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CS 325

Homework 8

March 8, 2020

# Problem 1

**a.**

First-Fit Pseudocode

```
c = capacity
s = [item0 ... itemN]
b = [Bin]
function firstFit():
        for item in s:
                itemAdded = false
                for bin in b:
                        if bin.capacity >= item.weight:
                                bin.items.append(item)
                                bin.capacity -=
item.weight
                                itemAdded = true
                                break
                if itemAdded == false:
                        b.append(Bin)
                        b.last.items.append(item)
                        b.last.capacity -= item.weight
```

First-Fit-Decreasing Pseudocode

```
c = capacity
s = [item0 ... itemN]
b = [Bin]
```

```
sortGreatestToLeastWeight(s)
firstFit()
```

Best Fit Pseudocode

```
function bestFit():
        for item in s:
                itemAdded = false
                bestBinIndex = -1
                bestBinCapacity = INF
                for bin in b:
                        if (bin.capacity >= item.weight)
&& (bin.capacity < bestBinCapacity):
                                bestBinIndex = bin.index
                                bestBinCapacity =
bin.capacity
                if bestBinIndex > -1:
                        bin.items.append(item)
                        bin.capacity -= item.weight
                        itemAdded = true
                if itemAdded == false:
                        b.append(Bin)
                        b.last.items.append(item)
                        b.last.capacity -= item.weight
```

**b.**

Zip file submitted to TEACH.

**c.**

A Python script generated 45 test cases, each with a pseudorandom bin capacity (from 1 to 100), and a pseudorandom number of items (from 1 to 100) with pseudorandom weights (from 1 to the bin capacity). For 45 test cases, the First Fit Decreasing algorithm at least tied for the most efficient outcome every time. After that, the Best Fit algorithm was at least as good as First Fit for all but

one test case.

Performance Ranking:

1. First Fit Decreasing
2. Best Fit
3. First Fit

Console output for 45 test cases:

```
Test Case 1 First Fit: 3 , First Fit Decreasing: 3 , Best
Fit: 3
Test Case 2 First Fit: 36 , First Fit Decreasing: 35 ,
Best Fit: 35
Test Case 3 First Fit: 28 , First Fit Decreasing: 26 ,
Best Fit: 27
Test Case 4 First Fit: 28 , First Fit Decreasing: 26 ,
Best Fit: 28
Test Case 5 First Fit: 39 , First Fit Decreasing: 37 ,
Best Fit: 38
Test Case 6 First Fit: 17 , First Fit Decreasing: 16 ,
Best Fit: 17
Test Case 7 First Fit: 23 , First Fit Decreasing: 22 ,
Best Fit: 23
Test Case 8 First Fit: 52 , First Fit Decreasing: 49 ,
Best Fit: 51
Test Case 9 First Fit: 43 , First Fit Decreasing: 42 ,
Best Fit: 42
Test Case 10 First Fit: 10 , First Fit Decreasing: 9 ,
Best Fit: 10
Test Case 11 First Fit: 47 , First Fit Decreasing: 44 ,
Best Fit: 46
Test Case 12 First Fit: 10 , First Fit Decreasing: 10 ,
Best Fit: 10
Test Case 13 First Fit: 15 , First Fit Decreasing: 14 ,
Best Fit: 15
```

```
Test Case 14 First Fit: 7 , First Fit Decreasing: 6 , Best
Fit: 7
Test Case 15 First Fit: 16 , First Fit Decreasing: 15 ,
Best Fit: 15
Test Case 16 First Fit: 31 , First Fit Decreasing: 28 ,
Best Fit: 30
Test Case 17 First Fit: 13 , First Fit Decreasing: 12 ,
Best Fit: 13
Test Case 18 First Fit: 14 , First Fit Decreasing: 14 ,
Best Fit: 15
Test Case 19 First Fit: 31 , First Fit Decreasing: 29 ,
Best Fit: 30
Test Case 20 First Fit: 46 , First Fit Decreasing: 44 ,
Best Fit: 45
Test Case 21 First Fit: 42 , First Fit Decreasing: 40 ,
Best Fit: 42
Test Case 22 First Fit: 48 , First Fit Decreasing: 45 ,
Best Fit: 48
Test Case 23 First Fit: 15 , First Fit Decreasing: 14 ,
Best Fit: 15
Test Case 24 First Fit: 3 , First Fit Decreasing: 3 , Best
Fit: 3
Test Case 25 First Fit: 48 , First Fit Decreasing: 46 ,
Best Fit: 47
Test Case 26 First Fit: 14 , First Fit Decreasing: 13 ,
Best Fit: 14
Test Case 27 First Fit: 24 , First Fit Decreasing: 22 ,
Best Fit: 24
Test Case 28 First Fit: 28 , First Fit Decreasing: 26 ,
Best Fit: 27
Test Case 29 First Fit: 41 , First Fit Decreasing: 40 ,
Best Fit: 41
Test Case 30 First Fit: 37 , First Fit Decreasing: 35 ,
```

```
Best Fit: 37
Test Case 31 First Fit: 30 , First Fit Decreasing: 29 ,
Best Fit: 30
Test Case 32 First Fit: 2 , First Fit Decreasing: 2 , Best
Fit: 2
Test Case 33 First Fit: 27 , First Fit Decreasing: 25 ,
Best Fit: 26
Test Case 34 First Fit: 29 , First Fit Decreasing: 28 ,
Best Fit: 29
Test Case 35 First Fit: 36 , First Fit Decreasing: 36 ,
Best Fit: 36
Test Case 36 First Fit: 48 , First Fit Decreasing: 45 ,
Best Fit: 48
Test Case 37 First Fit: 46 , First Fit Decreasing: 43 ,
Best Fit: 45
Test Case 38 First Fit: 21 , First Fit Decreasing: 20 ,
Best Fit: 21
Test Case 39 First Fit: 16 , First Fit Decreasing: 15 ,
Best Fit: 16
Test Case 40 First Fit: 23 , First Fit Decreasing: 22 ,
Best Fit: 22
Test Case 41 First Fit: 7 , First Fit Decreasing: 7 , Best
Fit: 7
Test Case 42 First Fit: 56 , First Fit Decreasing: 53 ,
Best Fit: 56
Test Case 43 First Fit: 49 , First Fit Decreasing: 47 ,
Best Fit: 48
Test Case 44 First Fit: 47 , First Fit Decreasing: 44 ,
Best Fit: 46
Test Case 45 First Fit: 40 , First Fit Decreasing: 39 ,
Best Fit: 39
```

## Problem 2

(LINDO code and output follows summaries)

**a.**

Six items S = {4, 4, 4, 6, 6, 6} and bin capacity of 10

The optimal solution uses three bins in the following manner:

| Bin 1 | Item 1, Item 6 |
|---|---|
| Bin 2 | Item 3, Item 4 |
| Bin 3 | Item 2, Item 5 |

**b.**

Five items S = {20, 10, 15, 10, 5} and bin capacity of 20

The optimal solution uses three bins in the following manner:

| Bin 1 | Item 3, Item 5 |
|---|---|
| Bin 2 | Item 1 |
| Bin 3 | Item 2, Item 4 |

