1 | 2 | 1000 | 1.2092e+0 (2.03e-2) + | 1.7368e+00(3.00e-02)- | 1.3864e+0 (2.13e-2) |
| WFG1 | 3 | 100 | 1.3825e+0 (2.62e-2) + | 1.7742e+00(2.16e-02)- | 1.5872e+0 (1.67e-2) |
| WFG1 | 3 | 200 | 1.4901e+0 (8.74e-3) + | 1.7787e+00(1.14e-02)- | 1.5829e+0 (7.51e-3) |
| WFG1 | 3 | 500 | 1.5120e+0 (6.94e-3) + | 1.7724e+00(9.97e-03)- | 1.5991e+0 (9.23e-3) |
| WFG1 | 3 | 1000 | 1.5079e+0 (4.51e-3) + | 1.7811e+00(1.76e-02)- | 1.5903e+0 (1.19e-2) |
| WFG1 | 5 | 100 | 2.1122e+0 (3.38e-2) - | 2.1318e+00(2.36e-02)- | 2.0110e+0 (2.93e-2) |
| WFG1 | 5 | 200 | 2.0830e+0 (4.76e-2) - | 2.1339e+00(3.06e-02)- | 2.0071e+0 (1.28e-2) |
| WFG1 | 5 | 500 | 2.1208e+0 (3.18e-2) - | 2.1447e+00(2.60e-02)- | 2.0096e+0 (2.30e-2) |
| WFG1 | 5 | 1000 | 1.9982e+0 (3.01e-2) + | 2.1200e+00(2.75e-02)+ | 2.1607e+0 (3.70e-2) |
| WFG1 | 8 | 100 | 2.7112e+0 (2.38e-2) - | 2.8745e+00(5.06e-02)- | 2.6508e+0 (2.50e-2) |
| WFG1 | 8 | 200 | 2.7211e+0 (3.64e-2) - | 2.8563e+00(6.43e-02)- | 2.6401e+0 (2.00e-2) |
| WFG1 | 8 | 500 | 2.8153e+0 (6.01e-2) - | 2.8508e+00(2.55e-02)- | 2.6538e+0 (3.33e-2) |
| WFG1 | 8 | 1000 | 2.8165e+0 (2.72e-2) = | 2.8484e+00(4.04e-02)= | 2.8140e+0 (5.60e-2) |
| WFG1 | 10 | 100 | 3.0821e+0 (5.26e-2) = | 3.4354e+00(1.36e-01)- | 3.0278e+0 (2.83e-2) |
| WFG1 | 10 | 200 | 3.0674e+0 (3.18e-2) = | 3.4922e+00(6.61e-02)- | 3.0462e+0 (2.01e-2) |
| WFG1 | 10 | 500 | 3.2152e+0 (5.08e-2) - | 3.4473e+00(1.22e-01)- | 3.0566e+0 (2.62e-2) |
| WFG1 | 10 | 1000 | 3.1960e+0 (5.75e-2) = | 3.4637e+00(1.06e-01)- | 3.1995e+0 (4.98e-2) |
| WFG2 | 2 | 101 | 4.9124e-2 (8.29e-3) + | 2.0187e-01(1.88e-02)- | 1.6965e-1 (5.99e-3) |
| WFG2 | 2 | 201 | 1.1277e-1 (8.55e-3) + | 1.9319e-01(2.51e-02)= | 1.8455e-1 (1.00e-2) |
| WFG2 | 2 | 501 | 2.0690e-1 (5.70e-2) = | 1.8632e-01(1.23e-02)= | 1.8244e-1 (7.91e-3) |
| WFG2 | 2 | 1001 | 2.4098e-1 (2.40e-2) - | 2.0907e-01(2.68e-02)- | 1.7151e-1 (1.05e-2) |
| WFG2 | 3 | 100 | 2.1042e-1 (2.19e-2) + | 4.3528e-01(6.86e-02)- | 2.7215e-1 (1.11e-2) |
| WFG2 | 3 | 200 | 2.6159e-1 (1.44e-2) + | 4.8381e-01(5.64e-02)- | 2.8162e-1 (1.20e-2) |
| WFG2 | 3 | 500 | 3.2830e-1 (1.92e-2) - | 4.6578e-01(3.73e-02)- | 3.0717e-1 (1.69e-2) |
| WFG2 | 3 | 1000 | 3.5707e-1 (8.92e-3) - | 4.6163e-01(5.09e-02)- | 3.2326e-1 (1.45e-2) |
| WFG2 | 5 | 100 | 7.8136e-1 (5.04e-2) - | 1.8722e+00(8.23e-01)- | 5.0634e-1 (1.48e-2) |
| WFG2 | 5 | 200 | 8.8675e-1 (7.01e-2) - | 2.2128e+00(7.60e-01)- | 5.5282e-1 (1.92e-2) |
| WFG2 | 5 | 500 | 9.7600e-1 (7.38e-2) - | 2.1876e+00(6.74e-01)- | 5.7927e-1 (1.76e-2) |
| WFG2 | 5 | 1000 | 9.5845e-1 (5.53e-2) - | 2.2469e+00(9.61e-01)- | 7.2980e-1 (2.70e-2) |
| WFG2 | 8 | 101 | 1.5378e+0 (6.40e-2) - | 4.3127e+00(1.05e+00)- | 1.1968e+0 (2.06e-2) |
| WFG2 | 8 | 201 | 1.5346e+0 (6.39e-2) - | 5.2802e+00(1.41e+00)- | 1.2357e+0 (2.93e-2) |
| WFG2 | 8 | 501 | 1.4939e+0 (5.47e-2) - | 5.4225e+00(1.52e+00)- | 1.2865e+0 (3.89e-2) |
| WFG2 | 8 | 1001 | 1.4369e+0 (5.65e-2) = | 5.0449e+00(1.07e+00)- | 1.3762e+0 (4.31e-2) |
| WFG2 | 10 | 101 | 1.8060e+0 (9.99e-2) - | 6.5905e+00(1.99e+00)- | 1.4342e+0 (4.64e-2) |
