

70068 Scheduling and Resource Allocation CW

Ali Abbas

November 27, 2024

1 Question 1

Everything in this section will use 0-based indexing.

1.1 LCL Proof

The *Least Cost Last (LCL)* rule solves the scheduling problem $1|prec|f_{\max}$ optimally, in $O(n^2)$ time, by constructing an optimal schedule from back to front.

Definitions

- $N = \{1, 2, \dots, n\}$ is the index set of all jobs
- $L \subseteq N$ is the subset of jobs without successors (which can be scheduled last)
- $p(S) = \sum_{j \in S} p_j$ is the total processing time of a subset S
- $f_{\max}^*(S)$ is the cost of the optimal schedule for subset S
- f_{\max} denotes the maximum (not necessarily optimal) cost across all jobs in a schedule
- $f_j(p(N))$ is a cost function which assigns a penalty/cost depending on job j and the time at which the machine has finished processing, $p(N)$
 - In the notation of the coursework specification $g_j(\cdot) = f_j(\cdot)$
 - In the next section we'll use $g_j(C_j) = T_j = \max(0, C_j - d_j)$ (tardiness)

Proof and Discussion

1. One job in L must be scheduled last. A job can be selected for the final job which minimises $f_j(p(N))$, but it can never result in a cost lower than the cost of the optimal schedule, otherwise that would be the optimal schedule. This is expressed as such:

$$f_{\max}^*(N) \geq \min_{j \in L} f_j(p(N))$$

2. And removing a job $j \in N$ can't increase the optimal cost any more, since the cost of scheduling a job last is ≥ 0 , so omitting it cannot result in a more expensive schedule:

$$f_{\max}^*(N) \geq f_{\max}^*(N - \{j\}), \forall j \in N$$

3. We can then select a $J_l \in L$ that minimises $f_j(p(N))$:

$$f_l(p(N)) = \min_{j \in L} f_j(p(N))$$

Which gives us:

$$f_{\max}^*(N) \geq \max\{f_l(p(N)), f_{\max}^*(N - \{l\})\}$$

4. The right hand side of the above inequality is the cost of an optimal schedule, where J_l is processed last, so you can recursively apply the LCL rule to $N - \{J_l\}$ and construct a schedule in reverse order
 - Since J_l is found in $O(n)$ time, then with n , repeated applications of the LCL rule yields the optimal schedule in $O(n^2)$ time

You can also show that *LCL* is optimal by using the *adjacent pairwise interchange argument*:

- You take an optimal schedule S and assume it isn't an *LCL* schedule

- Since it's not an *LCL* schedule, there must exist at least one pair where a lower cost job precedes a higher cost one
- It can then be shown that swapping these jobs yields a lower cost schedule, which is a contradiction since we took an optimal schedule
- So by virtue of the fact that a lower cost job can precede a higher cost one leads to a contradiction
- And so such pairs cannot exist for an optimal schedule, so we can reject the assumption that this isn't an *LCL* schedule
- And by contradiction then we have that *LCL* is optimal for $1|prec|f_{\max}$

Small Example

Example Setup:

Jobs: J0, J1, J2, J3, J4

Processing Times: $p=[2,3,1,2,3]$

Due Dates: $d=[6,5,7,4,9]$

Precedence Constraints (DAG): $J0 \rightarrow J1, J0 \rightarrow J2, J3 \rightarrow J4$

Cost Function: $f_j(C_j) = T_j = \max(0, C_j - d_j)$

Iterations We can schedule jobs in reverse order using the *Least Cost Last (LCL)* rule:

0. Available jobs: $V = \{1, 2, 4\}$ (no successors)
 $p(N) = 11$

$$f_1(p(N)) = \max(0, 11 - 5) = 6, \quad f_2(p(N)) = \max(0, 11 - 4) = 7, \quad f_4(p(N)) = \max(0, 11 - 9) = 2$$

Select J_4 (minimises $f_j(p(N))$)

Partial schedule cost: 2

Updated schedule: [4]

