Chapter 8
Lists for Multi-dimensional Data

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Motivations

Distance Table (in miles)

	Chicago	Boston	New York	Atlanta	Miami	Dallas	Houston
Chicago	0	983	787	714	1375	967	1087
Boston	983	0	214	1102	1763	1723	1842
New York	787	214	0	888	1549	1548	1627
Atlanta	714	1102	888	0	661	781	810
Miami	1375	1763	1549	661	0	1426	1187
Dallas	967	1723	1548	781	1426	0	239
Houston	1087	1842	1627	810	1187	239	0

```
distances = [
    [0, 983, 787, 714, 1375, 967, 1087],
    [983, 0, 214, 1102, 1763, 1723, 1842],
    [787, 214, 0, 888, 1549, 1548, 1627],
    [714, 1102, 888, 0, 661, 781, 810],
    [1375, 1763, 1549, 661, 0, 1426, 1187],
    [967, 1723, 1548, 781, 1426, 0, 239],
    [1087, 1842, 1627, 810, 1187, 239, 0]
]
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Objectives

- To give examples of representing data using two-dimensional lists (§8.1).
- To access elements in a two-dimensional list using row and column indexes (§8.2).
- To program common operations for two-dimensional lists (displaying lists, summing all elements, finding min and max elements, and random shuffling) (§8.2).
- To pass two-dimensional lists to functions (§8.3).
- To write a program for grading multiple-choice questions using two-dimensional lists (§8.4).
- To solve the closest-pair problem using two-dimensional lists (§§8.5-8.6).
- To check a Sudoku solution using two-dimensional lists (§§8.7-8.8).
- To use multidimensional lists (§8.9).

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Processing Two-Dimensional lists

You can view a two-dimensional list as a list that consists of rows. Each row is a list that contains the values. The rows can be accessed using the index, conveniently called a *row index*. The values in each row can be accessed through another index, conveniently called a *column index*.

```
matrix = [
    [1, 2, 3, 4, 5],
    [6, 7, 0, 0, 0],
    [0, 1, 0, 0, 0],
    [1, 0, 0, 0, 8],
    [0, 0, 9, 0, 3],
]
```

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

```
matrix[0] is [1, 2, 3, 4, 5]
matrix[1] is [6, 7, 0, 0, 0]
matrix[2] is [0, 1, 0, 0, 0]
matrix[3] is [1, 0, 0, 0, 8]
matrix[4] is [0, 0, 9, 0, 3]

matrix[0][0] is 1
matrix[4][4] is 3
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Processing Two-Dimensional lists

See the examples in the text.

1. (Initializing lists with input values)
2. (Initializing lists with random values)
3. (Printing lists)
4. (Summing all elements)
5. (Summing all elements by column)
6. (Which row has the largest sum)
7. (*Random shuffling*)

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Initializing lists with input values

```
matrix = [] # Create an empty list
numberOfRows = eval(input("Enter the number of rows: "))
numberOfColumns = eval(input("Enter the number of columns: "))

for row in range(0, numberOfRows):
    matrix.append([]) # Add an empty new row
    for column in range(0, numberOfColumns):
        value = eval(input("Enter an element and press Enter: "))
        matrix[row].append(value)

print(matrix)
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Initializing lists with random values

```
import random
matrix = [] # Create an empty list

numberOfRows = eval(input("Enter the number of rows: "))
numberOfColumns = eval(input("Enter the number of columns: "))
for row in range(0, numberOfRows):
    matrix.append([]) # Add an empty new row
    for column in range(0, numberOfColumns):
        matrix[row].append(random.randrange(0, 100))

print(matrix)
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Printing lists

```
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]] # Assume a list is given
for row in range(0, len(matrix)):
    for column in range(0, len(matrix[row])):
        print(matrix[row][column], end = " ")
    print() # Print a newline
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Summing all elements

```
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]] # Assume a list is given
total = 0

for row in range(0, len(matrix)):
    for column in range(0, len(matrix[row])):
        total += matrix[row][column]

print("Total is " + str(total)) # Print the total
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Summing elements by column

```
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]] # Assume a list is given
total = 0

for column in range(0, len(matrix[0])):
    for row in range(0, len(matrix)):
        total += matrix[row][column]
    print("Sum for column " + str(column) + " is " + str(total))
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Summing elements by column

```
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]] # Assume a list is given
maxRow = sum(matrix[0]) # Get sum of the first row in maxRow

indexOfMaxRow = 0
for row in range(1, len(matrix)):
    if sum(matrix[row]) > maxRow:
        maxRow = sum(matrix[row])
        indexOfMaxRow = row

print("Row " + str(indexOfMaxRow)
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Random shuffling

```
import random
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]] # Assume a list is given

for row in range(0, len(matrix)):
        for column in range(0, len(matrix[row])):
         i = random.randrange(0, len(matrix))
         j = random.randrange(0, len(matrix[row]))
         # Swap matrix[row][column] with matrix[i][j]
         matrix[row][column], matrix[i][j] = \
             matrix[i][j], matrix[row][column]

print(matrix)
```

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Passing Tow-Dimensional Lists to Functions

PassTwoDimensionalList

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Problem: Grading Multiple-Choice Test

- Objective: write a program that grades multiple-choice test.

