**Solution to a Maze through Genetic Algorithm**

* **Maze Diagram**
* **Description**

The goal is for the bot to start from the lower –left most cell and reach the upper right most cell through the maze. It is a maze of size 8\*8. The bot is considered to have made a valid move when it moves forward, turns left or right without crashing into a wall.

The following settings are maintained for the Genetic Algorithm:

**Population size:** 150

**Mutation probability:** 0.07

**Crossover probability:** 0.6

**Selection process:** Roulette wheel

**Maximum chromosome length:** 30 – Each chromosome contains a plan, which is essentially an array of characters, with each character supposed to represent a valid move.

**Effective chromosome length:** This is the number of valid moves the bot can make before it reaches the goal or crashes into a wall.

**Expected optimal length:** This is used to calculate the fitness function. This is to differentiate fitness between the shortest path to the goal and paths longer than that yet reaching the goal.

**Fitness function:** 8.839\*(11.313-d)

Where d = diagonal distance between the point where the bot crashed and the goal

**Maximum possible fitness:** 100

* **Flow Chart**

START

Max population fitness < 93

Set Seed for random number selection

Is population diverse?

N

Compute current population fitness

Y

N

END

END

Declare current and next population.

Y

Perform GA on the current population

Compute current population fitness

* **Report**

***Output is in the form***

***Generation: min\_fitness average\_fitness max\_fitness***

1. **Observation:** Invalid values on the chromosome string.

**Reason:** Program Error, accessing wrong address.

--------------------------------------------------

 1 : 11.6056 16.8867 40.7018

 1001 : 11.6056 18.8959 32.6798

 2001 : 11.6056 16.2736 24.4752

 3001 : 11.6056 15.705 24.9942

 4001 : 11.6056 16.5498 20.9372

 5001 : 11.6056 17.9246 30.9608

 6001 : 11.6056 17.5387 24.9942

 7001 : 11.6056 18.3853 55.8006

 TRACE MOVES : R\_E

--------------------------------------------------

1. **Observation:** Converging too soon.

**Reason:** Very high mutation probability.

--------------------------------------------------

 1 : 11.6056 14.1488 30.9608

 501 : 12.494 28.4653 30.9608

 1001 : 11.6056 28.2514 30.9608

 1501 : 11.6056 29.3473 30.9608

 2001 : 11.6056 28.7182 30.9608

 2501 : 11.6056 27.4124 30.9608

 3001 : 11.6056 26.5271 30.9608

 3501 : 16.6086 27.6953 30.9608

 3939 : 30.9608 30.9608 30.9608

 TRACE MOVES : RFR

--------------------------------------------------

1. **Observation:** Converging too soon.

**Reason:** Effective length of chromosome converging to zero.

--------------------------------------------------

 1 : 11.6056 17.7344 32.6798

 1001 : 11.6056 15.4232 18.5041

 2001 : 11.6056 14.7091 18.5041

 3001 : 11.6056 15.7254 18.5041

 4001 : 11.6056 14.9941 18.5041

 5001 : 11.6056 15.7977 18.5041

 6001 : 11.6056 14.5307 18.5041

 7001 : 11.6056 16.2338 18.5041

 8001 : 11.6056 16.2328 18.5041

 9001 : 11.6056 15.2817 18.5041

 10001 : 11.6056 16.951 18.5041

 11001 : 11.6056 16.5624 18.5041

 12001 : 11.6056 15.122 18.5041

 13001 : 11.6056 15.9301 18.5041

 14001 : 11.6056 14.9345 18.5041

 15001 : 11.6056 13.1338 18.5041

 16001 : 11.6056 16.483 18.5041

 17001 : 11.6056 16.1418 18.5041

 18001 : 11.6056 15.0194 18.5041

 19001 : 11.6056 14.6929 18.5041

 20001 : 11.6056 15.1255 18.5041

 21001 : 11.6056 14.6722 18.5041

 22001 : 11.6056 15.8578 18.5041

 23001 : 11.6056 15.8599 18.5041

 24001 : 11.6056 15.2782 18.5041

 25001 : 11.6056 15.7841 18.5041

 26001 : 11.6056 16.6452 18.5041

 27001 : 11.6056 15.3631 18.5041

 28001 : 11.6056 14.654 18.5041

 29001 : 11.6056 13.9662 18.5041

 30001 : 11.6056 16.6502 18.5041

 31001 : 11.6056 16.6154 18.5041

 32001 : 11.6056 15.3807 18.5041

 33001 : 11.6056 16.066 18.5041

 34001 : 11.6056 14.8931 18.5041

 35001 : 11.6056 15.5379 18.5041

 36001 : 11.6056 16.0059 18.5041

 37001 : 11.6056 15.9048 18.5041

 38001 : 11.6056 16.859 18.5041

 39001 : 11.6056 15.4277 18.5041

 40001 : 11.6056 15.5425 18.5041

 41001 : 11.6056 16.811 18.5041

 42001 : 11.6056 15.1918 18.5041

 43001 : 11.6056 15.2989 18.5041

 44001 : 11.6056 15.8922 18.5041

 45001 : 11.6056 15.8613 18.5041

 46001 : 11.6056 15.2817 18.5041

 47001 : 11.6056 14.2755 18.5041

 48001 : 11.6056 12.629 18.5041

 49001 : 11.6056 15.3944 18.5041

 50001 : 11.6056 15.922 18.5041

 51001 : 11.6056 16.6371 18.5041

 52001 : 11.6056 15.4197 18.5041

 53001 : 11.6056 15.6279 18.5041

 54001 : 11.6056 16.72 18.5041

 55001 : 11.6056 14.9194 18.5041

 56001 : 11.6056 15.4899 18.5041

 57001 : 11.6056 16.95 18.5041

 58001 : 11.6056 15.3059 18.5041

 59001 : 11.6056 14.4307 18.5041

 60001 : 11.6056 15.2943 18.5041

 61001 : 11.6056 16.3718 18.5041

 62001 : 11.6056 15.8002 18.5041

 63001 : 11.6056 15.5955 18.5041

 64001 : 11.6056 16.2647 18.5041

 65001 : 11.6056 15.4045 18.5041

 66001 : 11.6056 16.8752 18.5041

 67001 : 11.6056 14.7045 18.5041

 68001 : 11.6056 15.1816 18.5041

 69001 : 11.6056 15.8876 18.5041

 70001 : 11.6056 16.482 18.5041

 71001 : 11.6056 15.7012 18.5041

 72001 : 11.6056 16.441 18.5041

 73001 : 11.6056 16.244 18.5041

 74001 : 11.6056 15.2999 18.5041

 75001 : 11.6056 15.9357 18.5041

 76001 : 11.6056 14.886 18.5041

 77001 : 11.6056 16.8398 18.5041

 78001 : 11.6056 14.6227 18.5041

 78365 : 11.6056 11.6056 11.6056

 TRACE MOVES :

--------------------------------------------------

1. **Observation:** Terminated one move away from the goal.

**Reason:** Termination condition was less ambitious.

**Maximum Fitness:** 91.1566

**Moves:** FFFRFFFFRFLFLFFFF

--------------------------------------------------

 0 : 28.7333 28.7333 28.7333

 TRACE MOVES :

--------------------------------------------------

 1 : 11.6056 16.8468 32.6798

 1001 : 11.6056 33.9303 63.5515

 TRACE MOVES : FFFRFFFLFF

--------------------------------------------------

 2001 : 11.6056 34.4289 63.5515

 TRACE MOVES : FFFRFFFLFF

--------------------------------------------------

 3001 : 11.6056 39.4526 64.6396

 TRACE MOVES : FFFRFFFLFFF

--------------------------------------------------

 4001 : 11.6056 37.6511 63.5515

 TRACE MOVES : FFFRFFLRLFF

--------------------------------------------------

 5001 : 11.6056 36.1503 63.5515

 TRACE MOVES : FFFRFFLRLFF

--------------------------------------------------

 6001 : 11.6056 33.0602 62.4949

 TRACE MOVES : FFFRFFFLR

--------------------------------------------------

 7001 : 11.6056 33.3166 62.4949

 TRACE MOVES : FFFRFLRFFL

--------------------------------------------------

 7890 : 11.6056 37.2692 91.1566

 TRACE MOVES : FFFRFLRFLRRFLFLFFFFF

--------------------------------------------------

 1 : 11.6056 18.5983 40.7018

 1001 : 11.6056 36.5544 62.4949

 TRACE MOVES : FFFRFFFF

--------------------------------------------------

 2001 : 11.6056 33.8827 62.4949

 TRACE MOVES : FFFRFFFF

--------------------------------------------------

 3001 : 11.6056 35.1346 60.4664

 TRACE MOVES : FFFRFFFL

--------------------------------------------------

 4001 : 11.6056 36.8997 64.6396

 TRACE MOVES : FFFRFFFLFF

--------------------------------------------------

 5001 : 11.6056 32.1546 62.4949

 TRACE MOVES : FFFRFFFF

--------------------------------------------------

 6001 : 11.6056 35.5833 64.6396

 TRACE MOVES : FFFRFFFLFF

--------------------------------------------------

 7001 : 11.6056 37.9103 64.6396

 TRACE MOVES : FFFRFFFLFF

--------------------------------------------------

 8001 : 11.6056 35.5131 62.4949

 TRACE MOVES : FFFRFFFF

--------------------------------------------------

 8818 : 11.6056 37.7787 91.1566

 TRACE MOVES : FFFRFFFFRFLFLFFFF

--------------------------------------------------

1. **Observation:** Reaching local maximas which are couple of moves away from the goal.