1. Available jobs: $V = \{1, 2, 3\}$ (no successors)
 $p(N) = 8$

$$f_1(p(N)) = \max(0, 8 - 5) = 3, \quad f_2(p(N)) = \max(0, 8 - 4) = 4, \quad f_3(p(N)) = \max(0, 8 - 7) = 1$$

Select J_3 (minimises $f_j(p(N))$)

Partial schedule cost: 2

Updated schedule: [3, 4]

2. Available jobs: $V = \{1, 2\}$ (no successors)
 $p(N) = 6$

$$f_1(p(N)) = \max(0, 6 - 5) = 1, \quad f_2(p(N)) = \max(0, 6 - 4) = 2$$

Select J_1 (minimises $f_j(p(N))$)

Partial schedule cost: 2

Updated schedule: [1, 3, 4]

3. Available jobs: $V = \{2\}$ (no successors)
 $p(N) = 3$

$$f_2(p(N)) = \max(0, 3 - 4) = 0$$

Select J_2

Partial schedule cost: 2

Updated schedule: [2, 1, 3, 4]

4. Available jobs: $V = \{0\}$ (no successors)
 $p(N) = 2$

$$f_0(p(N)) = \max(0, 2 - 6) = 0$$

Select J_0

Partial schedule cost: 2

Updated schedule: [0, 2, 1, 3, 4]

Results

- Final schedule: $[J_0, J_2, J_1, J_3, J_4]$

- Completion times:

$$C_0 = 2, C_2 = 3, C_1 = 6, C_3 = 8, C_4 = 11$$

- Tardiness:

$$T_0 = 0, T_2 = 0, T_1 = 1, T_3 = 1, T_4 = 2$$

- Maximum cost:

$$f_{\max} = \max(T_0, T_2, T_1, T_3, T_4) = 2$$

1.2 LCL Implementation

Iterations

0. Available jobs: $V = \{0, 30\}$ (no successors)

$$p(N) = 170$$

$$f_0(p(N)) = \max(0, 170 - 172) = 0, \quad f_{30}(p(N)) = \max(0, 170 - 269) = 0$$

Select J_{30} (minimises $f_j(p(N))$)

Partial schedule cost: 0

Updated schedule: $[30]$

1. Available jobs: $V = \{0, 1, 10\}$ (no successors)

$$p(N) = 160$$

$$f_0(p(N)) = \max(0, 160 - 172) = 0, \quad f_1(p(N)) = \max(0, 160 - 82) = 78, \quad f_{10}(p(N)) = \max(0, 160 - 253) = 0$$

Select J_0 (minimises $f_j(p(N))$)

Partial schedule cost: 0

Updated schedule: $[0, 30]$

...

4. Available jobs: $V = \{1, 4\}$ (no successors)

$$p(N) = 147$$

$$f_1(p(N)) = \max(0, 147 - 82) = 65, \quad f_4(p(N)) = \max(0, 147 - 93) = 54$$

Select J_1 (minimises $f_j(p(N))$) Partial schedule cost: 65

Updated schedule: $[1, 14, 10, 0, 30]$

This iteration was notable since it incurred the maximum tardiness incurred for this problem.

...

17. Available jobs: $V = \{17, 18, 20, 5\}$ (no successors)

$$p(N) = 68$$

$$f_{17}(p(N)) = \max(0, 68 - 77) = 0, \quad f_{18}(p(N)) = \max(0, 68 - 88) = 0,$$

$$f_{20}(p(N)) = \max(0, 68 - 71) = 0, \quad f_5(p(N)) = \max(0, 68 - 71) = 0$$

Select J_{17} (arbitrarily breaking the tie)

Partial schedule cost: 65

Updated schedule: $[17, 16, 15, 13, 28, 12, 27, 26, 25, 24, 23, 11, 4, 1, 14, 10, 0, 30]$

...

30. Available jobs: $V = \{29\}$ (no successors)

$$p(N) = 2$$

$$f_{29}(p(N)) = \max(0, 2 - 329) = 0$$

Select J_{29} (minimises $f_j(p(N))$)

Final schedule cost: 65

Final schedule: $[29, 9, 8, 3, 2, 7, 6, 22, 21, 5, 20, 19, 18, 17, 16, 15, 13, 28, 12, 27, 26, 25, 24, 23, 11, 4, 1, 14, 10, 0, 30]$

Note: the tie breaking doesn't specify any ordering in the current implementation (since the set of available jobs is backed by a hash table).