| WFG2 | 10 | 201 | 1.8197e+0 (9.21e-2) - | 6.7680e+00(2.00e+00)- | 1.4897e+0 (6.34e-2) |
| WFG2 | 10 | 501 | 1.8437e+0 (1.52e-1) - | 6.8893e+00(1.75e+00)- | 1.5601e+0 (8.69e-2) |
| WFG2 | 10 | 1001 | 1.9247e+0 (1.50e-1) = | 6.8256e+00(1.99e+00)- | 1.7821e+0 (1.27e-1) |
| WFG3 | 2 | 101 | 8.0930e-2 (8.67e-3) + | 1.4147e-01(6.19e-03)- | 1.2736e-1 (7.83e-3) |
| WFG3 | 2 | 201 | 1.8363e-1 (1.40e-2) - | 1.4324e-01(5.36e-03)= | 1.3611e-1 (8.30e-3) |
| WFG3 | 2 | 501 | 2.8589e-1 (1.07e-2) - | 1.5221e-01(1.11e-02)- | 1.3523e-1 (6.16e-3) |
| WFG3 | 2 | 1001 | 3.1522e-1 (2.72e-2) - | 1.4853e-01(5.41e-03)- | 1.3520e-1 (1.02e-2) |
| WFG3 | 3 | 100 | 2.7218e-1 (2.67e-2) + | 2.5985e-01(1.69e-02)+ | 3.2416e-1 (1.59e-2) |

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|------|----|------|------------------------------|------------------------------|----------------------------|
| WFG3 | 3 | 200 | 3.5619e-1 (2.24e-2) = | 2.9367e-01(2.05e-02)+ | 3.4552e-1 (1.73e-2) |
| WFG3 | 3 | 500 | 4.7541e-1 (2.26e-2) - | 2.9218e-01(2.33e-02)+ | 3.7091e-1 (2.00e-2) |
| WFG3 | 3 | 1000 | 4.0861e-1 (9.46e-3) - | 2.8121e-01(1.84e-02)+ | 3.6457e-1 (7.98e-3) |
| WFG3 | 5 | 100 | 1.0615e+0 (8.44e-2) - | 9.8838e-01(1.25e-01)- | 5.9375e-1 (3.14e-2) |
| WFG3 | 5 | 200 | 1.1097e+0 (4.68e-2) - | 9.5496e-01(1.53e-01)- | 6.3256e-1 (4.62e-2) |
| WFG3 | 5 | 500 | 1.1070e+0 (8.24e-2) - | 9.8040e-01(9.85e-02)- | 6.8104e-1 (9.27e-2) |
| WFG3 | 5 | 1000 | 9.7353e-1 (8.32e-2) = | 1.0419e+00(1.15e-01)- | 9.2953e-1 (3.72e-2) |
| WFG3 | 8 | 101 | 2.0577e+0 (8.00e-2) + | 3.5018e+00(4.12e-01)- | 2.2319e+0 (5.89e-2) |
| WFG3 | 8 | 201 | 2.0274e+0 (1.21e-1) = | 3.4152e+00(3.36e-01)- | 2.1652e+0 (1.93e-1) |
| WFG3 | 8 | 501 | 1.5024e+0 (1.15e-1) + | 3.6173e+00(2.24e-01)- | 2.0726e+0 (1.50e-1) |
| WFG3 | 8 | 1001 | 1.5075e+0 (1.68e-1) + | 3.2482e+00(4.10e-01)- | 2.5123e+0 (6.40e-2) |
| WFG3 | 10 | 101 | 2.6346e+0 (1.26e-1) + | 2.0492e+00(2.66e-01)+ | 3.0854e+0 (1.81e-1) |
| WFG3 | 10 | 201 | 2.5373e+0 (1.28e-1) + | 2.0302e+00(1.16e-01)+ | 3.0089e+0 (3.13e-1) |
| WFG3 | 10 | 501 | 1.8946e+0 (1.99e-1) + | 2.0902e+00(1.25e-01)+ | 2.8836e+0 (2.04e-1) |
| WFG3 | 10 | 1001 | 1.4461e+0 (8.69e-2) + | 2.0090e+00(1.55e-01)+ | 3.0806e+0 (1.78e-1) |
| WFG4 | 2 | 100 | 5.3378e-2 (5.38e-3) + | 1.0807e-01(2.94e-03)+ | 1.2645e-1 (3.86e-3) |
| WFG4 | 2 | 200 | 7.6977e-2 (8.43e-3) + | 1.1856e-01(4.05e-03)+ | 1.2845e-1 (2.49e-3) |
| WFG4 | 2 | 500 | 1.1765e-1 (7.13e-3) + | 1.2543e-01(3.80e-03)+ | 1.3101e-1 (3.24e-3) |
| WFG4 | 2 | 1000 | 1.1100e-1 (1.28e-3) + | 1.3032e-01(2.56e-03)= | 1.2881e-1 (3.76e-3) |
| WFG4 | 3 | 100 | 2.8974e-1 (7.27e-3) - | 2.2346e-01(5.06e-03)= | 2.3064e-1 (8.49e-3) |
| WFG4 | 3 | 200 | 3.6853e-1 (1.86e-2) - | 2.2849e-01(5.12e-03)+ | 2.3747e-1 (6.72e-3) |
| WFG4 | 3 | 500 | 3.4295e-1 (9.59e-3) - | 2.3857e-01(1.46e-02)= | 2.4558e-1 (9.02e-3) |
| WFG4 | 3 | 1000 | 2.8636e-1 (7.94e-3) - | 2.2918e-01(8.23e-03)+ | 2.4896e-1 (5.19e-3) |
| WFG4 | 5 | 100 | 1.2040e+0 (3.03e-2) - | 1.0367e+00(6.04e-03)+ | 1.0561e+0 (5.97e-3) |
| WFG4 | 5 | 200 | 1.1459e+0 (1.32e-2) - | 1.0458e+00(1.59e-02)= | 1.0542e+0 (6.35e-3) |