**Reason:** Made no changes to the program.

**Maximum Fitness:** 87.49

**Moves:** FFFRFFFFRFLFLFFF

--------------------------------------------------

 1 : 11.6056 17.7956 40.7018

 1001 : 11.6056 31.9067 62.4949

 2001 : 11.6056 32.7025 62.4949

 3001 : 11.6056 35.2059 64.6396

 4001 : 11.6056 36.448 63.5515

 5001 : 11.6056 34.0715 63.5515

 6001 : 11.6056 36.2672 64.6396

 7001 : 11.6056 36.867 63.5515

 8001 : 11.6056 35.7532 64.6396

 9001 : 11.6056 34.0665 64.6396

 10001 : 11.6056 39.1215 64.6396

 11001 : 11.6056 36.3372 64.6396

 12001 : 11.6056 34.5885 64.6396

 13001 : 11.6056 35.9983 63.5515

 14001 : 11.6056 38.9148 64.6396

 15001 : 11.6056 35.1774 63.5515

 16001 : 11.6056 34.2369 63.5515

 17001 : 11.6056 32.6858 64.6396

 18001 : 11.6056 34.6671 64.6396

 19001 : 11.6056 31.6576 64.6396

 20001 : 11.6056 34.1154 64.6396

 21001 : 11.6056 34.8188 64.6396

 22001 : 11.6056 38.0121 63.5515

 23001 : 11.6056 34.6342 64.6396

 24001 : 11.6056 32.113 63.5515

 25001 : 11.6056 38.9889 63.5515

 26001 : 11.6056 34.3295 63.5515

 27001 : 11.6056 37.3743 64.6396

 28001 : 11.6056 31.8195 63.5515

 29001 : 11.6056 35.1619 63.5515

 30001 : 11.6056 34.794 63.5515

 31001 : 11.6056 33.4726 64.6396

 32001 : 11.6056 38.6243 64.6396

 33001 : 11.6056 30.9233 60.4664

 34001 : 11.6056 34.6423 64.6396

 35001 : 11.6056 35.8709 63.5515

 36001 : 11.6056 40.1475 64.6396

 37001 : 11.6056 38.1588 63.5515

 38001 : 11.6056 36.1184 64.6396

 39001 : 11.6056 34.3213 63.5515

 40001 : 11.6056 32.5001 62.4949

 41001 : 11.6056 37.7395 64.6396

 42001 : 11.6056 36.2717 64.6396

 43001 : 11.6056 36.1488 62.4949

 44001 : 11.6056 36.6538 64.6396

 45001 : 11.6056 32.2647 64.6396

 46001 : 11.6056 34.7215 63.5515

 47001 : 11.6056 37.6913 64.6396

 48001 : 11.6056 34.9646 64.6396

 49001 : 11.6056 33.8345 64.6396

 50001 : 11.6056 33.2767 64.6396

 51001 : 11.6056 31.7511 64.6396

 52001 : 11.6056 33.324 63.5515

 53001 : 11.6056 32.7151 64.6396

 54001 : 11.6056 34.6899 64.6396

 55001 : 11.6056 30.6493 62.4949

 56001 : 11.6056 37.7553 64.6396

 57001 : 11.6056 35.8641 63.5515

 58001 : 11.6056 36.1174 63.5515

 59001 : 11.6056 33.4046 62.4949

 60001 : 11.6056 38.9026 64.6396

 61001 : 11.6056 31.3136 62.4949

 62001 : 11.6056 30.9205 62.4949

 63001 : 11.6056 37.5274 64.6396

 64001 : 11.6056 34.4845 64.6396

 65001 : 11.6056 34.0961 63.5515

 66001 : 11.6056 39.3249 63.5515

 67001 : 11.6056 34.0979 64.6396

 68001 : 11.6056 33.8012 63.5515

 69001 : 11.6056 35.766 63.5515

 70001 : 11.6056 34.8857 64.6396

 71001 : 11.6056 36.6805 64.6396

 72001 : 11.6056 32.0525 63.5515

 73001 : 11.6056 34.0427 63.5515

 74001 : 11.6056 33.7881 63.5515

 75001 : 11.6056 38.479 63.5515

 76001 : 11.6056 34.4306 63.5515

 77001 : 11.6056 34.2291 64.6396

 78001 : 11.6056 36.0924 63.5515

 79001 : 11.6056 34.8384 64.6396

 80001 : 11.6056 34.802 64.6396

 81001 : 11.6056 33.6177 62.4949

 82001 : 11.6056 31.3047 63.5515

 83001 : 11.6056 38.2755 64.6396

 84001 : 11.6056 35.1293 64.6396

 85001 : 11.6056 35.2817 63.5515

 86001 : 11.6056 35.5154 63.5515

 87001 : 11.6056 35.2391 64.6396

 88001 : 11.6056 32.0713 63.5515

 89001 : 11.6056 29.8026 63.5515

 90001 : 11.6056 34.4373 64.6396

 91001 : 11.6056 33.6576 62.4949

 92001 : 11.6056 38.3053 64.6396

 93001 : 11.6056 34.5563 63.5515

 94001 : 11.6056 34.1804 64.6396

 95001 : 11.6056 36.3393 64.6396

 96001 : 11.6056 33.1096 63.5515

 97001 : 11.6056 36.2521 64.6396

 98001 : 11.6056 37.5437 64.6396

 99001 : 11.6056 32.0348 63.5515

 100001 : 11.6056 31.7572 60.4664

 101001 : 11.6056 41.1544 63.5515

 102001 : 11.6056 34.9211 63.5515

 103001 : 11.6056 34.0513 64.6396

 104001 : 11.6056 37.6088 63.5515

 105001 : 11.6056 31.2141 62.4949

 106001 : 11.6056 35.7058 64.6396

 107001 : 11.6056 37.1402 64.6396

 108001 : 11.6056 36.3305 64.6396

 109001 : 11.6056 33.4675 60.4664

 110001 : 11.6056 34.5317 64.6396

 111001 : 11.6056 34.0491 62.4949

 112001 : 11.6056 39.122 63.5515

 113001 : 11.6056 36.5694 62.4949

 114001 : 11.6056 32.4907 64.6396

 115001 : 11.6056 30.4727 62.4949

 116001 : 11.6056 36.9547 64.6396

 117001 : 11.6056 33.3683 64.6396

 118001 : 11.6056 35.081 63.5515

 119001 : 11.6056 35.1897 63.5515

 120001 : 11.6056 33.8191 64.6396

 121001 : 11.6056 32.5807 63.5515

 122001 : 11.6056 32.7934 64.6396

 123001 : 11.6056 33.7917 64.6396

 124001 : 11.6056 33.4093 64.6396

 125001 : 11.6056 35.9221 64.6396

 126001 : 11.6056 34.2338 63.5515

 127001 : 11.6056 33.1894 63.5515

 128001 : 11.6056 31.3227 62.4949

 129001 : 11.6056 37.5229 63.5515

 130001 : 11.6056 36.5322 64.6396

 131001 : 11.6056 34.3252 64.6396

 132001 : 11.6056 37.9098 63.5515

 133001 : 11.6056 40.0989 64.6396

 134001 : 11.6056 34.4478 62.4949

 135001 : 11.6056 35.1853 64.6396

 136001 : 11.6056 34.4267 64.6396

 137001 : 11.6056 39.5005 64.6396

 138001 : 11.6056 35.4906 64.6396

 139001 : 11.6056 31.52 63.5515

 140001 : 11.6056 34.3587 63.5515

 141001 : 11.6056 35.6187 62.4949

 142001 : 11.6056 33.0303 63.5515

 143001 : 11.6056 33.8373 63.5515

 144001 : 11.6056 38.8761 63.5515

 145001 : 11.6056 31.3479 63.5515

 146001 : 11.6056 33.5685 63.5515

 147001 : 11.6056 33.1566 62.4949

 148001 : 11.6056 37.0087 64.6396

 149001 : 11.6056 33.1103 64.6396

 150001 : 11.6056 34.718 63.5515

 151001 : 11.6056 36.3944 63.5515

 152001 : 11.6056 33.2795 63.5515

 153001 : 11.6056 35.5967 64.6396

 154001 : 11.6056 30.6343 63.5515

 155001 : 11.6056 34.1852 64.6396

 156001 : 11.6056 38.1493 64.6396

 157001 : 11.6056 30.0964 62.4949

 158001 : 11.6056 34.8831 64.6396

 159001 : 11.6056 36.1646 64.6396

 160001 : 11.6056 34.9927 63.5515

 161001 : 11.6056 34.5534 64.6396

 162001 : 11.6056 39.5524 63.5515

 163001 : 11.6056 34.9679 64.6396

 164001 : 11.6056 33.4898 64.6396

 165001 : 11.6056 34.9932 64.6396

 166001 : 11.6056 31.7147 63.5515

 167001 : 11.6056 35.8504 64.6396

 168001 : 11.6056 35.8218 62.4949

 169001 : 11.6056 34.3532 62.4949

 170001 : 11.6056 34.4956 63.5515

 171001 : 11.6056 30.495 63.5515

 172001 : 11.6056 36.437 63.5515

 173001 : 11.6056 38.988 64.6396

 174001 : 11.6056 36.2386 64.6396

 175001 : 11.6056 34.3726 64.6396

 176001 : 11.6056 35.65 64.6396

 177001 : 11.6056 34.3598 64.6396

