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Project Due date: 9/26/2020

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#### IV. Main (...)

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Step 0: nameInFile argv[1]

inFile open nameInFile

nameDebugFile nameInFile + "\_DeBug"

DebugFile open nameDebugFile

Step 1: computeCharCounts (inFile, charCountAry)

Step 2: printCountAry (charCountAry, DebugFile)

Step 3: constructHuffmanLList (charCountAry, DebugFile) // see algorithm below.

Step 4: constructHuffmanBinTree (listHead, DebugFile) // see algorithm below.

Step 5: constructCharCode (Root, "") // "" is an empty string; see algorithm below.

Step 6: printList (listHead, DebugFile)

Step 7: preOrderTraversal (Root, DebugFile)

inOrderTraversal (Root, DebugFile )

postOrderTraversal (Root, DebugFile)

step 8: userInterface ( ) // given below

step 9: close all files.

### **SOURCE CODE**

```
#include <iostream>
```

```
#include <bits/stdc++.h>
```

```
#include <string>
```

```
#include <fstream>
```

```
#include <stdlib.h>
```

```
using namespace std;
```

```
ofstream debugFile;
```

```
//global file names for ease of access
```

```
char* nameDebugFile;
```

```
char* compressedname;
```

```
char* decompressname;
```

```
char* inputname;
```

```
char* input2name;
```

```

/**
* Matthew Flammia, 23661371
* CSCI 323.35 Project 4
* To compile, use the command:
* g++ -std=gnu++0x -o FlammiaM_Project4_CPP main.cpp
* You must include 1 Data File, any more or any less will terminate the
program.
* When entering the filename during runtime, you MUST include the extension!
Otherwise it will not find the file correctly
**/

```

```

class huffman{
public:
class treeNode{
public:
//object variables
string chStr;
int frequency;
string code;
treeNode* left;
treeNode* right;
treeNode* next;
//constructor
treeNode(){
this->chStr = "";
this->frequency = -1;
this->code = "";
this->left = nullptr;
this->right = nullptr;
this->next = nullptr;
}
treeNode(string chStr, int frequency, string code, treeNode* left,
treeNode* right, treeNode* next){
this->chStr = chStr;
this->frequency = frequency;
this->code = code;
this->left = left;
this->right = right;
this->next = next;
}
//methods
void printNode(){

```

```

        debugFile.open(nameDebugFile, ios::out | ios::app);
        debugFile<<"("<< this->chStr <<">,<"< this->frequency
<<">,<"< this->code;
        //the following prevents null pointer issues
        if(this->next!=nullptr){
            debugFile<<">,<"<<this->next->chStr;
        }
        else{
            debugFile<<">,<NULL";
        }
        if(this->left!=nullptr){
            debugFile<<">,<"<<this->left->chStr;
        }
        else{
            debugFile<<">,<NULL";
        }
        if(this->right!=nullptr){
            debugFile<<">,<"<<this->right->chStr;
        }
        else{
            debugFile<<">,<NULL";
        }
        debugFile<<">);\n";
        debugFile.close();
    }
    bool isLeaf(){
        //checks if node is a leaf
        if(this->left==nullptr && this->right==nullptr)
            return true;
        return false;
    }
};

class linkedList{
public:
    //object variables
    treeNode* head;
    //constructor
    linkedList(){
        this->head = new
treeNode("dummy",0,"",nullptr,nullptr,nullptr);
    }
    //methods

```

```

treeNode* findSpot(treeNode** headref, treeNode* newNode){
    //horrendous. you must use a reference to the head node as
to not overwrite it. took 3 hours to figure out. other than that no different
    treeNode* spot = *headref;
    while(spot->next != nullptr){
        if(spot->next->frequency >= newNode->frequency)
            return spot;
        spot = spot->next;
    }
    return spot;
}

void insertOneNode(treeNode* spot, treeNode* newNode){
    //basic insert code
    newNode->next = spot->next;
    spot->next = newNode;
}

treeNode* removeHead(){
    if(this->isEmpty()){
        //checks incase you remove
        cout<<"ERROR: attempting to remove from empty list\n";
        exit(0);
    }
    //also misserable. a pointer reference. took 2 hours to
figure out

    treeNode* temp = *&this->head->next;
    this->head->next = *&this->head->next->next;
    return temp;
}

void printList(){
    debugFile.open(nameDebugFile, ios::out | ios::app);
    debugFile<<"Printing Linked List...\n";
    debugFile.close();
    treeNode* readHead = this->head;
    //simple loop, just calls print node until at end
    while(readHead->next!=nullptr){
        readHead->printNode();
        readHead = readHead->next;
    }
    readHead->printNode();
}

```

```

        bool isEmpty(){
            //simple empty check
            if(this->head->next == nullptr)
                return true;
            return false;
        }
    };

    class binaryTree{
    public:
        //object variables
        treeNode* root;
        //constructor
        binaryTree(){
            this->root = new treeNode("",-1,"",nullptr,nullptr,nullptr);
        }
        //methods
        //bunch of traversal prints, all work recursively
        void preOrderTraversal(treeNode* node){
            if(node == nullptr)
                return;
            node->printNode();
            preOrderTraversal(node->left);
            preOrderTraversal(node->right);
        }
        void inOrderTraversal(treeNode* node){
            if(node == nullptr)
                return;
            inOrderTraversal(node->left);
            node->printNode();
            inOrderTraversal(node->right);
        }
        void postOrderTraversal(treeNode* node){
            if(node == nullptr)
                return;
            postOrderTraversal(node->left);
            postOrderTraversal(node->right);
            node->printNode();
        }
    };

    //huffman class object variables
    int charCountAry[256];

```

```

string charCode[256];
linkedList list;
binaryTree tree;

//constructor
huffman(){
    for(int i=0;i<256;i++){
        this->charCountAry[i] = 0;
        this->charCode[i] = "";
    }
}

//methods of huffman
void computeCharCounts(ifstream& input){
    char character;
    while(!input.eof()){
        input.get(character);
        int index = (int)character;
        this->charCountAry[index]++;
    }
}

void printCountary(){
    //simple print, it prints count array
    debugFile.open(nameDebugFile, ios::out | ios::app);
    debugFile<<"Printing Count Array\n";
    for(int i=0;i<256;i++){
        if(charCountAry[i]!=0){
            debugFile<<"char"<<i<<" "<<charCountAry[i]<<endl;
        }
    }
    debugFile.close();
}

void constructHuffmanLList(){
    //creates the linked list, using find spot and insert methods
    debugFile.open(nameDebugFile, ios::out | ios::app);
    debugFile<<"making list\n";
    debugFile.close();
    for(int i=0;i<256;i++){
        if(this->charCountAry[i]>0){
            char input = i;
            string charToString(1,input);
            if(i==10)
                charToString = "\\n";

```

```

        treeNode* node = new
treeNode(charToString, this->charCountAry[i], "", nullptr, nullptr, nullptr);

this->list.insertOneNode(this->list.findSpot(&this->list.head, node), node);
        this->list.printList();
    }
}

void constructHuffmanBinTree(){
    //creates binary tree
    debugFile.open(nameDebugFile, ios::out | ios::app);
    debugFile<<"Making Binary Tree\n";
    debugFile.close();
    while(this->list.head->next->next != nullptr){
        //takes first 2 nodes of linked list
        treeNode* node1 = this->list.head->next;
        treeNode* node2 = this->list.head->next->next;
        //merges chstr of nodes 1 and 2
        string newchstr = node1->chStr + "," + node2->chStr;
        //merges frequency of nodes 1 and 2
        int newfrequency = node1->frequency + node2->frequency;
        //creates new node
        treeNode* newnode = new
treeNode(newchstr, newfrequency, "", node1, node2, nullptr);
        //inserts new node

list.insertOneNode(list.findSpot(&this->list.head, newnode), newnode);
        //sets head->next to 2 positions next
        this->list.head->next = this->list.head->next->next->next;
        //prints the list after insert
        list.printList();
    }
    //once done sets the root to the lists beginning
    this->tree.root = this->list.head->next;
}

void constructCharCode(treeNode* root, string code){
    //recursively calls to create a charcode
    //break statement
    if(root->isLeaf()){
        root->code = code;
        int index = root->chStr[0];
    }
}