Students' Answers to the Questions:

	0	1	2	3	4	5	6	7	8	9
Student 0	A	B	A	C	C	D	E	E	A	D
Student 1	D	B	A	B	C	A	E	E	A	D
Student 2	E	D	D	A	C	B	E	E	A	D
Student 3	C	B	A	E	D	C	E	E	A	D
Student 4	A	B	D	C	C	D	E	E	A	D
Student 5	B	B	E	C	C	D	E	E	A	D
Student 6	B	B	A	C	C	D	E	E	A	D
Student 7	E	B	E	C	C	D	E	E	A	D

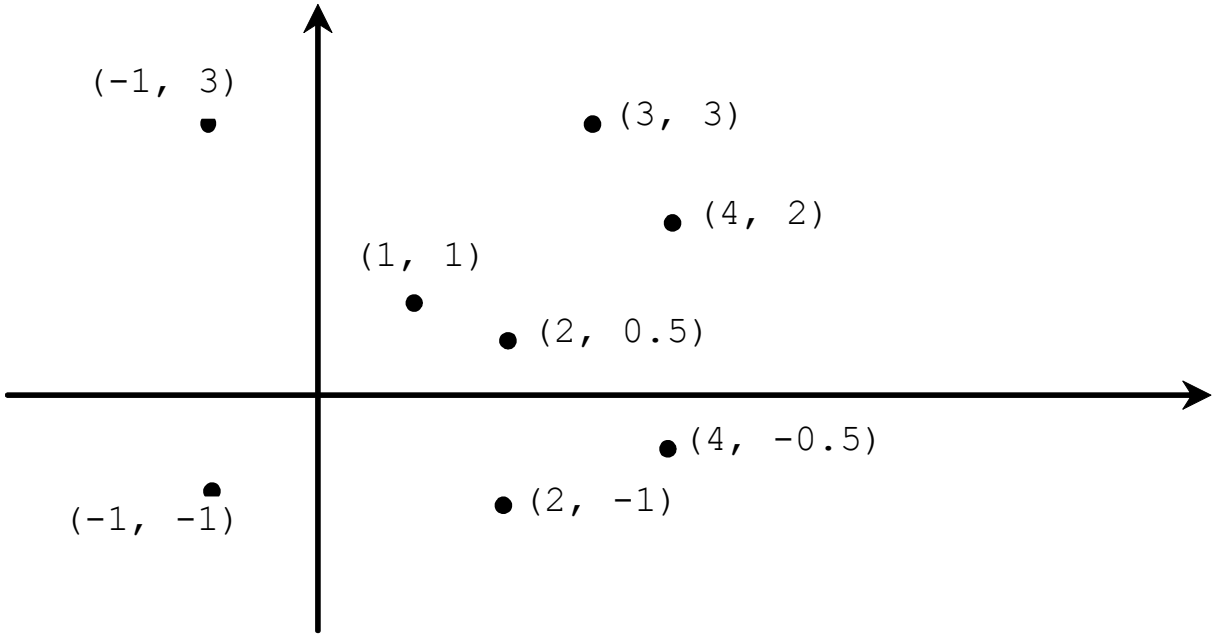
Key to the Questions:

	0	1	2	3	4	5	6	7	8	9
Key	D	B	D	C	C	D	A	E	A	D

GradeExam

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Problem: Finding Two Points Nearest to Each Other



	x	y
0	-1	3
1	-1	-1
2	1	1
3	2	0.5
4	2	-1
5	3	3
6	4	2
7	4	-0.5

https://liveexample.pearsoncmg.com/dsanimation/ClosestPaireBook.html

FindNearestPoints

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

What is Sudoku?

