LAB – 10

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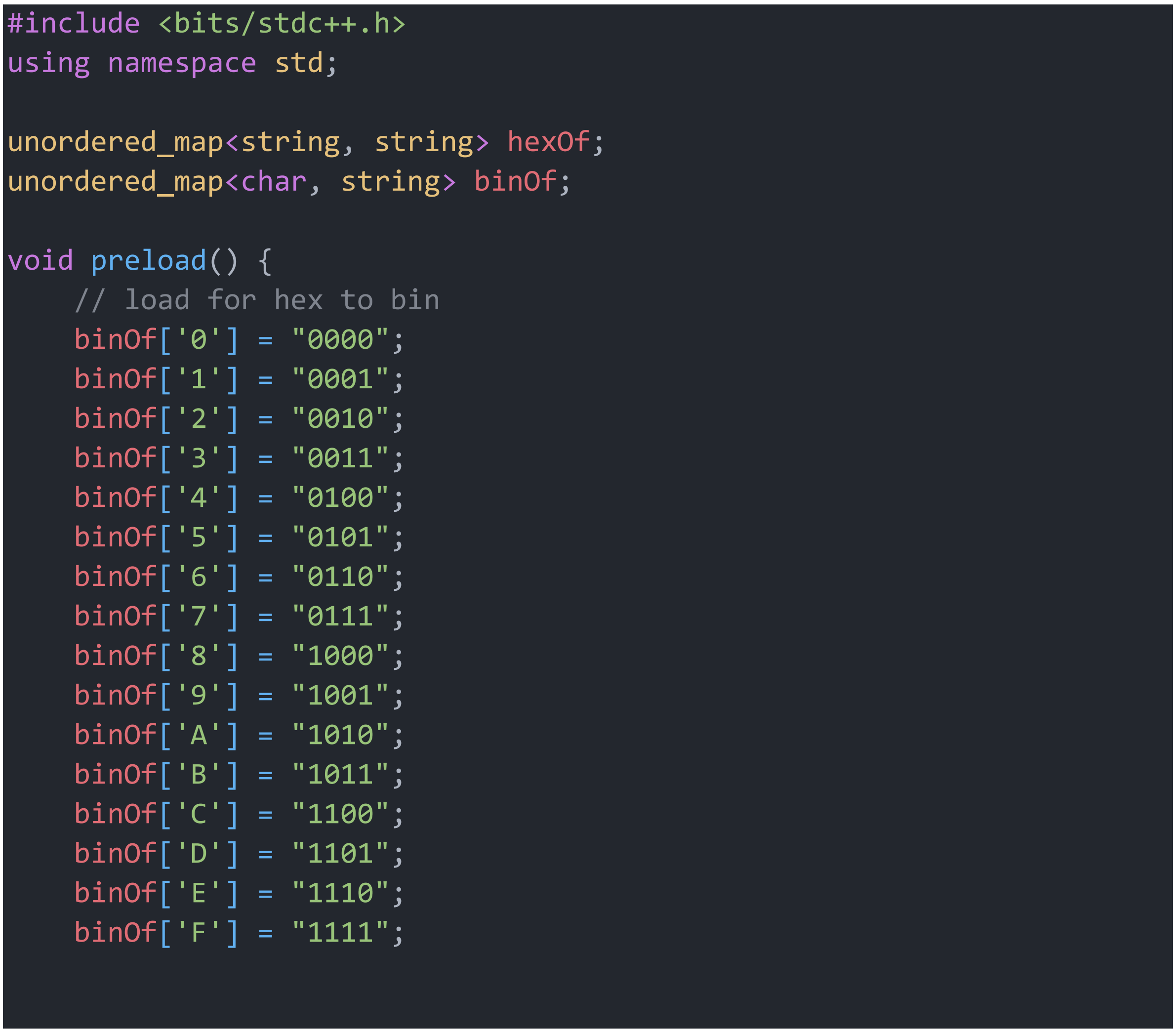
Aim: Write a program to implement DES Cipher.

