Appendix 1 improved results for j30 in test 1

Appendix Table 1 the improved solutions for J30 sets (77 instances)

|  |  |  |  |
| --- | --- | --- | --- |
| J30 instances number | The optimum value given by PSPLIB | The improved solution obtained from this paper | Use time(second) |
| j301\_1 | 43 | 41 | 1.35s |
| j301\_4 | 62 | 61 | 5.28s |
| j302\_9 | 54 | 51 | 2.94s |
| j303\_6 | 54 | 53 | 0.8s |
| J303\_9 | 65 | 60 | 1.96s |
| J303\_10 | 59 | 57 | 0.66s |
| J305\_2 | 82 | 75 | 0.92s |
| J305\_7 | 76 | 61 | 3.31s |
| J306\_2 | 51 | 50 | 15.11s |
| J306\_5 | 67 | 58 | 2.14s |
| J306\_9 | 51 | 48 | 1.9s |
| J309\_6 | 59 | 57 | 31s |
| J309\_8 | 91 | 89 | 21s |
| J3011\_1 | 54 | 53 | 2.61s |
| J3013\_4 | 72 | 70 | 157s |
| J3014\_9 | 46 | 45 | 29.33s |
| J3014\_10 | 61 | 60 | 42s |
| J3017\_1 | 64 | 61 | 17s |
| J3018\_5 | 52 | 50 | 0.67 |
| J3018\_8 | 52 | 49 | 0.55s |
| J3018\_10 | 49 | 47 | 1.45s |
| J3019\_7 | 57 | 56 | 0.711s |
| J3021\_1 | 84 | 79 | 2.4s |
| J3021\_2 | 59 | 58 | 12.5s |
| J3021\_6 | 76 | 74 | 9.38s |
| J3021\_7 | 65 | 64 | 3.77s |
| J3021\_10 | 69 | 67 | 52s |
| J3022\_3 | 63 | 61 | 0.87s |
| J3023\_5 | 52 | 48 | 2.73s |
| J3023\_9 | 63 | 60 | 1.57s |
| J3025\_4 | 81 | 73 | 57.18s |
| J3025\_5 | 72 | 63 | 8.12s |
| J3025\_10 | 58 | 57 | 35.96s |
| J3029\_5 | 98 | 97 | 66.58s |
| J3029\_10 | 76 | 75 | 13.26s |
| J3030\_10 | 53 | 52 | 70.04s |
| J3033\_6 | 59 | 53 | 0.81s |
| J3033\_9 | 65 | 63 | 84.79s |
| J3034\_1 | 68 | 65 | 1.92s |
| J3034\_2 | 44 | 42 | 2.12s |
| J3034\_8 | 58 | 52 | 0.74s |
| J3035\_4 | 50 | 49 | 1.78s |
| J3035\_6 | 58 | 56 | 1.244s |
| J3037\_3 | 81 | 64 | 6.01s |
| J3037\_5 | 80 | 79 | 6.7s |
| J3037\_6 | 73 | 72 | 4.98s |
| J3037\_9 | 57 | 54 | 4.58s |
| J3037\_10 | 81 | 79 | 4.66s |
| J3038\_1 | 48 | 47 | 1.54s |
| J3038\_3 | 59 | 58 | 4.17s |
| J3038\_9 | 63 | 57 | 48.68s |
| J3039\_9 | 64 | 58 | 1.83s |
| J3039\_10 | 60 | 58 | 1.466s |
| J3041\_1 | 86 | 85 | 9.17s |
| J3041\_2 | 89 | 81 | 12.36s |
| J3041\_3 | 85 | 81 | 5.99s |
| J3041\_4 | 78 | 75 | 5.44s |
| J3041\_5 | 99 | 98 | 36.86s |
| J3041\_6 | 103 | 102 | 7.25s |
| J3041\_10 | 99 | 96 | 5.53s |
| J3042\_3 | 60 | 59 | 15.42s |
| J3042\_6 | 66 | 65 | 3.299s |
| J3042\_8 | 82 | 77 | 0.83s |
| J3043\_10 | 60 | 59 | 1.56s |
| J3045\_2 | 125 | 111 | 43.11s |
| J3045\_5 | 86 | 84 | 6.95s |
| J3045\_6 | 129 | 128 | 75.52s |
| J3045\_7 | 101 | 100 | 32.18s |
| J3046\_6 | 59 | 58 | 4.23s |
| J3047\_5 | 47 | 46 | 9.31s |
| J3047\_7 | 66 | 63 | 1.96s |