```

```

        //if index is a backslash, convert it to a new line
character
        if(index == 92)
            index = 10;
        this->charCode[index] = code;
    }
    else{
        //recursive call
        constructCharCode(root->left,code+"0");
        constructCharCode(root->right,code+"1");
    }
}

void encode(ifstream& input, ofstream& output){
    input.open(inputname);
    output.open(compressedname);
    char character;
    debugFile.open(nameDebugFile, ios::out | ios::app);
    //loops until file end
    while(!input.eof()){
        input.get(character);
        int index = (int)character;
        string code = this->charCode[index];
        output<<code;
        debugFile<<index<<":"<<code<<endl;
    }
    debugFile.close();
    input.close();
    output.close();
}

void decode(ifstream& input, ofstream& output){
    treeNode* spot = this->tree.root;
    treeNode* reserve = this->tree.root;
    input.open(input2name);
    output.open(decompressname);
    char character;
    //loops until file end
    while(!input.eof()){
        //character found
        if(spot->isLeaf()){
            if(spot->chStr == "\\n"){
                output<<"\n";
            }

```



```

        else{
            output<<spot->chStr;
        }
        spot = this->tree.root;
    }
    else{
        //tests which direction to go
        input.get(character);
        int oneBit = (int)character - '0';
        if(oneBit == 0){
            spot = spot->left;
        }
        else if(oneBit == 1){
            spot = spot->right;
        }
        else{
            //happens if a 1 or 0 isnt read
            cout<<"Error! Non-Binary bit read.\n";
            cout<<"Bit read:"<<oneBit<<endl;
            exit(0);
        }
    }
}

output.close();
input.close();
}

void userInterface(){
    string nameOrg;
    string nameCompress;
    string nameDecompress;
    char yesNo;
    //goto loop label
    question:
    cout<<"Would you like to encode a file? y/n\n";
    cin>>yesNo;
    if(yesNo == 'n' || yesNo == 'N')
        exit(0);
    else{
        cout<<"Please enter the name of your file.\n";
        cin>>nameOrg;
        //name creation for compressed and decompressed files
        nameCompress = nameOrg + "_Compress.txt";
    }
}

```

```

        nameDecompress = nameOrg + "_DeCompress.txt";
        //gets length of names
        int org = nameOrg.length();
        int comp = nameCompress.length();
        int decomp = nameDecompress.length();
        //creates char arrays for names
        char orgAr[org+1];
        char compAr[comp+1];
        char decompAr[decomp+1];
        //converts string names into char arrays
        strcpy(orgAr, nameOrg.c_str());
        strcpy(compAr, nameCompress.c_str());
        strcpy(decompAr, nameDecompress.c_str());
        //sets global names to char array names
        compressedname = compAr;
        decompressname = decompAr;
        inputname = orgAr;
        input2name = compAr;
        //creates file streams
        ifstream input;
        ofstream outCompress;
        ifstream input2;
        ofstream outDecompress;
        //encodes or compresses
        encode(input,outCompress);
        //decodes based on compress
        decode(input2, outDecompress);
        cout<<"Done\n";
    }
    goto question;
}

};

//helpful functions
void seperation(){
    debugFile.open(nameDebugFile, ios::out | ios::app);

    debugFile<<"~~~~~\n";
    debugFile.close();
}

```

```

int main(int argc, char* argv[]){
    if(argc != 2){
        cout<<"You must supply only 1 data file!\n";
        return 0;
    }
    //gets filename
    char* nameInFile = argv[1];
    //creates initial ifstream
    ifstream input(nameInFile);
    nameDebugFile = strcat(nameInFile, "_Debug.txt");
    //creates huffman class
    huffman huff;
    //data structure creation
    cout<<"Creating necessary structures, Please wait.\r";
    huff.computeCharCounts(input);
    cout<<"Creating necessary structures, Please wait..\r";
    seperation();
    huff.printCountary();
    cout<<"Creating necessary structures, Please wait...\r";
    seperation();
    huff.constructHuffmanLList();
    cout<<"Creating necessary structures, Please wait....\r";
    seperation();
    huff.constructHuffmanBinTree();

    debugFile.open(nameDebugFile, ios::out | ios::app);

    debugFile<<"~~~~~\n";
    ~~~~~\n";
    debugFile<<"Making Char Code\n";
    cout<<"Creating necessary structures, Please wait.....\r";
    huff.constructCharCode(huff.tree.root, "");
    debugFile.close();
    cout<<"Creating necessary structures, Please wait.....\r";
    seperation();
    huff.list.printList();
    debugFile.close();

    debugFile.open(nameDebugFile, ios::out | ios::app);

    debugFile<<"~~~~~\n";
    ~~~~~\n";

```

```

        debugFile<<"preOrder Traversal\n";
        debugFile.close();
        cout<<"Creating necessary structures, Please wait.....\r";
        huff.tree.preOrderTraversal(huff.tree.root);
        debugFile.open(nameDebugFile, ios::out | ios::app);

debugFile<<"~~~~~\n";
~~~~~\n";
        debugFile<<"InOrder Traversal\n";
        debugFile.close();
        cout<<"Creating necessary structures, Please wait.....\r";
        huff.tree.inOrderTraversal(huff.tree.root);
        debugFile.open(nameDebugFile, ios::out | ios::app);

debugFile<<"~~~~~\n";
~~~~~\n";
        debugFile<<"PostOrder Traversal\n";
        debugFile.close();
        cout<<"Creating necessary structures, Please wait.....\r";
        huff.tree.postOrderTraversal(huff.tree.root);
        cout<<"Creating necessary structures, Please wait.....Done\n";
        //opens user interface for rest of program
        huff.userInterface();

        input.close();
        debugFile.close();
        return 0;
}

```

## **OUTPUTS**

### **INPUT TEXT FILE**

The Gettysburg Address is a speech by U.S. President Abraham Lincoln, one of the best known in American history. It was delivered by Lincoln during the American Civil War, on the afternoon of Thursday, November 19, 1863, at the dedication of the Soldiers' National Cemetery in Gettysburg, Pennsylvania, four and a half months after the Union armies defeated those of the Confederacy at the Battle of Gettysburg. Four score and seven years ago our fathers brought forth on this continent a new nation, conceived in liberty,

and dedicated to the proposition that all men are created equal.  
Now we are engaged in a great civil war, testing whether that nation,  
or any nation so conceived and so dedicated, can long endure.  
We are met on a great battlefield of that war. We have come to dedicate  
a portion of that field, as a final resting place for those  
who here gave their lives that that nation might live.  
It is altogether fitting and proper that we should do this.  
But, in a larger sense, we can not dedicate, we can not consecrate,  
we can not hallow this ground. The brave men, living and dead,  
who struggled here, have consecrated it,  
far above our poor power to add or detract. The world will little note,  
nor long remember what we say here, but it can never forget what they did  
here.

It is for us the living, rather,  
to be dedicated here to the unfinished work which they  
who fought here have thus far so nobly advanced.

It is rather for us to be here dedicated to the great task remaining  
before us that from these honored dead we take increased devotion to  
that cause for which they gave the last full measure of devotion that  
we here highly resolve that these dead shall not have died in vain  
that this nation, under God, shall have a new birth of freedom  
and that government of the people, by the people, for the people,  
shall not perish from the earth.

The Gettysburg Address is a speech by U.S. President Abraham Lincoln,  
one of the best known in American history.

It was delivered by Lincoln during the American Civil War,  
on the afternoon of Thursday, November 19, 1863, at the dedication of the  
Soldiers'

National Cemetery in Gettysburg, Pennsylvania,  
four and a half months after the Union armies defeated those of the  
Confederacy  
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It is for us the living, rather, to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced.