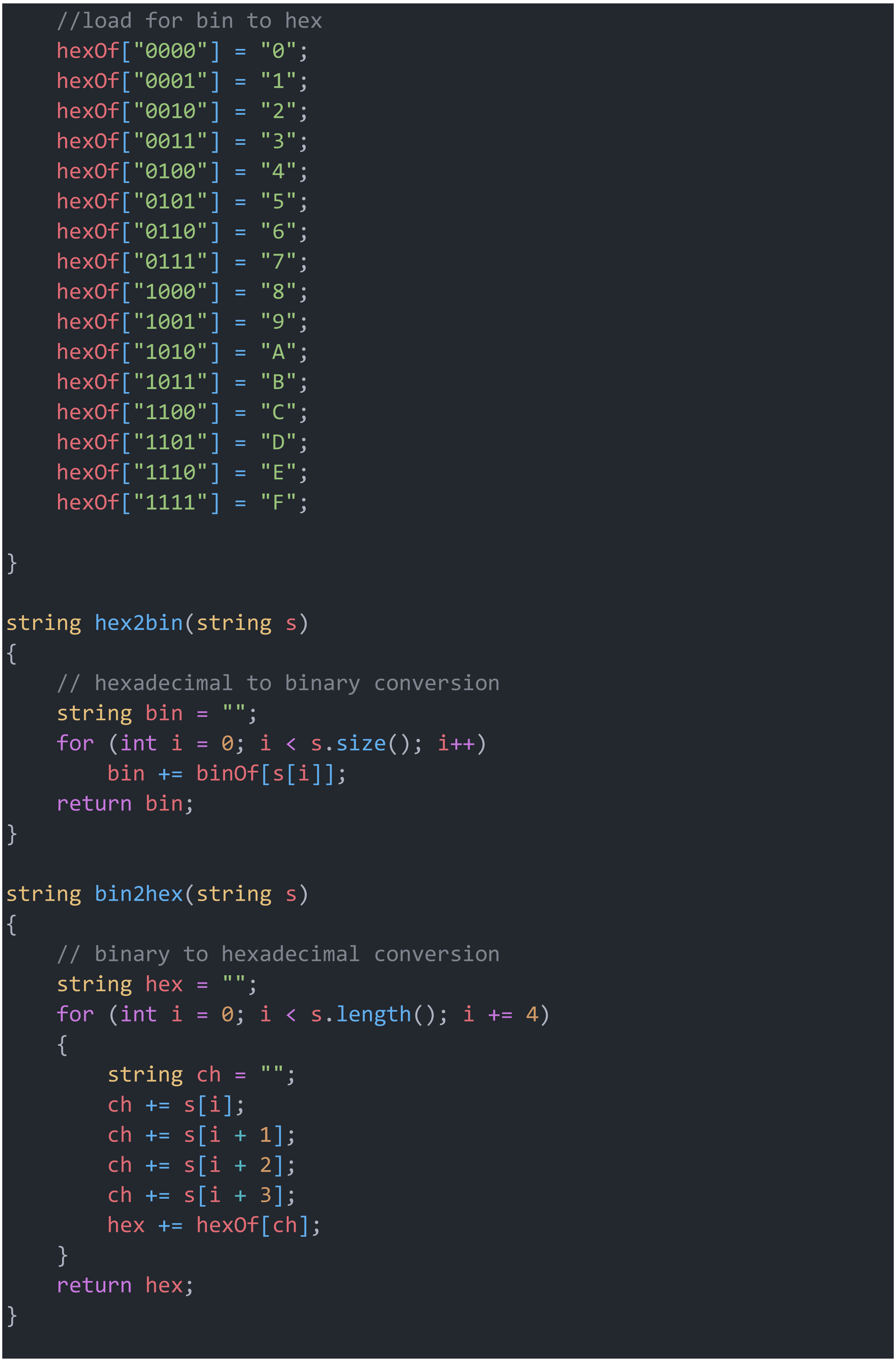
- Round Function Implementation

❖ **Program :** DES Cipher (Round Function)

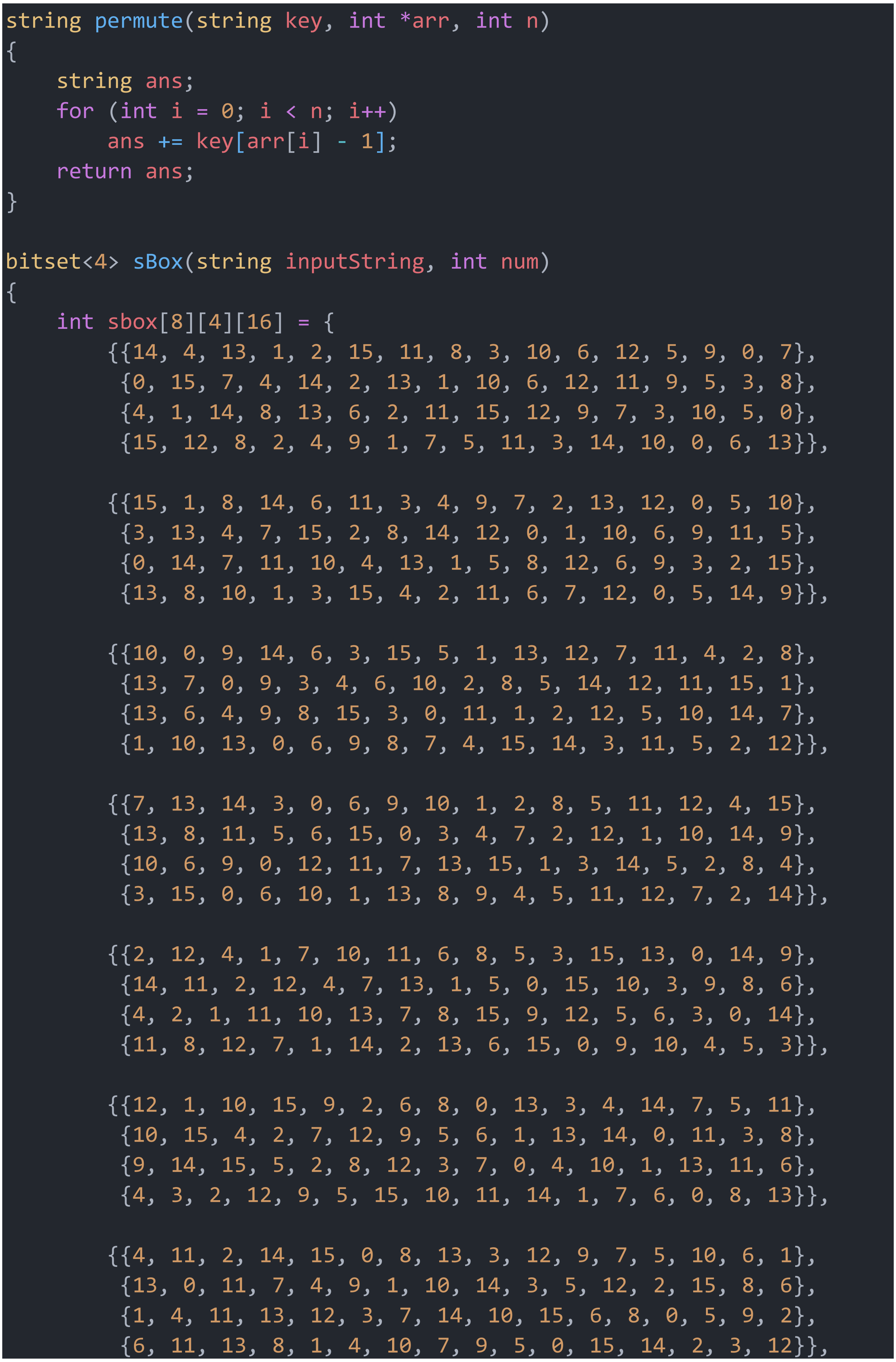
➢ **Source Code:**



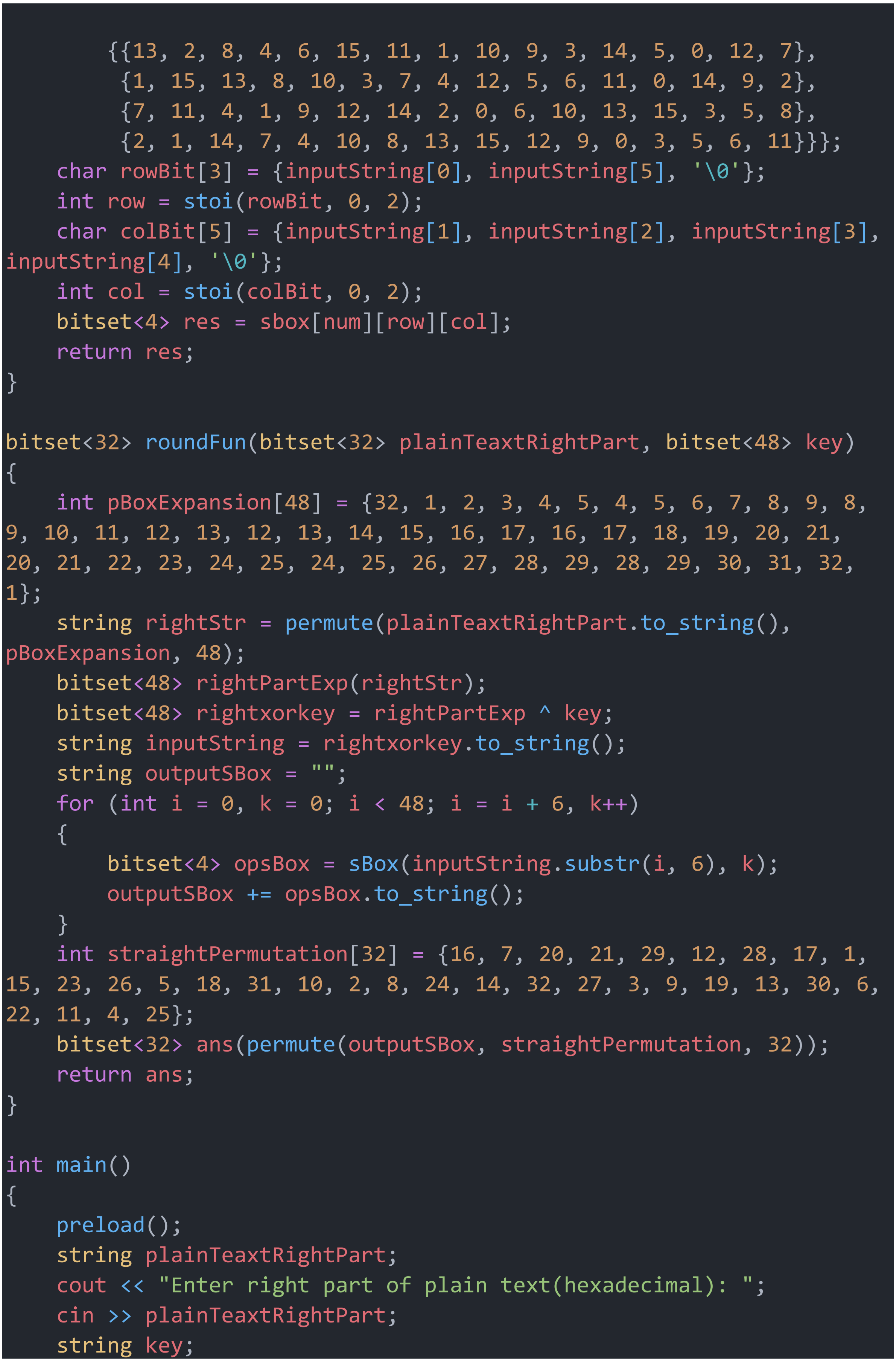
```
#include <bits/stdc++.h>
using namespace std;

unordered_map<string, string> hexOf;