j301\_1.sm,

solution: [0, 8, 0, 0, 6, 24, 8, 4, 6, 6, 16, 13, 4, 15, 16, 13, 18, 10, 13, 25, 23, 24, 32, 36, 32, 25, 25, 33, 18, 39, 36, 41]

j301\_4.sm,

solution: [0, 0, 10, 0, 10, 3, 9, 17, 24, 24, 33, 28, 25, 3, 20, 37, 37, 34, 12, 37, 32, 24, 31, 18, 34, 33, 12, 44, 46, 52, 44, 61]

j302\_9.sm,

solution: [0, 0, 0, 0, 8, 5, 7, 10, 17, 8, 16, 25, 1, 17, 1, 30, 16, 5, 16, 23, 4, 30, 26, 30, 37, 36, 31, 10, 42, 45, 39, 51]

j303\_6.sm

solution: [0, 0, 2, 0, 1, 1, 1, 3, 2, 2, 10, 14, 10, 14, 24, 13, 25, 13, 20, 24, 2, 30, 24, 14, 4, 30, 39, 37, 18, 43, 34, 53]

j303\_9.sm

solution: [0, 0, 0, 0, 6, 11, 1, 14, 1, 15, 2, 2, 6, 28, 13, 21, 8, 2, 20, 22, 21, 15, 11, 16, 13, 32, 31, 42, 42, 20, 51, 60]

j303\_10.sm

solution: [0, 0, 0, 0, 2, 12, 4, 9, 9, 5, 14, 9, 13, 17, 8, 23, 23, 18, 14, 18, 8, 30, 32, 4, 30, 37, 44, 24, 48, 40, 12, 57]

j305\_2.sm,

solution: [0, 0, 9, 14, 14, 27, 24, 14, 23, 24, 9, 39, 27, 27, 37, 33, 37, 38, 32, 22, 23, 38, 44, 46, 39, 57, 45, 34, 67, 53, 53, 75]

j305\_7.sm,

solution: [0, 0, 0, 0, 9, 30, 9, 6, 14, 22, 28, 10, 41, 41, 6, 14, 21, 21, 36, 20, 48, 14, 36, 14, 20, 30, 24, 30, 56, 38, 51, 61]

j306\_2.sm,

solution: [0, 0, 0, 0, 6, 4, 12, 4, 15, 13, 17, 20, 21, 12, 23, 13, 30, 28, 21, 29, 32, 31, 37, 23, 31, 39, 38, 38, 40, 37, 48, 50]

j306\_5.sm,

solution: [0, 0, 0, 0, 9, 4, 19, 9, 14, 26, 1, 4, 13, 17, 19, 11, 20, 13, 33, 9, 26, 34, 41, 26, 34, 48, 43, 34, 57, 42, 53, 58]

j306\_9.sm,

solution: [0, 0, 0, 0, 9, 10, 6, 13, 6, 17, 17, 19, 17, 20, 10, 13, 24, 13, 19, 9, 21, 23, 31, 32, 13, 22, 35, 23, 40, 30, 32, 48]

j309\_6.sm,

solution: [0, 0, 1, 0, 11, 12, 8, 6, 36, 46, 17, 48, 17, 1, 15, 11, 12, 16, 21, 28, 25, 27, 36, 52, 25, 35, 43, 44, 54, 53, 44, 57]

j309\_8.sm,

solution: [0, 10, 0, 0, 10, 16, 10, 48, 34, 18, 43, 16, 26, 16, 38, 49, 34, 27, 59, 69, 38, 83, 69, 10, 77, 59, 79, 49, 84, 85, 79, 89]

j3011\_1.sm,

solution: [0, 0, 0, 0, 1, 1, 8, 17, 5, 1, 7, 17, 9, 26, 22, 15, 8, 15, 27, 19, 8, 31, 29, 37, 26, 31, 40, 40, 31, 45, 40, 53]