2 Question 2

2.1 Tabu Search

0. **Candidate schedule costs:** [341, 341, 341, 341, 341, 341, 338, 343, 341, 341, 341, 339, 351, 331, 359, 341, 336, 346, 336, 346, 336]
Tabu list: { (17, 25) }
Best cost so far: 331
Tabu list used?: No
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 25, 24, 16, 14, 5, 23, 15, 4, 10, 1, 0, 30]
Selected neighbour cost: 331
1. **Candidate schedule costs:** [331, 331, 331, 331, 331, 331, 328, 333, 331, 331, 331, 329, 341, 331, 326, 336, 326, 336, 326]
Tabu list: { (17, 25), (5, 14) }
Best cost so far: 326
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 25, 24, 16, 5, 14, 23, 15, 4, 10, 1, 0, 30]
Selected neighbour cost: 326
2. **Candidate schedule costs:** [326, 326, 326, 326, 326, 326, 323, 328, 326, 326, 326, 324, 336, 326, 320, 331, 326, 321, 331, 321]
Tabu list: { (17, 25), (5, 14), (5, 16) }
Best cost so far: 320
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 25, 24, 5, 16, 14, 23, 15, 4, 10, 1, 0, 30]
Selected neighbour cost: 320
3. **Candidate schedule costs:** [320, 320, 320, 320, 320, 320, 317, 322, 320, 320, 320, 318, 330, 302, 326, 320, 315, 325, 315]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24) }
Best cost so far: 302
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 25, 5, 24, 16, 14, 23, 15, 4, 10, 1, 0, 30]
Selected neighbour cost: 302
4. **Candidate schedule costs:** [302, 302, 302, 302, 302, 302, 299, 304, 302, 302, 302, 300, 312, 292, 320, 302, 302, 297, 307, 297]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25) }
Best cost so far: 292
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 5, 25, 24, 16, 14, 23, 15, 4, 10, 1, 0, 30]
Selected neighbour cost: 292
5. **Candidate schedule costs:** [292, 292, 292, 292, 292, 292, 289, 294, 292, 292, 292, 290, 288, 302, 292, 292, 287, 297, 287]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23) }
Best cost so far: 287
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 5, 25, 24, 16, 14, 15, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 287
6. **Candidate schedule costs:** [287, 287, 287, 287, 287, 287, 284, 289, 287, 287, 287, 285, 283, 297, 287, 282, 292, 292, 282]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15) }
Best cost so far: 282
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 5, 25, 24, 16, 15, 14, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 282

7. **Candidate schedule costs:** [282, 282, 282, 282, 282, 282, 279, 284, 282, 282, 282, 280, 278, 292, 282, 287, 282, 287, 277]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10) }
Best cost so far: 277
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 17, 5, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 277
8. **Candidate schedule costs:** [277, 277, 277, 277, 277, 277, 274, 279, 277, 277, 277, 275, 273, 287, 277, 282, 277, 282]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17) }
Best cost so far: 273
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 21, 2, 26, 27, 7, 6, 18, 20, 5, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 273
9. **Candidate schedule costs:** [273, 273, 273, 273, 273, 273, 270, 275, 273, 273, 273, 271, 273, 277, 283, 273, 278, 273, 278]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21) }
Best cost so far: 270
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 19, 2, 21, 26, 27, 7, 6, 18, 20, 5, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 270
10. **Candidate schedule costs:** [270, 270, 270, 270, 270, 267, 273, 270, 270, 270, 270, 268, 270, 274, 280, 270, 275, 270, 275]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19) }
Best cost so far: 267
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 6, 18, 20, 5, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 267
11. **Candidate schedule costs:** [267, 267, 267, 267, 270, 267, 267, 267, 267, 267, 267, 265, 267, 271, 277, 267, 272, 267, 272]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20) }
Best cost so far: 265
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 6, 20, 18, 5, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 265
12. **Candidate schedule costs:** [265, 265, 265, 265, 268, 265, 265, 265, 265, 259, 267, 263, 269, 275, 265, 270, 265, 270]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20) }
Best cost so far: 259
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 18, 5, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 259
13. **Candidate schedule costs:** [259, 259, 259, 259, 262, 259, 259, 259, 259, 259, 265, 259, 257, 263, 269, 259, 264, 259, 264]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 28, 22, 9, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
14. **Candidate schedule costs:** [257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20),

