Table 1: Greedy Algorithm (50 Runs)

| Test Problem | p | n | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0 | 0 | 0.1 | 0.01 | 1.2 | 1.2 | 1.2 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 0 | 0 | 0.0 | 0.01 | 0.6 | 0.6 | 0.6 | 0 |
| 3 | 10 | 100 | 198 | 4250 | 0 | 0 | 0.1 | 0.01 | 3.5 | 3.5 | 3.5 | 0 |
| 4 | 20 | 100 | 196 | 3034 | 0 | 0 | 0.1 | 0.01 | 2 | 1.8 | 2.2 | 0.2 |
| 5 | 33 | 100 | 196 | 1355 | 0 | 0 | 0.1 | 0.01 | 2.6 | 1.7 | 4.4 | 0.69 |
| 6 | 5 | 200 | 786 | 7824 | 0 | 0 | 0.1 | 0.02 | 2.6 | 2.6 | 2.6 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 0 | 0 | 0.1 | 0.02 | 0.3 | 0.3 | 0.3 | 0 |
| 8 | 20 | 200 | 792 | 4445 | 0 | 0 | 0.1 | 0.02 | 1.6 | 1.5 | 2.3 | 0.16 |
| 9 | 40 | 200 | 785 | 2734 | 0.1 | 0 | 0.1 | 0.02 | 4.9 | 4.1 | 5.2 | 0.48 |
| 10 | 67 | 200 | 786 | 1255 | 0.1 | 0.1 | 0.2 | 0.02 | 5.5 | 3.6 | 7.8 | 1.6 |
| 11 | 5 | 300 | 1772 | 7696 | 0 | 0 | 0.1 | 0.02 | 0.3 | 0.3 | 0.3 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.1 | 0 | 0.1 | 0.03 | 0.3 | 0.3 | 0.3 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 0.2 | 0.1 | 0.2 | 0.03 | 2.3 | 2.3 | 2.3 | 0 |
| 14 | 60 | 300 | 1771 | 2968 | 0.3 | 0.2 | 0.4 | 0.03 | 2.5 | 2.1 | 3.1 | 0.26 |
| 15 | 100 | 300 | 1754 | 1729 | 0.5 | 0.4 | 0.6 | 0.04 | 6.2 | 4.5 | 7.9 | 0.83 |
| 16 | 5 | 400 | 3153 | 8162 | 0.1 | 0 | 0.1 | 0.03 | 0.9 | 0.9 | 0.9 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.1 | 0.1 | 0.2 | 0.04 | 0.3 | 0.3 | 0.3 | 0 |
| 18 | 40 | 400 | 3134 | 4809 | 0.4 | 0.3 | 0.6 | 0.07 | 1.4 | 1.3 | 1.5 | 0.07 |
| 19 | 80 | 400 | 3134 | 2845 | 0.8 | 0.6 | 0.9 | 0.06 | 3.9 | 3.6 | 4.3 | 0.19 |
| 20 | 133 | 400 | 3144 | 1789 | 1.4 | 1.3 | 1.6 | 0.07 | 7.6 | 5.8 | 8.9 | 0.69 |

Table 1: Greedy Algorithm (50 Runs)

| Test Problem | p | n | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.1 | 0 | 0.2 | 0.04 | 0 | 0 | 0 | 0 |
| 22 | 10 | 500 | 4896 | 8579 | 0.2 | 0.1 | 0.2 | 0.04 | 1.1 | 1.1 | 1.1 | 0 |
| 23 | 50 | 500 | 4903 | 4619 | 0.7 | 0.5 | 0.8 | 0.05 | 1.6 | 1.5 | 1.8 | 0.11 |
| 24 | 100 | 500 | 4914 | 2961 | 1.9 | 1.4 | 2.5 | 0.36 | 2.2 | 1.8 | 2.5 | 0.16 |
| 25 | 167 | 500 | 4894 | 1828 | 2.8 | 2.6 | 3.2 | 0.12 | 7.9 | 6.6 | 9.6 | 0.65 |
| 26 | 5 | 600 | 7069 | 9917 | 0.1 | 0.1 | 0.2 | 0.03 | 1.8 | 1.8 | 1.8 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 0.2 | 0.2 | 0.3 | 0.04 | 0.8 | 0.8 | 0.8 | 0 |
| 28 | 60 | 600 | 7054 | 4498 | 1.5 | 1.2 | 1.7 | 0.1 | 1.8 | 1.7 | 2.2 | 0.12 |
| 29 | 120 | 600 | 7042 | 3033 | 3 | 2.7 | 3.5 | 0.17 | 3.5 | 2.5 | 4.5 | 0.53 |
| 30 | 200 | 600 | 7042 | 1989 | 5.2 | 4.9 | 5.8 | 0.22 | 9.1 | 7.1 | 10.1 | 0.55 |
| 31 | 5 | 700 | 9601 | 10086 | 0.1 | 0.1 | 0.2 | 0.03 | 0 | 0 | 0 | 0 |
| 32 | 10 | 700 | 9584 | 9297 | 0.2 | 0.1 | 0.3 | 0.04 | 0.4 | 0.4 | 0.4 | 0 |
| 33 | 70 | 700 | 9616 | 4700 | 1.8 | 1.6 | 2.0 | 0.1 | 2.1 | 2 | 2.3 | 0.11 |
| 34 | 140 | 700 | 9585 | 3013 | 3.7 | 3.5 | 4.1 | 0.13 | 2.9 | 2 | 3.8 | 0.56 |
| 35 | 5 | 800 | 12548 | 10400 | 0.2 | 0.1 | 0.4 | 0.06 | 0.1 | 0.1 | 0.1 | 0 |
| 36 | 10 | 800 | 12560 | 9934 | 0.6 | 0.5 | 0.7 | 0.03 | 0.2 | 0.2 | 0.2 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 2.8 | 2.4 | 3.9 | 0.25 | 1.5 | 1.2 | 1.9 | 0.2 |
| 38 | 5 | 900 | 15898 | 11060 | 0.3 | 0.3 | 0.4 | 0.02 | 0.8 | 0.8 | 0.8 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 0.6 | 0.5 | 0.7 | 0.04 | 0.3 | 0.3 | 0.3 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 3.6 | 3.2 | 4.1 | 0.22 | 1.8 | 1.3 | 2 | 0.18 |

Table 2: Fast Greedy Algorithm Results (50 Runs)

| Test Problem | p | n | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0 | 0 | 0.1 | 0.01 | 20.3 | 20.3 | 20.3 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 0 | 0 | 0.1 | 0.01 | 66.3 | 66.3 | 66.3 | 0 |
| 3 | 10 | 100 | 198 | 4250 | 0 | 0 | 0.1 | 0.01 | 64.9 | 64.9 | 64.9 | 0 |
| 4 | 20 | 100 | 196 | 3034 | 0.1 | 0.1 | 0.1 | 0.01 | 178.3 | 178.3 | 178.3 | 0 |
| 5 | 33 | 100 | 196 | 1355 | 0.1 | 0.1 | 0.1 | 0.01 | 376.4 | 376.4 | 376.4 | 0 |
| 6 | 5 | 200 | 786 | 7824 | 0 | 0 | 0.1 | 0.01 | 10.1 | 10.1 | 10.1 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 0 | 0 | 0.1 | 0.01 | 41.8 | 41.8 | 41.8 | 0 |
| 8 | 20 | 200 | 792 | 4445 | 0.1 | 0.1 | 0.1 | 0.01 | 108.4 | 108.4 | 108.4 | 0 |
| 9 | 40 | 200 | 785 | 2734 | 0.1 | 0.1 | 0.2 | 0.01 | 221.2 | 221.2 | 221.2 | 0 |
| 10 | 67 | 200 | 786 | 1255 | 0.2 | 0.2 | 0.3 | 0.02 | 457.9 | 457.9 | 457.9 | 0 |
| 11 | 5 | 300 | 1772 | 7696 | 0 | 0 | 0.1 | 0.01 | 11.1 | 11.1 | 11.1 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.1 | 0 | 0.1 | 0.02 | 36.2 | 36.2 | 36.2 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 0.1 | 0.1 | 0.2 | 0.02 | 110.1 | 110.1 | 110.1 | 0 |
| 14 | 60 | 300 | 1771 | 2968 | 0.2 | 0.2 | 0.3 | 0.02 | 262.5 | 262.5 | 262.5 | 0 |
| 15 | 100 | 300 | 1754 | 1729 | 0.4 | 0.3 | 0.5 | 0.03 | 417.7 | 417.4 | 418.2 | 0.4 |
| 16 | 5 | 400 | 3153 | 8162 | 0.1 | 0 | 0.1 | 0.03 | 6.8 | 6.8 | 6.8 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.1 | 0 | 0.1 | 0.03 | 37.1 | 37.1 | 37.1 | 0 |
| 18 | 40 | 400 | 3134 | 4809 | 0.2 | 0.1 | 0.2 | 0.03 | 122.7 | 122.7 | 122.7 | 0 |
| 19 | 80 | 400 | 3134 | 2845 | 0.3 | 0.3 | 0.4 | 0.03 | 262.5 | 262.5 | 262.5 | 0 |
| 20 | 133 | 400 | 3144 | 1789 | 0.5 | 0.5 | 0.7 | 0.05 | 547 | 547 | 547 | 0 |

