Discipline of Computing and Information Technology
Semester 2, 2022 - SENG1120/6120

Assignment 3

Due using the Canvas Assignment submission facility:
11:59PM – Sunday October 30th, 2022

Specification version 3.0.1

NOTE: *The important information about submission and code specifics at the end of this assignment specification***.**

INTRODUCTION

In lectures, we have discussed the benefits of using binary search trees and hash tables to store information. In this assignment you will implement both and compare their performances in terms of speed of access.

ASSIGNMENT TASK

You are in charge of inventory management support in a factory. You are required to create binary search tree and hash table data structures to store instances of a class `MechPart`. Both data structures should have functions to add, remove, display, overloaded operators, among others. The classes MUST be implemented as class templates. The binary search tree class must be called `BSTree` and will use as nodes instances of `BTNode`. The hash table class must be named `HTable`.

You will be provided a demo file, a `MechPart` class, and a text file with a list of part codes and quantities, and your classes need to interface with them. The binary search tree contents must be printed using an **inorder traversal**. The hash table class must store the instances of `MechPart` in **an array of size 5,000**, and the contents can be printed from position 0 to n-1, but only for those positions that contain a valid entry.

The hash function to be used is provided below. You can copy-and-paste that code to your `HTable` class:

```
template <typename T>
int HTable<T>::hashfunc ( const T& value ) {
     int position = 0;
     string temp = value.get_code ( );

     for ( int i=0; i<(int)temp.length( ); i++ ) {
          position += ( i+1 ) * ( i+1 ) * temp.at( i );
     }
     return position % TABLE_SIZE;
}
```

A few points:

- As you implement the classes, you will notice that even though `HTable` and `BSTree` are generic class templates, they only work with `MechPart`. That is, some public functions in the `HTable` and `BSTree` classes refer directly (*and only make sense*) with `MechPart`.
- That was a design decision for this assignment. We could get around that, but it would make the assignment extremely challenging for most students.
- In this assignment you are expected to derive your Data Structure Public Interfaces from the `TreeHashTableDemo.cpp` file, for both `BSTree` and `HTable`
- When you implement the classes, start small and then add more and more functionality as you go. Start by implementing `BSTree` and comment out everything in the demo file and in the `makefile` that refers to `HTable`. This way, you can test your code as you go. Once `BSTree` is working, you can move on to `HTable`.
- The solution provided in the next page is the result that you should get if your code is correct. The computational time will differ, as this was run on Alex's personal computer, but the hash table should be faster than the binary search tree
  .

What does the demo code do? The demo code reads the code and quantity of 100 Mechanical Parts from a file and populates the binary search tree with the data in the form of a `MechPart`. Then, it removes and adds some of the elements 100,000 times, and prints some statistics about the process.

After that, it does the same for the hash table, and the program finishes.

SENG6120/BONUS TASK

(1.5 marks) For students in SENG6120, there is an extra requirement:
The 100 mechanical parts in the input file provided ***do not induce any collisions*** in a hash table with 5,000 positions. If you reduce the size of the array in the hash table to 300 positions, however, there will be 16 collisions.

Your task is to create a hash table with buckets that eliminates the problem of collisions by having a `LinkedList` in each position of the array. This way, if two or more elements map to the same position of the array, they are stored as different nodes in the linked list for that position.

Test you approach by reducing the size of the array to 300 and making sure that all 100 elements are stored correctly, and the demo provided still works.

SUBMISSION

Make sure your code works with the files supplied, and DO NOT change them. For marking, we will add the main file to the project and compile it using the makefile, together with your own files. If it does not compile or run, your mark will be zero.

Your submission should be made using the Assignments section of the course Canvas site. **Incorrectly submitted assignments will not be marked.** You should provide the `.h/.hpp` and `.cpp` files related to the `HTable`, `BSTree` and ~~`BSTNode`~~ `BTNode` classes (*if you are attempting the Bonus Question or are a 6120 student*, include your `LinkedList` and `Node` classes as well).

If necessary, provide a `readme.txt` file containing any instructions or comments for the marker. Each program file should have a proper header comment section including your name, course and student number, and your code should be properly documented.