- (6, 20), (5, 18), (22, 28) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 22, 28, 9, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
15. **Candidate schedule costs:** [257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 22, 9, 28, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
16. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 9, 22, 28, 8, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
17. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 9, 22, 8, 28, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
18. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 22, 28, 13, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
19. **Candidate schedule costs:** [257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 22, 13, 28, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
20. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 13, 22, 28, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
21. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]

- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 9, 13, 8, 22, 28, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
22. **Candidate schedule costs:** [257, 257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 13, 9, 8, 22, 28, 12, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
23. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 13, 9, 8, 22, 12, 28, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
24. **Candidate schedule costs:** [257, 257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 13, 9, 8, 12, 22, 28, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
25. **Candidate schedule costs:** [257, 257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 13, 9, 12, 8, 22, 28, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
26. **Candidate schedule costs:** [257, 257, 257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12) }
- Best cost so far:** 257
- Tabu list used?:** Yes
- Selected neighbour:** [29, 13, 12, 9, 8, 22, 28, 11, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
- Selected neighbour cost:** 257
27. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
- Tabu list:** { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28) }
- Best cost so far:** 257

- Tabu list used?:** Yes
Selected neighbour: [29, 13, 12, 9, 8, 22, 11, 28, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
28. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 9, 8, 11, 22, 28, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
29. **Candidate schedule costs:** [257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 9, 11, 8, 22, 28, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
30. **Candidate schedule costs:** [257, 257, 257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 8, 22, 28, 3, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
31. **Candidate schedule costs:** [257, 257, 257, 257, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28) }
Best cost so far: 257
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 8, 22, 3, 28, 2, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 257
32. **Candidate schedule costs:** [257, 257, 257, 257, 251, 260, 257, 257, 257, 257, 257, 263, 259, 267, 257, 262, 257, 262]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28) }
Best cost so far: 251
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 8, 22, 3, 2, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 251
33. **Candidate schedule costs:** [251, 251, 251, 257, 251, 251, 251, 251, 251, 251, 257, 253, 261, 251, 256, 251, 256]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22) }
Best cost so far: 251
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 8, 3, 22, 2, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4,

- 1, 10, 0, 30]
Selected neighbour cost: 251
34. **Candidate schedule costs:** [251, 251, 251, 237, 257, 251, 251, 251, 251, 251, 257, 253, 261, 251, 256, 251, 256]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22) }
Best cost so far: 237
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 8, 3, 2, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 237
35. **Candidate schedule costs:** [237, 237, 251, 237, 237, 237, 237, 237, 237, 237, 243, 239, 247, 237, 242, 237, 242]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8) }
Best cost so far: 237
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 3, 8, 2, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 237
36. **Candidate schedule costs:** [237, 237, 237, 231, 251, 237, 237, 237, 237, 237, 237, 237, 237, 243, 239, 247, 237, 242, 237, 242]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8) }
Best cost so far: 231
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 9, 3, 2, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 231
37. **Candidate schedule costs:** [231, 231, 237, 231, 231, 231, 231, 231, 231, 231, 231, 237, 233, 241, 231, 236, 231, 236]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9) }
Best cost so far: 231
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 3, 9, 2, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 231
38. **Candidate schedule costs:** [231, 231, 230, 237, 231, 231, 231, 231, 231, 231, 231, 231, 237, 233, 241, 231, 236, 231, 236]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 11, 3, 2, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
39. **Candidate schedule costs:** [230, 231, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 13, 12, 3, 11, 2, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230