Table 2: Fast Greedy Algorithm Results (50 Runs)

| Test Problem | p | n | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.1 | 0 | 0.2 | 0.04 | 7.6 | 7.6 | 7.6 | 0 |
| 22 | 10 | 500 | 4896 | 8579 | 0.1 | 0.1 | 0.2 | 0.02 | 24.9 | 24.8 | 24.9 | 0.06 |
| 23 | 50 | 500 | 4903 | 4619 | 0.3 | 0.2 | 0.3 | 0.03 | 142.3 | 142.3 | 142.3 | 0 |
| 24 | 100 | 500 | 4914 | 2961 | 0.5 | 0.4 | 0.8 | 0.08 | 286.1 | 285.9 | 286.3 | 0.2 |
| 25 | 167 | 500 | 4894 | 1828 | 0.6 | 0.6 | 0.8 | 0.04 | 499 | 499 | 499 | 0 |
| 26 | 5 | 600 | 7069 | 9917 | 0.1 | 0.1 | 0.2 | 0.04 | 5.4 | 5.4 | 5.4 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 0.1 | 0.1 | 0.2 | 0.02 | 24.1 | 24.1 | 24.1 | 0 |
| 28 | 60 | 600 | 7054 | 4498 | 0.3 | 0.3 | 0.4 | 0.04 | 132.7 | 132.2 | 133.3 | 0.55 |
| 29 | 120 | 600 | 7042 | 3033 | 0.5 | 0.5 | 0.6 | 0.04 | 279.7 | 279.7 | 279.7 | 0 |
| 30 | 200 | 600 | 7042 | 1989 | 0.8 | 0.7 | 0.9 | 0.04 | 542.6 | 542.6 | 542.6 | 0 |
| 31 | 5 | 700 | 9601 | 10086 | 0.2 | 0.1 | 0.2 | 0.03 | 7.4 | 7.4 | 7.4 | 0 |
| 32 | 10 | 700 | 9584 | 9297 | 0.2 | 0.1 | 0.2 | 0.03 | 28.5 | 28.5 | 28.5 | 0 |
| 33 | 70 | 700 | 9616 | 4700 | 0.4 | 0.3 | 0.5 | 0.04 | 167.8 | 167.8 | 167.8 | 0 |
| 34 | 140 | 700 | 9585 | 3013 | 0.6 | 0.6 | 0.9 | 0.05 | 302.9 | 302.9 | 302.9 | 0 |
| 35 | 5 | 800 | 12548 | 10400 | 0.2 | 0.1 | 0.3 | 0.04 | 4.3 | 4.3 | 4.3 | 0 |
| 36 | 10 | 800 | 12560 | 9934 | 0.2 | 0.2 | 0.3 | 0.04 | 26.4 | 26.4 | 26.4 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 0.5 | 0.4 | 0.5 | 0.03 | 172.2 | 172.2 | 172.2 | 0.02 |
| 38 | 5 | 900 | 15898 | 11060 | 0.2 | 0.2 | 0.3 | 0.03 | 5.9 | 5.9 | 5.9 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 0.2 | 0.2 | 0.3 | 0.03 | 23.3 | 23.3 | 23.3 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 0.6 | 0.5 | 0.7 | 0.04 | 167.6 | 167.6 | 167.6 | 0 |

Table 3: Stingy Algorithm Results (50 Runs)

| Test Problem | p | n | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 3.3 | 3.2 | 4.2 | 0.16 | 116.1 | 116.1 | 116.1 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 3.3 | 3.2 | 3.6 | 0.11 | 131.9 | 126.3 | 138.1 | 3.4 |
| 3 | 10 | 100 | 198 | 4250 | 3.3 | 3.2 | 3.6 | 0.11 | 130.6 | 130.4 | 131 | 0.29 |
| 4 | 20 | 100 | 196 | 3034 | 3.1 | 3 | 3.7 | 0.12 | 108.5 | 106.7 | 110.2 | 1.78 |
| 5 | 33 | 100 | 196 | 1355 | 2.9 | 2.8 | 3.4 | 0.15 | 145 | 138.5 | 155.6 | 8.07 |
| 6 | 5 | 200 | 786 | 7824 | 28.2 | 27.8 | 30.2 | 0.47 | 99.2 | 99.2 | 99.2 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 28.1 | 27.6 | 28.7 | 0.36 | 125.3 | 124.5 | 126.1 | 0.81 |
| 8 | 20 | 200 | 792 | 4445 | 27.8 | 27.4 | 28.4 | 0.34 | 131.3 | 128.7 | 133 | 2.1 |
| 9 | 40 | 200 | 785 | 2734 | 26.9 | 26.5 | 27.5 | 0.37 | 135.3 | 132.2 | 137.1 | 2.34 |
| 10 | 67 | 200 | 786 | 1255 | 25 | 24.4 | 28.5 | 0.77 | 173.2 | 173.2 | 173.2 | 0 |
| 11 | 5 | 300 | 1772 | 7696 | 131.8 | 131.5 | 132.3 | 0.38 | 154.2 | 148.2 | 172.4 | 12.12 |
| 12 | 10 | 300 | 1758 | 6634 | 131.4 | 131.1 | 131.6 | 0.23 | 163 | 163 | 163 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 130.1 | 129.7 | 130.7 | 0.44 | 149.6 | 149.6 | 149.6 | 0 |
| 14 | 60 | 300 | 1771 | 2968 | 125.5 | 125.2 | 125.9 | 0.26 | 138.7 | 137 | 140.6 | 1.97 |
| 15 | 100 | 300 | 1754 | 1729 | 116.4 | 115.8 | 117.4 | 0.38 | 125.8 | 123.7 | 127.3 | 1.03 |
| 16 | 5 | 400 | 3153 | 8162 | 406.3 | 406.1 | 406.5 | 0.17 | 149.7 | 149.7 | 149.7 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 406.8 | 405.4 | 408.1 | 1.41 | 136.8 | 135.4 | 141 | 2.79 |
| 18 | 40 | 400 | 3134 | 4809 | 402.4 | 400.1 | 408.2 | 3.86 | 135.7 | 134.2 | 136.9 | 1.26 |
| 19 | 80 | 400 | 3134 | 2845 | 389.6 | 388.9 | 390.5 | 0.69 | 124.3 | 124 | 124.7 | 0.33 |
| 20 | 133 | 400 | 3144 | 1789 | 359 | 358.8 | 359.2 | 0.19 | 128.2 | 128.2 | 128.2 | 0 |