Remember that your code will conform to C++98 standards, and should compile and run correctly using Cygwin, gcc and the supplied makefile. There should be no segmentation faults or memory leaks during or after the execution of the program.

Compress all your files into a *single .zip file*, using your **student number** as the filename (*do not use .rar, .7z, .gz, or any other compressed format*). For example, if your student number is **`c9876543`**, you would name your submission:

`c9876543.zip`

If you have attempted the Bonus Requirement (*or you are a 6120 student*), please include a blank text file in the same folder as your source files, simply called **`Bonus.txt`** – this is to make it clear to the marker that you are attempting this.

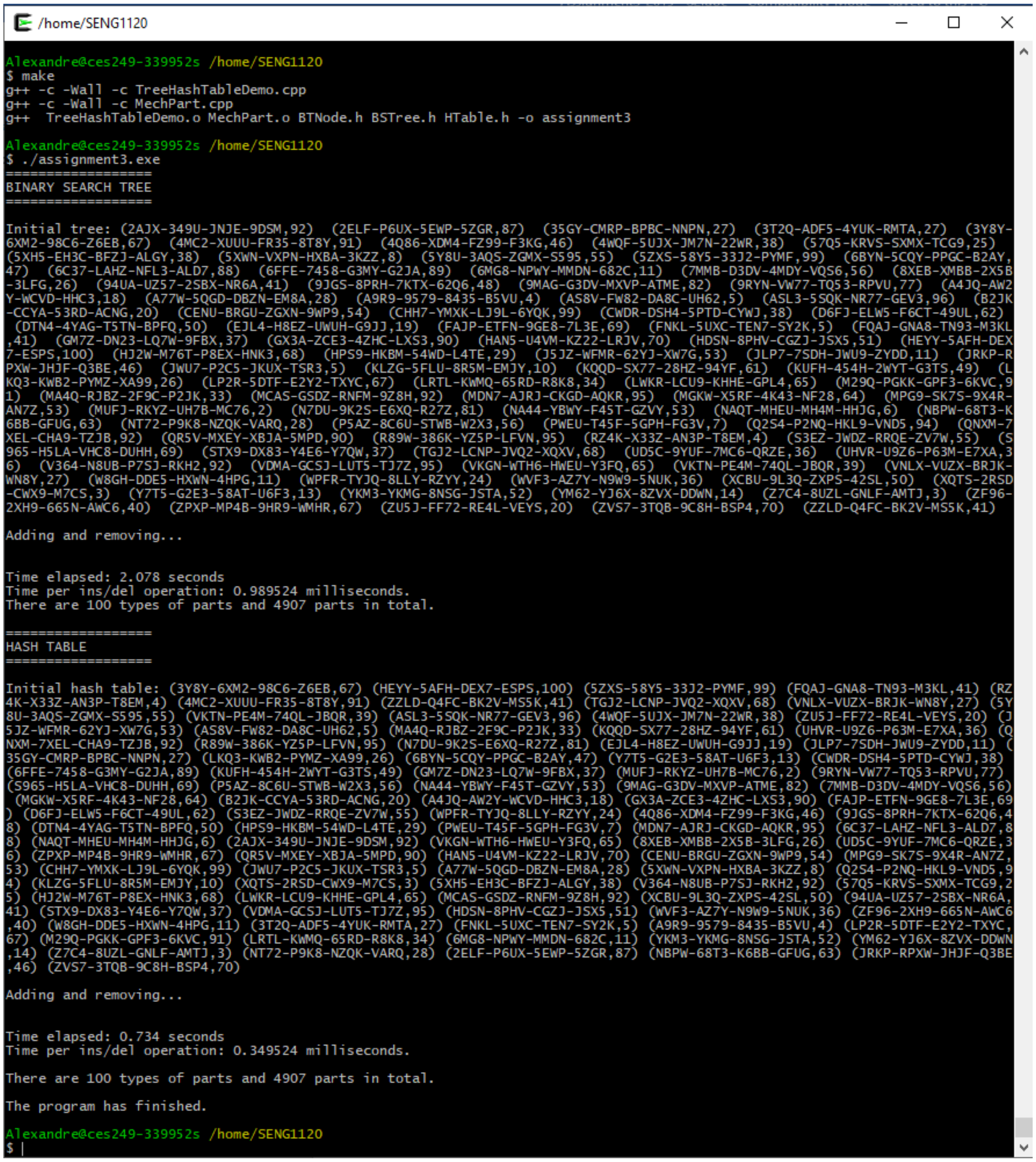
Submit by selecting the **Assignment 3** link that will be found in the **Assignments** section on **Canvas**.

