Austin Smothers

CISP 430

Assignment 7

Johnny Appleseed would have loved data structures.

Look at all the trees he could have made.

Sequence 1) 1, 3, 4, 5, 6, 9, 7, 8, 2

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| --- | --- |
| Pivot Node: 1 | Right Height: 0 |
| Action: Insert: 1 | Left Height: 0 |
| Rotation Case: None | Balance Factor: 0 |

|  |  |
| --- | --- |
| Pivot Node: 1 | Right Height: 1 |
| Action: Insert: 3 | Left Height: 0 |
| Rotation Case: None | Balance Factor: -1 |

|  |  |
| --- | --- |
| Pivot Node: 1 | Right Height: 2 |
| Action: Insert: 4 | Left Height: 0 |
| Rotation Case: RR Required | Balance Factor: -2 |

|  |  |
| --- | --- |
| Pivot Node: 3 | Right Height: 1 |
| Action: RR Rotation | Left Height: 1 |
| Rotation Case: None | Balance Factor: 0 |

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| --- | --- |
| Pivot Node: 3 | Right Height: 2 |
| Action: Insert: 5 | Left Height: 1 |
| Rotation Case: None | Balance Factor: -1 |

|  |  |
| --- | --- |
| Pivot Node: 3 | Right Height: 3 |
| Action: Insert: 6 | Left Height: 1 |
| Rotation Case: RR Required | Balance Factor: -2 |

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 2 |
| Action: RR Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: 0 |

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| --- | --- |
| Pivot Node: 4 | Right Height: 3 |
| Action: Insert: 9 | Left Height: 2 |
| Rotation Case: RR Required at 5 | Balance Factor: -1 |
| Left Pivot: 3 | Right Pivot: 5 |

Balance Factor : -2

RR Rotation Required

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 2 |
| Action: RR Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot: 3 | Right Pivot: 6 |

Balance Factor: 1 Balance Factor: 0

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 3 |
| Action: Insert: 7 | Left Height: 2 |
| Rotation Case: None | Balance Factor: -1 |
| Left Pivot: 3 | Right Pivot: 6 |
| Lower Left Pivot: None | Lower Right Pivot: 9 |

Balance Factor: 1 Balance Factor: -1

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 4 |
| Action: Insert: 8 | Left Height: 2 |
| Rotation Case: LR Required at 8 | Balance Factor: -2 |
| Left Pivot Node: 3 | Right Pivot Node: 6 |
| Lower Left Pivot: None | Lower Right Pivot: 9 |

Balance Factor: 1 Balance Factor: -2

Balance: -2

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 3 |
| Action: LR Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: -1 |
| Left Pivot Node: 3 | Right Pivot Node: 6 |
| Lower Left Pivot: None | Lower Right Pivot: 8 |

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 3 |
| Action: Insert: 2 | Left Height: 3 |
| Rotation Case: LR Required at 2 | Balance Factor: 0 |
| Left Pivot Node: 3 | Right Pivot Node: 6 |
| Lower Left Pivot: None | Lower Right Pivot: 8 |

Balance Factor: 2

|  |  |
| --- | --- |
| Pivot Node: 4 | Right Height: 3 |
| Action: LR Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: -1 |
| Left Pivot Node: 2 | Right Pivot Node: 6 |
| Lower Left Pivot: None | Lower Right Pivot: 8 |

Finished

Sequence 2) 9, 7, 2, 8, 1, 3, 5, 4, 6

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| --- | --- |
| Pivot Node: 9 | Right Height: 0 |
| Action: Insert: 9 | Left Height: 0 |
| Rotation Case: None | Balance Factor: 0 |

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| --- | --- |
| Pivot Node: 9 | Right Height: 0 |
| Action: Insert: 7 | Left Height: 1 |
| Rotation Case: None | Balance Factor: 1 |

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| --- | --- |
| Pivot Node: 9 | Right Height: 0 |
| Action: Insert: 2 | Left Height: 2 |
| Rotation Case: LL Required | Balance Factor: 2 |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 1 |
| Action: LL Rotation | Left Height: 1 |
| Rotation Case: None | Balance Factor: 0 |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: Insert: 8 | Left Height: 1 |
| Rotation Case: None | Balance Factor: -1 |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: Insert: 1 | Left Height: 2 |
| Rotation Case: None | Balance Factor: 0 |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: Insert: 3 | Left Height: 2 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot: 2 | Right Pivot: 9 |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: Insert: 5 | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot: 2 | Right Pivot: 9 |