 178001 : 11.6056 32.0239 62.4949

 179001 : 11.6056 36.4844 62.4949

 180001 : 11.6056 32.5326 63.5515

 181001 : 11.6056 35.1311 64.6396

 182001 : 11.6056 32.4596 63.5515

 183001 : 11.6056 34.0615 64.6396

 184001 : 11.6056 33.3764 64.6396

 185001 : 11.6056 36.4928 63.5515

 186001 : 11.6056 36.5734 64.6396

 187001 : 11.6056 37.069 62.4949

 188001 : 11.6056 31.6991 64.6396

 189001 : 11.6056 34.1544 64.6396

 190001 : 11.6056 37.383 63.5515

 191001 : 11.6056 35.8328 64.6396

 192001 : 11.6056 38.7879 64.6396

 193001 : 11.6056 32.4433 63.5515

 194001 : 11.6056 31.9812 63.5515

 195001 : 11.6056 35.2673 64.6396

 196001 : 11.6056 33.1409 63.5515

 197001 : 11.6056 37.3009 64.6396

 198001 : 11.6056 33.281 63.5515

 199001 : 11.6056 37.2747 63.5515

 200001 : 11.6056 34.6939 63.5515

 201001 : 11.6056 39.794 64.6396

 202001 : 11.6056 33.8278 64.6396

 203001 : 11.6056 34.0924 55.8006

 204001 : 11.6056 34.5177 72.0442

 205001 : 11.6056 31.0186 64.6396

 206001 : 11.6056 37.3302 64.6396

 207001 : 11.6056 34.212 62.4949

 208001 : 11.6056 35.0407 62.4949

 209001 : 11.6056 33.7533 62.4949

 210001 : 11.6056 36.7099 63.5515

 211001 : 11.6056 34.1756 63.5515

 212001 : 11.6056 33.5513 63.5515

 213001 : 11.6056 36.0514 63.5515

 214001 : 11.6056 34.4478 62.4949

 215001 : 11.6056 33.6795 64.6396

 216001 : 11.6056 34.6468 64.6396

 217001 : 11.6056 27.3113 55.8006

 218001 : 11.6056 34.5806 62.4949

 219001 : 11.6056 35.4106 63.5515

 220001 : 11.6056 33.3132 63.5515

 221001 : 11.6056 34.9887 62.4949

 222001 : 11.6056 37.8628 63.5515

 223001 : 11.6056 34.9009 64.6396

 224001 : 11.6056 35.2455 64.6396

 225001 : 11.6056 34.5708 63.5515

 226001 : 11.6056 33.1913 63.5515

 227001 : 11.6056 35.0204 63.5515

 228001 : 11.6056 34.1853 62.4949

 229001 : 11.6056 34.2943 62.4949

 230001 : 11.6056 33.6158 63.5515

 231001 : 11.6056 35.8376 64.6396

 232001 : 11.6056 35.5222 62.4949

 233001 : 11.6056 38.6301 63.5515

 234001 : 11.6056 37.0114 64.6396

 235001 : 11.6056 35.3813 64.6396

 236001 : 11.6056 36.3156 63.5515

 237001 : 11.6056 33.3763 64.6396

 238001 : 11.6056 32.5639 62.4949

 239001 : 11.6056 34.0144 63.5515

 240001 : 11.6056 36.2838 63.5515

 241001 : 11.6056 37.2562 63.5515

 242001 : 11.6056 36.1142 64.6396

 243001 : 11.6056 37.0571 64.6396

 244001 : 11.6056 34.3583 64.6396

 245001 : 11.6056 36.8302 64.6396

 246001 : 11.6056 36.1547 62.4949

 247001 : 11.6056 35.2947 63.5515

 248001 : 11.6056 32.0435 64.6396

 249001 : 11.6056 33.545 62.4949

 250001 : 11.6056 35.0489 64.6396

 251001 : 11.6056 34.6005 63.5515

 252001 : 11.6056 32.0722 62.4949

 253001 : 11.6056 37.5955 64.6396

 254001 : 11.6056 35.8102 63.5515

 255001 : 11.6056 35.9784 64.6396

 256001 : 11.6056 36.3871 64.6396

 257001 : 11.6056 32.7466 64.6396

 258001 : 11.6056 31.5257 64.6396

 259001 : 11.6056 34.3987 64.6396

 260001 : 11.6056 36.4235 63.5515

 261001 : 11.6056 37.7699 64.6396

 262001 : 11.6056 33.515 63.5515

 263001 : 11.6056 34.2314 63.5515

 264001 : 11.6056 33.5206 64.6396

 265001 : 11.6056 37.0701 63.5515

 266001 : 11.6056 39.5393 64.6396

 267001 : 11.6056 37.7289 63.5515

 268001 : 11.6056 33.4397 63.5515

 269001 : 11.6056 32.0139 62.4949

 270001 : 11.6056 31.3277 63.5515

 271001 : 11.6056 39.4015 63.5515

 272001 : 11.6056 34.5554 63.5515

 273001 : 11.6056 33.9918 80.231

 TRACE MOVES : FFFRFFFFRFLFLFF

--------------------------------------------------

 274001 : 11.6056 35.798 62.4949

 275001 : 11.6056 33.7197 63.5515

 276001 : 11.6056 34.2572 63.5515

 277001 : 11.6056 35.208 64.6396

 278001 : 11.6056 38.9712 72.0442

 279001 : 11.6056 35.5803 63.5515

 280001 : 11.6056 34.2554 64.6396

 281001 : 11.6056 33.6118 63.5515

 282001 : 11.6056 36.9337 64.6396

 283001 : 11.6056 30.9055 62.4949

 284001 : 11.6056 32.7549 64.6396

 285001 : 11.6056 35.4735 62.4949

 286001 : 11.6056 32.7919 63.5515

 287001 : 11.6056 34.248 63.5515

 288001 : 11.6056 34.8729 63.5515

 289001 : 11.6056 35.7432 62.4949

 290001 : 11.6056 37.9706 63.5515

 291001 : 11.6056 32.4318 63.5515

 292001 : 11.6056 36.841 63.5515

 293001 : 11.6056 32.3672 62.4949

 294001 : 11.6056 37.5442 64.6396

 295001 : 11.6056 36.8657 63.5515

 296001 : 11.6056 36.6901 63.5515

 297001 : 11.6056 35.5143 64.6396

 298001 : 11.6056 33.0764 63.5515

 299001 : 11.6056 34.898 63.5515

 300001 : 11.6056 29.5034 55.8006

 301001 : 11.6056 35.789 64.6396

 302001 : 11.6056 39.4892 64.6396

 303001 : 11.6056 34.0097 64.6396

 304001 : 11.6056 30.1701 63.5515

 305001 : 11.6056 35.6575 64.6396

 306001 : 11.6056 34.9757 63.5515

 307001 : 11.6056 37.7532 63.5515

 308001 : 11.6056 35.1975 62.4949

 309001 : 11.6056 37.0008 64.6396

 310001 : 11.6056 36.4847 63.5515

 311001 : 11.6056 34.9858 64.6396

 312001 : 11.6056 34.4134 62.4949

 313001 : 11.6056 32.1368 63.5515

 314001 : 11.6056 36.1872 63.5515

 315001 : 11.6056 34.9161 64.6396

 316001 : 11.6056 32.2064 62.4949

 317001 : 11.6056 34.9102 64.6396

 318001 : 11.6056 38.6117 64.6396

 319001 : 11.6056 33.9991 63.5515

 320001 : 11.6056 37.1922 63.5515

 321001 : 11.6056 30.8388 62.4949

 322001 : 11.6056 36.131 63.5515

 323001 : 11.6056 33.6736 64.6396

 324001 : 11.6056 33.043 63.5515

 325001 : 11.6056 36.6096 64.6396

 326001 : 11.6056 35.7482 63.5515

 327001 : 11.6056 39.3637 64.6396

 328001 : 11.6056 32.1842 62.4949

 329001 : 11.6056 33.2703 63.5515

 330001 : 11.6056 36.8513 64.6396

 331001 : 11.6056 37.2436 64.6396

 332001 : 11.6056 31.8328 63.5515

 333001 : 11.6056 30.1123 62.4949

 334001 : 11.6056 33.6423 62.4949

 335001 : 11.6056 34.3865 63.5515

 336001 : 11.6056 36.0685 63.5515

 337001 : 11.6056 29.2848 62.4949

 338001 : 11.6056 32.9011 64.6396

 339001 : 11.6056 39.8349 64.6396

 340001 : 11.6056 33.6862 63.5515

 341001 : 11.6056 35.5212 62.4949

 342001 : 11.6056 36.974 63.5515

 343001 : 11.6056 38.8421 63.5515

 344001 : 11.6056 36.8684 63.5515

 345001 : 11.6056 38.6239 64.6396

 346001 : 11.6056 34.1463 64.6396

 347001 : 11.6056 34.9676 64.6396

 348001 : 11.6056 32.6015 63.5515

 349001 : 11.6056 36.1787 63.5515

 350001 : 11.6056 34.5773 63.5515

 351001 : 11.6056 34.7753 64.6396

 352001 : 11.6056 33.5738 62.4949

 353001 : 11.6056 35.7944 63.5515

 354001 : 11.6056 33.9324 64.6396

 355001 : 11.6056 35.095 63.5515