Remember that your code should compile and run correctly using GNU C++. **Test it using Cygwin**.

Late submissions are subject to the rules specified in the Course Outline.

This assignment is worth 15.0 marks of your final result for the course.

EXPECTED OUTPUT



```
Alexandre@ces249-339952s /home/SENG1120
$ make
g++ -c -Wall -c TreeHashTableDemo.cpp
g++ -c -Wall -c MechPart.cpp
g++  TreeHashTableDemo.o MechPart.o BTNode.h BSTree.h HTable.h -o assignment3

Alexandre@ces249-339952s /home/SENG1120
$ ./assignment3.exe
==================
BINARY SEARCH TREE
==================

Initial tree: (2AJX-349U-JNJE-9DSM,92)  (2ELF-P6UX-5EWP-5ZGR,87)  (35GY-CMRP-BPBC-NNPN,27)  (3T2Q-ADF5-4YUK-RMTA,27)  (3Y8Y-
6XM2-98C6-Z6EB,67)  (4MC2-XUUU-FR35-8T8Y,91)  (4Q86-XDM4-FZ99-F3KG,46)  (4WQF-5UJX-JM7N-22WR,38)  (57Q5-KRVS-SXMX-TCG9,25)
(5XH5-EH3C-BFZJ-ALGY,38)  (5XWN-VXPN-HXBA-3KZZ,8)  (5Y8U-3AQS-ZGMX-S595,55)  (5ZXS-58Y5-33J2-PYMF,99)  (6BYN-5CQY-PPGC-B2AY,
47)  (6C37-LAHZ-NFL3-ALD7,88)  (6FFE-7458-G3MY-G2JA,89)  (6MG8-NPWY-MMDN-682C,11)  (7MMB-D3DV-4MDY-VQS6,56)  (8XEB-XMBB-2X5B
-3LFG,26)  (94UA-UZ57-2SBX-NR6A,41)  (9JGS-8PRH-7KTX-62Q6,48)  (9MAG-G3DV-MXVP-ATME,82)  (9RYN-VW77-TQ53-RPVU,77)  (A4JQ-AW2
Y-WCVD-HHC3,18)  (A77W-5QGD-DBZN-EM8A,28)  (A9R9-9579-8435-B5VU,4)  (AS8V-FW82-DA8C-UH62,5)  (ASL3-5SQK-NR77-GEV3,96)  (B2JK
-CCYA-53RD-ACNG,20)  (CENU-BRGU-ZGXN-9WP9,54)  (CHH7-YMXK-LJ9L-6YQK,99)  (CWDR-DSH4-5PTD-CYWJ,38)  (D6FJ-ELW5-F6CT-49UL,62)
 (DTN4-4YAG-T5TN-BPFQ,50)  (EJL4-H8EZ-UWUH-G9JJ,19)  (FAJP-ETFN-9GE8-7L3E,69)  (FNKL-5UXC-TEN7-SY2K,5)  (FQAJ-GNA8-TN93-M3KL
,41)  (GM7Z-DN23-LQ7W-9FBX,37)  (GX3A-ZCE3-4ZHC-LXS3,90)  (HAN5-U4VM-KZ22-LRJV,70)  (HDSN-8PHV-CGZJ-JSX5,51)  (HEYY-5AFH-DEX
7-ESPS,100)  (HJ2W-M76T-P8EX-HNK3,68)  (HPS9-HKBM-54WD-L4TE,29)  (J5JZ-WFMR-62YJ-XW7G,53)  (JLP7-7SDH-JWU9-ZYDD,11)  (JRKP-R
PXW-JHJF-Q3BE,46)  (JWU7-P2C5-JKUX-TSR3,5)  (KLZG-5FLU-8R5M-EMJY,10)  (KQQD-SX77-28HZ-94YF,61)  (KUFH-454H-2WYT-G3TS,49)  (L
KQ3-KWB2-PYMZ-XA99,26)  (LP2R-5DTF-E2Y2-TXYC,67)  (LRTL-KWMQ-65RD-R8K8,34)  (LWKR-LCU9-KHHE-GPL4,65)  (M29Q-PGKK-GPF3-6KVC,9