Table 4: **Alternate Algorithm - Greedy (50 Runs)**

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0 | 0 | 0.1 | 0.01 | 1.2 | 1.2 | 1.2 | 0 | 2 | 2 | 2 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 0.2 | 0.1 | 0.3 | 0.06 | 0.3 | 0.3 | 0.3 | 0 | 3.9 | 3 | 5 | 0.81 |
| 3 | 10 | 100 | 198 | 4250 | 0.2 | 0.1 | 0.4 | 0.09 | 2 | 2 | 2 | 0.03 | 4.4 | 3 | 7 | 1.31 |
| 4 | 20 | 100 | 196 | 3034 | 0.4 | 0.1 | 0.5 | 0.09 | 1.8 | 1.8 | 1.8 | 0 | 3.7 | 2 | 4 | 0.56 |
| 5 | 33 | 100 | 196 | 1355 | 1.1 | 0.8 | 1.6 | 0.21 | 0.5 | 0.4 | 0.6 | 0.04 | 6.1 | 5 | 8 | 0.95 |
| 6 | 5 | 200 | 786 | 7824 | 0 | 0 | 0.1 | 0.01 | 2.6 | 2.6 | 2.6 | 0 | 2 | 2 | 2 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 0.1 | 0 | 0.2 | 0.04 | 0.3 | 0.2 | 0.3 | 0.01 | 2.4 | 2 | 3 | 0.5 |
| 8 | 20 | 200 | 792 | 4445 | 0.5 | 0.2 | 0.6 | 0.11 | 0.3 | 0.3 | 0.3 | 0 | 4.3 | 3 | 5 | 0.84 |
| 9 | 40 | 200 | 785 | 2734 | 1.3 | 1 | 1.9 | 0.25 | 1.9 | 1.9 | 2.4 | 0.07 | 5.8 | 5 | 8 | 0.94 |
| 10 | 67 | 200 | 786 | 1255 | 2.9 | 1.8 | 4.4 | 0.7 | 1.9 | 1.8 | 3 | 0.3 | 7.5 | 5 | 11 | 1.55 |
| 11 | 5 | 300 | 1772 | 7696 | 0.1 | 0.1 | 0.1 | 0.01 | 0.2 | 0.2 | 0.2 | 0 | 3 | 3 | 3 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.1 | 0.1 | 0.1 | 0.01 | 0.3 | 0.3 | 0.3 | 0 | 2 | 2 | 2 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 0.7 | 0.4 | 1 | 0.17 | 1.9 | 1.9 | 1.9 | 0 | 4.4 | 3 | 5 | 0.78 |
| 14 | 60 | 300 | 1771 | 2968 | 2.2 | 1.6 | 3.7 | 0.55 | 0.9 | 0.9 | 1 | 0.02 | 6.4 | 5 | 10 | 1.35 |
| 15 | 100 | 300 | 1754 | 1729 | 4.5 | 2.6 | 7.2 | 1.12 | 0.8 | 0.8 | 1.3 | 0.08 | 7.8 | 5 | 12 | 1.71 |
| 16 | 5 | 400 | 3153 | 8162 | 0 | 0 | 0.1 | 0.01 | 0.9 | 0.9 | 0.9 | 0 | 2 | 2 | 2 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.1 | 0.1 | 0.2 | 0.01 | 0.2 | 0.2 | 0.2 | 0 | 3 | 3 | 3 | 0 |
| 18 | 40 | 400 | 3134 | 4809 | 1.3 | 0.8 | 1.6 | 0.13 | 0.5 | 0.5 | 0.5 | 0 | 5.9 | 4 | 6 | 0.48 |
| 19 | 80 | 400 | 3134 | 2845 | 3.4 | 2.1 | 4.8 | 0.67 | 0.8 | 0.8 | 1.2 | 0.08 | 7.3 | 5 | 10 | 1.25 |
| 20 | 133 | 400 | 3144 | 1789 | 7 | 3.5 | 11.3 | 1.7 | 1.7 | 1.1 | 2.3 | 0.35 | 8.9 | 5 | 13 | 1.87 |

Table 4: **Alternate Algorithm - Greedy (50 Runs)**

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0 | 0 | 0.1 | 0.01 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 |
| 22 | 10 | 500 | 4896 | 8579 | 0.1 | 0.1 | 0.1 | 0.01 | 1.1 | 1.1 | 1.1 | 0 | 2 | 2 | 2 | 0 |
| 23 | 50 | 500 | 4903 | 4619 | 1.2 | 0.7 | 2.4 | 0.33 | 1 | 1 | 1.1 | 0.03 | 4.6 | 3 | 8 | 0.99 |
| 24 | 100 | 500 | 4914 | 2961 | 4.1 | 2.7 | 5.8 | 0.87 | 1 | 0.9 | 1.1 | 0.04 | 7.1 | 5 | 9 | 1.25 |
| 25 | 167 | 500 | 4894 | 1828 | 7.3 | 4.4 | 10.5 | 1.45 | 1.8 | 1.8 | 1.9 | 0.04 | 7.5 | 5 | 10 | 1.31 |
| 26 | 5 | 600 | 7069 | 9917 | 0 | 0 | 0.1 | 0.01 | 1.8 | 1.8 | 1.8 | 0 | 2 | 2 | 2 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 0.1 | 0.1 | 0.2 | 0.01 | 0.6 | 0.6 | 0.6 | 0 | 3 | 3 | 3 | 0 |
| 28 | 60 | 600 | 7054 | 4498 | 2 | 0.8 | 3.5 | 0.56 | 0.6 | 0.5 | 0.6 | 0.03 | 5.9 | 3 | 9 | 1.34 |
| 29 | 120 | 600 | 7042 | 3033 | 4.8 | 3.1 | 7.1 | 1.13 | 1.1 | 1.1 | 1.4 | 0.05 | 7 | 5 | 10 | 1.4 |
| 30 | 200 | 600 | 7042 | 1989 | 8.4 | 5.3 | 11.9 | 1.61 | 1.5 | 1.5 | 1.7 | 0.06 | 7.3 | 5 | 10 | 1.19 |
| 31 | 5 | 700 | 9601 | 10086 | 0 | 0 | 0.1 | 0.01 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 |
| 32 | 10 | 700 | 9584 | 9297 | 0.2 | 0.1 | 0.2 | 0.02 | 0.2 | 0.2 | 0.2 | 0.02 | 3 | 3 | 3 | 0 |
| 33 | 70 | 700 | 9616 | 4700 | 2.8 | 1.4 | 5.2 | 0.65 | 1.3 | 1.3 | 1.4 | 0.03 | 6.8 | 4 | 11 | 1.33 |
| 34 | 140 | 700 | 9585 | 3013 | 6.3 | 3.9 | 10.2 | 1.53 | 1.5 | 1.5 | 1.6 | 0.05 | 7.8 | 5 | 12 | 1.64 |
| 35 | 5 | 800 | 12548 | 10400 | 0 | 0 | 0.1 | 0.01 | 0.1 | 0.1 | 0.1 | 0 | 2 | 2 | 2 | 0 |
| 36 | 10 | 800 | 12560 | 9934 | 0.2 | 0.1 | 0.2 | 0.02 | 0.1 | 0.1 | 0.1 | 0 | 3 | 3 | 3 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 3.1 | 2.1 | 5.2 | 0.65 | 1.1 | 1.1 | 1.1 | 0.01 | 6.7 | 5 | 10 | 1.16 |
| 38 | 5 | 900 | 15898 | 11060 | 0 | 0 | 0.1 | 0.01 | 0.8 | 0.8 | 0.8 | 0 | 2 | 2 | 2 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 0.1 | 0.1 | 0.1 | 0.01 | 0.3 | 0.3 | 0.3 | 0 | 2 | 2 | 2 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 2.8 | 1.2 | 4.5 | 0.69 | 0.9 | 0.9 | 0.9 | 0.02 | 5.6 | 3 | 8 | 1.13 |

