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Algorithms  
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## Proof of Correctness and Runtimes for Sudoku Solver

Table

Problem	Runtime in Milliseconds
puz0	154
puz1	124
puz2	151
puz3	141
puz4	154
puz5	148
puz6	144
puz7	168
puz8	157
puz9	177

file: ./sudokuPuzzles/puz0

Sudoku problem:

```
0 0 0 7 0 0 2 0 0
0 2 3 0 0 0 0 7 0
4 0 0 0 0 2 0 0 1
0 0 0 0 0 1 8 4 0
8 0 0 0 2 0 1 9 0
0 0 5 0 0 0 0 0 2
0 5 0 0 6 0 0 0 0
```

```
2 0 0 0 0 9 0 0 8
0 0 6 3 0 0 5 0 0
```

Solution is invalid  
Run Time = 154 msec

25 initial digits given

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file: ./sudokuPuzzles/puz1

Sudoku problem:

```
5 4 0 2 0 9 0 0 1
0 0 0 5 0 0 0 0 4
0 0 7 0 0 0 9 0 0
8 0 0 0 3 0 0 6 7
0 0 0 6 0 5 0 0 0
9 3 0 0 1 0 0 0 2
0 0 1 0 0 0 6 0 0
2 0 0 0 0 6 0 0 0
3 0 0 1 0 7 0 4 9
```

Solution:

```
5 4 3 2 6 9 8 7 1
6 8 9 5 7 1 3 2 4
1 2 7 8 4 3 9 5 6
8 1 5 9 3 2 4 6 7
4 7 2 6 8 5 1 9 3
9 3 6 7 1 4 5 8 2
7 9 1 4 2 8 6 3 5
2 5 4 3 9 6 7 1 8
3 6 8 1 5 7 2 4 9
```

Solution is valid  
Run Time = 124 msec

28 initial digits given

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file: ./sudokuPuzzles/puz2

Sudoku problem:

```
4 0 0 0 0 0 8 0 5
0 3 0 0 0 0 0 0 0
0 0 0 7 0 0 0 0 0
```

```
0 2 0 0 0 0 0 6 0
0 0 0 0 8 0 4 0 0
0 0 0 0 1 0 0 0 0
0 0 0 6 0 3 0 7 0
5 0 0 2 0 0 0 0 0
1 0 4 0 0 0 0 0 0
```

Solution:

```
4 1 7 3 6 9 8 2 5
6 3 2 1 5 8 9 4 7
9 5 8 7 2 4 3 1 6
8 2 5 4 3 7 1 6 9
7 9 1 5 8 6 4 3 2
3 4 6 9 1 2 7 5 8
2 8 9 6 4 3 5 7 1
5 7 3 2 9 1 6 8 4
1 6 4 8 7 5 2 9 3
```

Solution is valid

Run Time = 151 msec

17 initial digits given

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file: ./sudokuPuzzles/puz3

Sudoku problem:

```
0 0 0 0 0 0 0 0 0
0 5 4 0 9 0 0 6 7
0 0 1 0 2 0 0 4 8
0 0 0 6 0 0 0 0 0
7 3 0 0 0 0 0 0 4
5 8 0 0 0 0 0 3 0
0 6 0 9 0 7 0 0 0
0 4 0 8 6 0 0 7 9
0 0 8 0 4 0 0 0 3
```

Solution:

```
6 2 7 5 8 4 3 9 1
8 5 4 3 9 1 2 6 7
3 9 1 7 2 6 5 4 8
4 1 9 6 7 3 8 2 5
7 3 6 2 5 8 9 1 4
5 8 2 4 1 9 7 3 6
1 6 5 9 3 7 4 8 2
2 4 3 8 6 5 1 7 9
```

9 7 8 1 4 2 6 5 3

Solution is valid  
Run Time = 141 msec

27 initial digits given

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file: ./sudokuPuzzles/puz4

Sudoku problem:

4	0	0	0	0	0	8	0	5
0	3	0	0	0	0	0	0	0
0	0	0	7	0	0	0	0	0
0	2	0	0	0	0	0	6	0
0	0	0	0	8	0	4	0	0
0	0	0	0	1	0	0	0	0
0	0	0	6	0	3	0	7	0
5	0	0	2	0	0	0	0	0
1	0	4	0	0	0	0	0	0

Solution:

4	1	7	3	6	9	8	2	5
6	3	2	1	5	8	9	4	7
9	5	8	7	2	4	3	1	6
8	2	5	4	3	7	1	6	9
7	9	1	5	8	6	4	3	2
3	4	6	9	1	2	7	5	8
2	8	9	6	4	3	5	7	1
5	7	3	2	9	1	6	8	4
1	6	4	8	7	5	2	9	3

Solution is valid  
Run Time = 154 msec

17 initial digits given

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file: ./sudokuPuzzles/puz5

Sudoku problem:

3	0	0	0	8	0	0	0	0
0	0	0	7	0	0	0	0	5
1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3	6	0

```
0 0 2 0 0 4 0 0 0
0 7 0 0 0 0 0 0 0
0 0 0 0 6 0 1 3 0
0 4 5 2 0 0 0 0 0
0 0 0 0 0 0 8 0 0
```

Solution:

```
3 5 4 1 8 6 9 2 7
2 9 8 7 4 3 6 1 5
1 6 7 9 5 2 4 8 3
4 8 1 5 2 7 3 6 9
9 3 2 6 1 4 5 7 8
5 7 6 3 9 8 2 4 1
7 2 9 8 6 5 1 3 4
8 4 5 2 3 1 7 9 6
6 1 3 4 7 9 8 5 2
```

Solution is valid

Run Time = 148 msec

17 initial digits given

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file: ./sudokuPuzzles/puz6

Sudoku problem:

```
0 0 0 5 0 3 0 0 0
0 0 0 0 6 0 7 0 0
5 0 8 0 0 0 0 1 6
3 6 0 0 2 0 0 0 0
0 0 0 4 0 1 0 0 0
0 0 0 0 3 0 0 0 5
6 7 0 0 0 0 2 0 8
0 0 4 0 7 0 0 0 0
0 0 0 2 0 0 5 0 0
```

Solution:

```
7 4 6 5 1 3 8 9 2
1 3 2 8 6 9 7 5 4
5 9 8 7 4 2 3 1 6
3 6 7 9 2 5 4 8 1
9 2 5 4 8 1 6 7 3
4 8 1 6 3 7 9 2 5
6 7 9 1 5 4 2 3 8
2 5 4 3 7 8 1 6 9
8 1 3 2 9 6 5 4 7
```

Solution is valid  
Run Time = 144 msec

23 initial digits given

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file: ./sudokuPuzzles/puz7

Sudoku problem:

0	0	0	0	1	0	7	8	0
5	0	0	0	0	9	0	0	0
0	0	0	0	0	0	0	4	0
0	2	0	0	0	0	0	0	0
0	0	0	6	0	0	0	0	3
0	7	4	0	8	0	0	0	0
0	0	0	0	0	3	0	0	2
0	8	0	0	4	0	0	1	0
6	0	0	5	0	0	0	0	0

Solution:

2	6	9	3	1	4	7	8	5
5	4	8	7	6	9	2	3	1
7	3	1	8	5	2	6	4	9
1	2	6	4	3	7	9	5	8
8	9	5	6	2	1	4	7	3
3	7	4	9	8	5	1	2	6
4	5	7	1	9	3	8	6	2
9	8	3	2	4	6	5	1	7
6	1	2	5	7	8	3	9	4

Solution is valid  
Run Time = 168 msec

19 initial digits given

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file: ./sudokuPuzzles/puz8

Sudoku problem:

0	5	2	0	0	6	8	0	0
0	0	0	0	0	7	0	2	0
0	0	0	0	0	0	6	0	0
0	0	4	8	0	0	9	0	0
2	0	0	4	1	0	0	0	0

```
0 0 1 0 0 0 0 0 8
0 0 6 1 0 0 3 8 0
0 0 0 0 9 0 0 0 6
3 0 0 6 0 0 1 0 9
```

Solution:

```
1 5 2 9 4 6 8 3 7
9 6 3 5 8 7 4 2 1
8 4 7 2 3 1 6 9 5
5 7 4 8 6 3 9 1 2
2 8 9 4 1 5 7 6 3
6 3 1 7 2 9 5 4 8
7 9 6 1 5 2 3 8 4
4 1 5 3 9 8 2 7 6
3 2 8 6 7 4 1 5 9
```

Solution is valid

Run Time = 157 msec

24 initial digits given

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file: ./sudokuPuzzles/puz9

Sudoku problem:

```
0 2 0 0 0 0 0 0 0
0 0 0 6 0 0 0 0 3
0 7 4 0 8 0 0 0 0
0 0 0 0 0 3 0 0 2
0 8 0 0 4 0 0 1 0
6 0 0 5 0 0 0 0 0
0 0 0 0 1 0 7 8 0
5 0 0 0 0 9 0 0 0
0 0 0 0 0 0 0 4 0
```

Solution:

```
1 2 6 4 3 7 9 5 8
8 9 5 6 2 1 4 7 3
3 7 4 9 8 5 1 2 6
4 5 7 1 9 3 8 6 2
9 8 3 2 4 6 5 1 7
6 1 2 5 7 8 3 9 4
2 6 9 3 1 4 7 8 5
5 4 8 7 6 9 2 3 1
7 3 1 8 5 2 6 4 9
```

Solution is valid  
Run Time = 177 msec

19 initial digits given

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