It is rather for us to be here dedicated to the great task remaining before us that from these honored dead we take increased devotion to that cause for which they gave the last full measure of devotion that we here highly resolve that these dead shall not have died in vain that this nation, under God, shall have a new birth of freedom and that government of the people, by the people, for the people, shall not perish from the earth.

The Gettysburg Address is a speech by U.S. President Abraham Lincoln, one of the best known in American history.

It was delivered by Lincoln during the American Civil War, on the afternoon of Thursday, November 19, 1863, at the dedication of the Soldiers'

National Cemetery in Gettysburg, Pennsylvania, four and a half months after the Union armies defeated those of the Confederacy at the Battle of Gettysburg.

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Confederacy  
at the Battle of Gettysburg.

Four score and seven years ago our fathers  
brought forth on this continent a new nation, conceived in liberty,  
and dedicated to the proposition that all men are created equal.

Now we are engaged in a great civil war, testing whether that nation,  
or any nation so conceived and so dedicated, can long endure.

We are met on a great battlefield of that war. We have come to dedicate  
a portion of that field, as a final resting place for those  
who here gave their lives that that nation might live.

It is altogether fitting and proper that we should do this.

But, in a larger sense, we can not dedicate, we can not consecrate,  
we can not hallow this ground. The brave men, living and dead,  
who struggled here, have consecrated it,  
far above our poor power to add or detract. The world will little note,  
nor long remember what we say here, but it can never forget what they did  
here.

It is for us the living, rather,

to be dedicated here to the unfinished work which they  
who fought here have thus far so nobly advanced.

It is rather for us to be here dedicated to the great task remaining  
before us that from these honored dead we take increased devotion to  
that cause for which they gave the last full measure of devotion that  
we here highly resolve that these dead shall not have died in vain  
that this nation, under God, shall have a new birth of freedom  
and that government of the people, by the people, for the people,  
shall not perish from the earth.

The Gettysburg Address is a speech by U.S. President Abraham Lincoln,  
one of the best known in American history.

It was delivered by Lincoln during the American Civil War,  
on the afternoon of Thursday, November 19, 1863, at the dedication of the  
Soldiers'

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and that government of the people, by the people, for the people,  
shall not perish from the earth.

## **DEBUG FILE**

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~~~~~

Printing Count Array

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char39 11  
char44 330  
char46 154  
char49 22  
char51 11  
char54 11

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char57 11  
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~~~~~  
making list  
Printing Linked List...

[illegible]

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Printing Linked List...
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( <1> , <22> , <> , <.> , <NULL> , <NULL> ) ;  
( <.> , <154> , <> , <,> , <NULL> , <NULL> ) ;  
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( <\n> , <343> , <> , < > , <NULL> , <NULL> ) ;  
( < > , <3674> , <> , <NULL> , <NULL> , <NULL> ) ;
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```
Printing Linked List...
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( <1>, <22>, <>, <.>, <NULL>, <NULL> );
( <.>, <154>, <>, <, >, <NULL>, <NULL> );
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```

```
Printing Linked List...
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Printing Linked List...

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Printing Linked List...

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Printing Linked List...

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Making Binary Tree  
 Printing Linked List...

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Printing Linked List...

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Printing Linked List...

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Printing Linked List...

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Printing Linked List...

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Printing Linked List...

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(<r>,<1100>,<>,<n>,<NULL>,<NULL>);
(<n>,<1122>,<>,<o>,<NULL>,<NULL>);
(<o>,<1265>,<>,<a>,<NULL>,<NULL>);
(<a>,<1386>,<>,<t>,<NULL>,<NULL>);
(<t>,<1694>,<>,<e>,<NULL>,<NULL>);
(<e>,<2277>,<>,< >,<NULL>,<NULL>);
(< >,<3674>,<>,<NULL>,<NULL>,<NULL>);
```

Printing Linked List...

```
(<dummy>,<0>,<>,<w,v>,<NULL>,<NULL>);
(<w,v>,<616>,<>,< , ,g>,<w>,<v>);
(< , ,g>,<671>,<>,<s>,< , >,<g>);
(<s>,<671>,<>,<\n,k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);
(<\n,k,T,U,S,9,8,q,F,p>,<695>,<>,<d>,<\n>,<k,T,U,S,9,8,q,F,p>);
(<d>,<792>,<>,<f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<f,B,1,P,L,A,N,C,y>,<825>,<>,<c,m,b>,<f>,<B,1,P,L,A,N,C,y>);
(<c,m,b>,<869>,<>,<i>,<c>,<m,b>);
(<i>,<935>,<>,<h>,<NULL>,<NULL>);
(<h>,<1056>,<>,<r>,<NULL>,<NULL>);
(<r>,<1100>,<>,<n>,<NULL>,<NULL>);
(<n>,<1122>,<>,<l,u , ' ,6,3,W,I,G ,.>,<NULL>,<NULL>);
(<l,u , ' ,6,3,W,I,G ,.>,<1166>,<>,<o>,<l>,<u , ' ,6,3,W,I,G ,.>);
(<o>,<1265>,<>,<a>,<NULL>,<NULL>);
(<a>,<1386>,<>,<t>,<NULL>,<NULL>);
(<t>,<1694>,<>,<e>,<NULL>,<NULL>);
(<e>,<2277>,<>,< >,<NULL>,<NULL>);
(< >,<3674>,<>,<NULL>,<NULL>,<NULL>);
```

Printing Linked List...

```
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(<s>,<671>,<>,<\n,k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);
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(<d>,<792>,<>,<f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<f,B,1,P,L,A,N,C,y>,<825>,<>,<c,m,b>,<f>,<B,1,P,L,A,N,C,y>);
(<c,m,b>,<869>,<>,<i>,<c>,<m,b>);
(<i>,<935>,<>,<h>,<NULL>,<NULL>);
(<h>,<1056>,<>,<r>,<NULL>,<NULL>);
(<r>,<1100>,<>,<n>,<NULL>,<NULL>);
```

```

(<n>, <1122>, <>, <l, u, ' , 6, 3, W, I, G, .>, <NULL>, <NULL>);
(<l, u, ' , 6, 3, W, I, G, .>, <1166>, <>, <o>, <l>, <u, ' , 6, 3, W, I, G, .>);
(<o>, <1265>, <>, <w, v, , , g>, <NULL>, <NULL>);
(<w, v, , , g>, <1287>, <>, <a>, <w, v>, <, , g>);
(<a>, <1386>, <>, <t>, <NULL>, <NULL>);
(<t>, <1694>, <>, <e>, <NULL>, <NULL>);
(<e>, <2277>, <>, < >, <NULL>, <NULL>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);
Printing Linked List...
(<dummy>, <0>, <>, <d>, <NULL>, <NULL>);
(<d>, <792>, <>, <f, B, 1, P, L, A, N, C, y>, <NULL>, <NULL>);
(<f, B, 1, P, L, A, N, C, y>, <825>, <>, <c, m, b>, <f>, <B, 1, P, L, A, N, C, y>);
(<c, m, b>, <869>, <>, <i>, <c>, <m, b>);
(<i>, <935>, <>, <h>, <NULL>, <NULL>);
(<h>, <1056>, <>, <r>, <NULL>, <NULL>);
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(<l, u, ' , 6, 3, W, I, G, .>, <1166>, <>, <o>, <l>, <u, ' , 6, 3, W, I, G, .>);
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(<s, \n, k, T, U, S, 9, 8, q, F, p>, <1366>, <>, <a>, <s>, <\n, k, T, U, S, 9, 8, q, F, p>);
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(<t>, <1694>, <>, <e>, <NULL>, <NULL>);
(<e>, <2277>, <>, < >, <NULL>, <NULL>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);
Printing Linked List...
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(<c, m, b>, <869>, <>, <i>, <c>, <m, b>);
(<i>, <935>, <>, <h>, <NULL>, <NULL>);
(<h>, <1056>, <>, <r>, <NULL>, <NULL>);
(<r>, <1100>, <>, <n>, <NULL>, <NULL>);
(<n>, <1122>, <>, <l, u, ' , 6, 3, W, I, G, .>, <NULL>, <NULL>);
(<l, u, ' , 6, 3, W, I, G, .>, <1166>, <>, <o>, <l>, <u, ' , 6, 3, W, I, G, .>);
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(<s, \n, k, T, U, S, 9, 8, q, F, p>, <1366>, <>, <a>, <s>, <\n, k, T, U, S, 9, 8, q, F, p>);
(<a>, <1386>, <>, <d, f, B, 1, P, L, A, N, C, y>, <NULL>, <NULL>);
(<d, f, B, 1, P, L, A, N, C, y>, <1617>, <>, <t>, <d>, <f, B, 1, P, L, A, N, C, y>);
(<t>, <1694>, <>, <e>, <NULL>, <NULL>);
(<e>, <2277>, <>, < >, <NULL>, <NULL>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);
Printing Linked List...