Table 5: Alternate Algorithm - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0.1 | 0.1 | 0.2 | 0.03 | 2.9 | 2.9 | 2.9 | 0 | 4.3 | 4 | 5 | 0.44 |
| 2 | 10 | 100 | 193 | 4093 | 0.3 | 0.2 | 0.5 | 0.09 | 22.8 | 21.8 | 26.4 | 1.78 | 5.2 | 4 | 8 | 1.2 |
| 3 | 10 | 100 | 198 | 4250 | 0.3 | 0.1 | 0.5 | 0.1 | 13.5 | 11.4 | 22.6 | 3.08 | 5.8 | 3 | 9 | 1.49 |
| 4 | 20 | 100 | 196 | 3034 | 0.9 | 0.5 | 1.5 | 0.26 | 16.8 | 7.2 | 25 | 3.57 | 7.4 | 5 | 12 | 1.89 |
| 5 | 33 | 100 | 196 | 1355 | 2.1 | 1.1 | 3.3 | 0.53 | 23.4 | 14.4 | 33.1 | 5.87 | 10.7 | 6 | 16 | 2.43 |
| 6 | 5 | 200 | 786 | 7824 | 0.1 | 0.1 | 0.3 | 0.05 | 14.8 | 13.8 | 17.6 | 1.66 | 4.6 | 3 | 9 | 1.26 |
| 7 | 10 | 200 | 779 | 5631 | 0.3 | 0.2 | 0.5 | 0.06 | 13.5 | 12 | 19 | 2.42 | 4.9 | 4 | 7 | 0.77 |
| 8 | 20 | 200 | 792 | 4445 | 0.9 | 0.4 | 1.6 | 0.25 | 10.4 | 9.1 | 11.8 | 0.98 | 7.6 | 4 | 13 | 1.86 |
| 9 | 40 | 200 | 785 | 2734 | 1.9 | 1.3 | 3.2 | 0.37 | 22.2 | 20.8 | 23.8 | 1.37 | 8 | 6 | 13 | 1.37 |
| 10 | 67 | 200 | 786 | 1255 | 4.4 | 2.2 | 7 | 0.99 | 39.1 | 38.3 | 45.6 | 1.24 | 10.8 | 6 | 17 | 2.2 |
| 11 | 5 | 300 | 1772 | 7696 | 0.2 | 0.1 | 0.2 | 0.02 | 2.1 | 2.1 | 2.1 | 0 | 5 | 5 | 5 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.3 | 0.3 | 0.5 | 0.07 | 14 | 13.1 | 14.6 | 0.73 | 5.6 | 5 | 7 | 0.84 |
| 13 | 30 | 300 | 1760 | 4374 | 2 | 0.8 | 4 | 0.74 | 14.6 | 11.5 | 19.2 | 2.43 | 10.6 | 5 | 21 | 3.69 |
| 14 | 60 | 300 | 1771 | 2968 | 4 | 2.4 | 6 | 0.94 | 25.2 | 22.5 | 28.2 | 1.3 | 11 | 7 | 16 | 2.31 |
| 15 | 100 | 300 | 1754 | 1729 | 6.4 | 3.9 | 9.1 | 1.12 | 34.3 | 29 | 37.7 | 1.88 | 10.7 | 7 | 14 | 1.64 |
| 16 | 5 | 400 | 3153 | 8162 | 0.1 | 0.1 | 0.2 | 0.02 | 3.2 | 3.2 | 3.2 | 0 | 5 | 5 | 5 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.3 | 0.2 | 0.4 | 0.05 | 12.6 | 12.4 | 12.9 | 0.22 | 4.8 | 4 | 6 | 0.77 |
| 18 | 40 | 400 | 3134 | 4809 | 2.4 | 1.3 | 4.8 | 0.66 | 14.6 | 9.6 | 19.5 | 3.06 | 10 | 6 | 19 | 2.33 |
| 19 | 80 | 400 | 3134 | 2845 | 5.7 | 3.7 | 8.1 | 1.04 | 22.7 | 19.3 | 26.1 | 1.74 | 11.6 | 8 | 16 | 1.88 |
| 20 | 133 | 400 | 3144 | 1789 | 10.2 | 6.1 | 14.9 | 1.88 | 26 | 23.5 | 28.7 | 1.45 | 12.5 | 8 | 18 | 2.13 |

Table 5: Alternate Algorithm - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.2 | 0.1 | 0.2 | 0.04 | 12.4 | 12.4 | 12.4 | 0 | 5.8 | 5 | 7 | 0.93 |
| 22 | 10 | 500 | 4896 | 8579 | 0.2 | 0.2 | 0.3 | 0.03 | 15.5 | 15.5 | 15.5 | 0 | 4 | 4 | 4 | 0 |
| 23 | 50 | 500 | 4903 | 4619 | 2.6 | 1.6 | 4.3 | 0.56 | 13.8 | 11.6 | 16.2 | 1.2 | 8.7 | 6 | 14 | 1.62 |
| 24 | 100 | 500 | 4914 | 2961 | 6.9 | 4.6 | 11.4 | 1.23 | 18.8 | 17.3 | 20.5 | 0.66 | 11.4 | 8 | 17 | 1.74 |
| 25 | 167 | 500 | 4894 | 1828 | 13.4 | 7.6 | 20.9 | 2.42 | 29.1 | 24.7 | 32.8 | 2.03 | 13.1 | 8 | 20 | 2.15 |
| 26 | 5 | 600 | 7069 | 9917 | 0.1 | 0.1 | 0.1 | 0.02 | 4.3 | 4.3 | 4.3 | 0 | 3 | 3 | 3 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 0.3 | 0.2 | 0.4 | 0.08 | 11.9 | 11.7 | 12.2 | 0.22 | 5.4 | 4 | 7 | 1.03 |
| 28 | 60 | 600 | 7054 | 4498 | 3.6 | 1.6 | 5.2 | 0.73 | 17.3 | 16 | 18.7 | 0.79 | 9.8 | 5 | 14 | 1.8 |
| 29 | 120 | 600 | 7042 | 3033 | 9.1 | 5 | 13 | 1.52 | 20 | 17.9 | 23.1 | 1.15 | 12.3 | 7 | 17 | 1.86 |
| 30 | 200 | 600 | 7042 | 1989 | 15.5 | 10.6 | 19.9 | 2.18 | 29 | 25.8 | 31.9 | 1.49 | 12.6 | 9 | 16 | 1.62 |
| 31 | 5 | 700 | 9601 | 10086 | 0.2 | 0.1 | 0.3 | 0.05 | 13.5 | 13 | 15.1 | 0.86 | 6 | 4 | 8 | 1.37 |
| 32 | 10 | 700 | 9584 | 9297 | 0.3 | 0.3 | 0.4 | 0.03 | 14.2 | 14.1 | 14.2 | 0.04 | 5.2 | 5 | 6 | 0.43 |
| 33 | 70 | 700 | 9616 | 4700 | 4.4 | 2.8 | 6.6 | 0.97 | 19.1 | 17.7 | 21.1 | 0.85 | 10.1 | 7 | 15 | 1.91 |
| 34 | 140 | 700 | 9585 | 3013 | 11.3 | 8.3 | 15.8 | 1.82 | 20.9 | 19.3 | 22.9 | 0.88 | 13.1 | 10 | 18 | 1.94 |
| 35 | 5 | 800 | 12548 | 10400 | 0.1 | 0.1 | 0.2 | 0.03 | 1.4 | 1.4 | 1.4 | 0 | 4.5 | 4 | 5 | 0.5 |
| 36 | 10 | 800 | 12560 | 9934 | 0.2 | 0.2 | 0.3 | 0.02 | 15.5 | 15.5 | 15.5 | 0 | 4 | 4 | 4 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 5.1 | 2.2 | 9.1 | 1.46 | 13.2 | 11.6 | 15.1 | 0.81 | 10.5 | 5 | 18 | 2.76 |
| 38 | 5 | 900 | 15898 | 11060 | 0.2 | 0.2 | 0.3 | 0.03 | 4.4 | 4.4 | 4.4 | 0 | 6 | 6 | 6 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 0.5 | 0.4 | 0.6 | 0.03 | 13.8 | 13.6 | 14.2 | 0.26 | 7 | 7 | 7 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 7.1 | 4.8 | 9 | 1.02 | 14.3 | 12.4 | 15.6 | 0.93 | 12.7 | 9 | 16 | 1.73 |