| WFG4 | 5 | 500 | 1.0759e+0 (1.34e-2) = | 1.0455e+00(1.42e-02)+ | 1.1859e+0 (3.20e-1) |
| WFG4 | 5 | 1000 | 1.0521e+0 (1.66e-2) + | 1.0387e+00(1.14e-02)+ | 1.1353e+0 (1.69e-2) |
| WFG4 | 8 | 100 | 3.3154e+0 (3.84e-2) - | 3.6061e+00(1.37e-01)- | 3.1920e+0 (3.04e-2) |
| WFG4 | 8 | 200 | 3.3462e+0 (4.62e-2) - | 3.5379e+00(8.20e-02)- | 3.2079e+0 (2.39e-2) |
| WFG4 | 8 | 500 | 3.2293e+0 (3.08e-2) - | 3.6328e+00(1.60e-01)- | 3.1822e+0 (1.84e-2) |
| WFG4 | 8 | 1000 | 3.2436e+0 (6.05e-2) = | 3.6028e+00(9.70e-02)- | 3.2678e+0 (4.27e-2) |
| WFG4 | 10 | 100 | 4.5792e+0 (3.93e-2) + | 4.4687e+00(5.82e-02)+ | 4.7190e+0 (1.23e-1) |
| WFG4 | 10 | 200 | 4.5845e+0 (4.52e-2) = | 4.4689e+00(5.22e-02)+ | 4.6203e+0 (9.04e-2) |
| WFG4 | 10 | 500 | 4.6422e+0 (3.09e-2) = | 4.4920e+00(5.26e-02)+ | 4.6596e+0 (9.84e-2) |
| WFG4 | 10 | 1000 | 4.6462e+0 (5.32e-2) - | 4.4566e+00(5.99e-02)+ | 4.5209e+0 (3.49e-2) |
| WFG5 | 2 | 100 | 6.2279e-2 (3.30e-4) + | 6.6299e-02(2.90e-03)= | 6.9319e-2 (2.45e-3) |
| WFG5 | 2 | 200 | 6.2247e-2 (1.12e-4) + | 6.4943e-02(3.24e-03)+ | 7.0663e-2 (3.27e-3) |
| WFG5 | 2 | 500 | 6.2467e-2 (1.51e-4) + | 6.5780e-02(3.26e-03)+ | 7.0263e-2 (2.36e-3) |
| WFG5 | 2 | 1000 | 6.2481e-2 (2.76e-5) + | 6.5604e-02(2.42e-03)= | 6.8693e-2 (3.12e-3) |
| WFG5 | 3 | 100 | 1.9131e-1 (4.04e-3) - | 1.5703e-01(4.02e-03)= | 1.6114e-1 (6.18e-3) |
| WFG5 | 3 | 200 | 1.9236e-1 (5.49e-3) - | 1.5658e-01(1.92e-03)+ | 1.6242e-1 (3.87e-3) |
| WFG5 | 3 | 500 | 1.8838e-1 (2.68e-3) - | 1.5695e-01(4.09e-03)+ | 1.6664e-1 (6.54e-3) |
| WFG5 | 3 | 1000 | 1.8856e-1 (2.60e-3) - | 1.5785e-01(3.48e-03)+ | 1.6605e-1 (6.94e-3) |
| WFG5 | 5 | 100 | 9.9644e-1 (1.46e-2) + | 1.0107e+00(2.47e-02)= | 1.0132e+0 (1.34e-3) |
| WFG5 | 5 | 200 | 9.7488e-1 (1.30e-2) + | 1.0164e+00(2.41e-02)= | 1.0150e+0 (3.04e-3) |
| WFG5 | 5 | 500 | 9.7150e-1 (1.35e-2) + | 1.0246e+00(2.05e-02)= | 1.0134e+0 (3.75e-3) |
| WFG5 | 5 | 1000 | 9.5339e-1 (1.02e-2) + | 1.0278e+00(3.54e-02)+ | 1.1103e+0 (1.31e-2) |
| WFG5 | 8 | 100 | 3.1965e+0 (3.12e-2) - | 3.7686e+00(7.88e-02)- | 3.0526e+0 (4.36e-2) |
| WFG5 | 8 | 200 | 3.1782e+0 (3.18e-2) - | 3.7841e+00(7.27e-02)- | 3.0415e+0 (4.23e-2) |

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|------|----|------|------------------------------|-------------------------------|----------------------------|
| WFG5 | 8 | 500 | 3.1840e+0 (4.64e-2) - | 3.8085e+00(5.56e-02)- | 3.0802e+0 (7.22e-2) |
| WFG5 | 8 | 1000 | 3.1810e+0 (9.85e-2) + | 3.7796e+00(5.70e-02)- | 3.4457e+0 (2.78e-2) |
| WFG5 | 10 | 100 | 4.4908e+0 (5.15e-2) - | 5.1854e+00(7.85e-02)- | 4.3701e+0 (5.38e-2) |
| WFG5 | 10 | 200 | 4.4226e+0 (3.33e-2) = | 5.1470e+00(1.04e-01)- | 4.4166e+0 (6.79e-2) |
| WFG5 | 10 | 500 | 4.5300e+0 (2.87e-2) = | 5.1936e+00(1.37e-01)- | 4.5010e+0 (3.98e-2) |
| WFG5 | 10 | 1000 | 4.6164e+0 (5.35e-2) + | 5.2520e+00(1.33e-01)- | 4.9927e+0 (7.12e-2) |
| WFG6 | 2 | 100 | 2.5580e-2 (1.89e-4) + | 2.5812e-02(1.57e-03)+ | 2.9661e-2 (2.43e-3) |
| WFG6 | 2 | 200 | 2.2242e-2 (2.21e-2) - | 1.3327e-02(1.17e-06) + | 1.7915e-2 (1.39e-3) |
| WFG6 | 2 | 500 | 3.8789e-2 (8.25e-2) - | 6.9084e-03(5.80e-06) + | 1.2482e-2 (3.05e-3) |