**a.**

LINDO Code:

```
MIN Y1 + Y2 + Y3 + Y4 + Y5 + Y6
ST
4 X11 + 4 X12 + 4 X13 + 6 X14 + 6 X15 + 6 X16 - 10 Y1 <= 0
4 X21 + 4 X22 + 4 X23 + 6 X24 + 6 X25 + 6 X26 - 10 Y2 <= 0
4 X31 + 4 X32 + 4 X33 + 6 X34 + 6 X35 + 6 X36 - 10 Y3 <= 0
4 X41 + 4 X42 + 4 X43 + 6 X44 + 6 X45 + 6 X46 - 10 Y4 <= 0
4 X51 + 4 X52 + 4 X53 + 6 X54 + 6 X55 + 6 X56 - 10 Y5 <= 0
4 X61 + 4 X62 + 4 X63 + 6 X64 + 6 X65 + 6 X66 - 10 Y5 <= 0
X11 + X21 + X31 + X41 + X51 + X61 = 1
X12 + X22 + X32 + X42 + X52 + X62 = 1
X13 + X23 + X33 + X43 + X53 + X63 = 1
X14 + X24 + X34 + X44 + X54 + X64 = 1
X15 + X25 + X35 + X45 + X55 + X65 = 1
X16 + X26 + X36 + X46 + X56 + X66 = 1
END
```

```
INT Y1
INT Y2
INT Y3
INT Y4
INT Y5
INT Y6
INT X11
INT X12
INT X13
INT X14
INT X15
INT X16
INT X21
INT X22
INT X23
INT X24
INT X25
INT X26
INT X31
INT X32
INT X33
INT X34
INT X35
INT X36
INT X41
INT X42
INT X43
INT X44
INT X45
INT X46
INT X51
INT X52
INT X53
```

```
INT X54
INT X55
INT X56
INT X61
INT X62
INT X63
INT X64
INT X65
INT X66
```

LINDO Output:

```
 LP OPTIMUM FOUND AT STEP      25
 OBJECTIVE VALUE =    2.00000000


 NEW INTEGER SOLUTION OF    2.00000000     AT BRANCH
0 PIVOT      25
 RE-INSTALLING BEST SOLUTION...

        OBJECTIVE FUNCTION VALUE

        1)      2.000000

  VARIABLE        VALUE          REDUCED COST
        Y1         0.000000          1.000000
        Y2         1.000000          1.000000
        Y3         0.000000          1.000000
        Y4         0.000000          1.000000
        Y5         1.000000          1.000000
        Y6         0.000000          1.000000
       X11         0.000000          0.000000
```

| | | |
|---|---|---|
| X12 | 0.000000 | 0.000000 |
| X13 | 0.000000 | 0.000000 |
| X14 | 0.000000 | 0.000000 |
| X15 | 0.000000 | 0.000000 |
| X16 | 0.000000 | 0.000000 |
| X21 | 1.000000 | 0.000000 |
| X22 | 0.000000 | 0.000000 |
| X23 | 0.000000 | 0.000000 |
| X24 | 0.000000 | 0.000000 |
| X25 | 0.000000 | 0.000000 |
| X26 | 1.000000 | 0.000000 |
| X31 | 0.000000 | 0.000000 |
| X32 | 0.000000 | 0.000000 |
| X33 | 0.000000 | 0.000000 |
| X34 | 0.000000 | 0.000000 |
| X35 | 0.000000 | 0.000000 |
| X36 | 0.000000 | 0.000000 |
| X41 | 0.000000 | 0.000000 |
| X42 | 0.000000 | 0.000000 |
| X43 | 0.000000 | 0.000000 |
| X44 | 0.000000 | 0.000000 |
| X45 | 0.000000 | 0.000000 |
| X46 | 0.000000 | 0.000000 |
| X51 | 0.000000 | 0.000000 |
| X52 | 0.000000 | 0.000000 |
| X53 | 1.000000 | 0.000000 |
| X54 | 1.000000 | 0.000000 |
| X55 | 0.000000 | 0.000000 |
| X56 | 0.000000 | 0.000000 |
| X61 | 0.000000 | 0.000000 |
| X62 | 1.000000 | 0.000000 |
| X63 | 0.000000 | 0.000000 |
| X64 | 0.000000 | 0.000000 |

```
       X65          1.000000          0.000000
       X66          0.000000          0.000000


       ROW    SLACK OR SURPLUS      DUAL PRICES
        2)          0.000000          0.000000
        3)          0.000000          0.000000
        4)          0.000000          0.000000
        5)          0.000000          0.000000
        6)          0.000000          0.000000
        7)          0.000000          0.000000
        8)          0.000000          0.000000
        9)          0.000000          0.000000
       10)          0.000000          0.000000
       11)          0.000000          0.000000
       12)          0.000000          0.000000
       13)          0.000000          0.000000

 NO. ITERATIONS=       25
 BRANCHES=     0 DETERM.=  1.000E    0
```