```

```

(<dummy>, <0>, <>, <h>, <NULL>, <NULL>);
(<h>, <1056>, <>, <r>, <NULL>, <NULL>);
(<r>, <1100>, <>, <n>, <NULL>, <NULL>);
(<n>, <1122>, <>, <l, u, ' , 6, 3, W, I, G, .>, <NULL>, <NULL>);
(<l, u, ' , 6, 3, W, I, G, .>, <1166>, <>, <o>, <l>, <u, ' , 6, 3, W, I, G, .>);
(<o>, <1265>, <>, <w, v, , , g>, <NULL>, <NULL>);
(<w, v, , , g>, <1287>, <>, <s, \n, k, T, U, S, 9, 8, q, F, p>, <w, v>, <, , g>);
(<s, \n, k, T, U, S, 9, 8, q, F, p>, <1366>, <>, <a>, <s>, <\n, k, T, U, S, 9, 8, q, F, p>);
(<a>, <1386>, <>, <d, f, B, 1, P, L, A, N, C, y>, <NULL>, <NULL>);
(<d, f, B, 1, P, L, A, N, C, y>, <1617>, <>, <t>, <d>, <f, B, 1, P, L, A, N, C, y>);
(<t>, <1694>, <>, <c, m, b, i>, <NULL>, <NULL>);
(<c, m, b, i>, <1804>, <>, <e>, <c, m, b>, <i>);
(<e>, <2277>, <>, < >, <NULL>, <NULL>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);

```

Printing Linked List...

```

(<dummy>, <0>, <>, <n>, <NULL>, <NULL>);
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(<l, u, ' , 6, 3, W, I, G, .>, <1166>, <>, <o>, <l>, <u, ' , 6, 3, W, I, G, .>);
(<o>, <1265>, <>, <w, v, , , g>, <NULL>, <NULL>);
(<w, v, , , g>, <1287>, <>, <s, \n, k, T, U, S, 9, 8, q, F, p>, <w, v>, <, , g>);
(<s, \n, k, T, U, S, 9, 8, q, F, p>, <1366>, <>, <a>, <s>, <\n, k, T, U, S, 9, 8, q, F, p>);
(<a>, <1386>, <>, <d, f, B, 1, P, L, A, N, C, y>, <NULL>, <NULL>);
(<d, f, B, 1, P, L, A, N, C, y>, <1617>, <>, <t>, <d>, <f, B, 1, P, L, A, N, C, y>);
(<t>, <1694>, <>, <c, m, b, i>, <NULL>, <NULL>);
(<c, m, b, i>, <1804>, <>, <h, r>, <c, m, b>, <i>);
(<h, r>, <2156>, <>, <e>, <h>, <r>);
(<e>, <2277>, <>, < >, <NULL>, <NULL>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);

```

Printing Linked List...

```

(<dummy>, <0>, <>, <o>, <NULL>, <NULL>);
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(<w, v, , , g>, <1287>, <>, <s, \n, k, T, U, S, 9, 8, q, F, p>, <w, v>, <, , g>);
(<s, \n, k, T, U, S, 9, 8, q, F, p>, <1366>, <>, <a>, <s>, <\n, k, T, U, S, 9, 8, q, F, p>);
(<a>, <1386>, <>, <d, f, B, 1, P, L, A, N, C, y>, <NULL>, <NULL>);
(<d, f, B, 1, P, L, A, N, C, y>, <1617>, <>, <t>, <d>, <f, B, 1, P, L, A, N, C, y>);
(<t>, <1694>, <>, <c, m, b, i>, <NULL>, <NULL>);
(<c, m, b, i>, <1804>, <>, <h, r>, <c, m, b>, <i>);
(<h, r>, <2156>, <>, <e>, <h>, <r>);
(<e>, <2277>, <>, <n, l, u, ' , 6, 3, W, I, G, .>, <NULL>, <NULL>);
(<n, l, u, ' , 6, 3, W, I, G, .>, <2288>, <>, < >, <n>, <l, u, ' , 6, 3, W, I, G, .>);
(< >, <3674>, <>, <NULL>, <NULL>, <NULL>);

```

Printing Linked List...

```

(<dummy>,<0>,<>,<s,\n,k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);
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(<a>,<1386>,<>,<d,f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<d,f,B,1,P,L,A,N,C,y>,<1617>,<>,<t>,<d>,<f,B,1,P,L,A,N,C,y>);
(<t>,<1694>,<>,<c,m,b,i>,<NULL>,<NULL>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<e>,<2277>,<>,<n,l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<n,l,u,' ,6,3,W,I,G, .>,<2288>,<>,<o,w,v, , ,g>,<n>,<l,u,' ,6,3,W,I,G, .>);
(<o,w,v, , ,g>,<2552>,<>,< >,<o>,<w,v, , ,g>);
(< >,<3674>,<>,<NULL>,<NULL>,<NULL>);

```

Printing Linked List...

```

(<dummy>,<0>,<>,<d,f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
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(<t>,<1694>,<>,<c,m,b,i>,<NULL>,<NULL>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<e>,<2277>,<>,<n,l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<n,l,u,' ,6,3,W,I,G, .>,<2288>,<>,<o,w,v, , ,g>,<n>,<l,u,' ,6,3,W,I,G, .>);
(<o,w,v, , ,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v, , ,g>);
(<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,< >,<s,\n,k,T,U,S,9,8,q,F,p>,<a>);
(< >,<3674>,<>,<NULL>,<NULL>,<NULL>);

```

Printing Linked List...

```

(<dummy>,<0>,<>,<c,m,b,i>,<NULL>,<NULL>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<e>,<2277>,<>,<n,l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<n,l,u,' ,6,3,W,I,G, .>,<2288>,<>,<o,w,v, , ,g>,<n>,<l,u,' ,6,3,W,I,G, .>);
(<o,w,v, , ,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v, , ,g>);
(<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<s,\n,k,T,U,S,9,8,q,F,p>,<a>);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< >,<d,f,B,1,P,L,A,N,C,y>,<t>);
(< >,<3674>,<>,<NULL>,<NULL>,<NULL>);

```

Printing Linked List...

```

(<dummy>,<0>,<>,<e>,<NULL>,<NULL>);
(<e>,<2277>,<>,<n,l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<n,l,u,' ,6,3,W,I,G, .>,<2288>,<>,<o,w,v, , ,g>,<n>,<l,u,' ,6,3,W,I,G, .>);
(<o,w,v, , ,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v, , ,g>);
(<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<s,\n,k,T,U,S,9,8,q,F,p>,<a>);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< >,<d,f,B,1,P,L,A,N,C,y>,<t>);
(< >,<3674>,<>,<c,m,b,i,h,r>,<NULL>,<NULL>);