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

https://liveexample.pearsoncmg.com/dsanimation/Sudoku.html

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Every row contains the numbers 1 to 9

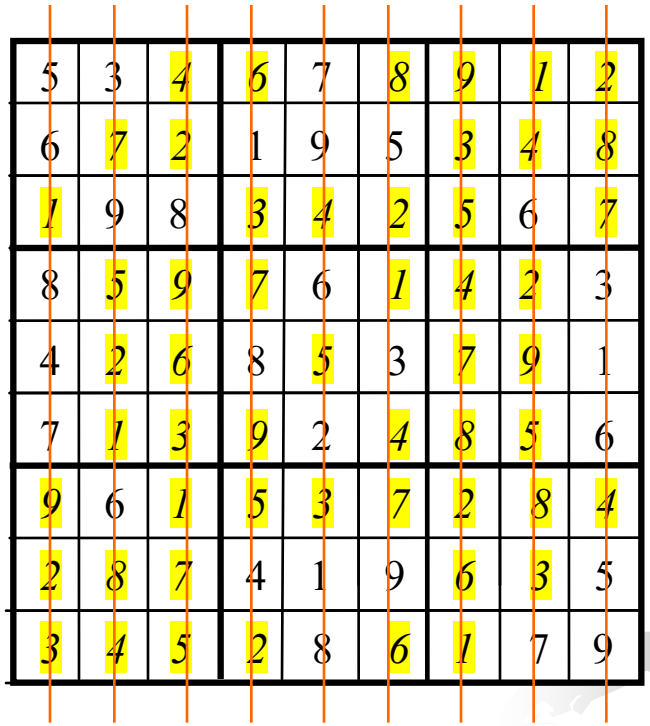
5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6							
			4	1	9			5
				8			7	9

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

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Every column contains the numbers 1 to 9

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



© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Every 3×3 box contains the numbers 1 to 9

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

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

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Checking Whether a Solution Is Correct

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

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

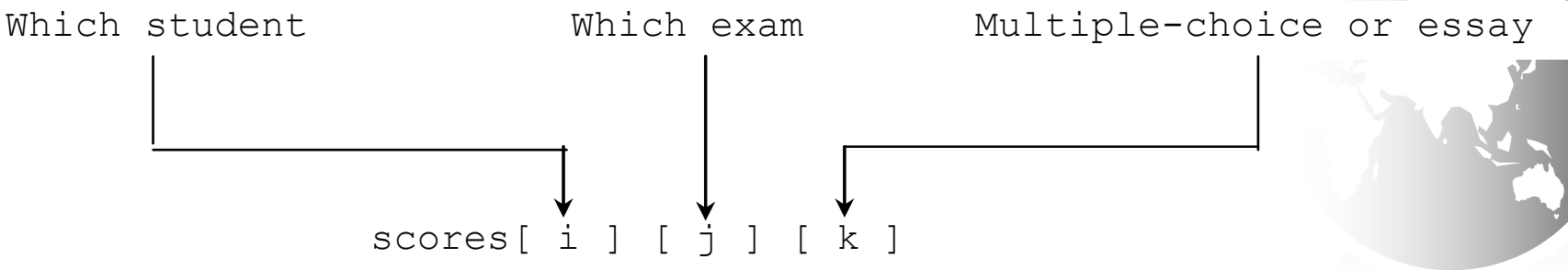
CheckSudokuSolution

TestCheckSudokuSolution

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Multidimensional lists

```
scores = [
  [[9.5, 20.5], [9.0, 22.5], [15, 33.5], [13, 21.5], [15, 2.5]],
  [[4.5, 21.5], [9.0, 22.5], [15, 34.5], [12, 20.5], [14, 9.5]],
  [[6.5, 30.5], [9.4, 10.5], [11, 33.5], [11, 23.5], [10, 2.5]],
  [[6.5, 23.5], [9.4, 32.5], [13, 34.5], [11, 20.5], [16, 9.5]],
  [[8.5, 26.5], [9.4, 52.5], [13, 36.5], [13, 24.5], [16, 2.5]],
  [[9.5, 20.5], [9.4, 42.5], [13, 31.5], [12, 20.5], [16, 6.5]]]
```



© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Problem: Weather Information

Suppose a meteorology station records the temperature and humidity at each hour of every day and stores the data for the past ten days in a text file named weather.txt. Each line of the file consists of four numbers that indicate the day, hour, temperature, and humidity. Your task is to write a program that calculates the average daily temperature and humidity for the 10 days.

```
1 1 76.4 0.92
1 2 77.7 0.93
...
10 23 97.7 0.71
10 24 98.7 0.74
```

(a)

```
10 24 98.7 0.74
1 2 77.7 0.93
...
10 23 97.7 0.71
1 1 76.4 0.92
```

(b)

Weather

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.

Problem: Guessing Birthday

Listing 3.8, GuessBirthday.java, gives a program that guesses a birthday. The program can be simplified by storing the numbers in five sets in a three-dimensional list, and it prompts the user for the answers using a loop, as shown in Listing 8.6.

GuessBirthdayUsingList

© Copyright 2018 by Pearson Education, Inc. All Rights Reserved.