**b.**

LINDO Code:

```
MIN Y1 + Y2 + Y3 + Y4 + Y5
ST
20 X11 + 10 X12 + 15 X13 + 10 X14 + 5 X15 - 20 Y1 <= 0
20 X21 + 10 X22 + 15 X23 + 10 X24 + 5 X25 - 20 Y2 <= 0
20 X31 + 10 X32 + 15 X33 + 10 X34 + 5 X35 - 20 Y3 <= 0
20 X41 + 10 X42 + 15 X43 + 10 X44 + 5 X45 - 20 Y4 <= 0
20 X51 + 10 X52 + 15 X53 + 10 X54 + 5 X55 - 20 Y5 <= 0
X11 + X21 + X31 + X41 + X51 = 1
X12 + X22 + X32 + X42 + X52 = 1
```

```
X13 + X23 + X33 + X43 + X53 = 1
X14 + X24 + X34 + X44 + X54 = 1
X15 + X25 + X35 + X45 + X55 = 1
END
INT Y1
INT Y2
INT Y3
INT Y4
INT Y5
INT X11
INT X12
INT X13
INT X14
INT X15
INT X21
INT X22
INT X23
INT X24
INT X25
INT X31
INT X32
INT X33
INT X34
INT X35
INT X41
INT X42
INT X43
INT X44
INT X45
INT X51
INT X52
INT X53
INT X54
```

```
INT X55
```

LINDO Output:

```
 LP OPTIMUM FOUND AT STEP      17
 OBJECTIVE VALUE =    3.00000000


 NEW INTEGER SOLUTION OF    3.00000000     AT BRANCH
0 PIVOT      17
 RE-INSTALLING BEST SOLUTION...

        OBJECTIVE FUNCTION VALUE

        1)      3.000000

  VARIABLE         VALUE          REDUCED COST
        Y1          1.000000          1.000000
        Y2          1.000000          1.000000
        Y3          1.000000          1.000000
        Y4          0.000000          1.000000
        Y5          0.000000          1.000000
       X11          0.000000          0.000000
       X12          0.000000          0.000000
       X13          1.000000          0.000000
       X14          0.000000          0.000000
       X15          1.000000          0.000000
       X21          1.000000          0.000000
       X22          0.000000          0.000000
       X23          0.000000          0.000000
       X24          0.000000          0.000000
       X25          0.000000          0.000000
```

```
      X31           0.000000            0.000000
      X32           1.000000            0.000000
      X33           0.000000            0.000000
      X34           1.000000            0.000000
      X35           0.000000            0.000000
      X41           0.000000            0.000000
      X42           0.000000            0.000000
      X43           0.000000            0.000000
      X44           0.000000            0.000000
      X45           0.000000            0.000000
      X51           0.000000            0.000000
      X52           0.000000            0.000000
      X53           0.000000            0.000000
      X54           0.000000            0.000000
      X55           0.000000            0.000000


      ROW    SLACK OR SURPLUS      DUAL PRICES
       2)           0.000000            0.000000
       3)           0.000000            0.000000
       4)           0.000000            0.000000
       5)           0.000000            0.000000
       6)           0.000000            0.000000
       7)           0.000000            0.000000
       8)           0.000000            0.000000
       9)           0.000000            0.000000
      10)           0.000000            0.000000
      11)           0.000000            0.000000

NO. ITERATIONS=       17
BRANCHES=     0 DETERM.=  1.000E     0
```