| WFG6 | 2 | 1000 | 8.7328e-2 (1.39e-1) = | 5.2322e-03(6.58e-06) + | 1.2221e-2 (4.94e-3) |
| WFG6 | 3 | 100 | 1.6593e-1 (3.15e-3) - | 1.3230e-01(8.86e-04) + | 1.4004e-1 (5.11e-3) |
| WFG6 | 3 | 200 | 1.6800e-1 (2.47e-3) - | 1.2930e-01(6.84e-04) + | 1.3283e-1 (3.45e-3) |
| WFG6 | 3 | 500 | 2.7654e-1 (1.89e-1) = | 1.2952e-01(6.50e-04) + | 1.9857e-1 (5.50e-2) |
| WFG6 | 3 | 1000 | 2.0035e-1 (9.18e-2) = | 1.2992e-01(9.09e-04) + | 1.7362e-1 (4.00e-2) |
| WFG6 | 5 | 100 | 1.0615e+0 (1.84e-2) = | 1.0300e+00(8.23e-03) + | 1.0606e+0 (8.55e-3) |
| WFG6 | 5 | 200 | 1.0263e+0 (1.24e-2) + | 1.0316e+00(8.83e-03)+ | 1.0734e+0 (2.12e-2) |
| WFG6 | 5 | 500 | 1.0013e+0 (2.48e-2) + | 1.0262e+00(9.29e-03)+ | 1.0849e+0 (2.12e-2) |
| WFG6 | 5 | 1000 | 9.7241e-1 (1.07e-2) + | 1.0314e+00(1.04e-02)+ | 1.3864e+0 (3.03e-2) |
| WFG6 | 8 | 100 | 3.3281e+0 (5.88e-2) - | 3.4873e+00(3.08e-01)- | 3.1393e+0 (8.91e-2) |
| WFG6 | 8 | 200 | 3.3033e+0 (3.70e-2) - | 3.4588e+00(5.74e-01)= | 3.1595e+0 (8.56e-2) |
| WFG6 | 8 | 500 | 3.4173e+0 (7.24e-2) - | 3.2709e+00(1.79e-01)= | 3.1892e+0 (5.75e-2) |
| WFG6 | 8 | 1000 | 3.3268e+0 (7.66e-2) + | 3.2212e+00(1.26e-01) + | 3.4520e+0 (6.52e-2) |
| WFG6 | 10 | 100 | 4.6295e+0 (4.10e-2) = | 5.6169e+00(4.84e-01)- | 4.6680e+0 (1.04e-1) |
| WFG6 | 10 | 200 | 4.6365e+0 (2.42e-2) = | 5.8026e+00(5.15e-01)- | 4.5751e+0 (7.01e-2) |
| WFG6 | 10 | 500 | 4.8264e+0 (2.12e-1) = | 5.6689e+00(4.01e-01)- | 4.6990e+0 (1.56e-1) |
| WFG6 | 10 | 1000 | 4.7804e+0 (1.09e-1) = | 5.4252e+00(4.37e-01)= | 4.9120e+0 (2.16e-1) |
| WFG7 | 2 | 100 | 2.1547e-2 (1.97e-3) + | 1.4255e-01(1.20e-02)- | 1.2382e-1 (9.87e-3) |
| WFG7 | 2 | 200 | 1.1791e-1 (1.77e-2) = | 1.4227e-01(7.72e-03)- | 1.2664e-1 (7.82e-3) |
| WFG7 | 2 | 500 | 2.5012e-1 (2.17e-2) - | 1.5189e-01(9.70e-03)- | 1.2925e-1 (5.48e-3) |
| WFG7 | 2 | 1000 | 2.7562e-1 (9.37e-3) - | 1.5401e-01(7.91e-03)- | 1.2301e-1 (4.64e-3) |
| WFG7 | 3 | 100 | 2.6992e-1 (9.35e-3) + | 3.0407e-01(7.31e-03)= | 2.9567e-1 (1.73e-2) |
| WFG7 | 3 | 200 | 3.9089e-1 (3.28e-2) - | 3.0233e-01(1.21e-02) = | 3.0577e-1 (9.44e-3) |
| WFG7 | 3 | 500 | 4.6539e-1 (2.90e-2) - | 3.1215e-01(1.50e-02) + | 3.3910e-1 (2.23e-2) |
| WFG7 | 3 | 1000 | 3.9969e-1 (6.68e-3) - | 3.1572e-01(8.95e-03) + | 3.4150e-1 (1.39e-2) |
| WFG7 | 5 | 100 | 1.2924e+0 (2.24e-2) - | 1.2390e+00(1.48e-02)- | 1.1053e+0 (6.00e-3) |
| WFG7 | 5 | 200 | 1.2925e+0 (3.45e-2) - | 1.2653e+00(2.37e-02)- | 1.1238e+0 (7.95e-3) |
| WFG7 | 5 | 500 | 1.2213e+0 (2.69e-2) - | 1.2571e+00(1.52e-02)- | 1.1375e+0 (6.22e-3) |
| WFG7 | 5 | 1000 | 1.2276e+0 (4.05e-2) = | 1.2680e+00(2.54e-02)= | 1.2482e+0 (2.09e-2) |
| WFG7 | 8 | 100 | 3.5875e+0 (5.30e-2) - | 4.1885e+00(5.92e-02)- | 3.1192e+0 (2.66e-2) |
| WFG7 | 8 | 200 | 3.5478e+0 (3.38e-2) - | 4.2056e+00(9.32e-02)- | 3.1565e+0 (2.86e-2) |
| WFG7 | 8 | 500 | 3.6222e+0 (5.63e-2) - | 4.1289e+00(6.25e-02)- | 3.1208e+0 (1.84e-2) |
| WFG7 | 8 | 1000 | 3.6886e+0 (8.71e-2) - | 4.1694e+00(9.97e-02)- | 3.3300e+0 (4.05e-2) |
| WFG7 | 10 | 100 | 4.8447e+0 (3.79e-2) - | 5.6428e+00(4.55e-01)- | 4.4828e+0 (4.43e-2) |