 356001 : 11.6056 36.3947 64.6396

 357001 : 11.6056 34.171 64.6396

 358001 : 11.6056 33.445 64.6396

 359001 : 11.6056 31.0132 63.5515

 360001 : 11.6056 34.6769 63.5515

 361001 : 11.6056 38.145 64.6396

 362001 : 11.6056 32.062 63.5515

 363001 : 11.6056 34.8281 62.4949

 364001 : 11.6056 37.8424 64.6396

 365001 : 11.6056 34.4647 64.6396

 366001 : 11.6056 34.8664 63.5515

 367001 : 11.6056 35.2256 64.6396

 368001 : 11.6056 37.0685 62.4949

 369001 : 11.6056 38.4705 64.6396

 370001 : 11.6056 33.2178 63.5515

 371001 : 11.6056 32.5213 63.5515

 372001 : 11.6056 36.9477 72.0442

 373001 : 11.6056 36.5922 64.6396

 374001 : 11.6056 31.3607 60.4664

 375001 : 11.6056 36.7135 64.6396

 376001 : 11.6056 31.1066 64.6396

 377001 : 11.6056 37.1348 64.6396

 378001 : 11.6056 34.6229 64.6396

 379001 : 11.6056 36.9153 64.6396

 380001 : 11.6056 37.1903 64.6396

 381001 : 11.6056 34.6632 64.6396

 382001 : 11.6056 36.9303 63.5515

 383001 : 11.6056 34.4775 64.6396

 384001 : 11.6056 34.7756 63.5515

 385001 : 11.6056 37.6813 64.6396

 386001 : 11.6056 30.8068 62.4949

 387001 : 11.6056 29.3592 55.8006

 388001 : 11.6056 31.0296 62.4949

 389001 : 11.6056 35.472 63.5515

 390001 : 11.6056 35.0944 64.6396

 391001 : 11.6056 32.0598 60.4664

 392001 : 11.6056 35.3432 62.4949

 393001 : 11.6056 32.8488 63.5515

 394001 : 11.6056 35.7414 64.6396

 395001 : 11.6056 36.5022 64.6396

 396001 : 11.6056 37.9598 63.5515

 397001 : 11.6056 34.7515 63.5515

 398001 : 11.6056 35.2213 64.6396

 399001 : 11.6056 34.3664 64.6396

 400001 : 11.6056 32.904 62.4949

 401001 : 11.6056 34.7458 62.4949

 402001 : 11.6056 35.271 64.6396

 403001 : 11.6056 32.1297 63.5515

 404001 : 11.6056 38.1008 63.5515

 405001 : 11.6056 33.3523 64.6396

 406001 : 11.6056 37.736 64.6396

 407001 : 11.6056 37.8892 64.6396

 408001 : 11.6056 37.8622 64.6396

 409001 : 11.6056 36.9838 63.5515

 410001 : 11.6056 34.9494 63.5515

 411001 : 11.6056 35.6444 64.6396

 412001 : 11.6056 35.4008 64.6396

 413001 : 11.6056 37.1643 64.6396

 414001 : 11.6056 33.0263 60.4664

 415001 : 11.6056 32.5215 63.5515

 416001 : 11.6056 35.5633 63.5515

 417001 : 11.6056 37.1747 63.5515

 418001 : 11.6056 31.4035 64.6396

 419001 : 11.6056 37.5192 64.6396

 420001 : 11.6056 38.9838 64.6396

 421001 : 11.6056 37.1432 63.5515

 422001 : 11.6056 31.622 63.5515

 423001 : 11.6056 33.5096 62.4949

 424001 : 11.6056 32.9988 63.5515

 425001 : 11.6056 34.6308 64.6396

 426001 : 11.6056 37.3468 63.5515

 427001 : 11.6056 35.6445 64.6396

 428001 : 11.6056 31.3465 63.5515

 429001 : 11.6056 33.5835 63.5515

 430001 : 11.6056 35.8907 63.5515

 431001 : 11.6056 36.4238 62.4949

 432001 : 11.6056 34.741 64.6396

 433001 : 11.6056 35.8224 63.5515

 434001 : 11.6056 31.9613 63.5515

 435001 : 11.6056 35.3056 64.6396

 436001 : 11.6056 31.7335 63.5515

 437001 : 11.6056 32.5806 63.5515

 438001 : 11.6056 34.3561 63.5515

 439001 : 11.6056 34.7934 72.0442

 440001 : 11.6056 33.9438 64.6396

 441001 : 11.6056 30.2223 64.6396

 442001 : 11.6056 36.3695 63.5515

 443001 : 11.6056 36.5425 63.5515

 444001 : 11.6056 34.5341 63.5515

 445001 : 11.6056 36.1584 64.6396

 446001 : 11.6056 33.8997 63.5515

 447001 : 11.6056 29.3397 63.5515

 448001 : 11.6056 36.6205 64.6396

 449001 : 11.6056 36.3336 64.6396

 450001 : 11.6056 31.3276 62.4949

 451001 : 11.6056 33.9208 64.6396

 452001 : 11.6056 35.7856 63.5515

 453001 : 11.6056 36.9723 62.4949

 454001 : 11.6056 37.5737 64.6396

 455001 : 11.6056 35.8833 64.6396

 456001 : 11.6056 35.9136 62.4949

 457001 : 11.6056 37.7494 64.6396

 458001 : 11.6056 33.9282 63.5515

 459001 : 11.6056 35.1587 64.6396

 460001 : 11.6056 39.0818 64.6396

 461001 : 11.6056 38.6641 64.6396

 462001 : 11.6056 30.4877 62.4949

 463001 : 11.6056 37.9543 64.6396

 464001 : 11.6056 39.5029 64.6396

 465001 : 11.6056 34.0571 63.5515

 466001 : 11.6056 37.424 63.5515

 467001 : 11.6056 36.1765 64.6396

 468001 : 11.6056 35.8923 63.5515

 469001 : 11.6056 37.0337 64.6396

 470001 : 11.6056 35.7515 63.5515

 471001 : 11.6056 35.1561 63.5515

 472001 : 11.6056 32.7519 64.6396

 473001 : 11.6056 32.2279 63.5515

 474001 : 11.6056 35.6583 63.5515

 475001 : 11.6056 31.7242 63.5515

 476001 : 11.6056 34.8773 64.6396

 477001 : 11.6056 37.1237 64.6396

 478001 : 11.6056 37.146 64.6396

 479001 : 11.6056 34.4443 64.6396

 480001 : 11.6056 35.4591 62.4949

 481001 : 11.6056 37.1329 64.6396

 482001 : 11.6056 36.5592 63.5515

 483001 : 11.6056 34.7984 63.5515

 484001 : 11.6056 37.5964 64.6396

 485001 : 11.6056 34.4131 63.5515

 486001 : 11.6056 35.162 64.6396

 487001 : 11.6056 37.4634 63.5515

 488001 : 11.6056 36.5549 64.6396

 489001 : 11.6056 34.8576 63.5515

 490001 : 11.6056 35.7328 63.5515

 491001 : 11.6056 32.6481 64.6396

 492001 : 11.6056 31.8897 64.6396

 493001 : 11.6056 33.834 63.5515

 494001 : 11.6056 35.681 63.5515

 495001 : 11.6056 35.2747 64.6396

 496001 : 11.6056 33.0511 62.4949

 497001 : 11.6056 35.469 64.6396

 498001 : 11.6056 34.3947 63.5515

 499001 : 11.6056 36.754 63.5515

 500001 : 11.6056 35.5635 64.6396

 501001 : 11.6056 31.756 64.6396

 502001 : 11.6056 34.6738 62.4949

 503001 : 11.6056 34.7594 63.5515

 504001 : 11.6056 35.8681 63.5515

 505001 : 11.6056 35.7508 64.6396

 506001 : 11.6056 35.2373 64.6396

 507001 : 11.6056 31.3046 62.4949

 508001 : 11.6056 36.5706 64.6396

 509001 : 11.6056 35.8689 64.6396

 510001 : 11.6056 37.2245 63.5515

 511001 : 11.6056 35.5415 64.6396

 512001 : 11.6056 35.2468 64.6396

 513001 : 11.6056 33.9264 63.5515

 514001 : 11.6056 35.7017 64.6396

 515001 : 11.6056 34.8742 62.4949

 516001 : 11.6056 36.0278 64.6396

 517001 : 11.6056 31.2096 63.5515

 518001 : 11.6056 37.3956 63.5515

 519001 : 11.6056 33.3355 62.4949

 520001 : 11.6056 32.8656 63.5515

 521001 : 11.6056 36.7793 64.6396

 522001 : 11.6056 36.8705 64.6396

 523001 : 11.6056 32.3938 63.5515

 524001 : 11.6056 33.8502 63.5515

 525001 : 11.6056 32.3914 63.5515

 526001 : 11.6056 32.6809 64.6396

 527001 : 11.6056 30.3866 63.5515

 528001 : 11.6056 31.7421 64.6396

 529001 : 11.6056 35.165 62.4949

 530001 : 11.6056 31.5462 62.4949

 531001 : 11.6056 35.1834 63.5515

 532001 : 11.6056 33.3332 63.5515

 533001 : 11.6056 30.0626 64.6396

 534001 : 11.6056 35.357 72.0442