1)  (MA4Q-RJBZ-2F9C-P2JK,33)  (MCAS-GSDZ-RNFM-9Z8H,92)  (MDN7-AJRJ-CKGD-AQKR,95)  (MGKW-X5RF-4K43-NF28,64)  (MPG9-SK7S-9X4R-
AN7Z,53)  (MUFJ-RKYZ-UH7B-MC76,2)  (N7DU-9K2S-E6XQ-R27Z,81)  (NA44-YBWY-F45T-GZVY,53)  (NAQT-MHEU-MH4M-HHJG,6)  (NBPW-68T3-K
6BB-GFUG,63)  (NT72-P9K8-NZQK-VARQ,28)  (P5AZ-8C6U-STWB-W2X3,56)  (PWEU-T45F-5GPH-FG3V,7)  (Q2S4-P2NQ-HKL9-VND5,94)  (QNXM-7
XEL-CHA9-TZJB,92)  (QR5V-MXEY-XBJA-5MPD,90)  (R89W-386K-YZ5P-LFVN,95)  (RZ4K-X33Z-AN3P-T8EM,4)  (S3EZ-JWDZ-RRQE-ZV7W,55)  (S
965-H5LA-VHC8-DUHH,69)  (STX9-DX83-Y4E6-Y7QW,37)  (TGJ2-LCNP-JVQ2-XQXV,68)  (UD5C-9YUF-7MC6-QRZE,36)  (UHVR-U9Z6-P63M-E7XA,3
6)  (V364-N8UB-P7SJ-RKH2,92)  (VDMA-GCSJ-LUT5-TJ7Z,95)  (VKGN-WTH6-HWEU-Y3FQ,65)  (VKTN-PE4M-74QL-JBQR,39)  (VNLX-VUZX-BRJK-
WN8Y,27)  (W8GH-DDE5-HXWN-4HPG,11)  (WPFR-TYJQ-8LLY-RZYY,24)  (WVF3-AZ7Y-N9W9-5NUK,36)  (XCBU-9L3Q-ZXPS-42SL,50)  (XQTS-2RSD
-CWX9-M7CS,3)  (Y7T5-G2E3-58AT-U6F3,13)  (YKM3-YKMG-8NSG-JSTA,52)  (YM62-YJ6X-8ZVX-DDWN,14)  (Z7C4-8UZL-GNLF-AMTJ,3)  (ZF96-
2XH9-665N-AWC6,40)  (ZPXP-MP4B-9HR9-WMHR,67)  (ZU5J-FF72-RE4L-VEYS,20)  (ZVS7-3TQB-9C8H-BSP4,70)  (ZZLD-Q4FC-BK2V-MS5K,41)

Adding and removing...


Time elapsed: 2.078 seconds
Time per ins/del operation: 0.989524 milliseconds.
There are 100 types of parts and 4907 parts in total.

==================
HASH TABLE
==================

Initial hash table: (3Y8Y-6XM2-98C6-Z6EB,67) (HEYY-5AFH-DEX7-ESPS,100) (5ZXS-58Y5-33J2-PYMF,99) (FQAJ-GNA8-TN93-M3KL,41) (RZ
4K-X33Z-AN3P-T8EM,4) (4MC2-XUUU-FR35-8T8Y,91) (ZZLD-Q4FC-BK2V-MS5K,41) (TGJ2-LCNP-JVQ2-XQXV,68) (VNLX-VUZX-BRJK-WN8Y,27) (5Y
8U-3AQS-ZGMX-S595,55) (VKTN-PE4M-74QL-JBQR,39) (ASL3-5SQK-NR77-GEV3,96) (4WQF-5UJX-JM7N-22WR,38) (ZU5J-FF72-RE4L-VEYS,20) (J
5JZ-WFMR-62YJ-XW7G,53) (AS8V-FW82-DA8C-UH62,5) (MA4Q-RJBZ-2F9C-P2JK,33) (KQQD-SX77-28HZ-94YF,61) (UHVR-U9Z6-P63M-E7XA,36) (Q
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4) (KLZG-5FLU-8R5M-EMJY,10) (XQTS-2RSD-CWX9-M7CS,3) (5XH5-EH3C-BFZJ-ALGY,38) (V364-N8UB-P7SJ-RKH2,92) (57Q5-KRVS-SXMX-TCG9,2
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,46) (ZVS7-3TQB-9C8H-BSP4,70)