```

```

(<c,m,b,i,h,r>,<3960>,<>,<NULL>,<c,m,b,i>,<h,r>);
Printing Linked List...
(<dummy>,<0>,<>,<o,w,v,,,g>,<NULL>,<NULL>);
(<o,w,v,,,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v,,,g>);
(<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<s,\n,k,T,U,S,9,8,q,F,p>,<a>);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< >,<d,f,B,1,P,L,A,N,C,y>,<t>);
(< >,<3674>,<>,<c,m,b,i,h,r>,<NULL>,<NULL>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G, .>,<c,m,b,i>,<h,r>);
(<e,n,l,u,' ,6,3,W,I,G, .>,<4565>,<>,<NULL>,<e>,<n,l,u,' ,6,3,W,I,G, .>);
Printing Linked List...
(<dummy>,<0>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<NULL>,<NULL>);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< >,<d,f,B,1,P,L,A,N,C,y>,<t>);
(< >,<3674>,<>,<c,m,b,i,h,r>,<NULL>,<NULL>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G, .>,<c,m,b,i>,<h,r>);
(<e,n,l,u,' ,6,3,W,I,G, .>,<4565>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<e>,<n,l,u,' ,6,3,W,I,G, .>);
(<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<5304>,<>,<NULL>,<o,w,v,,,g>,<s,\n,k,T,U,S,9,8,q,F,p,a>);
Printing Linked List...
(<dummy>,<0>,<>,<c,m,b,i,h,r>,<NULL>,<NULL>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G, .>,<c,m,b,i>,<h,r>);
(<e,n,l,u,' ,6,3,W,I,G, .>,<4565>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<e>,<n,l,u,' ,6,3,W,I,G, .>);
(<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<5304>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<o,w,v,,,g>,<s,\n,k,T,U,S,9,8,q,F,p,a>);
(<d,f,B,1,P,L,A,N,C,y,t>,< >,<6985>,<>,<NULL>,<d,f,B,1,P,L,A,N,C,y,t>,< >);
Printing Linked List...
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(<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<5304>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<o,w,v,,,g>,<s,\n,k,T,U,S,9,8,q,F,p,a>);
(<d,f,B,1,P,L,A,N,C,y,t>,< >,<6985>,<>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G, .>,<d,f,B,1,P,L,A,N,C,y,t>,< >);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G, .>,<8525>,<>,<NULL>,<c,m,b,i,h,r>,<e,n,l,u,' ,6,3,W,I,G, .>);
Printing Linked List...
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(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G, .>,<8525>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t>,<c,m,b,i,h,r>,<e,n,l,u,' ,6,3,W,I,G, .>);
(<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t>,< >,<12289>,<>,<NULL>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<d,f,B,1,P,L,A,N,C,y,t>,< >);

```

Printing Linked List...

```
(<dummy>,<0>,<>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,
q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >,<NULL>,<NULL>);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1
,P,L,A,N,C,y,t,
>,<20814>,<>,<NULL>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<o,w,v,,,g,s,\n,k,T,U,
S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >);
```

Making Char Code

Printing Linked List...

```
(<dummy>,<0>,<>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,
q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >,<NULL>,<NULL>);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1
,P,L,A,N,C,y,t,
>,<20814>,<>,<NULL>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<o,w,v,,,g,s,\n,k,T,U,
S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >);
```