j3013\_4.sm,

solution: [0, 0, 10, 0, 8, 30, 22, 18, 16, 20, 26, 36, 43, 36, 29, 40, 50, 33, 49, 58, 42, 50, 49, 61, 58, 25, 56, 43, 61, 67, 57, 70]

j3014\_9.sm,

solution: [0, 0, 0, 0, 5, 19, 5, 9, 29, 10, 14, 14, 29, 28, 31, 21, 32, 20, 38, 14, 31, 22, 6, 33, 28, 33, 41, 39, 43, 42, 43, 45]

j3014\_10.sm

solution: [0, 0, 0, 0, 15, 21, 9, 14, 5, 21, 21, 28, 28, 17, 17, 27, 27, 45, 35, 1, 36, 36, 45, 43, 37, 5, 51, 47, 52, 52, 52, 60]

j3017\_1.sm,

solution: [0, 0, 0, 0, 5, 5, 23, 5, 13, 32, 14, 9, 2, 11, 13, 23, 14, 42, 32, 5, 16, 42, 32, 51, 55, 42, 32, 52, 52, 60, 45, 61]

j3018\_5.sm,

solution: [0, 0, 0, 0, 2, 2, 4, 6, 9, 9, 16, 17, 2, 18, 4, 13, 4, 14, 22, 18, 27, 18, 27, 24, 22, 37, 35, 35, 43, 41, 45, 50]

j3018\_8.sm,

solution: [0, 0, 0, 0, 2, 4, 4, 6, 4, 13, 13, 8, 18, 6, 14, 13, 22, 3, 18, 10, 16, 25, 25, 29, 19, 27, 33, 32, 23, 36, 42, 49]

j3018\_10.sm

solution: [0, 0, 0, 0, 3, 1, 1, 9, 3, 9, 12, 9, 20, 12, 5, 21, 21, 9, 24, 21, 9, 22, 23, 29, 22, 25, 14, 35, 29, 45, 35, 47]

j3019\_7.sm,

solution: [0, 0, 7, 0, 10, 14, 15, 17, 25, 7, 7, 10, 22, 17, 14, 28, 14, 26, 27, 37, 22, 29, 28, 29, 23, 37, 37, 25, 32, 47, 47, 56]

j3021\_1.sm,

solution: [0, 0, 0, 0, 5, 15, 25, 5, 26, 9, 26, 34, 31, 2, 14, 36, 43, 49, 36, 52, 31, 49, 52, 64, 52, 55, 44, 62, 73, 74, 64, 79]

j3021\_2.sm,

solution: [0, 0, 0, 2, 8, 9, 9, 20, 14, 14, 27, 20, 11, 22, 18, 38, 27, 27, 34, 14, 24, 37, 38, 41, 41, 49, 45, 49, 55, 51, 43, 58]

j3021\_6.sm,

solution: [0, 0, 0, 15, 9, 20, 15, 9, 15, 1, 24, 9, 24, 24, 20, 28, 38, 9, 48, 34, 28, 48, 58, 38, 48, 58, 64, 54, 68, 58, 68, 74]

j3021\_7.sm,

solution: [0, 0, 0, 11, 10, 18, 9, 11, 10, 5, 38, 30, 20, 31, 45, 31, 46, 22, 46, 37, 38, 30, 43, 48, 38, 43, 47, 48, 45, 51, 54, 64]

j3021\_10.sm

solution: [0, 0, 0, 0, 7, 27, 17, 6, 25, 27, 36, 10, 41, 24, 36, 24, 46, 7, 32, 41, 50, 50, 13, 46, 50, 59, 16, 54, 56, 59, 61, 67]

j3022\_3.sm,

solution: [0, 0, 0, 0, 10, 10, 16, 16, 23, 26, 26, 23, 16, 16, 26, 10, 6, 31, 31, 39, 10, 39, 35, 20, 23, 32, 48, 34, 48, 46, 53, 61]

j3023\_5.sm,

solution: [0, 0, 0, 0, 4, 7, 14, 4, 20, 7, 4, 14, 4, 5, 15, 13, 28, 22, 22, 15, 16, 22, 24, 27, 22, 27, 34, 37, 20, 44, 27, 48]