40. **Candidate schedule costs:** [230, 230, 230, 231, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 13, 3, 12, 11, 2, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
41. **Candidate schedule costs:** [230, 230, 230, 231, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 3, 13, 12, 11, 2, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
42. **Candidate schedule costs:** [230, 230, 231, 230, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 3, 13, 12, 2, 11, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
43. **Candidate schedule costs:** [230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 3, 13, 2, 12, 11, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
44. **Candidate schedule costs:** [230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13) }
Best cost so far: 230
Tabu list used?: Yes
Selected neighbour: [29, 3, 2, 13, 12, 11, 9, 8, 22, 28, 19, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230
45. **Candidate schedule costs:** [230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 230, 236, 232, 240, 230, 235, 230, 235]
Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28) }
Best cost so far: 230

Selected neighbour: [29, 3, 2, 13, 12, 11, 9, 8, 22, 19, 28, 21, 26, 27, 7, 20, 6, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 230

- 11

Selected neighbour cost: 230

Selected neighbour cost: 230

Selected neighbour cost: 230

Selected neighbour cost: 230

Selected neighbour cost: 230

Selected neighbour cost: 230

- Best cost so far: 230
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 28, 27, 6, 26, 5, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 230
63. Candidate schedule costs: [230, 230, 230, 230, 230, 230, 230, 228, 232, 240, 230, 235, 230, 235]
 Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26) }
 Best cost so far: 228
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 28, 27, 6, 5, 26, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 228
64. Candidate schedule costs: [228, 228, 228, 228, 228, 228, 230, 228, 238, 228, 233, 228, 233]
 Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27) }
 Best cost so far: 228
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 28, 6, 27, 5, 26, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 228
65. Candidate schedule costs: [228, 228, 228, 228, 228, 228, 228, 225, 230, 228, 238, 228, 233, 228, 233]
 Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27) }
 Best cost so far: 225
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 28, 6, 5, 27, 26, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 225
66. Candidate schedule costs: [225, 225, 225, 225, 225, 225, 228, 225, 225, 235, 225, 230, 225, 230]
 Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28) }
 Best cost so far: 225
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 28, 5, 27, 26, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 225
67. Candidate schedule costs: [225, 225, 225, 225, 225, 225, 222, 228, 225, 225, 235, 225, 230, 225, 230]
 Tabu list: { (17, 25), (5, 14), (5, 16), (5, 24), (5, 25), (15, 23), (14, 15), (1, 10), (5, 17), (2, 21), (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28) }
 Best cost so far: 222
 Tabu list used?: Yes
 Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 28, 27, 26, 18, 17, 25, 24, 16, 15, 14, 23, 4, 1, 10, 0, 30]
 Selected neighbour cost: 222

- 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28) }
- Best cost so far:** 173
Tabu list used?: Yes
Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 18, 17, 16, 15, 14, 28, 27, 26, 25, 24, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 173
89. **Candidate schedule costs:** [173, 173, 173, 173, 173, 173, 178, 173, 173, 178]
Tabu list: { (2, 19), (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 18, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 1, 10, 0, 30]
Selected neighbour cost: 178
90. **Candidate schedule costs:** [178, 178, 178, 178, 178, 178, 173, 184, 178, 183]
Tabu list: { (18, 20), (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 3, 2, 19, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 18, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
91. **Candidate schedule costs:** [183, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (6, 20), (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 3, 19, 2, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 18, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
92. **Candidate schedule costs:** [183, 183, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (5, 18), (22, 28), (9, 28), (9, 22), (8, 28), (8, 22), (13, 28), (13, 22), (8, 13), (9, 13), (12, 28), (12, 22), (8, 12), (9, 12), (11, 28), (11, 22), (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 3, 2, 13, 12, 11, 9, 8, 7, 22, 21, 20, 6, 5, 18, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183