Adding and removing...


Time elapsed: 0.734 seconds
Time per ins/del operation: 0.349524 milliseconds.

There are 100 types of parts and 4907 parts in total.

The program has finished.

Alexandre@ces249-339952s /home/SENG1120
$ |
Alexandre@ces249-339952s /home/SENG1120
$ make
g++ -c -Wall -c TreeHashTableDemo.cpp
g++ -c -Wall -c MechPart.cpp
g++  TreeHashTableDemo.o MechPart.o BTNode.h BSTree.h HTable.h -o assignment3

Alexandre@ces249-339952s /home/SENG1120
$ ./assignment3.exe
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BINARY SEARCH TREE
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Initial tree: (2AJX-349U-JNJE-9DSM,92)  (2ELF-P6UX-5EWP-5ZGR,87)  (35GY-CMRP-BPBC-NNPN,27)  (3T2Q-ADF5-4YUK-
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(R89W-386K-YZ5P-LFVN,95)  (RZ4K-X33Z-AN3P-T8EM,4)  (S3EZ-JWDZ-RRQE-ZV7W,55)  (S965-H5LA-VHC8-DUHH,69)  (STX9-DX83-
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(W8GH-DDE5-HXWN-4HPG,11)  (WPFR-TYJQ-8LLY-RZYY,24)  (WVF3-AZ7Y-N9W9-5NUK,36)  (XCBU-9L3Q-ZXPS-42SL,50)  (XQTS-
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(ZZLD-Q4FC-BK2V-MS5K,41)

Adding and removing...


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==================
HASH TABLE
==================

Initial hash table: (3Y8Y-6XM2-98C6-Z6EB,67) (HEYY-5AFH-DEX7-ESPS,100) (5ZXS-58Y5-33J2-PYMF,99) (FQAJ-GNA8-TN93-
M3KL,41) (RZ4K-X33Z-AN3P-T8EM,4) (4MC2-XUUU-FR35-8T8Y,91) (ZZLD-Q4FC-BK2V-MS5K,41) (TGJ2-LCNP-JVQ2-XQXV,68) (VNLX-
VUZX-BRJK-WN8Y,27) (5Y8U-3AQS-ZGMX-S595,55) (VKTN-PE4M-74QL-JBQR,39) (ASL3-5SQK-NR77-GEV3,96) (4WQF-5UJX-JM7N-
22WR,38) (ZU5J-FF72-RE4L-VEYS,20) (J5JZ-WFMR-62YJ-XW7G,53) (AS8V-FW82-DA8C-UH62,5) (MA4Q-RJBZ-2F9C-P2JK,33) (KQQD-
SX77-28HZ-94YF,61) (UHVR-U9Z6-P63M-E7XA,36) (QNXM-7XEL-CHA9-TZJB,92) (R89W-386K-YZ5P-LFVN,95) (N7DU-9K2S-E6XQ-
R27Z,81) (EJL4-H8EZ-UWUH-G9JJ,19) (JLP7-7SDH-JWU9-ZYDD,11) (35GY-CMRP-BPBC-NNPN,27) (LKQ3-KWB2-PYMZ-XA99,26)
(6BYN-5CQY-PPGC-B2AY,47) (Y7T5-G2E3-58AT-U6F3,13) (CWDR-DSH4-5PTD-CYWJ,38) (6FFE-7458-G3MY-G2JA,89) (KUFH-454H-