j3023\_9.sm,

solution: [0, 0, 0, 0, 4, 5, 6, 15, 15, 2, 2, 12, 12, 19, 27, 5, 20, 18, 25, 27, 20, 21, 6, 27, 35, 36, 37, 45, 21, 51, 27, 60]

j3025\_3.sm,

solution: [0, 21, 0, 0, 8, 8, 12, 26, 19, 8, 35, 19, 26, 10, 39, 43, 39, 26, 43, 45, 36, 53, 38, 53, 45, 67, 61, 49, 70, 67, 70, 75]

j3025\_4.sm,

solution: [0, 8, 0, 0, 20, 8, 13, 8, 21, 16, 45, 20, 27, 23, 37, 49, 31, 37, 41, 41, 41, 51, 58, 51, 23, 65, 59, 49, 68, 65, 68, 73]

j3025\_5.sm,

solution: [0, 0, 0, 0, 8, 7, 22, 2, 33, 11, 27, 19, 41, 23, 35, 23, 19, 35, 40, 51, 46, 42, 58, 40, 59, 33, 54, 54, 62, 61, 59, 63]

j3025\_9.sm,

solution: [0, 0, 7, 1, 7, 14, 18, 24, 1, 14, 18, 45, 23, 27, 28, 28, 32, 43, 27, 31, 35, 35, 41, 56, 54, 54, 66, 56, 72, 62, 72, 80]

j3025\_10.sm

solution: [0, 0, 2, 0, 8, 19, 27, 9, 7, 11, 13, 6, 13, 26, 11, 7, 13, 34, 46, 22, 35, 22, 27, 36, 44, 35, 44, 49, 50, 50, 46, 57]

j3029\_5.sm,

solution: [0, 0, 0, 2, 4, 9, 19, 26, 14, 41, 24, 27, 50, 37, 37, 47, 71, 40, 58, 32, 67, 54, 91, 63, 84, 79, 79, 84, 91, 82, 93, 97]

j3029\_10.sm

solution: [0, 22, 0, 0, 1, 10, 13, 6, 13, 11, 22, 26, 26, 33, 11, 43, 24, 45, 42, 52, 36, 47, 27, 52, 60, 29, 45, 60, 62, 56, 69, 75]

j3030\_10.sm

solution: [0, 0, 0, 0, 8, 8, 6, 16, 17, 38, 25, 23, 6, 47, 16, 15, 27, 34, 17, 18, 34, 11, 25, 30, 43, 43, 30, 38, 45, 47, 49, 52]

j3033\_6.sm,

solution: [0, 0, 0, 3, 3, 3, 12, 3, 22, 12, 12, 22, 24, 27, 33, 22, 27, 13, 30, 27, 35, 32, 35, 29, 35, 37, 45, 41, 41, 47, 47, 53]

j3033\_9.sm,

solution: [0, 0, 0, 0, 11, 16, 2, 19, 2, 10, 4, 24, 24, 21, 21, 19, 24, 25, 34, 37, 34, 34, 31, 25, 34, 42, 37, 47, 47, 42, 57, 63]

j3034\_1.sm,

solution: [0, 13, 0, 0, 10, 3, 10, 23, 14, 20, 20, 20, 26, 14, 28, 27, 35, 30, 35, 45, 39, 28, 38, 45, 38, 49, 48, 55, 57, 55, 46, 65]

j3034\_2.sm,

solution: [0, 0, 0, 3, 7, 7, 10, 3, 11, 13, 9, 9, 15, 15, 19, 11, 13, 17, 26, 18, 21, 19, 21, 20, 28, 31, 26, 26, 37, 36, 35, 42]

j3034\_8.sm,

solution: [0, 0, 0, 0, 5, 5, 9, 1, 11, 11, 1, 7, 17, 15, 18, 18, 9, 21, 19, 27, 27, 11, 22, 33, 33, 35, 21, 38, 42, 40, 19, 52]

j3035\_4.sm,

solution: [0, 0, 12, 0, 4, 12, 12, 4, 8, 1, 18, 18, 13, 13, 16, 21, 14, 18, 31, 20, 17, 20, 29, 22, 29, 29, 31, 22, 35, 33, 40, 49]