 535001 : 11.6056 35.1366 64.6396

 536001 : 11.6056 37.0328 64.6396

 537001 : 11.6056 35.3057 64.6396

 538001 : 11.6056 32.8795 64.6396

 539001 : 11.6056 32.6043 64.6396

 540001 : 11.6056 36.9404 64.6396

 541001 : 11.6056 36.7366 64.6396

 542001 : 11.6056 39.7388 63.5515

 543001 : 11.6056 34.8349 62.4949

 544001 : 11.6056 33.8258 63.5515

 545001 : 11.6056 35.7308 63.5515

 546001 : 11.6056 35.9028 63.5515

 547001 : 11.6056 33.2724 63.5515

 548001 : 11.6056 37.0721 72.0442

 549001 : 11.6056 33.8737 64.6396

 550001 : 11.6056 33.9049 62.4949

 551001 : 11.6056 31.64 62.4949

 552001 : 11.6056 37.2854 64.6396

 553001 : 11.6056 37.5201 63.5515

 554001 : 11.6056 32.4372 62.4949

 555001 : 11.6056 36.035 64.6396

 556001 : 11.6056 34.6886 62.4949

 557001 : 11.6056 31.7164 62.4949

 558001 : 11.6056 34.1047 63.5515

 559001 : 11.6056 34.2337 64.6396

 560001 : 11.6056 37.1554 63.5515

 561001 : 11.6056 34.36 64.6396

 562001 : 11.6056 36.684 64.6396

 563001 : 11.6056 35.4258 64.6396

 564001 : 11.6056 33.5973 64.6396

 565001 : 11.6056 37.3906 64.6396

 566001 : 11.6056 32.1458 63.5515

 567001 : 11.6056 31.7807 64.6396

 568001 : 11.6056 33.8202 64.6396

 569001 : 11.6056 33.3864 64.6396

 570001 : 11.6056 33.9264 72.0442

 571001 : 11.6056 35.6334 64.6396

 572001 : 11.6056 36.3735 63.5515

 573001 : 11.6056 34.6445 63.5515

 574001 : 11.6056 34.3337 64.6396

 575001 : 11.6056 38.5149 64.6396

 576001 : 11.6056 38.599 63.5515

 577001 : 11.6056 31.1418 64.6396

 578001 : 11.6056 31.1316 63.5515

 579001 : 11.6056 34.5253 64.6396

 580001 : 11.6056 35.2593 62.4949

 581001 : 11.6056 37.0335 63.5515

 582001 : 11.6056 33.6387 60.4664

 583001 : 11.6056 35.7104 64.6396

 584001 : 11.6056 29.4797 63.5515

 585001 : 11.6056 32.3649 63.5515

 586001 : 11.6056 35.566 63.5515

 587001 : 11.6056 32.8647 62.4949

 588001 : 11.6056 35.5073 62.4949

 589001 : 11.6056 38.2226 64.6396

 590001 : 11.6056 37.1606 64.6396

 591001 : 11.6056 31.3956 62.4949

 592001 : 11.6056 30.3004 63.5515

 593001 : 11.6056 34.2319 64.6396

 594001 : 11.6056 33.4395 64.6396

 595001 : 11.6056 36.7195 64.6396

 596001 : 11.6056 33.6218 64.6396

 597001 : 11.6056 34.7953 63.5515

 598001 : 11.6056 29.6171 63.5515

 599001 : 11.6056 38.7744 64.6396

 600001 : 11.6056 34.1924 63.5515

 601001 : 11.6056 35.792 62.4949

 602001 : 11.6056 34.0009 62.4949

 603001 : 11.6056 33.5863 64.6396

 604001 : 11.6056 36.6461 64.6396

 605001 : 11.6056 38.76 63.5515

 606001 : 11.6056 36.3774 64.6396

 607001 : 11.6056 33.3747 63.5515

 608001 : 11.6056 34.9969 63.5515

 609001 : 11.6056 38.5112 64.6396

 610001 : 11.6056 35.1738 63.5515

 611001 : 11.6056 35.0537 64.6396

 612001 : 11.6056 37.6452 64.6396

 613001 : 11.6056 36.6694 63.5515

 614001 : 11.6056 36.9702 64.6396

 615001 : 11.6056 35.6041 63.5515

 616001 : 11.6056 33.6287 63.5515

 617001 : 11.6056 37.8654 62.4949

 618001 : 11.6056 36.5257 62.4949

 619001 : 11.6056 30.4164 62.4949

 620001 : 11.6056 36.9836 63.5515

 621001 : 11.6056 39.1465 64.6396

 622001 : 11.6056 37.1784 63.5515

 623001 : 11.6056 37.0384 64.6396

 624001 : 11.6056 34.3146 64.6396

 625001 : 11.6056 36.6233 63.5515

 626001 : 11.6056 35.3065 64.6396

 627001 : 11.6056 34.6612 63.5515

 628001 : 11.6056 34.5664 63.5515

 629001 : 11.6056 39.9652 64.6396

 630001 : 11.6056 36.9267 63.5515

 631001 : 11.6056 33.936 64.6396

 632001 : 11.6056 33.2884 62.4949

 633001 : 11.6056 33.3766 63.5515

 634001 : 11.6056 31.8269 63.5515

 635001 : 11.6056 36.9954 64.6396

 636001 : 11.6056 37.4298 63.5515

 637001 : 11.6056 37.1124 64.6396

 638001 : 11.6056 36.6557 63.5515

 639001 : 11.6056 35.992 63.5515

 640001 : 11.6056 31.9285 64.6396

 641001 : 11.6056 37.6438 64.6396

 642001 : 11.6056 35.8128 62.4949

 643001 : 11.6056 35.8312 63.5515

 644001 : 11.6056 36.3163 64.6396

 645001 : 11.6056 32.2233 64.6396

 646001 : 11.6056 33.7687 63.5515

 647001 : 11.6056 35.9894 63.5515

 648001 : 11.6056 33.84 63.5515

 649001 : 11.6056 37.3136 64.6396

 650001 : 11.6056 31.7981 64.6396

 651001 : 11.6056 33.3736 62.4949

 652001 : 11.6056 34.9424 63.5515

 653001 : 11.6056 34.2222 62.4949

 654001 : 11.6056 36.4627 62.4949

 655001 : 11.6056 35.918 63.5515

 656001 : 11.6056 29.0605 63.5515

 657001 : 11.6056 33.9351 62.4949

 658001 : 11.6056 34.7807 63.5515

 659001 : 11.6056 38.2203 64.6396

 660001 : 11.6056 34.5932 63.5515

 661001 : 11.6056 37.7558 64.6396

 662001 : 11.6056 33.2537 64.6396

 663001 : 11.6056 33.483 64.6396

 664001 : 11.6056 33.6808 64.6396

 665001 : 11.6056 32.3461 62.4949

 666001 : 11.6056 36.2567 64.6396

 667001 : 11.6056 34.5941 64.6396

 668001 : 11.6056 35.5114 64.6396

 669001 : 11.6056 29.0865 64.6396

 670001 : 11.6056 34.4762 64.6396

 671001 : 11.6056 31.7693 64.6396

 672001 : 11.6056 33.525 62.4949

 673001 : 11.6056 37.5429 87.4954

 TRACE MOVES : FFFRFFFFRFLFLFFF

--------------------------------------------------

 674001 : 11.6056 33.8937 63.5515

 675001 : 11.6056 34.8416 62.4949

 676001 : 11.6056 32.7291 62.4949

 677001 : 11.6056 33.6749 62.4949

 678001 : 11.6056 38.4233 62.4949

 679001 : 11.6056 37.7956 64.6396

 680001 : 11.6056 35.9215 64.6396

 681001 : 11.6056 33.3301 64.6396

 682001 : 11.6056 32.7702 63.5515

 683001 : 11.6056 35.156 64.6396

 684001 : 11.6056 32.2526 64.6396

 685001 : 11.6056 38.4232 64.6396

 686001 : 11.6056 34.4929 72.0442

 687001 : 11.6056 35.2303 64.6396

 688001 : 11.6056 28.7168 62.4949

 689001 : 11.6056 30.9165 62.4949

 690001 : 11.6056 37.8641 64.6396

 691001 : 11.6056 29.454 63.5515

 692001 : 11.6056 40.3074 64.6396

 693001 : 11.6056 37.8001 64.6396

 694001 : 11.6056 39.5156 64.6396

 695001 : 11.6056 33.0052 64.6396

 696001 : 11.6056 35.4281 64.6396

 697001 : 11.6056 36.0463 64.6396

 698001 : 11.6056 34.0892 62.4949

 699001 : 11.6056 35.344 63.5515

 700001 : 11.6056 35.603 64.6396

 701001 : 11.6056 36.1711 63.5515

 702001 : 11.6056 36.7567 63.5515

 703001 : 11.6056 35.3918 62.4949

 704001 : 11.6056 33.4542 64.6396

 705001 : 11.6056 31.7829 62.4949

 706001 : 11.6056 29.5591 62.4949

 707001 : 11.6056 35.0612 62.4949

 708001 : 11.6056 36.8839 63.5515

 709001 : 11.6056 36.4007 63.5515

 710001 : 11.6056 36.3834 64.6396

 711001 : 11.6056 32.6737 63.5515

 712001 : 11.6056 34.1459 64.6396