| WFG7 | 10 | 200 | 4.8418e+0 (4.70e-2) - | 5.5887e+00(3.02e-01)- | 4.4663e+0 (5.14e-2) |
| WFG7 | 10 | 500 | 4.9394e+0 (8.56e-2) - | 5.6143e+00(2.87e-01)- | 4.4638e+0 (1.18e-1) |
| WFG7 | 10 | 1000 | 4.9761e+0 (6.85e-2) - | 5.3640e+00(2.97e-01)- | 4.6457e+0 (1.11e-1) |
| WFG8 | 2 | 100 | 1.2646e-1 (1.51e-2) + | 2.5631e-01(1.05e-02)- | 2.3974e-1 (9.48e-3) |
| WFG8 | 2 | 200 | 2.0154e-1 (2.08e-2) + | 2.5753e-01(6.84e-03)- | 2.4560e-1 (1.27e-2) |
| WFG8 | 2 | 500 | 2.7606e-1 (1.29e-2) - | 2.5311e-01(1.60e-02)- | 1.7036e-1 (1.43e-2) |

| | | | | | |
|------|----|------|------------------------------|-------------------------------|----------------------------|
| WFG8 | 2 | 1000 | 2.4012e-1 (3.41e-2) - | 2.3905e-01(1.52e-02)- | 1.3687e-1 (4.02e-3) |
| WFG8 | 3 | 100 | 3.4036e-1 (1.34e-2) + | 3.6511e-01(6.17e-03)= | 3.7263e-1 (7.64e-3) |
| WFG8 | 3 | 200 | 4.6795e-1 (2.30e-2) - | 3.6269e-01(6.42e-03) = | 3.7016e-1 (7.34e-3) |
| WFG8 | 3 | 500 | 4.7332e-1 (1.50e-2) - | 3.5857e-01(7.12e-03) + | 3.7377e-1 (2.37e-3) |
| WFG8 | 3 | 1000 | 3.8075e-1 (3.70e-2) - | 3.5148e-01(6.19e-03) = | 3.5338e-1 (1.43e-2) |
| WFG8 | 5 | 100 | 1.3066e+0 (1.77e-2) - | 1.1830e+00(2.86e-02)- | 1.1426e+0 (4.87e-3) |
| WFG8 | 5 | 200 | 1.3276e+0 (4.31e-2) - | 1.1815e+00(1.07e-02)= | 1.1737e+0 (1.07e-2) |
| WFG8 | 5 | 500 | 1.2276e+0 (1.52e-2) - | 1.1847e+00(2.19e-02)= | 1.1718e+0 (1.33e-2) |
| WFG8 | 5 | 1000 | 1.0816e+0 (2.95e-2) + | 1.1917e+00(1.30e-02)+ | 1.3015e+0 (1.09e-2) |
| WFG8 | 8 | 100 | 3.4809e+0 (6.12e-2) - | 4.4365e+00(2.43e-01)- | 3.2508e+0 (6.18e-2) |
| WFG8 | 8 | 200 | 3.4557e+0 (4.05e-2) - | 4.6687e+00(6.27e-01)- | 3.2326e+0 (2.47e-2) |
| WFG8 | 8 | 500 | 3.4097e+0 (5.26e-2) - | 4.1164e+00(1.69e-01)- | 3.1741e+0 (4.80e-3) |
| WFG8 | 8 | 1000 | 3.4986e+0 (5.56e-2) - | 4.6518e+00(2.38e-01)- | 3.4078e+0 (3.16e-2) |
| WFG8 | 10 | 100 | 4.7533e+0 (5.37e-2) - | 5.9049e+00(4.21e-01)- | 4.6268e+0 (9.97e-2) |
| WFG8 | 10 | 200 | 4.7148e+0 (4.64e-2) - | 5.8954e+00(6.43e-01)- | 4.5396e+0 (8.20e-2) |
| WFG8 | 10 | 500 | 4.9660e+0 (1.59e-1) - | 5.9735e+00(4.18e-01)- | 4.7277e+0 (5.74e-2) |
| WFG8 | 10 | 1000 | 4.9745e+0 (1.72e-1) - | 6.0053e+00(5.22e-01)- | 4.7367e+0 (1.34e-1) |
| WFG9 | 2 | 100 | 2.9850e-2 (8.62e-3) + | 3.8821e-02(7.78e-03)+ | 7.4102e-2 (1.01e-2) |
| WFG9 | 2 | 200 | 4.7961e-2 (4.10e-2) = | 3.2095e-02(8.65e-03) + | 6.0157e-2 (3.15e-3) |
| WFG9 | 2 | 500 | 5.4861e-2 (7.75e-2) = | 5.3070e-02(2.90e-02) = | 5.1020e-2 (4.95e-3) |
| WFG9 | 2 | 1000 | 2.0243e-2 (3.27e-2) + | 2.8194e-02(7.11e-03) + | 4.0541e-2 (5.70e-3) |
| WFG9 | 3 | 100 | 2.1288e-1 (2.72e-2) + | 1.8901e-01(1.38e-02) + | 3.3069e-1 (1.89e-2) |
| WFG9 | 3 | 200 | 2.6746e-1 (1.25e-1) = | 1.8456e-01(7.45e-03) = | 1.8597e-1 (1.67e-2) |
| WFG9 | 3 | 500 | 3.6640e-1 (1.22e-1) - | 1.8179e-01(9.23e-03)= | 1.7455e-1 (1.27e-2) |
| WFG9 | 3 | 1000 | 2.6171e-1 (1.90e-2) - | 1.7059e-01(4.73e-03) = | 1.7183e-1 (1.09e-2) |
| WFG9 | 5 | 100 | 1.2006e+0 (3.82e-2) - | 1.0469e+00(1.26e-02)- | 1.0434e+0 (9.91e-3) |
| WFG9 | 5 | 200 | 1.2699e+0 (1.44e-1) - | 1.0529e+00(1.97e-02) = | 1.0619e+0 (9.93e-3) |