preOrder Traversal

```
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1
,P,L,A,N,C,y,t,
>,<20814>,<>,<NULL>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<o,w,v,,,g,s,\n,k,T,U,
S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<8525>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F
,p,a,d,f,B,1,P,L,A,N,C,y,t, >,<c,m,b,i,h,r>,<e,n,l,u,' ,6,3,W,I,G,.>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G,.>,<c,m,b,i>,<h,r>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<c,m,b>,<869>,<>,<i>,<c>,<m,b>);
(<c>,<418>,<00000>,<m,b>,<NULL>,<NULL>);
(<m,b>,<451>,<>,<l>,<m>,<b>);
(<m>,<220>,<000010>,<b>,<NULL>,<NULL>);
(<b>,<231>,<000011>,<u>,<NULL>,<NULL>);
(<i>,<935>,<0001>,<h>,<NULL>,<NULL>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<h>,<1056>,<0010>,<r>,<NULL>,<NULL>);
(<r>,<1100>,<0011>,<n>,<NULL>,<NULL>);
(<e,n,l,u,' ,6,3,W,I,G,.>,<4565>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<e>,<n
,l,u,' ,6,3,W,I,G,.>);
(<e>,<2277>,<010>,<n,l,u,' ,6,3,W,I,G,.>,<NULL>,<NULL>);
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(<n,l,u,' ,6,3,W,I,G, .>,<2288>,<>,<o,w,v, , ,g>,<n>,<l,u,' ,6,3,W,I,G, .>);
(<n>,<1122>,<01110>,<l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<l,u,' ,6,3,W,I,G, .>,<1166>,<>,<o>,<l>,<u,' ,6,3,W,I,G, .>);
(<l>,<561>,<01110>,<u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<u,' ,6,3,W,I,G, .>,<605>,<>,<w,v>,<u>,<' ,6,3,W,I,G, .>);
(<u>,<297>,<011110>,<' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<' ,6,3,W,I,G, .>,<308>,<>,<w>,<' ,6,3,W,I,G>,<.>);
(<' ,6,3,W,I,G>,<154>,<>,<.>,<' ,6,3,W>,<I,G>);
(<' ,6,3,W>,<66>,<>,<I,G>,<' ,6,3>,<W>);
(<' ,6,3>,<33>,<>,<W>,<'>,<6,3>);
(<'>,<11>,<0111110000>,<6,3>,<NULL>,<NULL>);
(<6,3>,<22>,<>,<9,8>,<6>,<3>);
(<6>,<11>,<01111100010>,<3>,<NULL>,<NULL>);
(<3>,<11>,<01111100011>,<'>,<NULL>,<NULL>);
(<W>,<33>,<011111001>,<N>,<NULL>,<NULL>);
(<I,G>,<88>,<>,<k,T>,<I>,<G>);
(<I>,<44>,<011111010>,<G>,<NULL>,<NULL>);
(<G>,<44>,<011111011>,<A>,<NULL>,<NULL>);
(<.>,<154>,<0111111>,<k,T,U,S,9,8,q,F>,<NULL>,<NULL>);
(<o,w,v, , ,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t,
>,<12289>,<>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G, .>,<o,w,v, , ,g,s,\n,k,T,U,S,9,8,q,F
,p,a,d,f,B,1,P,L,A,N,C,y,t,
>,<o,w,v, , ,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<d,f,B,1,P,L,A,N,C,y,t, >);
(<o,w,v, , ,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<5304>,<>,<d,f,B,1,P,L,A,N,C,y,t,
>,<o,w,v, , ,g>,<s,\n,k,T,U,S,9,8,q,F,p,a>);
(<o,w,v, , ,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v, , ,g>);
(<o>,<1265>,<1000>,<w,v, , ,g>,<NULL>,<NULL>);
(<w,v, , ,g>,<1287>,<>,<s,\n,k,T,U,S,9,8,q,F,p>,<w,v>,<, ,g>);
(<w,v>,<616>,<>,<, ,g>,<w>,<v>);
(<w>,<308>,<100100>,<v>,<NULL>,<NULL>);
(<v>,<308>,<100101>,<, >,<NULL>,<NULL>);
(<, ,g>,<671>,<>,<s>,<, >,<g>);
(<, >,<330>,<100110>,<g>,<NULL>,<NULL>);
(<g>,<341>,<100111>,<\n>,<NULL>,<NULL>);
(<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<s,\n,k,T,U,S,9,
8,q,F,p>,<a>);
(<s,\n,k,T,U,S,9,8,q,F,p>,<1366>,<>,<a>,<s>,<\n,k,T,U,S,9,8,q,F,p>);
(<s>,<671>,<10100>,<\n,k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);
(<\n,k,T,U,S,9,8,q,F,p>,<695>,<>,<d>,<\n>,<k,T,U,S,9,8,q,F,p>);
(<\n>,<343>,<101010>,<k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);
(<k,T,U,S,9,8,q,F,p>,<352>,<>,<f>,<k,T,U,S,9,8,q,F>,<p>);
(<k,T,U,S,9,8,q,F>,<176>,<>,<p>,<k,T>,<U,S,9,8,q,F>);

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(<k,T>,<88>,<>,<U,S,9,8,q,F>,<k>,<T>);
(<k>,<44>,<101011000>,<T>,<NULL>,<NULL>);
(<T>,<44>,<101011001>,<I>,<NULL>,<NULL>);
(<U,S,9,8,q,F>,<88>,<>,<B,1,P,L>,<U,S>,<9,8,q,F>);
(<U,S>,<44>,<>,<9,8,q,F>,<U>,<S>);
(<U>,<22>,<1010110100>,<S>,<NULL>,<NULL>);
(<S>,<22>,<1010110101>,<P>,<NULL>,<NULL>);
(<9,8,q,F>,<44>,<>,<k>,<9,8>,<q,F>);
(<9,8>,<22>,<>,<q,F>,<9>,<8>);
(<9>,<11>,<10101101100>,<8>,<NULL>,<NULL>);
(<8>,<11>,<10101101101>,<6>,<NULL>,<NULL>);
(<q,F>,<22>,<>,<U>,<q>,<F>);
(<q>,<11>,<10101101110>,<F>,<NULL>,<NULL>);
(<F>,<11>,<10101101111>,<9>,<NULL>,<NULL>);
(<p>,<176>,<1010111>,<B,1,P,L,A,N,C>,<NULL>,<NULL>);
(<a>,<1386>,<1011>,<d,f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<d,f,B,1,P,L,A,N,C,y,t,
>,<6985>,<>,<c,m,b,i,h,r,e,n,l,u,'6,3,W,I,G.>,<d,f,B,1,P,L,A,N,C,y,t>,< >);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< >,<d,f,B,1,P,L,A,N,C,y>,<t>);
(<d,f,B,1,P,L,A,N,C,y>,<1617>,<>,<t>,<d>,<f,B,1,P,L,A,N,C,y>);
(<d>,<792>,<11000>,<f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<f,B,1,P,L,A,N,C,y>,<825>,<>,<c,m,b>,<f>,<B,1,P,L,A,N,C,y>);
(<f>,<407>,<110010>,<B,1,P,L,A,N,C,y>,<NULL>,<NULL>);
(<B,1,P,L,A,N,C,y>,<418>,<>,<c>,<B,1,P,L,A,N,C>,<y>);
(<B,1,P,L,A,N,C>,<198>,<>,<y>,<B,1,P,L>,<A,N,C>);
(<B,1,P,L>,<88>,<>,<A,N,C>,<B,1>,<P,L>);
(<B,1>,<44>,<>,<P,L>,<B>,<1>);
(<B>,<22>,<1100110000>,<1>,<NULL>,<NULL>);
(<1>,<22>,<1100110001>,<'6,3>,<NULL>,<NULL>);
(<P,L>,<44>,<>,<U,S>,<P>,<L>);
(<P>,<22>,<1100110010>,<L>,<NULL>,<NULL>);
(<L>,<22>,<1100110011>,<B>,<NULL>,<NULL>);
(<A,N,C>,<110>,<>,<'6,3,W,I,G>,<A>,<N,C>);
(<A>,<44>,<110011010>,<N,C>,<NULL>,<NULL>);
(<N,C>,<66>,<>,<'6,3,W>,<N>,<C>);
(<N>,<33>,<1100110110>,<C>,<NULL>,<NULL>);
(<C>,<33>,<1100110111>,<B,1>,<NULL>,<NULL>);
(<y>,<220>,<1100111>,<m>,<NULL>,<NULL>);
(<t>,<1694>,<1101>,<c,m,b,i>,<NULL>,<NULL>);
(< >,<3674>,<111>,<c,m,b,i,h,r>,<NULL>,<NULL>);

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## InOrder Traversal

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(<c>,<418>,<00000>,<m,b>,<NULL>,<NULL>);
(<c,m,b>,<869>,<>,<i>,<c>,<m,b>);
(<m>,<220>,<000010>,<b>,<NULL>,<NULL>);
(<m,b>,<451>,<>,<l>,<m>,<b>);
(<b>,<231>,<000011>,<u>,<NULL>,<NULL>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<i>,<935>,<0001>,<h>,<NULL>,<NULL>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G,.>,<c,m,b,i>,<h,r>);
(<h>,<1056>,<0010>,<r>,<NULL>,<NULL>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<r>,<1100>,<0011>,<n>,<NULL>,<NULL>);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<8525>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F
,p,a,d,f,B,1,P,L,A,N,C,y,t, >,<c,m,b,i,h,r>,<e,n,l,u,' ,6,3,W,I,G,.>);
(<e>,<2277>,<010>,<n,l,u,' ,6,3,W,I,G,.>,<NULL>,<NULL>);
(<e,n,l,u,' ,6,3,W,I,G,.>,<4565>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<e>,<n
,l,u,' ,6,3,W,I,G,.>);
(<n>,<1122>,<0110>,<l,u,' ,6,3,W,I,G,.>,<NULL>,<NULL>);
(<n,l,u,' ,6,3,W,I,G,.>,<2288>,<>,<o,w,v,,,g>,<n>,<l,u,' ,6,3,W,I,G,.>);
(<l>,<561>,<01110>,<u,' ,6,3,W,I,G,.>,<NULL>,<NULL>);
(<l,u,' ,6,3,W,I,G,.>,<1166>,<>,<o>,<l>,<u,' ,6,3,W,I,G,.>);
(<u>,<297>,<011110>,<' ,6,3,W,I,G,.>,<NULL>,<NULL>);
(<u,' ,6,3,W,I,G,.>,<605>,<>,<w,v>,<u>,<' ,6,3,W,I,G,.>);
(<'>,<11>,<0111110000>,<6,3>,<NULL>,<NULL>);
(<' ,6,3>,<33>,<>,<W>,<'>,<6,3>);
(<6>,<11>,<01111100010>,<3>,<NULL>,<NULL>);
(<6,3>,<22>,<>,<9,8>,<6>,<3>);
(<3>,<11>,<01111100011>,<'>,<NULL>,<NULL>);
(<' ,6,3,W>,<66>,<>,<I,G>,<' ,6,3>,<W>);
(<W>,<33>,<011111001>,<N>,<NULL>,<NULL>);
(<' ,6,3,W,I,G>,<154>,<>,<.>,<' ,6,3,W>,<I,G>);
(<I>,<44>,<011111010>,<G>,<NULL>,<NULL>);
(<I,G>,<88>,<>,<k,T>,<I>,<G>);
(<G>,<44>,<011111011>,<A>,<NULL>,<NULL>);
(<' ,6,3,W,I,G,.>,<308>,<>,<w>,<' ,6,3,W,I,G>,<.>);
(<.>,<154>,<0111111>,<k,T,U,S,9,8,q,F>,<NULL>,<NULL>);
(<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.,o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1
,P,L,A,N,C,y,t,
>,<20814>,<>,<NULL>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G,.>,<o,w,v,,,g,s,\n,k,T,U,
S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t, >);
(<o>,<1265>,<1000>,<w,v,,,g>,<NULL>,<NULL>);
(<o,w,v,,,g>,<2552>,<>,<s,\n,k,T,U,S,9,8,q,F,p,a>,<o>,<w,v,,,g>);
```