Balance: -1

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: Insert: 4 | Left Height: 4 |
| Rotation Case: RL Required at 4 | Balance Factor: 2 |
| Left Pivot: 2 | Right Pivot: 9 |
| Lower Left Pivot: 3 | Lower Right Pivot: None |

Balance: -2

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 2 |
| Action: RL Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot: 2 | Right Pivot: 9 |
| Lower Left Pivot: 4 | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 4 |
| Action: Insert: 6 | Left Height: 2 |
| Rotation Case: RL Required at 3 | Balance Factor: 2 |
| Left Pivot: 2 | Right Pivot: 9 |
| Lower Left Pivot: 4 | Lower Right Pivot: None |

Balance Factor: -2

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 4 |
| Action: RL Rotation | Left Height: 2 |
| Rotation Case: RR Required at 4 | Balance Factor: 2 |
| Left Pivot: 3 | Right Pivot: 9 |
| Lower Left Pivot: 4 | Lower Right Pivot: None |

Balance: -1

Bal: -2

|  |  |
| --- | --- |
| Pivot Node: 7 | Right Height: 3 |
| Action: RR Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot: 3 | Right Pivot: 9 |
| Lower Left Pivot: 5 | Lower Right Pivot: None |

FINISHED

Sequence 3) 60, 35, 80, 55, 30, 25, 10, 75, 50, 15, 40, 90, 85, 70, 65

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 0 |
| Action: Insert: 60 | Left Height: 0 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: None | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 0 |
| Action: Insert: 35 | Left Height: 1 |
| Rotation Case: None | Balance Factor: -1 |
| Left Pivot Node: None | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 1 |
| Action: Insert: 80 | Left Height: 1 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: None | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 1 |
| Action: Insert: 55 | Left Height: 2 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 35 | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 1 |
| Action: Insert: 55 | Left Height: 2 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 35 | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 1 |
| Action: Insert: 25 | Left Height: 3 |
| Rotation Case: RR Required at 35 | Balance Factor: 2 |
| Left Pivot Node: 35 | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 60 | Right Height: 1 |
| Action: RR Rotation | Left Height: 4 |
| Rotation Case: LL Required at 55 | Balance Factor: 3 |
| Left Pivot Node: 55 | Right Pivot Node: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: LL Rotation | Left Height: 3 |
| Rotation Case: LL Required at 30 | Balance Factor: 1 |
| Left Pivot Node: 35 | Right Pivot Node: 60 |
| Lower Left Pivot: 30 | Lower Right Pivot: None |

Bal: 2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: LL Rotation | Left Height: 2 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 60 |
| Lower Left Pivot: None | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: Insert: 10 | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 30 | Right Pivot Node: 60 |
| Lower Left Pivot: 25 | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 3 |
| Action: Insert: 75 | Left Height: 3 |
| Rotation Case: RL Required at 75 | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 60 |
| Lower Left Pivot: 25 | Lower Right Pivot: 80 |

Balance: -2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: RL Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivot: 25 | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: Insert: 50 | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivot: None | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: Insert: 15 | Left Height: 4 |
| Rotation Case: LR Required at 15 | Balance Factor: 2 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivot: 25 | Lower Right Pivot: None |

Bal: 2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: LR Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivot: 15 | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: Insert: 40 | Left Height: 4 |
| Rotation Case: RL Required at 40 | Balance Factor: 2 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivot: 35 | Lower Right Pivot: None |

Bal: 2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 2 |
| Action: RL Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivot: None |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 3 |
| Action: Insert: 90 | Left Height: 3 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivot: 80 |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 4 |
| Action: Insert: 85 | Left Height: 3 |
| Rotation Case: RL Required at 85 | Balance Factor: -1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivot: 80 |

Bal: -2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 3 |
| Action: RL Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivot: 85 |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 3 |
| Action: Insert: 70 | Left Height: 3 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivots: 60 & 85 |

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 4 |
| Action: Insert: 65 | Left Height: 3 |
| Rotation Case: RL Required at 65 | Balance Factor: -1 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivots: 60 & 85 |

Bal: -2

|  |  |
| --- | --- |
| Pivot Node: 55 | Right Height: 3 |
| Action: RL Rotation | Left Height: 3 |
| Rotation Case: None | Balance Factor: 0 |
| Left Pivot Node: 30 | Right Pivot Node: 75 |
| Lower Left Pivots: 15 & 40 | Lower Right Pivots: 65 & 85 |