| WFG9 | 5 | 500 | 1.3413e+0 (7.13e-2) - | 1.0362e+00(1.21e-02) + | 1.0759e+0 (1.61e-2) |
| WFG9 | 5 | 1000 | 1.1384e+0 (8.46e-2) = | 1.0334e+00(1.03e-02) + | 1.1851e+0 (1.98e-2) |
| WFG9 | 8 | 100 | 3.7612e+0 (5.03e-2) - | 3.9191e+00(6.01e-02)- | 3.0253e+0 (2.74e-2) |
| WFG9 | 8 | 200 | 3.8530e+0 (5.88e-2) - | 3.8805e+00(1.29e-01)- | 3.0798e+0 (3.05e-2) |
| WFG9 | 8 | 500 | 3.7867e+0 (9.01e-2) - | 3.8128e+00(1.29e-01)- | 3.0605e+0 (3.92e-2) |
| WFG9 | 8 | 1000 | 3.6885e+0 (1.44e-1) - | 3.7313e+00(1.08e-01)- | 3.4628e+0 (6.34e-2) |
| WFG9 | 10 | 100 | 5.1466e+0 (9.37e-2) - | 5.2748e+00(9.74e-02)- | 4.6532e+0 (4.89e-2) |
| WFG9 | 10 | 200 | 5.2758e+0 (1.07e-1) - | 5.2504e+00(1.60e-01)- | 4.6372e+0 (7.13e-2) |
| WFG9 | 10 | 500 | 5.0246e+0 (1.26e-1) = | 5.2600e+00(6.79e-02)- | 5.0515e+0 (8.17e-2) |
| WFG9 | 10 | 1000 | 4.9593e+0 (1.03e-1) = | 5.2676e+00(1.39e-01)- | 4.9860e+0 (1.42e-1) |
| +/-= | | | 52/96/32 | 50/99/31 | |

TABLE A. 14

THE IGD RESULTS OF ALL ALGORITHMS ON 5-OBJECTIVE LSMOP1 AND LSMOP9, 2-OBJECTIVE UF3, 3-OBJECTIVE UF9, 5-OBJECTIVE DTLZ1 AND DTLZ2, AND 5-OBJECTIVE WFG2 AND WFG8 WITH 5000 AND 10000 DECISION VARIABLES.

| Problem | M | D | LSMOF | DGEA | LMEA | LSMOEA/D | MOEADVA | MOEA/PSL | AMOEAD | NN-CSO |
|---------|---|------|--|--------------------------|--------------------------|---------------------------|--------------------------|--|--|-------------------------------|
| LSMOP1 | 5 | 5000 | 9.3139e-1 (6.16e-3) - | 9.5070e-1 (6.51e-2) = | 1.0530e+1 (2.31e-1) - | 1.0874e+1 (3.91e-1) - | 1.0774e+1 (4.18e-1) - | 1.9955e+0 (1.68e+0) - | 6.9876e-1 (1.24e-2) + | 8.6393e-1 (9.68e-2) |
| LSMOP1 | 5 | 1000 | 9.3310e-1 0 (2.37e-3) - | 1.4113e+0 (5.01e-4) - | 1.0490e+1 (1.08e-1) - | 1.0782e+1 (4.51e-1) - | 1.0613e+1 (2.41e-1) - | 8.7397e+0 (1.10e+1) - | 7.1396e-1 (2.56e-2) + | 8.7742e-1 (6.24e-2) |
| LSMOP9 | 5 | 5000 | 2.4795e+0 (4.38e-1) - | 1.3574e+2 (1.22e+1) - | 3.7108e+2 (5.25e+0) - | 3.7007e+2 (6.25e+0) - | 3.7255e+2 (3.07e+0) - | 2.7608e+0 (1.30e-1) - | 2.5695e+0 (9.34e-3) - | 1.4232e+0 (7.27e-1) |
| LSMOP9 | 5 | 1000 | 2.3317e+0 0 (7.32e-2) - | 1.5923e+2 (1.59e+1) - | 3.7760e+2 (8.49e-1) - | 3.7614e+2 (2.79e+0) - | 3.7420e+2 (9.39e-1) - | 2.9184e+0 (1.61e-1) - | 2.9885e+0 (4.26e-3) - | 2.1580e+0 (3.34e-1) |
| UF3 | 2 | 5000 | 1.2222e-1 (1.06e-3) - | 1.2100e-1 (2.62e-3) - | 1.1391e+0 (7.94e-3) - | 1.1356e+0 (5.06e-3) - | 1.1371e+0 (7.42e-3) - | 4.6559e-1 (1.74e-1) - | 2.2282e-1 (4.16e-3) - | 1.1851e-1 (5.97e-4) |
| UF3 | 2 | 1000 | 1.2114e-1 0 (5.11e-4) - | 1.2134e-1 (5.06e-3) - | 1.1453e+0 (5.50e-3) - | 1.1479 e+0 (4.07e-3) - | 1.1457e+0 (3.68e-3) - | 3.4326e-1 (1.13e-1) - | 2.2277e-1 (2.74e-3) - | 1.1773e-1 (3.65e-4) |
| UF9 | 3 | 5000 | 6.2887e-1 (1.65e-2) + | 1.5021e+0 (1.75e-1) - | 4.6081e+0 (2.97e-2) - | 4.6021e+0 (1.62e-2) - | 4.6231e+0 (3.16e-2) - | 8.8941e-1 (1.24e-4) - | 7.5768e-1 (2.55e-2) = | 7.9618e-1 (5.44e-2) |
| UF9 | 3 | 1000 | 6.5166e-1 0 (2.86e-3) = | 1.4377e+0 (2.56e-2) - | 4.6291e+0 (2.42e-2) - | 4.6433e+0 (1.61e-2) - | 4.6118e+0 (1.00e-2) - | 8.8339e-1 (8.49e-6) - | 7.2767e-1 (4.25e-2) - | 6.4750e-1 (1.91e-3) |