Selected neighbour cost: 183

- 21

- (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18)
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 3, 2, 13, 12, 18, 11, 9, 8, 7, 6, 5, 22, 21, 20, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
108. **Candidate schedule costs:** [183, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (8, 11), (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 3, 2, 13, 18, 12, 11, 9, 8, 7, 6, 5, 22, 21, 20, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
109. **Candidate schedule costs:** [183, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (9, 11), (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 3, 2, 18, 13, 12, 11, 9, 8, 7, 6, 5, 22, 21, 20, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
110. **Candidate schedule costs:** [183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (3, 28), (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 3, 18, 2, 13, 12, 11, 9, 8, 7, 6, 5, 22, 21, 20, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
111. **Candidate schedule costs:** [183, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (2, 28), (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20, 26), (20, 27), (20, 28), (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 19, 18, 3, 2, 13, 12, 11, 9, 8, 7, 6, 5, 22, 21, 20, 17, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
Selected neighbour cost: 183
112. **Candidate schedule costs:** [183, 183, 183, 183, 178, 189, 183, 188, 178]
Tabu list: { (3, 22), (2, 22), (3, 8), (2, 8), (3, 9), (2, 9), (3, 11), (3, 12), (3, 13), (2, 11), (2, 12), (2, 13), (19, 28), (19, 22), (8, 19), (9, 19), (11, 19), (12, 19), (13, 19), (21, 28), (26, 27), (7, 26), (7, 27), (7, 28), (7, 21), (7, 22), (20,

Selected neighbour cost: 183

- 29

- (13, 17) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 12, 11, 16, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 183
141. **Candidate schedule costs:** [183, 183, 187, 183, 183, 183, 178, 189, 183, 188, 178]
- Tabu list:** { (6, 26), (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 12, 16, 11, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 183
142. **Candidate schedule costs:** [183, 183, 187, 183, 183, 183, 183, 183, 178, 189, 183, 188, 178]
- Tabu list:** { (5, 26), (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 16, 12, 11, 14, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 183
143. **Candidate schedule costs:** [183, 183, 187, 183, 183, 187, 183, 183, 178, 189, 183, 188, 178]
- Tabu list:** { (6, 27), (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 16, 12, 14, 11, 15, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 183
144. **Candidate schedule costs:** [183, 183, 187, 183, 183, 187, 183, 183, 183, 181, 189, 183, 188, 178]
- Tabu list:** { (5, 27), (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 16, 12, 14, 15, 11, 28, 27, 26, 25, 24, 23, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 181
145. **Candidate schedule costs:** [181, 181, 185, 181, 181, 185, 181, 181, 176, 183, 181, 181, 186, 176]
- Tabu list:** { (6, 28), (5, 28), (18, 26), (17, 26), (18, 27), (17, 27), (18, 28), (17, 28), (16, 24), (15, 24), (16, 25), (15, 25), (16, 26), (15, 26), (16, 27), (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14,

- 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 2, 8, 7, 6, 5, 22, 21, 20, 17, 13, 16, 14, 15, 28, 26, 27, 25, 24, 23, 12, 11, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 178
160. **Candidate schedule costs:** [178, 178, 182, 178, 178, 182, 173, 184, 178, 178, 183, 173]
- Tabu list:** { (15, 27), (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 3, 8, 2, 7, 6, 5, 22, 21, 20, 17, 13, 16, 14, 15, 28, 26, 27, 25, 24, 23, 12, 11, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 182
161. **Candidate schedule costs:** [182, 182, 182, 178, 182, 182, 186, 177, 188, 182, 182, 187, 177]
- Tabu list:** { (16, 28), (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 13, 16, 14, 15, 28, 26, 27, 25, 24, 23, 12, 11, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 182
162. **Candidate schedule costs:** [182, 182, 182, 182, 186, 177, 188, 182, 182, 187, 177]
- Tabu list:** { (15, 28), (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 13, 14, 15, 28, 26, 27, 25, 24, 23, 12, 11, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 186
163. **Candidate schedule costs:** [186, 186, 186, 182, 191, 181, 192, 186, 186, 191, 181]
- Tabu list:** { (14, 24), (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14) }
- Best cost so far:** 173
- Tabu list used?:** Yes
- Selected neighbour:** [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 14, 13, 15, 28, 26, 27, 25, 24, 23, 12, 11, 4, 10, 1, 0, 30]
- Selected neighbour cost:** 191
164. **Candidate schedule costs:** [191, 191, 191, 186, 194, 197, 191, 191, 196, 186]
- Tabu list:** { (14, 25), (14, 26), (14, 27), (14, 28), (14, 15), (1, 10), (2, 19), (3, 19), (6, 20), (6, 21), (6, 22), (5, 20),