Table 6: Fast Interchange Algorithm - Greedy (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0.1 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 0.2 | 0.1 | 0.2 | 0.02 | 0.3 | 0.3 | 0.3 | 0 | 3 | 3 | 3 | 0 |
| 3 | 10 | 100 | 198 | 4250 | 0.2 | 0.1 | 0.2 | 0.02 | 0.1 | 0.1 | 0.1 | 0 | 5 | 5 | 5 | 0 |
| 4 | 20 | 100 | 196 | 3034 | 0.2 | 0.2 | 0.3 | 0.02 | 0.4 | 0.4 | 0.4 | 0 | 3 | 3 | 3 | 0 |
| 5 | 33 | 100 | 196 | 1355 | 0.3 | 0.3 | 0.4 | 0.03 | 0.4 | 0.4 | 0.4 | 0 | 3 | 3 | 3 | 0 |
| 6 | 5 | 200 | 786 | 7824 | 0.2 | 0.2 | 0.3 | 0.02 | 0.3 | 0.3 | 0.3 | 0 | 7 | 7 | 7 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 0.3 | 0.3 | 0.4 | 0.02 | 0.2 | 0.2 | 0.2 | 0 | 2 | 2 | 2 | 0 |
| 8 | 20 | 200 | 792 | 4445 | 0.5 | 0.5 | 0.7 | 0.03 | 0.3 | 0.3 | 0.3 | 0 | 4 | 4 | 4 | 0 |
| 9 | 40 | 200 | 785 | 2734 | 0.9 | 0.9 | 1.2 | 0.05 | 0.7 | 0.7 | 0.7 | 0 | 11 | 11 | 11 | 0 |
| 10 | 67 | 200 | 786 | 1255 | 1.2 | 1.2 | 1.4 | 0.05 | 0.6 | 0.6 | 0.6 | 0 | 10 | 10 | 10 | 0 |
| 11 | 5 | 300 | 1772 | 7696 | 0.3 | 0.3 | 0.4 | 0.02 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.5 | 0.5 | 0.6 | 0.04 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 1.2 | 1.2 | 1.5 | 0.06 | 0 | 0 | 0 | 0 | 10 | 10 | 10 | 0 |
| 14 | 60 | 300 | 1771 | 2968 | 2 | 2 | 2.4 | 0.08 | 0.1 | 0.1 | 0.1 | 0 | 16 | 16 | 16 | 0 |
| 15 | 100 | 300 | 1754 | 1729 | 2.7 | 2.6 | 3.1 | 0.11 | 0.6 | 0.6 | 0.6 | 0 | 12 | 12 | 12 | 0 |
| 16 | 5 | 400 | 3153 | 8162 | 0.5 | 0.4 | 0.6 | 0.03 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.7 | 0.6 | 0.7 | 0.02 | 0 | 0 | 0 | 0 | 3 | 3 | 3 | 0 |
| 18 | 40 | 400 | 3134 | 4809 | 2.1 | 2 | 2.4 | 0.09 | 0.1 | 0.1 | 0.1 | 0 | 11 | 11 | 11 | 0 |
| 19 | 80 | 400 | 3134 | 2845 | 3.6 | 3.5 | 4.1 | 0.11 | 0.8 | 0.8 | 0.8 | 0 | 16 | 16 | 16 | 0 |
| 20 | 133 | 400 | 3144 | 1789 | 4.9 | 4.8 | 5.6 | 0.15 | 0.8 | 0.8 | 0.8 | 0 | 24 | 24 | 24 | 0 |

Table 6: Fast Interchange Algorithm - Greedy (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.5 | 0.5 | 0.7 | 0.04 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 22 | 10 | 500 | 4896 | 8579 | 0.8 | 0.8 | 0.9 | 0.02 | 1 | 1 | 1 | 0 | 2 | 2 | 2 | 0 |
| 23 | 50 | 500 | 4903 | 4619 | 3.3 | 3.2 | 3.9 | 0.14 | 0.1 | 0.1 | 0.1 | 0 | 16 | 16 | 16 | 0 |
| 24 | 100 | 500 | 4914 | 2961 | 5.6 | 5.5 | 6.3 | 0.2 | 0.4 | 0.4 | 0.5 | 0.03 | 14 | 14 | 14 | 0 |
| 25 | 167 | 500 | 4894 | 1828 | 7.8 | 7.6 | 8.4 | 0.22 | 1.2 | 1 | 1.3 | 0.08 | 23.8 | 23 | 25 | 0.48 |
| 26 | 5 | 600 | 7069 | 9917 | 0.7 | 0.7 | 0.9 | 0.04 | 0.1 | 0.1 | 0.1 | 0 | 7 | 7 | 7 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 1.1 | 1 | 1.3 | 0.07 | 0.1 | 0.1 | 0.1 | 0 | 6 | 6 | 6 | 0 |
| 28 | 60 | 600 | 7054 | 4498 | 4.8 | 4.6 | 5.6 | 0.22 | 0.3 | 0.3 | 0.3 | 0 | 16.5 | 16 | 17 | 0.51 |
| 29 | 120 | 600 | 7042 | 3033 | 8.3 | 8.1 | 9 | 0.22 | 0.5 | 0.5 | 0.5 | 0 | 21.9 | 21 | 22 | 0.35 |
| 30 | 200 | 600 | 7042 | 1989 | 11.2 | 11 | 11.9 | 0.25 | 1.1 | 1.1 | 1.1 | 0 | 16 | 16 | 16 | 0 |
| 31 | 5 | 700 | 9601 | 10086 | 0.7 | 0.7 | 0.9 | 0.04 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 32 | 10 | 700 | 9584 | 9297 | 1.3 | 1.2 | 1.5 | 0.06 | 0 | 0 | 0 | 0 | 6 | 6 | 6 | 0 |
| 33 | 70 | 700 | 9616 | 4700 | 6.7 | 6.5 | 7.2 | 0.18 | 0.5 | 0.5 | 0.5 | 0 | 22 | 22 | 22 | 0 |
| 34 | 140 | 700 | 9585 | 3013 | 11.5 | 11.3 | 12.2 | 0.29 | 1 | 0.9 | 1 | 0.03 | 28.3 | 28 | 29 | 0.47 |
| 35 | 5 | 800 | 12548 | 10400 | 0.9 | 0.8 | 0.9 | 0.03 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 |
| 36 | 10 | 800 | 12560 | 9934 | 1.5 | 1.4 | 1.7 | 0.08 | 0 | 0 | 0 | 0 | 4 | 4 | 4 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 8.8 | 8.6 | 9.6 | 0.24 | 0.5 | 0.4 | 0.6 | 0.07 | 20.8 | 19 | 22 | 1.33 |
| 38 | 5 | 900 | 15898 | 11060 | 1.1 | 1 | 1.2 | 0.05 | 0.6 | 0.6 | 0.6 | 0 | 4 | 4 | 4 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 1.7 | 1.6 | 1.9 | 0.07 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 11.2 | 11 | 11.7 | 0.21 | 0.5 | 0.4 | 0.5 | 0.02 | 18.5 | 18 | 19 | 0.5 |