| DTLZ1 | 5 | 5000 | 1.1039e+3 (2.92e+3) + | 1.2072e+4 (4.50e+3) = | 1.2711e+5 (4.92e+3) - | 1.2574e+5 (3.33e+3) - | 1.2370e+5 (9.77e+2) - | 3.3982e+4 (6.30e+3) - | 2.6421e+4 (3.24e+3) - | 1.5009e+4 (2.30e+3) |
| DTLZ1 | 5 | 1000 | 1.1824e+4 (1.61e+4) + | 2.3069e+4 (2.01e+3) + | 2.5275e+5 (1.27e+4) - | 2.5051e+5 (3.91e+3) - | 2.4828e+5 (1.23e+3) - | 7.0949e+4 (2.82e+3) - | 4.9604e+4 (4.25e+3) - | 3.0143e+4 (1.00e+3) |
| DTLZ2 | 5 | 5000 | 3.2036e+2 (7.09e+1) - | 2.8295e+1 (2.68e+0) - | 4.0236e+2 (2.30e+0) - | 4.0204e+2 (1.99e+0) - | 4.0238e+2 (2.18e+0) - | 1.3661e+2 (1.43e+2) - | 1.4428e+1 (1.23e+0) - | 1.3658e+1 (1.04e+0) |
| DTLZ2 | 5 | 1000 | 7.3561e+2 (6.95e+1) - | 6.0237e+1 (9.39e+0) - | 8.1184e+2 (2.33e+0) - | 8.0897e+2 (2.02e+0) - | 8.1300e+2 (2.64e+0) - | 3.5682e+2 (3.48e+2) - | 2.8494e+1 (1.28e+0) - | 2.7554e+1 (3.14e+0) |
| WFG2 | 5 | 5000 | 7.1205e-1 (3.64e-2) = | 7.7819e-1 (6.10e-2) - | 1.7830e+0 (2.69e-1) - | 1.7690e+0 (2.86e-1) - | 1.8467e+0 (2.06e-3) - | 8.8720e-1 (6.86e-2) - | 1.9647e+0 (5.28e-2) - | 7.1638e-1 (3.99e-2) |
| WFG2 | 5 | 1000 | 7.0344e-1 (4.04e-2) = | 7.6681e-1 (2.55e-2) = | 1.6756e+0 (2.94e-1) - | 1.7078e+0 (2.25e-1) - | 1.8461e+0 (1.51e-3) - | 8.4204e-1 (2.10e-2) - | 1.9722e+0 (8.28e-2) - | 7.1856e-1 (2.47e-2) |
| WFG8 | 5 | 5000 | 1.4042e+0 (9.26e-2) - | 1.3032e+0 (3.87e-2) - | 1.8368e+0 (5.67e-2) - | 1.8484e+0 (5.89e-2) - | 1.7849e+0 (2.00e-3) - | 1.1402e+0 (1.75e-2) + | 1.2365e+0 (3.28e-2) - | 1.2074e+0 (9.96e-3) |
| WFG8 | 5 | 1000 | 1.2713e+0 (3.58e-2) = | 1.3052e+0 (2.84e-2) = | 1.7765e+0 (3.74e-2) - | 1.8077e+0 (7.55e-2) - | 1.7754e+0 (2.78e-4) - | 1.2222e+0 (5.16e-2) - | 1.2211e+0 (4.89e-2) = | 1.1977e+0 (2.64e-2) |
| +/-= | | | 3/9/4 | 1/11/4 | 0/16/0 | 0/16/0 | 0/16/0 | 1/15/0 | 2/12/2 | |

TABLE A. 15
THE IGD COMPARISON RESULTS OF ALL COMPARED ALGORITHMS ON 20-OBJECTIVE, 50-OBJECTIVE AND 100-OBJECTIVE LSMOP1, LSMOP9, DTLZ1, DTLZ2, WFG2 AND WFG8 WITH 1000 DECISION VARIABLES.

| Problem | M | D | LSMOF | DGEA | LMEA | LSMOEA/D | MOEADVA | MOEA/PSL | AMOEAD | NN-CSO |
|---------|-----|------|--------------------------|--|--------------------------|--------------------------|--------------------------|--|--|--------------------------------------|
| LSMOP1 | 20 | 1000 | 2.6584e+0 (1.62e+0) = | 1.1334e+0 (2.62e-2) = | 1.0470e+1 (1.21e+0) - | 9.7027e+0 (7.43e-1) - | 1.1189e+1 (7.27e-1) - | 6.5171e+0 (3.59e+0) - | 8.6094e-1 (1.24e-1) + | 1.5015e+0 (3.00e-1) |
| LSMOP1 | 50 | 1000 | 2.5576e+0 (9.42e-1) = | 1.1847e+0 (1.07e-1) = | 1.0257e+1 (2.33e+0) - | 1.1006e+1 (1.07e+0) - | 1.0994e+1 (9.05e-1) - | 2.1923e+0 (2.11e+0) = | 9.415e-1 (1.25e-1) + | 1.6321e+0 (8.78e-1) |
| LSMOP1 | 100 | 1000 | 1.2155e+0 (4.93e-4) = | 1.2988e+0 (2.24e-1) = | 9.1316e+0 (1.03e+0) - | 8.3145e+0 (1.70e+0)- | 8.3725e+0 (6.49e-1) - | 1.1187e+0 (1.22e-1) = | 9.2754e-1 (2.35e-1) + | 1.4161e+0 (3.44e-1) |
| LSMOP9 | 20 | 1000 | 1.6507e+1 (1.63e-1) + | 2.0413e+3 (3.28e+2) - | 4.9409e+3 (1.54e+2) - | 4.9715e+3 (1.46e+2) - | 4.9791e+3 (1.55e+2) - | 1.5949e+1 (4.71e-1) + | 5.6433e+1 (1.89e+1) - | 3.8832e+1 (1.85e+1) |