Selected neighbour cost: 199

- 36

(10, 27), (10, 26) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 15, 14, 13, 28, 10, 26, 27, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 194

174. **Candidate schedule costs:** [194, 194, 194, 199, 189, 200, 194, 194, 194, 194]

Tabu list: { (6, 22), (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 15, 14, 13, 10, 28, 26, 27, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 194

175. **Candidate schedule costs:** [194, 194, 194, 199, 189, 199, 194, 194, 194]

Tabu list: { (5, 20), (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 15, 14, 10, 13, 28, 26, 27, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 199

176. **Candidate schedule costs:** [199, 199, 199, 204, 194, 205, 199, 199]

Tabu list: { (5, 21), (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 15, 14, 10, 28, 13, 26, 27, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 205

177. **Candidate schedule costs:** [205, 205, 205, 210, 205, 199, 207, 205, 205]

Tabu list: { (5, 22), (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 19, 18, 9, 8, 3, 2, 7, 6, 5, 22, 21, 20, 17, 16, 15, 14, 10, 28, 26, 13, 27, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 207

178. **Candidate schedule costs:** [207, 207, 207, 212, 207, 205, 210, 207]

Tabu list: { (18, 20), (18, 21), (18, 22), (5, 18), (6, 18), (7, 18), (8, 18), (9, 18), (11, 18), (12, 18), (13, 18), (2, 18), (3, 18), (9, 11), (9, 12), (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6,

(13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 8, 19, 3, 18, 2, 22, 21, 20, 7, 6, 5, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 210

193. **Candidate schedule costs:** [210, 210, 210, 208, 224, 210, 210, 215, 210, 210, 207, 220, 210]

Tabu list: { (9, 13), (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 8, 19, 3, 2, 18, 22, 21, 20, 7, 6, 5, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 208

194. **Candidate schedule costs:** [208, 208, 210, 208, 208, 208, 213, 208, 208, 205, 218, 208]

Tabu list: { (8, 11), (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 8, 3, 19, 2, 18, 22, 21, 20, 7, 6, 5, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 208

195. **Candidate schedule costs:** [208, 208, 206, 210, 208, 208, 208, 213, 208, 208, 205, 218, 208]

Tabu list: { (8, 12), (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 8, 3, 2, 19, 18, 22, 21, 20, 7, 6, 5, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 206

196. **Candidate schedule costs:** [206, 208, 206, 206, 206, 211, 206, 206, 203, 216, 206]

Tabu list: { (8, 13), (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 8, 3, 2, 19, 22, 18, 21, 20, 7, 6, 5, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 206

197. **Candidate schedule costs:** [206, 208, 206, 206, 206, 206, 206, 211, 206, 206, 203, 216, 206]

Tabu list: { (7, 11), (2, 9), (3, 9), (7, 12), (7, 13), (6, 11), (6, 12), (6, 13), (5, 11), (5, 12), (5, 13), (11, 22), (12,

- 19), (6, 18), (6, 19), (5, 18) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 3, 2, 22, 21, 20, 7, 6, 19, 5, 18, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]
Selected neighbour cost: 206
207. **Candidate schedule costs:** [206, 219, 206, 206, 206, 206, 211, 206, 206, 203, 216, 206]
Tabu list: { (5, 13), (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 3, 2, 22, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 13, 25, 24, 23, 12, 11, 4, 1, 0, 30]
Selected neighbour cost: 206
208. **Candidate schedule costs:** [206, 219, 206, 206, 211, 206, 206, 203, 216, 206]
Tabu list: { (11, 22), (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 3, 2, 22, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]
Selected neighbour cost: 216
209. **Candidate schedule costs:** [216, 229, 216, 216, 221, 216, 216, 206, 234, 216]
Tabu list: { (12, 22), (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 3, 22, 2, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]
Selected neighbour cost: 229
210. **Candidate schedule costs:** [229, 229, 216, 232, 229, 229, 234, 229, 229, 219, 247, 229]
Tabu list: { (13, 22), (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22) }
Best cost so far: 173
Tabu list used?: Yes
Selected neighbour: [29, 9, 8, 22, 3, 2, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]
Selected neighbour cost: 229
211. **Candidate schedule costs:** [229, 229, 232, 229, 229, 234, 229, 229, 219, 247, 229]
Tabu list: { (11, 21), (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12,

