

Problem 1

a) Pseudocode of the three algorithms

Algorithm 1 First-Fit

```
1: for All items  $i = 1, 2, \dots, n$  do
2:   for All bins  $j = 1, 2, \dots, n$  do
3:     if Item  $i$  fits in bin  $j$  then
4:       Pack object  $i$  in bin  $j$ 
5:       Break the loop and pack the next object
6:     end if
7:   end for
8:   if Item  $i$  did not fit in any available bin then
9:     Create new bin and pack object  $i$ 
10:  end if
11: end for
```

The run time of this algorithm is $O(n^2)$.

Algorithm 2 First-Fit-Decreasing

```
1: Sort items in decreasing order
2: Apply First-Fit to sorted items
```

The algorithm is dominated by the run time of the First-Fit algorithm so the run time of this algorithm is $O(n^2)$.

Algorithm 3 Best-Fit

```
1: for All items  $i = 1, 2, \dots, n$  do
2:   for All bins  $j = 1, 2, \dots, n$  do
3:     if Item  $i$  fits in bin  $j$  then
4:       Calculate remaining capacity after the item has been added
5:     end if
6:   end for
7:   Pack item  $i$  in bin  $j$ , where  $j$  is the bin with less free space after adding the item
8:   If no such bin exists, open a new one and add the item
9: end for
```

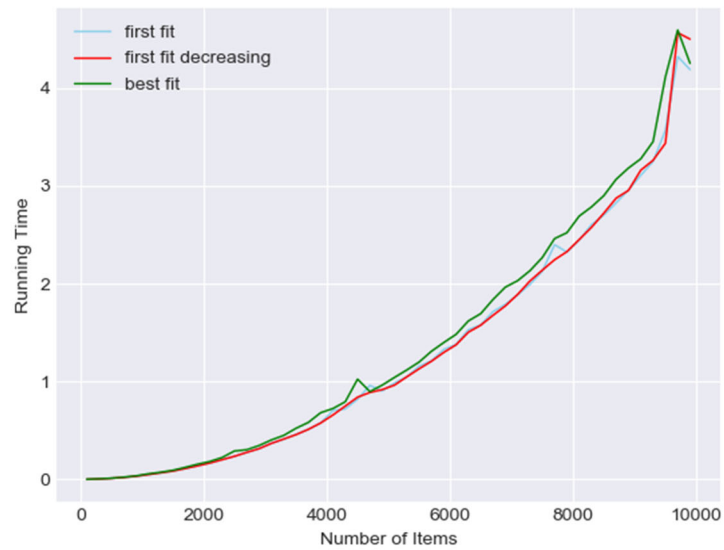
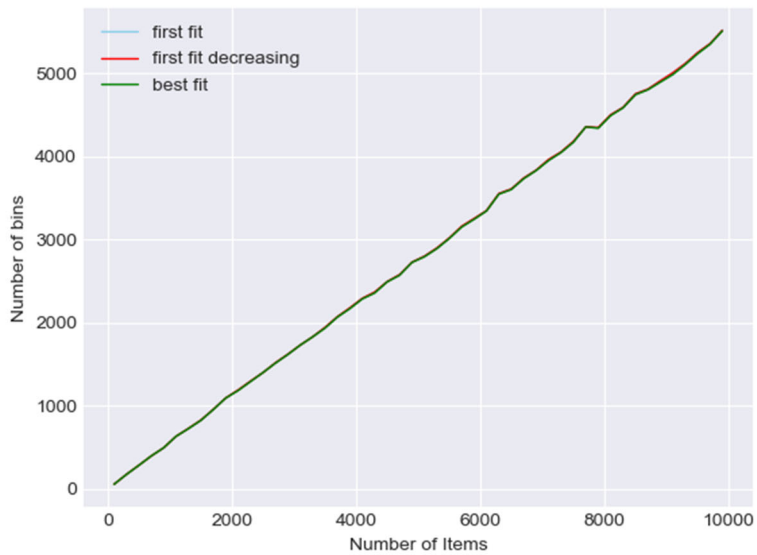
The run time of this algorithm is $O(n^2)$.

b) Implemented in binpack.py

c) Description of how the inputs were generated

i. First, an array of the number of items was generated, starting from 100 to 10,000 items in intervals of 200 items, obtaining an array of 50 bin packing instances. For each of these instances, the program generated the number of items with weights in a random selection from 1 to 10 and for each instance the three algorithms were executed. This resulted in run time, number of bins used, and the running time using a time function.

ii. These charts were obtained



In terms of number of bins, the three algorithms generally used the same number of bins, as shown in the first chart above. The plots are overlapping which means that they do not differ too much.

In terms of running time, the three algorithms take quadratic time to perform. However, the best fit algorithm takes more time than the other two. The first fit and the first fit decreasing take around the same time since they do not differ significantly as seen in the second chart above.