 713001 : 11.6056 34.6139 62.4949

 714001 : 11.6056 36.0702 64.6396

 715001 : 11.6056 37.3041 64.6396

 716001 : 11.6056 34.5091 63.5515

 717001 : 11.6056 34.1609 64.6396

 718001 : 11.6056 36.7353 63.5515

 719001 : 11.6056 36.9667 64.6396

 720001 : 11.6056 38.8552 64.6396

 721001 : 11.6056 32.6378 64.6396

 722001 : 11.6056 35.4056 64.6396

 723001 : 11.6056 34.48 64.6396

 724001 : 11.6056 36.7875 63.5515

 725001 : 11.6056 32.172 63.5515

 726001 : 11.6056 37.7036 64.6396

 727001 : 11.6056 36.2305 63.5515

 728001 : 11.6056 37.6228 64.6396

 729001 : 11.6056 37.3912 63.5515

 730001 : 11.6056 34.6283 63.5515

 731001 : 11.6056 36.6776 63.5515

 732001 : 11.6056 34.3794 63.5515

 733001 : 11.6056 33.6719 63.5515

 734001 : 11.6056 34.955 63.5515

 735001 : 11.6056 33.6951 62.4949

 736001 : 11.6056 32.5171 62.4949

 737001 : 11.6056 36.3634 63.5515

 738001 : 11.6056 37.3467 64.6396

 739001 : 11.6056 34.6289 63.5515

 740001 : 11.6056 37.3268 63.5515

 741001 : 11.6056 35.4739 64.6396

 742001 : 11.6056 35.1465 63.5515

 743001 : 11.6056 33.4185 62.4949

 744001 : 11.6056 37.4021 63.5515

 745001 : 11.6056 35.7233 72.0442

 746001 : 11.6056 32.6227 63.5515

 747001 : 11.6056 34.8421 64.6396

 748001 : 11.6056 34.2958 62.4949

 749001 : 11.6056 34.227 63.5515

 750001 : 11.6056 35.3004 63.5515

 751001 : 11.6056 40.1221 64.6396

 752001 : 11.6056 34.3547 63.5515

 753001 : 11.6056 33.7548 63.5515

 754001 : 11.6056 37.4207 64.6396

 755001 : 11.6056 34.5844 64.6396

 756001 : 11.6056 31.3823 64.6396

 757001 : 11.6056 34.1494 64.6396

 758001 : 11.6056 35.1318 63.5515

 759001 : 11.6056 36.8846 63.5515

 760001 : 11.6056 38.0739 64.6396

 761001 : 11.6056 38.4211 63.5515

 762001 : 11.6056 31.3013 63.5515

 763001 : 11.6056 33.6541 63.5515

 764001 : 11.6056 33.9156 62.4949

 765001 : 11.6056 34.7254 63.5515

 766001 : 11.6056 37.6618 64.6396

 767001 : 11.6056 34.7469 63.5515

 768001 : 11.6056 36.0621 64.6396

 769001 : 11.6056 34.0976 64.6396

 770001 : 11.6056 35.9457 63.5515

 771001 : 11.6056 36.5145 64.6396

 772001 : 11.6056 36.3863 63.5515

 773001 : 11.6056 38.4324 63.5515

 774001 : 11.6056 34.2142 64.6396

 775001 : 11.6056 36.3576 64.6396

 776001 : 11.6056 34.7296 63.5515

 777001 : 11.6056 34.0058 64.6396

 778001 : 11.6056 38.652 64.6396

 779001 : 11.6056 35.4803 63.5515

 780001 : 11.6056 32.8772 64.6396

 781001 : 11.6056 35.1476 64.6396

 782001 : 11.6056 35.514 64.6396

 783001 : 11.6056 34.4675 64.6396

 784001 : 11.6056 35.1258 62.4949

 785001 : 11.6056 31.6884 64.6396

 786001 : 11.6056 36.6586 64.6396

 787001 : 11.6056 28.2783 63.5515

 788001 : 11.6056 35.5819 63.5515

 789001 : 11.6056 35.0233 64.6396

 790001 : 11.6056 32.4596 62.4949

 791001 : 11.6056 37.0133 64.6396

 792001 : 11.6056 32.7661 64.6396

 793001 : 11.6056 31.5447 62.4949

 794001 : 11.6056 36.9797 63.5515

 795001 : 11.6056 35.4891 63.5515

 796001 : 11.6056 35.3796 63.5515

 797001 : 11.6056 36.0278 64.6396

 798001 : 11.6056 35.2404 64.6396

 799001 : 11.6056 34.6488 63.5515

 800001 : 11.6056 33.7373 63.5515

 801001 : 11.6056 30.8806 64.6396

 802001 : 11.6056 30.7714 64.6396

 803001 : 11.6056 33.9672 63.5515

 804001 : 11.6056 33.1448 64.6396

 805001 : 11.6056 33.1498 63.5515

 806001 : 11.6056 35.1597 64.6396

 807001 : 11.6056 34.8805 64.6396

 808001 : 11.6056 38.3438 64.6396

 809001 : 11.6056 35.739 63.5515

 810001 : 11.6056 33.0451 63.5515

 811001 : 11.6056 33.9024 62.4949

 812001 : 11.6056 31.9945 62.4949

 813001 : 11.6056 36.2377 64.6396

 814001 : 11.6056 35.8481 63.5515

 815001 : 11.6056 34.5686 63.5515

 816001 : 11.6056 36.0551 64.6396

 817001 : 11.6056 35.8105 63.5515

 818001 : 11.6056 32.5186 63.5515

 819001 : 11.6056 34.1494 64.6396

 820001 : 11.6056 36.3036 63.5515

 821001 : 11.6056 32.3567 64.6396

 822001 : 11.6056 36.1356 64.6396

 823001 : 11.6056 38.4552 64.6396

 824001 : 11.6056 35.4715 62.4949

 825001 : 11.6056 30.7463 63.5515

 826001 : 11.6056 33.0954 62.4949

 827001 : 11.6056 30.8691 62.4949

 828001 : 11.6056 32.2702 64.6396

 829001 : 11.6056 37.2932 63.5515

 830001 : 11.6056 34.3282 63.5515

 831001 : 11.6056 32.8624 62.4949

 832001 : 11.6056 37.379 64.6396

 833001 : 11.6056 31.507 63.5515

 834001 : 11.6056 32.5997 63.5515

 835001 : 11.6056 34.0375 63.5515

 836001 : 11.6056 35.7079 62.4949

 837001 : 11.6056 36.0815 63.5515

 838001 : 11.6056 35.1866 64.6396

 839001 : 11.6056 36.2445 62.4949

 840001 : 11.6056 36.3337 64.6396

 841001 : 11.6056 38.1972 64.6396

 842001 : 11.6056 31.4841 63.5515

 843001 : 11.6056 37.5484 63.5515

 844001 : 11.6056 34.7722 63.5515

 845001 : 11.6056 33.2906 63.5515

 846001 : 11.6056 30.0758 64.6396

 847001 : 11.6056 36.3947 63.5515

 848001 : 11.6056 38.8022 63.5515

 849001 : 11.6056 31.9396 62.4949

 850001 : 11.6056 36.9206 62.4949

 851001 : 11.6056 38.1175 63.5515

 852001 : 11.6056 40.2308 63.5515

 853001 : 11.6056 35.7876 63.5515

 854001 : 11.6056 35.3939 64.6396

 855001 : 11.6056 31.4238 64.6396

 856001 : 11.6056 36.1203 64.6396

 857001 : 11.6056 30.5867 64.6396

 858001 : 11.6056 36.2185 64.6396

 859001 : 11.6056 33.8068 63.5515

 860001 : 11.6056 37.2661 63.5515

 861001 : 11.6056 32.2467 64.6396

 862001 : 11.6056 34.4663 64.6396

 863001 : 11.6056 32.7991 63.5515

 864001 : 11.6056 36.8059 63.5515

 865001 : 11.6056 34.9598 64.6396

 866001 : 11.6056 33.9293 64.6396

 867001 : 11.6056 32.3547 63.5515

 868001 : 11.6056 36.6649 63.5515

 869001 : 11.6056 34.0028 64.6396

 870001 : 11.6056 29.7141 63.5515

 871001 : 11.6056 34.0943 63.5515

 872001 : 11.6056 35.0784 62.4949

 873001 : 11.6056 38.5333 63.5515

 874001 : 11.6056 35.6835 63.5515

 875001 : 11.6056 36.7982 64.6396

 876001 : 11.6056 33.4309 62.4949

 877001 : 11.6056 32.3313 62.4949

 878001 : 11.6056 38.7736 63.5515

 879001 : 11.6056 33.7227 62.4949

 880001 : 11.6056 35.3971 63.5515

 881001 : 11.6056 36.8209 63.5515

 882001 : 11.6056 34.1844 64.6396

 883001 : 11.6056 32.5299 63.5515

 884001 : 11.6056 35.5648 64.6396

 885001 : 11.6056 35.65 64.6396

 886001 : 11.6056 35.1628 64.6396

 887001 : 11.6056 36.9181 64.6396

 888001 : 11.6056 34.5473 64.6396

 889001 : 11.6056 38.01 63.5515

 890001 : 11.6056 35.0126 64.6396

 891001 : 11.6056 39.1631 64.6396