25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 9, 22, 8, 3, 2, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 229

212. **Candidate schedule costs:** [229, 229, 229, 232, 229, 229, 234, 229, 229, 219, 247, 229]

Tabu list: { (12, 21), (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 9, 8, 3, 2, 21, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 229

213. **Candidate schedule costs:** [229, 229, 232, 229, 229, 234, 229, 229, 219, 247, 229]

Tabu list: { (13, 21), (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 9, 8, 3, 21, 2, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 232

214. **Candidate schedule costs:** [232, 232, 232, 229, 234, 232, 232, 237, 232, 232, 222, 250, 232]

Tabu list: { (11, 20), (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21), (3, 21) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 9, 8, 21, 3, 2, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 232

215. **Candidate schedule costs:** [232, 232, 232, 234, 232, 232, 237, 232, 232, 222, 250, 232]

Tabu list: { (12, 20), (13, 20), (11, 17), (12, 17), (13, 17), (11, 16), (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21), (3, 21), (8, 21) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 9, 21, 8, 3, 2, 20, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 232

Selected neighbour: [29, 22, 21, 20, 9, 8, 3, 2, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 13, 24, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 234

221. **Candidate schedule costs:** [234, 234, 234, 239, 234, 234, 224, 252, 234]

Tabu list: { (12, 16), (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21), (3, 21), (8, 21), (9, 21), (2, 20), (3, 20), (8, 20), (9, 20), (13, 24) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 21, 20, 9, 8, 3, 2, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 24, 13, 23, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 252

222. **Candidate schedule costs:** [252, 252, 252, 257, 252, 252, 234, 257, 252]

Tabu list: { (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21), (3, 21), (8, 21), (9, 21), (2, 20), (3, 20), (8, 20), (9, 20), (13, 24), (13, 23) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: [29, 22, 21, 20, 9, 8, 3, 2, 7, 6, 5, 19, 18, 17, 16, 15, 14, 10, 28, 26, 27, 25, 24, 23, 13, 12, 11, 4, 1, 0, 30]

Selected neighbour cost: 257

223. **Candidate schedule costs:** [257, 257, 257, 262, 257, 257, 252]

Tabu list: { (11, 14), (11, 15), (12, 14), (12, 15), (11, 28), (12, 28), (11, 27), (12, 27), (11, 26), (12, 26), (26, 27), (11, 25), (12, 25), (11, 24), (12, 24), (11, 23), (12, 23), (2, 8), (3, 8), (13, 16), (13, 14), (13, 15), (4, 10), (10, 11), (10, 12), (10, 23), (10, 24), (14, 15), (10, 25), (10, 27), (10, 26), (10, 28), (10, 13), (13, 28), (13, 26), (13, 27), (5, 22), (6, 22), (7, 22), (5, 21), (6, 21), (7, 21), (5, 20), (6, 20), (9, 18), (9, 19), (8, 18), (8, 19), (7, 20), (3, 18), (2, 18), (3, 19), (2, 19), (18, 22), (19, 22), (18, 21), (19, 21), (18, 20), (19, 20), (7, 18), (7, 19), (6, 18), (6, 19), (5, 18), (5, 19), (13, 25), (2, 22), (3, 22), (8, 22), (9, 22), (2, 21), (3, 21), (8, 21), (9, 21), (2, 20), (3, 20), (8, 20), (9, 20), (13, 24), (13, 23) }

Best cost so far: 173

Tabu list used?: Yes

Selected neighbour: None

Selected neighbour cost: None

2.2 Best Schedule