Table 7: Fast Interchange Algorithm - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0.2 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 16 | 16 | 16 | 0 |
| 2 | 10 | 100 | 193 | 4093 | 0.2 | 0.2 | 0.3 | 0.02 | 0.2 | 0.2 | 0.2 | 0 | 30 | 30 | 30 | 0 |
| 3 | 10 | 100 | 198 | 4250 | 0.2 | 0.2 | 0.3 | 0.02 | 2.7 | 2.3 | 3.1 | 0.38 | 24.9 | 24 | 26 | 1 |
| 4 | 20 | 100 | 196 | 3034 | 0.3 | 0.3 | 0.4 | 0.02 | 1.2 | 1.2 | 1.2 | 0 | 31 | 31 | 31 | 0 |
| 5 | 33 | 100 | 196 | 1355 | 0.4 | 0.4 | 0.5 | 0.02 | 3.1 | 3.1 | 3.1 | 0 | 37 | 37 | 37 | 0 |
| 6 | 5 | 200 | 786 | 7824 | 0.3 | 0.3 | 0.4 | 0.02 | 0 | 0 | 0 | 0 | 24 | 24 | 24 | 0 |
| 7 | 10 | 200 | 779 | 5631 | 0.5 | 0.4 | 0.6 | 0.03 | 0 | 0 | 0 | 0 | 32 | 32 | 32 | 0 |
| 8 | 20 | 200 | 792 | 4445 | 0.7 | 0.7 | 0.8 | 0.03 | 0.4 | 0.4 | 0.4 | 0 | 47 | 47 | 47 | 0 |
| 9 | 40 | 200 | 785 | 2734 | 1.1 | 1 | 1.3 | 0.06 | 1.3 | 1.2 | 1.3 | 0.02 | 54.5 | 54 | 55 | 0.5 |
| 10 | 67 | 200 | 786 | 1255 | 1.4 | 1.4 | 1.7 | 0.06 | 2.2 | 2.2 | 2.2 | 0 | 61 | 61 | 61 | 0 |
| 11 | 5 | 300 | 1772 | 7696 | 0.4 | 0.4 | 0.6 | 0.04 | 0 | 0 | 0 | 0 | 21 | 21 | 21 | 0 |
| 12 | 10 | 300 | 1758 | 6634 | 0.7 | 0.7 | 0.7 | 0.02 | 0 | 0 | 0 | 0 | 33 | 33 | 33 | 0 |
| 13 | 30 | 300 | 1760 | 4374 | 1.5 | 1.4 | 1.7 | 0.06 | 1 | 0.9 | 1.1 | 0.07 | 61.2 | 60 | 62 | 0.98 |
| 14 | 60 | 300 | 1771 | 2968 | 2.5 | 2.4 | 2.9 | 0.12 | 1.1 | 1.1 | 1.2 | 0.04 | 93.4 | 90 | 95 | 1.3 |
| 15 | 100 | 300 | 1754 | 1729 | 3.2 | 3.1 | 3.6 | 0.13 | 2.6 | 2 | 3.3 | 0.33 | 95.8 | 94 | 98 | 1.02 |
| 16 | 5 | 400 | 3153 | 8162 | 0.6 | 0.6 | 0.6 | 0.02 | 0.3 | 0.3 | 0.3 | 0 | 20 | 20 | 20 | 0 |
| 17 | 10 | 400 | 3142 | 6999 | 0.9 | 0.9 | 1.1 | 0.04 | 0.2 | 0.2 | 0.2 | 0 | 33 | 33 | 33 | 0 |
| 18 | 40 | 400 | 3134 | 4809 | 2.6 | 2.5 | 3.3 | 0.16 | 0.3 | 0.2 | 0.3 | 0.01 | 78.3 | 78 | 79 | 0.46 |
| 19 | 80 | 400 | 3134 | 2845 | 4.3 | 4.2 | 4.8 | 0.13 | 1.5 | 1.3 | 1.7 | 0.12 | 112.7 | 110 | 116 | 1.5 |
| 20 | 133 | 400 | 3144 | 1789 | 5.6 | 5.5 | 6.3 | 0.17 | 3 | 2.8 | 3.4 | 0.16 | 119.2 | 117 | 122 | 1.13 |

Table 7: Fast Interchange Algorithm - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.7 | 0.7 | 0.9 | 0.04 | 0 | 0 | 0 | 0 | 17 | 17 | 17 | 0 |
| 22 | 10 | 500 | 4896 | 8579 | 1.3 | 1.2 | 1.5 | 0.06 | 1.4 | 1.4 | 1.4 | 0 | 45 | 45 | 45 | 0 |
| 23 | 50 | 500 | 4903 | 4619 | 4 | 3.9 | 4.6 | 0.14 | 0.6 | 0.5 | 0.7 | 0.1 | 101.4 | 100 | 102 | 0.93 |
| 24 | 100 | 500 | 4914 | 2961 | 6.7 | 6.6 | 7.5 | 0.2 | 1.4 | 1.3 | 1.5 | 0.07 | 141.2 | 138 | 144 | 1.84 |
| 25 | 167 | 500 | 4894 | 1828 | 8.9 | 8.8 | 9.6 | 0.25 | 2.2 | 1.8 | 2.8 | 0.24 | 142.3 | 139 | 144 | 1.24 |
| 26 | 5 | 600 | 7069 | 9917 | 1 | 1 | 1.2 | 0.05 | 0 | 0 | 0 | 0 | 28 | 28 | 28 | 0 |
| 27 | 10 | 600 | 7072 | 8307 | 1.5 | 1.4 | 1.8 | 0.08 | 0 | 0 | 0 | 0 | 42 | 42 | 42 | 0 |
| 28 | 60 | 600 | 7054 | 4498 | 5.9 | 5.8 | 6.6 | 0.2 | 0.8 | 0.7 | 0.9 | 0.07 | 131.3 | 129 | 133 | 1.25 |
| 29 | 120 | 600 | 7042 | 3033 | 9.9 | 9.8 | 10.7 | 0.24 | 1.4 | 1.2 | 1.6 | 0.1 | 183 | 180 | 187 | 1.95 |
| 30 | 200 | 600 | 7042 | 1989 | 13.2 | 13 | 13.8 | 0.22 | 2.4 | 2 | 2.9 | 0.22 | 179.1 | 176 | 184 | 2 |
| 31 | 5 | 700 | 9601 | 10086 | 1.2 | 1.1 | 1.3 | 0.05 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 0 |
| 32 | 10 | 700 | 9584 | 9297 | 1.8 | 1.8 | 2.1 | 0.07 | 0.1 | 0.1 | 0.1 | 0 | 46 | 46 | 46 | 0 |
| 33 | 70 | 700 | 9616 | 4700 | 8.1 | 8 | 8.7 | 0.15 | 0.6 | 0.5 | 1 | 0.12 | 156.4 | 155 | 161 | 0.99 |
| 34 | 140 | 700 | 9585 | 3013 | 13.8 | 13.5 | 14.4 | 0.25 | 1 | 0.7 | 1.4 | 0.17 | 204.7 | 200 | 211 | 2.8 |
| 35 | 5 | 800 | 12548 | 10400 | 1.3 | 1.3 | 1.5 | 0.05 | 0.3 | 0.3 | 0.3 | 0 | 24 | 24 | 24 | 0 |
| 36 | 10 | 800 | 12560 | 9934 | 2.3 | 2.2 | 2.7 | 0.1 | 0 | 0 | 0 | 0 | 52 | 52 | 52 | 0 |
| 37 | 80 | 800 | 12564 | 5057 | 10.7 | 10.5 | 11.4 | 0.25 | 0.9 | 0.7 | 1 | 0.1 | 171.4 | 169 | 178 | 2.69 |
| 38 | 5 | 900 | 15898 | 11060 | 1.6 | 1.5 | 1.9 | 0.06 | 0.7 | 0.7 | 0.7 | 0 | 26 | 26 | 26 | 0 |
| 39 | 10 | 900 | 15896 | 9423 | 2.4 | 2.3 | 2.7 | 0.1 | 0 | 0 | 0 | 0 | 46 | 46 | 46 | 0 |
| 40 | 90 | 900 | 15879 | 5128 | 13.5 | 13.2 | 14 | 0.25 | 1.2 | 1 | 1.3 | 0.07 | 175 | 173 | 178 | 1.7 |