(<w>,<308>,<100100>,<v>,<NULL>,<NULL>);  
 (<w,v>,<616>,<>,<,>,<g>,<w>,<v>);  
 (<v>,<308>,<100101>,<,>,<NULL>,<NULL>);  
 (<w,v,,>,<1287>,<>,<s,\n,k,T,U,S,9,8,q,F,p>,<w,v>,<,>,<g>);  
 (<,>,<330>,<100110>,<g>,<NULL>,<NULL>);  
 (<,>,<g>,<671>,<>,<s>,<,>,<g>);  
 (<g>,<341>,<100111>,<\n>,<NULL>,<NULL>);  
 (<o,w,v,,>,<g,s,\n,k,T,U,S,9,8,q,F,p,a>,<5304>,<>,<d,f,B,1,P,L,A,N,C,y,t,>,<o,w,v,,>,<g>,<s,\n,k,T,U,S,9,8,q,F,p,a>);  
 (<s>,<671>,<10100>,<\n,k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);  
 (<s,\n,k,T,U,S,9,8,q,F,p>,<1366>,<>,<a>,<s>,<\n,k,T,U,S,9,8,q,F,p>);  
 (<\n>,<343>,<101010>,<k,T,U,S,9,8,q,F,p>,<NULL>,<NULL>);  
 (<\n,k,T,U,S,9,8,q,F,p>,<695>,<>,<d>,<\n>,<k,T,U,S,9,8,q,F,p>);  
 (<k>,<44>,<101011000>,<T>,<NULL>,<NULL>);  
 (<k,T>,<88>,<>,<U,S,9,8,q,F>,<k>,<T>);  
 (<T>,<44>,<101011001>,<I>,<NULL>,<NULL>);  
 (<k,T,U,S,9,8,q,F>,<176>,<>,<p>,<k,T>,<U,S,9,8,q,F>);  
 (<U>,<22>,<1010110100>,<S>,<NULL>,<NULL>);  
 (<U,S>,<44>,<>,<9,8,q,F>,<U>,<S>);  
 (<S>,<22>,<1010110101>,<P>,<NULL>,<NULL>);  
 (<U,S,9,8,q,F>,<88>,<>,<B,1,P,L>,<U,S>,<9,8,q,F>);  
 (<9>,<11>,<10101101100>,<8>,<NULL>,<NULL>);  
 (<9,8>,<22>,<>,<q,F>,<9>,<8>);  
 (<8>,<11>,<10101101101>,<6>,<NULL>,<NULL>);  
 (<9,8,q,F>,<44>,<>,<k>,<9,8>,<q,F>);  
 (<q>,<11>,<10101101110>,<F>,<NULL>,<NULL>);  
 (<q,F>,<22>,<>,<U>,<q>,<F>);  
 (<F>,<11>,<10101101111>,<9>,<NULL>,<NULL>);  
 (<k,T,U,S,9,8,q,F,p>,<352>,<>,<f>,<k,T,U,S,9,8,q,F>,<p>);  
 (<p>,<176>,<1010111>,<B,1,P,L,A,N,C>,<NULL>,<NULL>);  
 (<s,\n,k,T,U,S,9,8,q,F,p,a>,<2752>,<>,<d,f,B,1,P,L,A,N,C,y,t>,<s,\n,k,T,U,S,9,8,q,F,p>,<a>);  
 (<a>,<1386>,<1011>,<d,f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);  
 (<o,w,v,,>,<g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t,>,<12289>,<>,<c,m,b,i,h,r,e,n,l,u,'6,3,W,I,G,.,>,<o,w,v,,>,<g,s,\n,k,T,U,S,9,8,q,F,p,a,d,f,B,1,P,L,A,N,C,y,t,>,<o,w,v,,>,<g,s,\n,k,T,U,S,9,8,q,F,p,a>,<d,f,B,1,P,L,A,N,C,y,t,>);  
 (<d>,<792>,<11000>,<f,B,1,P,L,A,N,C,y>,<NULL>,<NULL>);  
 (<d,f,B,1,P,L,A,N,C,y>,<1617>,<>,<t>,<d>,<f,B,1,P,L,A,N,C,y>);  
 (<f>,<407>,<110010>,<B,1,P,L,A,N,C,y>,<NULL>,<NULL>);  
 (<f,B,1,P,L,A,N,C,y>,<825>,<>,<c,m,b>,<f>,<B,1,P,L,A,N,C,y>);  
 (<B>,<22>,<1100110000>,<1>,<NULL>,<NULL>);

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(<B,1>,<44>,<>,<P,L>,<B>,<1>);
(<1>,<22>,<1100110001>,<' ,6,3>,<NULL>,<NULL>);
(<B,1,P,L>,<88>,<>,<A,N,C>,<B,1>,<P,L>);
(<P>,<22>,<1100110010>,<L>,<NULL>,<NULL>);
(<P,L>,<44>,<>,<U,S>,<P>,<L>);
(<L>,<22>,<1100110011>,<B>,<NULL>,<NULL>);
(<B,1,P,L,A,N,C>,<198>,<>,<y>,<B,1,P,L>,<A,N,C>);
(<A>,<44>,<110011010>,<N,C>,<NULL>,<NULL>);
(<A,N,C>,<110>,<>,<' ,6,3,W,I,G>,<A>,<N,C>);
(<N>,<33>,<1100110110>,<C>,<NULL>,<NULL>);
(<N,C>,<66>,<>,<' ,6,3,W>,<N>,<C>);
(<C>,<33>,<1100110111>,<B,1>,<NULL>,<NULL>);
(<B,1,P,L,A,N,C,y>,<418>,<>,<c>,<B,1,P,L,A,N,C>,<y>);
(<y>,<220>,<1100111>,<m>,<NULL>,<NULL>);
(<d,f,B,1,P,L,A,N,C,y,t>,<3311>,<>,< ,>,<d,f,B,1,P,L,A,N,C,y>,<t>);
(<t>,<1694>,<1101>,<c,m,b,i>,<NULL>,<NULL>);
(<d,f,B,1,P,L,A,N,C,y,t,
>,<6985>,<>,<c,m,b,i,h,r,e,n,l,u,' ,6,3,W,I,G, .>,<d,f,B,1,P,L,A,N,C,y,t>,< >);
(< ,>,<3674>,<111>,<c,m,b,i,h,r>,<NULL>,<NULL>);

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#### PostOrder Traversal

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(<c>,<418>,<00000>,<m,b>,<NULL>,<NULL>);
(<m>,<220>,<000010>,<b>,<NULL>,<NULL>);
(<b>,<231>,<000011>,<u>,<NULL>,<NULL>);
(<m,b>,<451>,<>,<l>,<m>,<b>);
(<c,m,b>,<869>,<>,<i>,<c>,<m,b>);
(<i>,<935>,<0001>,<h>,<NULL>,<NULL>);
(<c,m,b,i>,<1804>,<>,<h,r>,<c,m,b>,<i>);
(<h>,<1056>,<0010>,<r>,<NULL>,<NULL>);
(<r>,<1100>,<0011>,<n>,<NULL>,<NULL>);
(<h,r>,<2156>,<>,<e>,<h>,<r>);
(<c,m,b,i,h,r>,<3960>,<>,<e,n,l,u,' ,6,3,W,I,G, .>,<c,m,b,i>,<h,r>);
(<e>,<2277>,<010>,<n,l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<n>,<1122>,<0110>,<l,u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<l>,<561>,<01110>,<u,' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<u>,<297>,<011110>,<' ,6,3,W,I,G, .>,<NULL>,<NULL>);
(<'>,<11>,<0111110000>,<6,3>,<NULL>,<NULL>);
(<6>,<11>,<01111100010>,<3>,<NULL>,<NULL>);
(<3>,<11>,<01111100011>,<'>,<NULL>,<NULL>);
(<6,3>,<22>,<>,<9,8>,<6>,<3>);
(<' ,6,3>,<33>,<>,<W>,<'>,<6,3>);

```