| LSMOP9 | 50 | 1000 | 4.8217e+3 (1.27e+4) - | 1.5924e+4 (1.76e+3) - | 3.5695e+4 (4.55e+2) - | 3.5572e+4 (6.41e+2) - | 3.6153e+4 (4.60e+2) - | 8.5469e-1 (2.11e-1) + | 8.4583e+2 (3.68e+1) - | 5.5973e+2 (2.68e+1) |
| LSMOP9 | 100 | 1000 | 4.0583e+1 (4.34e+1)+ | 7.5754e+4 (7.28e+3)- | 1.5999e+5 (2.17e+3)- | 1.5774e+5 (2.83e+3)- | 1.5888e+5 (1.61e+3)- | 7.9767e-1 (1.74e-1) + | 5.2751e+3 (1.26e+2) - | 4.1730e+3 (2.85e+2) |
| DTLZ1 | 20 | 1000 | 9.9925e+3 (2.80e+3) - | 7.5612e+3 (2.34e+3) = | 2.2108e+4 (1.57e+3) - | 2.1926e+4 (6.57e+2) - | 2.1874e+4 (9.51e+2) - | 8.9582e+3 (3.87e+2) - | 7.0721e+3 (6.85e+2) - | 5.7768e+3 (1.39e+3) |
| DTLZ1 | 50 | 1000 | 7.2494e+3 (1.16e+3) - | 3.9538e+3 (1.48e+3) = | 2.2207e+4 (1.46e+3) - | 2.0959e+4 (1.18e+3) - | 2.1771e+4 (1.29e+3) - | 8.0003e+3 (1.20e+3) - | 6.6498e+3 (1.43e+3) - | 2.7294e+3 (1.25e+3) |
| DTLZ1 | 100 | 1000 | 5.8106e+3 (5.89e+2) - | 3.8815e+3 (8.70e+2) - | 1.9828e+4 (1.07e+3) - | 2.0085e+4 (1.04e+3)- | 2.0040e+4 (1.52e+3)- | 7.5242e+3 (6.37e+2) - | 5.9803e+3 (5.98e+2) - | 3.0483e+3 (4.92e+2) |
| DTLZ2 | 20 | 1000 | 8.7289e+1 (1.33e+1) - | 8.9914e+0 (1.26e+0) - | 7.6580e+1 (5.49e-1) - | 7.6034e+1 (8.36e-1) - | 7.6225e+1 (6.30e-1) - | 1.0944e+2 (4.67e+1) - | 8.6925e+0 (1.26e+0) - | 5.8713e+0 (1.09e+0) |
| DTLZ2 | 50 | 1000 | 9.8361e+1 (1.09e+1) - | 1.1454e+1 (6.61e+0) = | 7.4264e+1 (9.89e-1) - | 7.4621e+1 (1.14e+0) - | 7.4687e+1 (1.06e+0) - | 9.7953e+1 (3.65e+1) - | 1.4032e+1 (4.28e+0) = | 1.1886e+1 (3.23e+0) |
| DTLZ2 | 100 | 1000 | 1.0102e+2 (1.52e+1) - | 1.2899e+1 (1.94e+0) = | 7.0399e+1 (8.11e-1) - | 7.0776e+1 (5.66e-1)- | 6.9946e+1 (1.30e+0) - | 1.4031e+2 (7.47e+0) - | 1.5313e+1 (3.98e+0) - | 1.1233e+1 (3.00e+0) |
| WFG2 | 20 | 1001 | 4.5369e+0 (9.62e-2) + | 4.7435e+0 (1.71e-1) + | 8.5177e+0 (1.55e+0) - | 8.6584e+0 (1.02e+0) - | 9.2429e+0 (1.43e+0) - | 4.6432e+0 (2.73e-1) + | 6.7004e+0 (2.23e+0) = | 5.2299e+0 (2.61e-1) |
| WFG2 | 50 | 1001 | 9.4127e+0 (2.27e-1) + | 1.3403e+1 (3.00e-1) + | 2.6197e+1 (5.23e+0) = | 2.9524e+1 (5.06e+0) - | 3.0385e+1 (3.51e+0) - | 1.5674e+1 (1.55e+0) = | 3.1583e+1 (4.23e+0) - | 1.8739e+1 (6.98e+0) |
| WFG2 | 100 | 1001 | 2.7071e+1 (8.95e-1) + | 4.0397e+1 (1.20e+0) + | 6.6794e+1 (4.70e+0) - | 6.2398e+1 (8.33e+0)- | 6.2105e+1 (6.97e+0) - | 3.9927e+1 (1.92e+0) + | 6.5723e+1 (7.25e+0) - | 4.9086e+1 (9.12e+0) |
| WFG8 | 20 | 1000 | 1.3900e+1 (8.32e-2) + | 1.6449e+1 (5.46e-1) = | 2.5534e+1 (9.31e-1) - | 2.5843e+1 (1.08e+0) - | 2.5978e+1 (7.49e-1) - | 1.6563e+1 (1.10e+0) = | 2.2782e+1 (1.03e+0) - | 1.5704e+1 (1.40e+0) |
| WFG8 | 50 | 1000 | 3.6024e+1 (6.91e-1) + | 4.2696e+1 (1.58e+0) = | 9.1577e+1 (1.61e+0) - | 9.2501e+1 (1.52e+0) - | 9.1607e+1 (1.70e+0) - | 7.1229e+1 (4.70e+0) - | 9.1324e+1 (3.06e+0) - | 4.4519e+1 (6.01e+0) |
| WFG8 | 100 | 1000 | 7.9616e+1 (1.76e+0) + | 9.1456e+1 (2.70e+0) = | 2.0368e+2 (2.13e+0) - | 2.0457e+2 (2.12e+0)- | 2.0445e+2 (9.35e-1) - | 1.8062e+2 (2.12e+0) - | 2.0463e+2 (4.29e+1) - | 1.0117e+2 (2.01e+1) |
| +/-= | | | 8/7/3 | 3/5/10 | 0/17/1 | 0/18/0 | 0/18/0 | 5/9/4 | 3/13/2 | |