Table 8: Interchange Algorithm of Teitz and Bart - Greedy (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0.1 | 0 | 0.1 | 0.02 | 0 | 0 | 0 | 0 | 0.1 | 0 | 6 | 0.85 |
| 2 | 10 | 100 | 193 | 4093 | 0.1 | 0 | 0.1 | 0.01 | 0.3 | 0.3 | 0.3 | 0 | 0.1 | 0 | 3 | 0.42 |
| 3 | 10 | 100 | 198 | 4250 | 0.1 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 0.1 | 0 | 7 | 0.99 |
| 4 | 20 | 100 | 196 | 3034 | 0.1 | 0.1 | 0.2 | 0.02 | 0.4 | 0.4 | 0.4 | 0 | 0.1 | 0 | 3 | 0.42 |
| 5 | 33 | 100 | 196 | 1355 | 0.1 | 0.1 | 0.2 | 0.02 | 0.4 | 0.4 | 0.4 | 0 | 0.1 | 0 | 3 | 0.42 |
| 6 | 5 | 200 | 786 | 7824 | 0.1 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 0.2 | 0 | 8 | 1.13 |
| 7 | 10 | 200 | 779 | 5631 | 0.2 | 0.1 | 0.2 | 0.02 | 0.2 | 0.2 | 0.2 | 0 | 0 | 0 | 2 | 0.28 |
| 8 | 20 | 200 | 792 | 4445 | 0.3 | 0.2 | 0.3 | 0.02 | 0.3 | 0.3 | 0.3 | 0 | 0.1 | 0 | 4 | 0.57 |
| 9 | 40 | 200 | 785 | 2734 | 0.7 | 0.7 | 0.9 | 0.04 | 0.7 | 0.7 | 0.7 | 0 | 0.2 | 0 | 12 | 1.7 |
| 10 | 67 | 200 | 786 | 1255 | 0.6 | 0.6 | 0.7 | 0.02 | 0.6 | 0.6 | 0.6 | 0 | 0.2 | 0 | 10 | 1.41 |
| 11 | 5 | 300 | 1772 | 7696 | 0.1 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 0.1 | 0 | 3 | 0.42 |
| 12 | 10 | 300 | 1758 | 6634 | 0.3 | 0.2 | 0.4 | 0.03 | 0 | 0 | 0 | 0 | 0.1 | 0 | 4 | 0.57 |
| 13 | 30 | 300 | 1760 | 4374 | 0.7 | 0.7 | 0.9 | 0.04 | 0 | 0 | 0 | 0 | 0.2 | 0 | 10 | 1.41 |
| 14 | 60 | 300 | 1771 | 2968 | 1.2 | 1.2 | 1.5 | 0.07 | 0.1 | 0.1 | 0.1 | 0 | 0.3 | 0 | 16 | 2.26 |
| 15 | 100 | 300 | 1754 | 1729 | 1.7 | 1.6 | 2 | 0.07 | 0.6 | 0.6 | 0.6 | 0 | 0.2 | 0 | 12 | 1.7 |
| 16 | 5 | 400 | 3153 | 8162 | 0.4 | 0.3 | 0.5 | 0.03 | 0 | 0 | 0 | 0 | 0.1 | 0 | 6 | 0.85 |
| 17 | 10 | 400 | 3142 | 6999 | 0.4 | 0.4 | 0.5 | 0.02 | 0 | 0 | 0 | 0 | 0.1 | 0 | 3 | 0.42 |
| 18 | 40 | 400 | 3134 | 4809 | 2.1 | 2 | 2.4 | 0.08 | 0 | 0 | 0 | 0 | 0.2 | 0 | 12 | 1.7 |
| 19 | 80 | 400 | 3134 | 2845 | 3.7 | 3.6 | 4.1 | 0.12 | 0.6 | 0.6 | 0.6 | 0 | 0.4 | 0 | 21 | 2.97 |
| 20 | 133 | 400 | 3144 | 1789 | 5.1 | 5 | 5.9 | 0.19 | 0.1 | 0.1 | 0.1 | 0 | 0.6 | 0 | 30 | 4.24 |

Table 8: Interchange Algorithm of Teitz and Bart - Greedy (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.2 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.14 |
| 22 | 10 | 500 | 4896 | 8579 | 0.6 | 0.5 | 0.7 | 0.04 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0.28 |
| 23 | 50 | 500 | 4903 | 4619 | 3.7 | 3.6 | 4.1 | 0.1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 18 | 2.55 |
| 24 | 100 | 500 | 4914 | 2961 | 6.3 | 6.2 | 6.9 | 0.19 | 0.3 | 0.3 | 0.3 | 0 | 0.4 | 0 | 18 | 2.55 |
| 25 | 167 | 500 | 4894 | 1828 | 10.1 | 8.6 | 12.3 | 1.43 | 0.9 | 0.7 | 1 | 0.07 | 0.6 | 0 | 29 | 4.1 |
| 26 | 5 | 600 | 7069 | 9917 | 0.4 | 0.4 | 0.6 | 0.03 | 0.1 | 0.1 | 0.1 | 0 | 0.1 | 0 | 7 | 0.99 |
| 27 | 10 | 600 | 7072 | 8307 | 1.2 | 1.1 | 1.4 | 0.06 | 0 | 0 | 0 | 0 | 0.2 | 0 | 8 | 1.13 |
| 28 | 60 | 600 | 7054 | 4498 | 5.8 | 5.7 | 6.5 | 0.2 | 0.2 | 0.2 | 0.2 | 0 | 0.3 | 0 | 17 | 2.4 |
| 29 | 120 | 600 | 7042 | 3033 | 11.8 | 10 | 14 | 1.65 | 0.2 | 0.2 | 0.2 | 0 | 0.6 | 0 | 28 | 3.96 |
| 30 | 200 | 600 | 7042 | 1989 | 13.9 | 13.7 | 15.6 | 0.44 | 1.1 | 1.1 | 1.1 | 0 | 0.3 | 0 | 17 | 2.4 |
| 31 | 5 | 700 | 9601 | 10086 | 0.3 | 0.2 | 0.3 | 0.02 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.14 |
| 32 | 10 | 700 | 9584 | 9297 | 1 | 1 | 1.2 | 0.05 | 0 | 0 | 0 | 0 | 0.1 | 0 | 6 | 0.85 |
| 33 | 70 | 700 | 9616 | 4700 | 8.8 | 8.6 | 9.4 | 0.21 | 0.5 | 0.5 | 0.5 | 0 | 0.5 | 0 | 23 | 3.25 |
| 34 | 140 | 700 | 9585 | 3013 | 19.5 | 15.2 | 20.9 | 1.88 | 0.4 | 0.4 | 0.5 | 0.01 | 0.8 | 0 | 38 | 5.37 |
| 35 | 5 | 800 | 12548 | 10400 | 0.7 | 0.6 | 0.7 | 0.03 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.28 |
| 36 | 10 | 800 | 12560 | 9934 | 1.2 | 1.2 | 1.4 | 0.05 | 0 | 0 | 0 | 0 | 0.1 | 0 | 4 | 0.57 |
| 37 | 80 | 800 | 12564 | 5057 | 17.9 | 12.4 | 21.2 | 3.65 | 0.2 | 0.2 | 0.3 | 0.01 | 0.6 | 0 | 28 | 3.96 |
| 38 | 5 | 900 | 15898 | 11060 | 1.3 | 1.2 | 1.5 | 0.06 | 0 | 0 | 0 | 0 | 0.2 | 0 | 9 | 1.27 |
| 39 | 10 | 900 | 15896 | 9423 | 1.5 | 1.5 | 1.7 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0.28 |
| 40 | 90 | 900 | 15879 | 5128 | 22.9 | 22.6 | 23.6 | 0.3 | 0.3 | 0.3 | 0.3 | 0 | 0.5 | 0 | 24 | 3.39 |