2WYT-G3TS,49) (GM7Z-DN23-LQ7W-9FBX,37) (MUFJ-RKYZ-UH7B-MC76,2) (9RYN-VW77-TQ53-RPVU,77) (S965-H5LA-VHC8-DUHH,69)
(P5AZ-8C6U-STWB-W2X3,56) (NA44-YBWY-F45T-GZVY,53) (9MAG-G3DV-MXVP-ATME,82) (7MMB-D3DV-4MDY-VQS6,56) (MGKW-X5RF-
4K43-NF28,64) (B2JK-CCYA-53RD-ACNG,20) (A4JQ-AW2Y-WCVD-HHC3,18) (GX3A-ZCE3-4ZHC-LXS3,90) (FAJP-ETFN-9GE8-7L3E,69)
(D6FJ-ELW5-F6CT-49UL,62) (S3EZ-JWDZ-RRQE-ZV7W,55) (WPFR-TYJQ-8LLY-RZYY,24) (4Q86-XDM4-FZ99-F3KG,46) (9JGS-8PRH-
7KTX-62Q6,48) (DTN4-4YAG-T5TN-BPFQ,50) (HPS9-HKBM-54WD-L4TE,29) (PWEU-T45F-5GPH-FG3V,7) (MDN7-AJRJ-CKGD-AQKR,95)
(6C37-LAHZ-NFL3-ALD7,88) (NAQT-MHEU-MH4M-HHJG,6) (2AJX-349U-JNJE-9DSM,92) (VKGN-WTH6-HWEU-Y3FQ,65) (8XEB-XMBB-
2X5B-3LFG,26) (UD5C-9YUF-7MC6-QRZE,36) (ZPXP-MP4B-9HR9-WMHR,67) (QR5V-MXEY-XBJA-5MPD,90) (HAN5-U4VM-KZ22-LRJV,70)
(CENU-BRGU-ZGXN-9WP9,54) (MPG9-SK7S-9X4R-AN7Z,53) (CHH7-YMXK-LJ9L-6YQK,99) (JWU7-P2C5-JKUX-TSR3,5) (A77W-5QGD-
DBZN-EM8A,28) (5XWN-VXPN-HXBA-3KZZ,8) (Q2S4-P2NQ-HKL9-VND5,94) (KLZG-5FLU-8R5M-EMJY,10) (XQTS-2RSD-CWX9-M7CS,3)
(5XH5-EH3C-BFZJ-ALGY,38) (V364-N8UB-P7SJ-RKH2,92) (57Q5-KRVS-SXMX-TCG9,25) (HJ2W-M76T-P8EX-HNK3,68) (LWKR-LCU9-
KHHE-GPL4,65) (MCAS-GSDZ-RNFM-9Z8H,92) (XCBU-9L3Q-ZXPS-42SL,50) (94UA-UZ57-2SBX-NR6A,41) (STX9-DX83-Y4E6-Y7QW,37)
(VDMA-GCSJ-LUT5-TJ7Z,95) (HDSN-8PHV-CGZJ-JSX5,51) (WVF3-AZ7Y-N9W9-5NUK,36) (ZF96-2XH9-665N-AWC6,40) (W8GH-DDE5-
HXWN-4HPG,11) (3T2Q-ADF5-4YUK-RMTA,27) (FNKL-5UXC-TEN7-SY2K,5) (A9R9-9579-8435-B5VU,4) (LP2R-5DTF-E2Y2-TXYC,67)
(M29Q-PGKK-GPF3-6KVC,91) (LRTL-KWMQ-65RD-R8K8,34) (6MG8-NPWY-MMDN-682C,11) (YKM3-YKMG-8NSG-JSTA,52) (YM62-YJ6X-
8ZVX-DDWN,14) (Z7C4-8UZL-GNLF-AMTJ,3) (NT72-P9K8-NZQK-VARQ,28) (2ELF-P6UX-5EWP-5ZGR,87) (NBPW-68T3-K6BB-GFUG,63)
(JRKP-RPXW-JHJF-Q3BE,46) (ZVS7-3TQB-9C8H-BSP4,70)

Adding and removing...


Time elapsed: 0.734 seconds
Time per ins/del operation: 0.349524 milliseconds.

There are 100 types of parts and 4907 parts in total.

The program has finished.

Alexandre@ces249-339952s /home/SENG1120
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GOOD LUCK

Dan and Alex

~~*v3.0.0 2022-09-23*~~

v3.0.1 2022-10-12 – corrected typo on page 3, Submission section