```

(<W>,<33>,<011111001>,<N>,<NULL>,<NULL>);
(<' ,6,3,W>,<66>,<>,<I,G>,<' ,6,3>,<W>);
(<I>,<44>,<011111010>,<G>,<NULL>,<NULL>);
(<G>,<44>,<011111011>,<A>,<NULL>,<NULL>);
(<I,G>,<88>,<>,<k,T>,<I>,<G>);
(<' ,6,3,W,I,G>,<154>,<>,<.>,<' ,6,3,W>,<I,G>);
(<.>,<154>,<0111111>,<k,T,U,S,9,8,q,F>,<NULL>,<NULL>);
(<' ,6,3,W,I,G,.>,<308>,<>,<w>,<' ,6,3,W,I,G,.>);
(<u,' ,6,3,W,I,G,.>,<605>,<>,<w,v>,<u>,<' ,6,3,W,I,G,.>);
(<l,u,' ,6,3,W,I,G,.>,<1166>,<>,<o>,<l>,<u,' ,6,3,W,I,G,.>);
(<n,l,u,' ,6,3,W,I,G,.>,<2288>,<>,<o,w,v,,,g>,<n>,<l,u,' ,6,3,W,I,G,.>);
(<e,n,l,u,' ,6,3,W,I,G,.>,<4565>,<>,<o,w,v,,,g,s,\n,k,T,U,S,9,8,q,F,p,a>,<e>,<n
,l,u,' ,6,3,W,I,G,.>);
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118:100101  
101:010  
114:0011  
32:111  
102:110010  
111:1000  
114:0011  
103:100111  
101:010  
116:1101  
32:111  
119:100100  
104:0010  
97:1011  
116:1101  
32:111  
116:1101  
104:0010  
101:010  
121:1100111  
32:111  
100:11000  
105:0001  
100:11000  
32:111

104:0010  
101:010  
114:0011  
101:010  
46:0111111  
32:111  
10:101010  
10:101010

## **TEXTDATA1**

Four score and seven years ago our fathers  
brought forth on this continent a new nation, conceived in liberty,  
and dedicated to the proposition that all men are created equal.  
Now we are engaged in a great civil war, testing whether that nation,  
or any nation so conceived and so dedicated, can long endure.  
We are met on a great battlefield of that war. We have come to dedicate  
a portion of that field, as a final resting place for those  
who here gave their lives that that nation might live.  
It is altogether fitting and proper that we should do this.  
But, in a larger sense, we can not dedicate, we can not consecrate,  
we can not hallow this ground. The brave men, living and dead,  
who struggled here, have consecrated it,  
far above our poor power to add or detract. The world will little note,  
nor long remember what we say here, but it can never forget what they did  
here.

## **TEXTDATA1 COMPRESSED**

1010110111110000111100011111010000001000001101011110110110001111010001010  
010101001101111100111010101100111010011110111001111000111100001111000111111100  
101011110100100100011101001111010100000110011100001111010011100101101111110010  
100000111101001011110000110111110100100001101001110000010000110110100010110010  
0110110111110111110110010100100111011010111101000110000110100011011100000100001  
100000001000011001010101100011100010110111011100001000011010001111011100111100  
110111101010101101101100011111000010110000001000001011110101011000111110110001  
111101001001011110101110011100010101111000101000001110100011000011011111010010  
101111011111011011100111011100001001001101111011001101011100000001101010111101  
010110001110101010110111001111010110111001111111010101100110110100010010011110  
01000101111011001101011101001101001111011100111010110001110001011011110111110  
011100110101011110111100000000110010100010111011110010010110011100110111110101  
010100110100010110100111111100100001001011010010010001111111010010101111011110

1101011110100011000011010011011110101010000011111011011011001111101101011110  
100011000011011110100100011100000100001100000001000011001010101100011110110110  
110001111010010001111100001011000000100000101111010101100010011011100000101101  
10111011101000011010011111101001101100001111000110100111111111010100111110010  
101111011001101011100001001011011111000011011110111111001110011010101111011110  
00011101111011101011100101100100001010011101100011110001100101111101001010111  
011111001001011001101111111110111110010101110010101110010101011100000100000001  
001011111011000111110000101100000010000010111101010111101010101111110101111000  
001111010001100001101111000110010111110100101011110111111001000010100111011000  
10011011110111010011110111111001000010110101101111001101010100110100010110  
10011111110101110111010110000001011111001010000011111101001010001010001011110  
101010010000101000111001001000110101111001111011100101010111110100100100001001  
11110111000011001010101010011111010010101111011111101001010111101111011010111  
01000110000110111000010000110011100101101111011100001100101010011111111101010  
011111010110111100011010011110110111011011000100111010110100100100011111110010  
000111011101000101101001111111011011011000111101011100111000101011101000111111  
101001010111101111100100010111101000010100001111001110110001111100010001111101  
00100001101000111111101010110011000001111011011001101110001011011110111101110  
101100111001110100011111101000100110101000101001101111001000101110000010110110  
1110110100011011111100001011000000100000101111010100110111100100010111000001  
011011011101101000110111100000100001101010001000000001110111101010100110111101  
010100100010111000001011011011101101000110111100101011011100111010001001001111  
10100100001101001111001110011100001111001101100001111111110101100100100101110  
000110011101110010101011100001001001101001101110111000011001010001011010011111  
110110110110001111100001010111100010011011110101010010000101000111101001101001  
1011110100111100111011100101100011100100100011010100110111100101011100101010111  
000001000011010100010000000011101111010101100011100011101100110111101010110010  
101100111111011000011100010010101011110000111100011111101011110001000001111110  
10111100010010001000111111101100011110111100011000111100000111111000010110100  
111011000001101011111111110101100100100101111001001000001101110110001111001000  
0010111001110111011110000111011101011100101110110100011010101001101111010100110  
100000111110111010000110100111111001101000001001000001000001101000111111001000  
0101011110111110010001011110100101111001111110010010001101010011011110000110111  
101101111000111011110000010110110111011001010010101000111111100101000001110011  
101011011111001000010101111011111101001001011001111111100000011100011100100100  
01101001111111111101010101010

## **TEXTDATA1 DECOMPRESSED**

Four score and seven years ago our fathers  
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and dedicated to the proposition that all men are created equal.  
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## **TEXTDATA2**

The Gettysburg Address is a speech by U.S. President Abraham Lincoln, one of the best known in American history. It was delivered by Lincoln during the American Civil War, on the afternoon of Thursday, November 19, 1863, at the dedication of the Soldiers National Cemetery in Gettysburg, Pennsylvania, four and a half months after the Union armies defeated those of the Confederacy at the Battle of Gettysburg.

## **TEXTDATA2 COMPRESSED**

1010110010010010111011111011011011101110011110100000011011110001110011111111  
0011010110001100000011010101001010011100011010011110111111010010101110100100000  
000101110000111100111111010110100011111110101101010111111111001100100011010  
101000001110000100110110111111001101000001100111011001010110000101111100110011  
000101100000010000111001101001101111010101000011001011110001100101111101001001  
011100001101010100110111110101100001101000100100011011100010110111110011010000  
0100100011000100000101101101110010000110100110110000011100111011111111101010  
011111010110111110010010111010011111000010011100001100101010001101011000111000  
0111100111111111001100110001011000000100001110011011111000011110001100010110100  
111111110100100101111100110100000100100011000100000101101101111100110111000110  
010100010111011101111100110110011100110111101010100001101111101001001011110111  
100101101010001101101000100001101111000110010111101011001001001111000111010011  
000101111001111001101111100110110100010010101000001000001101000111111100110001  
10101101100100110111110011000110101101101011111000100111110001110011011110111  
011111101001001011111000010110000001000001011110100011000011011110001100101111  
101001001011110101101011000011101100000010100011101001111010101100110110101111  
010001100001101011011101111100110111010000010010110101000111100111111000101101

110111110110101101110111001111010000001101111000111001111001101111100110010010  
011001101010011001110111010010110110110000110111001101111010101100101000011110  
001111110110110110001111011111001010110111011001011100001010000110110100101010  
01111011110010110101000111111010010010111101011010001100001100001101111011001  
1000010000101010100111110000101100100101011110101100011111010010100010100010  
111100011001011111010010010111110011011110000110110010010110000100011101100000  
11001111111010101011110111110100100101111100110000101111011101011100101111000  
11001011101111101101011011101110011110100000011011110001110011101111111110101  
0101010

## **TEXTDATA2\_DECOMPRESSED**

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National Cemetery in Gettysburg, Pennsylvania,  
four and a half months after the Union armies defeated those of the  
Confederacy  
at the Battle of Gettysburg.