Table 9: Interchange Algorithm of Teitz and Bart - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 1 | 5 | 100 | 198 | 5819 | 0.1 | 0.1 | 0.1 | 0.01 | 0 | 0 | 0 | 0 | 0.3 | 0 | 17 | 2.4 |
| 2 | 10 | 100 | 193 | 4093 | 0.1 | 0.1 | 0.2 | 0.02 | 0 | 0 | 0 | 0 | 0.6 | 0 | 31 | 4.38 |
| 3 | 10 | 100 | 198 | 4250 | 0.2 | 0.1 | 0.2 | 0.01 | 0 | 0 | 0 | 0 | 0.6 | 0 | 30 | 4.24 |
| 4 | 20 | 100 | 196 | 3034 | 0.2 | 0.2 | 0.3 | 0.02 | 0.4 | 0.4 | 0.4 | 0 | 0.6 | 0 | 32 | 4.53 |
| 5 | 33 | 100 | 196 | 1355 | 0.3 | 0.2 | 0.3 | 0.02 | 1.3 | 1.3 | 1.3 | 0 | 0.8 | 0 | 40 | 5.66 |
| 6 | 5 | 200 | 786 | 7824 | 0.2 | 0.1 | 0.2 | 0.03 | 0 | 0 | 0 | 0 | 0.5 | 0 | 24 | 3.39 |
| 7 | 10 | 200 | 779 | 5631 | 0.2 | 0.2 | 0.3 | 0.02 | 0 | 0 | 0 | 0 | 0.6 | 0 | 32 | 4.53 |
| 8 | 20 | 200 | 792 | 4445 | 0.6 | 0.5 | 0.6 | 0.03 | 0.2 | 0.2 | 0.2 | 0 | 1 | 0 | 50 | 7.07 |
| 9 | 40 | 200 | 785 | 2734 | 0.9 | 0.9 | 1.1 | 0.06 | 0.7 | 0.7 | 0.7 | 0.02 | 1.1 | 0 | 57 | 8.06 |
| 10 | 67 | 200 | 786 | 1255 | 1.4 | 1.2 | 1.8 | 0.19 | 1.1 | 0.8 | 1.2 | 0.16 | 1.3 | 0 | 66 | 9.33 |
| 11 | 5 | 300 | 1772 | 7696 | 0.2 | 0.2 | 0.3 | 0.02 | 0 | 0 | 0 | 0 | 0.4 | 0 | 21 | 2.97 |
| 12 | 10 | 300 | 1758 | 6634 | 0.4 | 0.4 | 0.5 | 0.02 | 0 | 0 | 0 | 0 | 0.7 | 0 | 33 | 4.67 |
| 13 | 30 | 300 | 1760 | 4374 | 1.5 | 1.4 | 1.7 | 0.08 | 0.3 | 0.3 | 0.3 | 0 | 1.3 | 0 | 63 | 8.91 |
| 14 | 60 | 300 | 1771 | 2968 | 2.6 | 2.4 | 3.4 | 0.27 | 0.2 | 0.1 | 0.2 | 0.05 | 2 | 0 | 100 | 14.14 |
| 15 | 100 | 300 | 1754 | 1729 | 4.2 | 3.3 | 5.7 | 0.78 | 0.8 | 0.5 | 1.2 | 0.17 | 2.3 | 0 | 116 | 16.4 |
| 16 | 5 | 400 | 3153 | 8162 | 0.3 | 0.3 | 0.4 | 0.02 | 0.3 | 0.3 | 0.3 | 0 | 0.4 | 0 | 20 | 2.83 |
| 17 | 10 | 400 | 3142 | 6999 | 0.6 | 0.5 | 0.6 | 0.02 | 0.2 | 0.2 | 0.2 | 0 | 0.7 | 0 | 33 | 4.67 |
| 18 | 40 | 400 | 3134 | 4809 | 2.7 | 2.6 | 3.1 | 0.1 | 0 | 0 | 0 | 0 | 1.6 | 0 | 82 | 11.6 |
| 19 | 80 | 400 | 3134 | 2845 | 4.7 | 4.6 | 6 | 0.25 | 0.6 | 0.4 | 0.6 | 0.09 | 2.5 | 0 | 123 | 17.39 |
| 20 | 133 | 400 | 3144 | 1789 | 7.5 | 6.3 | 8.9 | 0.83 | 0.6 | 0.4 | 1 | 0.13 | 2.7 | 0 | 134 | 18.95 |

Table 9: Interchange Algorithm of Teitz and Bart - Random (50 Runs)

| Test Problem | n | p | Edges | Optimal Solution | Computational Time (seconds) | | | | Gap to Optimal (percent) | | | | Iterations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev | Mean | Min | Max | Std Dev |
| 21 | 5 | 500 | 4909 | 9138 | 0.4 | 0.4 | 0.5 | 0.02 | 0 | 0 | 0 | 0 | 0.3 | 0 | 17 | 2.4 |
| 22 | 10 | 500 | 4896 | 8579 | 1.5 | 1.5 | 1.8 | 0.06 | 1 | 1 | 1 | 0 | 1 | 0 | 49 | 6.93 |
| 23 | 50 | 500 | 4903 | 4619 | 8.7 | 8.5 | 9.3 | 0.21 | 0.1 | 0.1 | 0.1 | 0 | 2.3 | 0 | 113 | 15.98 |
| 24 | 100 | 500 | 4914 | 2961 | 10.8 | 10.4 | 12.8 | 0.65 | 0.5 | 0.3 | 0.7 | 0.13 | 3 | 0 | 152 | 21.5 |
| 25 | 167 | 500 | 4894 | 1828 | 13.8 | 11 | 17.3 | 1.62 | 1 | 0.6 | 1.4 | 0.2 | 3.1 | 0 | 155 | 21.92 |
| 26 | 5 | 600 | 7069 | 9917 | 0.6 | 0.6 | 0.7 | 0.03 | 0 | 0 | 0 | 0 | 0.6 | 0 | 28 | 3.96 |
| 27 | 10 | 600 | 7072 | 8307 | 1.6 | 1.5 | 1.8 | 0.05 | 0 | 0 | 0 | 0 | 0.9 | 0 | 43 | 6.08 |
| 28 | 60 | 600 | 7054 | 4498 | 10.3 | 9.8 | 12.3 | 0.8 | 0.3 | 0.2 | 0.4 | 0.08 | 2.8 | 0 | 140 | 19.8 |
| 29 | 120 | 600 | 7042 | 3033 | 15.5 | 13.4 | 18 | 1.9 | 1 | 0.9 | 1.1 | 0.07 | 3.8 | 0 | 189 | 26.73 |
| 30 | 200 | 600 | 7042 | 1989 | 20.6 | 18.1 | 28.4 | 2.98 | 0.9 | 0.5 | 1.3 | 0.2 | 4.1 | 0 | 204 | 28.85 |
| 31 | 5 | 700 | 9601 | 10086 | 0.7 | 0.7 | 0.8 | 0.03 | 0 | 0 | 0 | 0 | 0.5 | 0 | 25 | 3.54 |
| 32 | 10 | 700 | 9584 | 9297 | 1.9 | 1.8 | 2.3 | 0.09 | 0 | 0 | 0 | 0 | 0.9 | 0 | 47 | 6.65 |
| 33 | 70 | 700 | 9616 | 4700 | 13.9 | 10.9 | 16.8 | 0.74 | 0.2 | 0.1 | 0.5 | 0.08 | 3.4 | 0 | 168 | 23.76 |
| 34 | 140 | 700 | 9585 | 3013 | 19.6 | 18.8 | 24.8 | 1.63 | 0.4 | 0.2 | 0.5 | 0.07 | 4.3 | 0 | 213 | 30.12 |
| 35 | 5 | 800 | 12548 | 10400 | 1.3 | 1.2 | 1.5 | 0.06 | 0 | 0 | 0 | 0 | 0.5 | 0 | 25 | 3.54 |
| 36 | 10 | 800 | 12560 | 9934 | 1.8 | 1.7 | 2.1 | 0.08 | 0 | 0 | 0 | 0 | 1 | 0 | 52 | 7.35 |
| 37 | 80 | 800 | 12564 | 5057 | 21.2 | 15.6 | 25.1 | 3.31 | 0.1 | 0 | 0.2 | 0.04 | 3.7 | 0 | 186 | 26.3 |
| 38 | 5 | 900 | 15898 | 11060 | 1.9 | 1.8 | 2.2 | 0.06 | 0 | 0 | 0 | 0 | 0.6 | 0 | 30 | 4.24 |
| 39 | 10 | 900 | 15896 | 9423 | 2 | 1.9 | 2.3 | 0.09 | 0 | 0 | 0 | 0 | 0.9 | 0 | 46 | 6.51 |
| 40 | 90 | 900 | 15879 | 5128 | 28.4 | 19.7 | 43.1 | 7.87 | 0.7 | 0.3 | 1.1 | 0.24 | 3.9 | 0 | 196 | 27.72 |