j3035\_6.sm,

solution: [0, 1, 0, 0, 1, 9, 6, 6, 9, 16, 1, 10, 6, 10, 7, 13, 18, 23, 33, 23, 25, 13, 33, 39, 39, 18, 33, 39, 46, 42, 49, 56]

j3037\_2.sm,

solution: [0, 0, 0, 0, 8, 8, 2, 11, 12, 3, 2, 16, 8, 17, 27, 18, 12, 16, 30, 18, 37, 27, 27, 48, 36, 37, 48, 50, 58, 40, 36, 67]

j3037\_3.sm,

solution: [0, 0, 0, 0, 4, 15, 15, 24, 21, 9, 15, 34, 21, 44, 25, 5, 32, 49, 28, 44, 42, 34, 42, 52, 52, 50, 46, 46, 58, 58, 54, 64]

j3037\_5.sm,

solution: [0, 0, 10, 27, 18, 18, 18, 20, 27, 27, 37, 37, 45, 37, 37, 45, 57, 47, 45, 47, 64, 54, 64, 64, 73, 65, 57, 68, 78, 68, 76, 79]

j3037\_6.sm,

solution: [0, 0, 0, 6, 11, 8, 11, 18, 22, 29, 22, 39, 8, 23, 18, 44, 39, 39, 46, 29, 39, 48, 33, 49, 56, 54, 49, 51, 67, 67, 66, 72]

j3037\_9.sm,

solution: [0, 0, 0, 0, 5, 6, 10, 6, 12, 17, 21, 21, 21, 32, 37, 30, 5, 17, 32, 43, 42, 35, 32, 33, 35, 47, 40, 50, 52, 37, 47, 54]

j3037\_10.sm

solution: [0, 5, 0, 0, 33, 11, 7, 13, 11, 23, 13, 33, 15, 23, 44, 36, 19, 48, 34, 48, 33, 44, 56, 57, 48, 56, 19, 37, 65, 62, 73, 79]

j3038\_1.sm,

solution: [0, 6, 0, 0, 1, 1, 1, 13, 6, 11, 6, 6, 13, 8, 13, 12, 15, 15, 18, 10, 20, 22, 30, 22, 33, 37, 33, 30, 38, 42, 38, 47]

j3038\_3.sm,

solution: [0, 0, 0, 0, 3, 11, 21, 6, 11, 21, 11, 21, 24, 14, 14, 33, 24, 37, 24, 25, 31, 33, 38, 47, 38, 42, 30, 37, 49, 43, 47, 58]

j3038\_9.sm,

solution: [0, 0, 0, 0, 7, 7, 15, 9, 9, 23, 7, 23, 15, 13, 23, 11, 26, 26, 24, 31, 38, 47, 28, 38, 35, 35, 44, 44, 52, 48, 47, 57]

j3039\_9.sm,

solution: [0, 0, 0, 0, 10, 5, 12, 21, 16, 5, 12, 5, 18, 18, 16, 21, 28, 26, 35, 36, 30, 26, 36, 36, 36, 41, 48, 43, 49, 51, 48, 58]

j3039\_10.sm

solution: [0, 0, 0, 0, 13, 8, 8, 13, 16, 16, 19, 2, 19, 14, 16, 28, 17, 13, 28, 22, 32, 19, 32, 40, 39, 40, 44, 37, 49, 49, 29, 58]

j3041\_1.sm,

solution: [0, 0, 8, 0, 3, 3, 13, 18, 18, 18, 21, 24, 42, 28, 34, 32, 54, 42, 71, 28, 49, 36, 64, 42, 54, 54, 65, 63, 71, 80, 80, 85]

j3041\_2.sm,

solution: [0, 0, 8, 10, 8, 13, 19, 22, 27, 25, 22, 25, 19, 34, 33, 39, 27, 54, 49, 49, 54, 62, 54, 41, 62, 64, 52, 73, 74, 70, 79, 81]

j3041\_3.sm,

solution: [0, 0, 0, 20, 10, 20, 10, 30, 50, 7, 56, 30, 43, 30, 48, 40, 59, 43, 49, 50, 56, 62, 60, 56, 59, 64, 66, 66, 72, 75, 64, 81]