 892001 : 11.6056 33.6115 64.6396

 893001 : 11.6056 33.2253 62.4949

 894001 : 11.6056 34.6887 62.4949

 895001 : 11.6056 35.8166 64.6396

 896001 : 11.6056 33.7454 64.6396

 897001 : 11.6056 36.2019 64.6396

 898001 : 11.6056 32.9686 63.5515

 899001 : 11.6056 36.1147 64.6396

 900001 : 11.6056 33.8111 63.5515

 901001 : 11.6056 26.618 55.8006

 902001 : 11.6056 37.2179 64.6396

 903001 : 11.6056 36.5882 63.5515

 904001 : 11.6056 32.9825 62.4949

 905001 : 11.6056 30.2914 63.5515

 906001 : 11.6056 34.0748 60.4664

 907001 : 11.6056 36.2796 63.5515

 908001 : 11.6056 36.2459 63.5515

 909001 : 11.6056 34.4279 62.4949

 910001 : 11.6056 39.3198 64.6396

 911001 : 11.6056 34.3474 64.6396

 912001 : 11.6056 36.781 63.5515

 913001 : 11.6056 32.4772 63.5515

 914001 : 11.6056 33.8847 64.6396

 915001 : 11.6056 37.4273 63.5515

 916001 : 11.6056 39.3048 63.5515

 917001 : 11.6056 34.504 62.4949

 918001 : 11.6056 34.9411 63.5515

 919001 : 11.6056 35.7597 63.5515

 920001 : 11.6056 37.5757 64.6396

 921001 : 11.6056 36.3771 64.6396

 922001 : 11.6056 32.1841 63.5515

 923001 : 11.6056 33.6061 62.4949

 924001 : 11.6056 32.9041 63.5515

 925001 : 11.6056 39.0002 64.6396

 926001 : 11.6056 32.3722 63.5515

 927001 : 11.6056 32.2355 63.5515

 928001 : 11.6056 33.1087 64.6396

 929001 : 11.6056 37.0764 64.6396

 930001 : 11.6056 33.2548 62.4949

 931001 : 11.6056 36.4001 64.6396

 932001 : 11.6056 31.8972 62.4949

 933001 : 11.6056 35.3164 64.6396

 934001 : 11.6056 34.6393 63.5515

 935001 : 11.6056 34.8594 64.6396

 936001 : 11.6056 32.8047 63.5515

 937001 : 11.6056 38.8874 64.6396

 938001 : 11.6056 32.9989 63.5515

 939001 : 11.6056 36.1737 63.5515

 940001 : 11.6056 35.2784 63.5515

 941001 : 11.6056 33.1969 63.5515

 942001 : 11.6056 35.8232 63.5515

 943001 : 11.6056 35.9232 63.5515

 944001 : 11.6056 34.7467 64.6396

 945001 : 11.6056 35.7143 63.5515

 946001 : 11.6056 37.0278 63.5515

 947001 : 11.6056 36.2033 63.5515

 948001 : 11.6056 37.9107 64.6396

 949001 : 11.6056 35.6332 64.6396

 950001 : 11.6056 32.6398 63.5515

 951001 : 11.6056 34.2746 63.5515

 952001 : 11.6056 34.6553 64.6396

 953001 : 11.6056 35.9827 63.5515

 954001 : 11.6056 31.9051 62.4949

 955001 : 11.6056 35.1836 64.6396

 956001 : 11.6056 38.6925 64.6396

 957001 : 11.6056 36.2313 64.6396

 958001 : 11.6056 34.066 63.5515

 959001 : 11.6056 33.4394 64.6396

 960001 : 11.6056 29.2175 63.5515

 961001 : 11.6056 37.0026 64.6396

 962001 : 11.6056 34.3181 64.6396

 963001 : 11.6056 38.0567 64.6396

 964001 : 11.6056 36.1006 63.5515

 965001 : 11.6056 36.0881 64.6396

 966001 : 11.6056 31.5011 63.5515

 967001 : 11.6056 32.2869 62.4949

 968001 : 11.6056 34.8045 63.5515

 969001 : 11.6056 40.102 64.6396

 970001 : 11.6056 35.4463 64.6396

 971001 : 11.6056 33.6391 62.4949

 972001 : 11.6056 35.814 64.6396

 973001 : 11.6056 37.3095 64.6396

 974001 : 11.6056 33.9903 64.6396

 975001 : 11.6056 32.3923 64.6396

 976001 : 11.6056 35.1324 64.6396

 977001 : 11.6056 35.0218 64.6396

 978001 : 11.6056 34.5918 64.6396

 979001 : 11.6056 32.6546 63.5515

 980001 : 11.6056 34.7862 63.5515

 981001 : 11.6056 34.7745 63.5515

 982001 : 11.6056 34.8229 63.5515

 983001 : 11.6056 34.3696 63.5515

 984001 : 11.6056 30.0841 72.0442

 985001 : 11.6056 32.9623 63.5515

 986001 : 11.6056 34.2712 63.5515

 987001 : 11.6056 38.8349 63.5515

 988001 : 11.6056 37.8362 64.6396

 989001 : 11.6056 35.6418 63.5515

 990001 : 11.6056 35.5768 63.5515

 991001 : 11.6056 34.3733 63.5515

 992001 : 11.6056 35.9358 64.6396

 993001 : 11.6056 35.6724 63.5515

 994001 : 11.6056 33.7203 63.5515

 995001 : 11.6056 37.0665 64.6396

 996001 : 11.6056 34.5956 62.4949

 997001 : 11.6056 32.4063 62.4949

 998001 : 11.6056 37.7832 64.6396

 999001 : 11.6056 32.85 64.6396

 1000001 : 11.6056 35.7467 63.5515

 1001001 : 11.6056 38.0992 62.4949

 1002001 : 11.6056 35.6634 64.6396

* **Program**

#include "iostream"

#include "iomanip"

#include "fstream"

#include <cstdlib>

#include <ctime>

#include <cmath>

using namespace std;

const int MAZE\_SIZE=8, MAX\_CHROMOSOME\_SIZE=30, POPULATION\_SIZE=150, NO\_OF\_VALID\_BOT\_MOVEMENTS=3, EXPECTED\_OPTIMAL\_SOL\_LEN=19;

const int start\_row = MAZE\_SIZE - 1, start\_column = 0, goal\_row = 0, goal\_column=MAZE\_SIZE - 1;

const double CROSSOVER\_PROB = 0.6, MUTATION\_PROB = 0.07;

enum DIRECTIONS {F,R,L,B};

ofstream outfile;

/\* Statistics \*/

double maximum\_fitness=0.0, average\_fitness=0.0, minimum\_fitness=0.0, sum\_fitness=0.0;

//

// Generate a random number between 0 and 1

// return a uniform number in [0,1].

double unifRand()

{

 return rand() / double(RAND\_MAX);

}

//

// Generate a random number in a real interval.

// param a one end point of the interval

// param b the other end of the interval

// return a inform rand numberin [a,b].

double unifRand(double a, double b)

{

 return (b-a)\*unifRand() + a;

}

//

// Generate a random integer between 1 and a given value.

// param n the largest value

// return a uniform random value in [1,...,n]

long unifRand(long n)

{

 if (n < 0) n = -n;

 if (n==0) return 0;

 /\* There is a slight error in that this code can produce a return value of n+1

 \*\*

 \*\* return long(unifRand()\*n) + 1;

 \*/

 //Fixed code

 long guard = (long) (unifRand() \* n) +1;

 return (guard > n)? n : guard;

}

//

// Reset the random number generator with the system clock.

void seed()

{

 srand(time(0));

}

//calculating the manhattan distance using pythagoras theorem.

double diagonal\_distance(int length, int height)

{

 return sqrt(pow(length,2.0)+pow(height,2.0));

}

//receives a valid move and modifies it to a different move or returns same based on mutation probability

char MUTATE(char x)

{

 long n;

 char mx;

 if( unifRand() < MUTATION\_PROB)

 {

 n = unifRand(NO\_OF\_VALID\_BOT\_MOVEMENTS);

 switch(n)

 {

 case 1:

 mx = 'F';

 break;

 case 2:

 mx = 'R';

 break;

 case 3:

 mx = 'L';

 break;

 default:

 mx = 'F';

 break;

 }

 }

 else

 mx = x;

 return(mx);

}

//This class defines the maze.

class MAZE

{

public:

 char layout[MAZE\_SIZE][MAZE\_SIZE];

 MAZE()

 {

 //initialize all the cells of the maze as empty "E"

 for(int i=0;i<MAZE\_SIZE;i++)

 {

 for(int j=0;j<MAZE\_SIZE;j++)

 {

 layout[i][j] = 'E';

 }

 }

 //block cells marked as wall "W"

 layout[0][2] = 'W';

 layout[0][5] = 'W';

 layout[1][1] = 'W';

 layout[1][2] = 'W';

 layout[1][3] = 'W';

 layout[1][5] = 'W';

 layout[2][3] = 'W';

 layout[2][5] = 'W';

 layout[3][1] = 'W';

 layout[3][2] = 'W';

 layout[3][3] = 'W';

 layout[3][5] = 'W';

 layout[3][6] = 'W';

 layout[4][6] = 'W';

 layout[5][1] = 'W';

 layout[5][2] = 'W';

 layout[5][3] = 'W';

 layout[5][4] = 'W';

 layout[5][6] = 'W';

 layout[6][3] = 'W';

 layout[7][3] = 'W';

 }

};

//global maze object

MAZE objMaze;

//Defining the chromosome

class Chromosome

{

private:

 DIRECTIONS curr\_direction;

 bool valid\_move;

public:

 char plan[MAX\_CHROMOSOME\_SIZE];

 int active\_length;

 double fitness;

 int end\_row,end\_column;

 Chromosome()

 {

 for(int i=0;i<MAX\_CHROMOSOME\_SIZE;i++)

 {

 switch(unifRand(NO\_OF\_VALID\_BOT\_MOVEMENTS))

 {

 case 1 :

 //case to move forward

 plan[i] = 'F';

 break;

 case 2 :

 //case to move forward

 plan[i] = 'R';

 break;

 case 3 :

 //case to move forward

 plan[i] = 'L';

 break;

 default :

 //default move forward

 plan[i] = 'F';

 break;

 }

 }

 active\_length = EXPECTED\_OPTIMAL\_SOL\_LEN - 1 + unifRand(MAX\_CHROMOSOME\_SIZE - EXPECTED\_OPTIMAL\_SOL\_LEN + 1);

 end\_row = 0;

 end\_column = 0;

 }

 void compute\_fitness()

 {

 if(end\_row == MAZE\_SIZE && end\_column == MAZE\_SIZE)

 {

 fitness = 100;

 }

 else

 {

 //function of diagonal distance

 fitness = 8.839 \* (11.313 - (diagonal\_distance(goal\_row - end\_row + 1, goal\_column - end\_column+1)));

 //

 if(active\_length > MAX\_CHROMOSOME\_SIZE - 10)

 fitness -= MAX\_CHROMOSOME\_SIZE - active\_length;

 if(fitness < 0)

 fitness = 0;

 }

 }

 void Attempt\_To\_Cross()

 {

 end\_row = start\_row;

 end\_column = start\_column;

 valid\_move = true;

 curr\_direction = F;

 for(int i=0;i< MAX\_CHROMOSOME\_SIZE;i++)

 {

 switch(plan[i])

 {

 case 'F':

 switch(curr\_direction)

 {

 case F:

 curr\_direction = F;

 break;

 case R:

 curr\_direction = R;

 break;

 case L:

 curr\_direction = L;

 break;

 case B:

 curr\_direction = B;

 break;

 }

 break;

 case 'R':

 switch(curr\_direction)

 {

 case F:

 curr\_direction = R;

 break;

 case R:

 curr\_direction = B;

 break;

 case L:

 curr\_direction = F;

 break;

 case B:

 curr\_direction = L;

 break;

 }

 break;

 case 'L':

 switch(curr\_direction)

 {

 case F:

 curr\_direction = L;

 break;

 case R:

 curr\_direction = F;

 break;

 case L:

 curr\_direction = B;

 break;

 case B:

 curr\_direction = R;

 break;

 }

 break;

 default:

 break;

 }

 switch(curr\_direction)

 {

 case F:

 end\_row--;

 break;

 case R:

 end\_column++;

 break;

 case L:

 end\_column--;

 break;

 case B:

 end\_row++;

 break;

 }

 //if invalid move retrace step and terminate

 if(end\_row == -1)

 {

 end\_row++;

 valid\_move = false;

 }

 else if(end\_column == -1)

 {

 end\_column++;

 valid\_move = false;

 }

 else if(end\_row >= MAZE\_SIZE)

 {

 end\_row--;

 valid\_move = false;

 }

 else if(end\_column >= MAZE\_SIZE)

 {

 end\_column--;

 valid\_move = false;

 }

 else if(objMaze.layout[end\_row][end\_column] == 'W')

 {

 switch(curr\_direction)

 {

 case F:

 end\_row++;

 break;

 case R:

 end\_column--;

 break;

 case L:

 end\_column++;

 break;

 case B:

 end\_row--;

 break;

 }

 valid\_move = false;

 }

 if(valid\_move == false)

 {

 active\_length = i;

 break;

 }

 }

 }

};

//Globally decalring the generations

Chromosome generations[2][POPULATION\_SIZE];

//compute fitness statistics for the current generation

void compute\_generation\_fitness( int curr\_gen, bool attempt\_to\_cross )

{

 int i;

 double fitness;

 sum\_fitness = 0.0;

 minimum\_fitness = 999.0;

 maximum\_fitness = 0.0;

 for (i = 0 ; i < POPULATION\_SIZE ; i++) {

 if(attempt\_to\_cross)

 generations[curr\_gen][i].Attempt\_To\_Cross();

 generations[curr\_gen][i].compute\_fitness();

 fitness = generations[curr\_gen][i].fitness;

 sum\_fitness += fitness;

 if (fitness > maximum\_fitness) maximum\_fitness = fitness;

 if (fitness < minimum\_fitness) minimum\_fitness = fitness;

 }

 average\_fitness = sum\_fitness / (double)POPULATION\_SIZE;

 return;

}

//Roulette wheel selection of parent from the current generation to perform ga

int select\_parent( int curr\_gen )

{

 int i = unifRand(POPULATION\_SIZE-1);

 int count = POPULATION\_SIZE;

 double select=0.0;

 while (count>=0)

 {

 select = generations[curr\_gen][i].fitness;

 if (unifRand() < (select / sum\_fitness)) return i;

 if (++i >= POPULATION\_SIZE) i = 0;

 count--;

 }

 return( unifRand(POPULATION\_SIZE-1) );

}

//passing the current generation through ga

int perform\_ga( int curr\_gen )

{

 int i, j, new\_gen;

 int parent\_1, parent\_2;

 int crossover;

 new\_gen = (curr\_gen == 0) ? 1 : 0;

 for ( i = 0 ; i < POPULATION\_SIZE ; i+=2 ) {

 /\* i is child\_1, i+1 is child\_2 \*/

 parent\_1 = select\_parent(curr\_gen);

 parent\_2 = select\_parent(curr\_gen);

 if (unifRand() < CROSSOVER\_PROB) {

 crossover = unifRand(MAX\_CHROMOSOME\_SIZE);

 } else {

 crossover = MAX\_CHROMOSOME\_SIZE;

 }

 for (j = 0 ; j < MAX\_CHROMOSOME\_SIZE ; j++) {

 if (j < crossover) {

 generations[new\_gen][i].plan[j] =

 MUTATE(generations[curr\_gen][parent\_1].plan[j]);

 generations[new\_gen][i+1].plan[j] =

 MUTATE(generations[curr\_gen][parent\_2].plan[j]);

 } else {

 generations[new\_gen][i].plan[j] =

 MUTATE(generations[curr\_gen][parent\_2].plan[j]);

 generations[new\_gen][i+1].plan[j] =

 MUTATE(generations[curr\_gen][parent\_1].plan[j]);

 }

 }

 }

 return new\_gen;

}

//output the best path

void trace\_best( int curr\_gen )

{

 int i, best;

 double best\_fitness = 0.0;

 for (i = 0 ; i < POPULATION\_SIZE ; i++) {

 if (generations[curr\_gen][i].fitness > best\_fitness) {

 best\_fitness = generations[curr\_gen][i].fitness;

 best = i;

 }

 }

 outfile.open("errorlog.txt",ios::app | ios::out);

 outfile << setw(15) << "TRACE MOVES : ";

 for(int j=0;j<generations[curr\_gen][best].active\_length;j++)

 outfile << generations[curr\_gen][best].plan[j];

 outfile << endl;

 for(int j=0;j<50;j++)

 {

 outfile << "-";

 }

 outfile << endl;

 outfile.close();

 return;

}

void main()

{

 seed();

 outfile.open("errorlog.txt",ios::app | ios::out);

 for(int j=0;j<50;j++)

 {

 outfile << "-";

 }

 outfile << endl;

 outfile << setw(35) << " FRESH START ";

 outfile << endl;

 for(int j=0;j<50;j++)

 {

 outfile << "-";

 }

 outfile << endl;

 outfile.close();

 int curr\_gen = 0;

 int generation = 0;

 compute\_generation\_fitness( curr\_gen, false );

 while ((average\_fitness < (0.999 \* maximum\_fitness)) && (maximum\_fitness < 93.0))

 {

 curr\_gen = perform\_ga( curr\_gen );

 compute\_generation\_fitness( curr\_gen, true );

 if (((generation++) % 10000) == 0)

 {

 outfile.open("errorlog.txt",ios::app | ios::out);

 outfile << setw(15) << generation << " : "

 << minimum\_fitness << " "

 << average\_fitness << " "

 << maximum\_fitness << " ";

 outfile << endl;

 outfile.close();

 if(maximum\_fitness > 80)

 trace\_best( curr\_gen );

 }

 }

 outfile.open("errorlog.txt",ios::app | ios::out);

 outfile << setw(15) << generation << " : "

 << minimum\_fitness << " "

 << average\_fitness << " "

 << maximum\_fitness << " ";

 outfile << endl;

 outfile.close();

 trace\_best( curr\_gen );

}