j3041\_4.sm,

solution: [0, 0, 0, 0, 6, 7, 20, 29, 9, 8, 9, 25, 23, 4, 29, 29, 18, 15, 24, 36, 43, 50, 33, 39, 50, 33, 52, 55, 65, 56, 65, 75]

j3041\_5.sm,

solution: [0, 0, 26, 0, 10, 39, 36, 10, 36, 26, 26, 18, 47, 58, 52, 33, 46, 58, 46, 68, 52, 78, 71, 62, 78, 86, 81, 71, 85, 95, 86, 98]

j3041\_6.sm,

solution: [0, 0, 0, 12, 9, 16, 27, 9, 12, 31, 27, 43, 32, 36, 49, 72, 53, 20, 53, 76, 77, 57, 65, 81, 37, 72, 73, 83, 91, 83, 96, 102]

j3041\_10.sm

solution: [0, 0, 0, 0, 2, 9, 41, 9, 32, 19, 20, 32, 22, 55, 28, 20, 55, 50, 46, 22, 46, 75, 55, 82, 65, 65, 58, 64, 86, 67, 86, 96]

j3042\_3.sm,

solution: [0, 11, 0, 0, 1, 10, 1, 18, 11, 10, 16, 16, 30, 20, 30, 30, 40, 10, 40, 20, 20, 48, 32, 41, 42, 48, 32, 41, 55, 48, 51, 59]

j3042\_6.sm,

solution: [0, 0, 0, 0, 7, 6, 13, 23, 13, 13, 31, 7, 17, 14, 34, 47, 23, 34, 27, 23, 34, 43, 39, 47, 49, 39, 51, 53, 60, 43, 55, 65]

j3042\_8.sm,

solution: [0, 0, 0, 3, 13, 16, 22, 7, 15, 15, 22, 22, 28, 37, 28, 28, 36, 45, 58, 40, 32, 32, 40, 48, 42, 40, 53, 61, 58, 52, 70, 77]

j3043\_10.sm

solution: [0, 0, 0, 0, 9, 6, 1, 18, 6, 25, 7, 25, 7, 18, 12, 18, 27, 12, 27, 35, 33, 41, 27, 47, 30, 46, 44, 47, 52, 41, 56, 59]

j3045\_2.sm,

solution: [0, 0, 10, 0, 1, 10, 18, 18, 33, 25, 34, 39, 4, 84, 76, 26, 34, 49, 49, 67, 59, 67, 92, 95, 107, 101, 93, 103, 92, 109, 109, 111]

j3045\_5.sm,

solution: [0, 10, 0, 0, 10, 32, 14, 10, 14, 19, 21, 31, 41, 16, 50, 47, 32, 56, 51, 50, 56, 41, 48, 70, 61, 71, 60, 64, 74, 74, 75, 84]

j3045\_6.sm,

solution: [0, 0, 0, 17, 17, 7, 28, 24, 28, 35, 9, 43, 33, 61, 36, 52, 22, 70, 83, 83, 79, 41, 61, 49, 71, 79, 108, 68, 118, 99, 90, 128]

j3045\_7.sm,

solution: [0, 0, 2, 0, 12, 20, 20, 21, 30, 10, 30, 38, 59, 61, 46, 50, 62, 50, 72, 77, 38, 28, 51, 92, 94, 67, 72, 85, 92, 85, 98, 100]

j3046\_6.sm,

solution: [0, 0, 0, 0, 5, 7, 10, 19, 10, 22, 5, 7, 10, 19, 19, 10, 25, 30, 34, 35, 13, 28, 35, 30, 37, 37, 44, 37, 54, 50, 44, 58]

j3047\_5.sm,

solution: [0, 0, 0, 0, 7, 7, 9, 11, 17, 20, 11, 14, 17, 15, 7, 20, 14, 23, 23, 21, 29, 27, 33, 29, 34, 34, 29, 33, 39, 40, 44, 46]

j3047\_7.sm,

solution: [0, 0, 0, 0, 13, 5, 5, 7, 5, 11, 20, 9, 12, 16, 16, 12, 23, 11, 22, 32, 24, 24, 23, 34, 36, 34, 40, 46, 40, 43, 54, 63]