unordered_map<char, string> binOf;

void preload() {
    // load for hex to bin
    binOf['0'] = "0000";
    binOf['1'] = "0001";
    binOf['2'] = "0010";
    binOf['3'] = "0011";
    binOf['4'] = "0100";
    binOf['5'] = "0101";
    binOf['6'] = "0110";
    binOf['7'] = "0111";
    binOf['8'] = "1000";
    binOf['9'] = "1001";
    binOf['A'] = "1010";
    binOf['B'] = "1011";
    binOf['C'] = "1100";
    binOf['D'] = "1101";
    binOf['E'] = "1110";
    binOf['F'] = "1111";
```



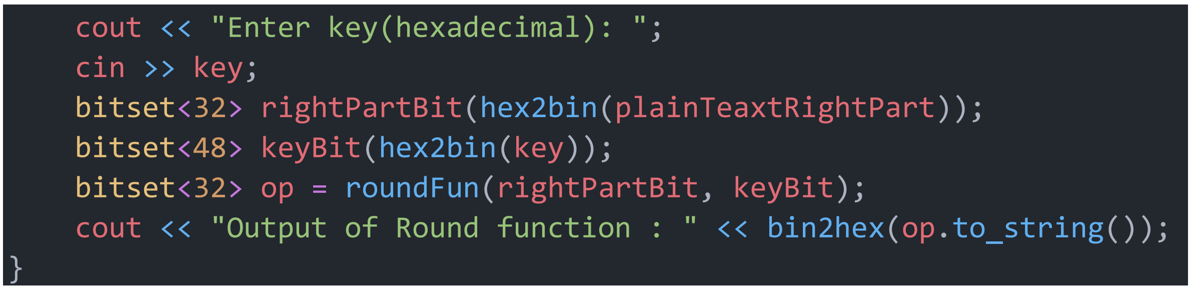
```
    //load for bin to hex
    hexOf["0000"] = "0";
    hexOf["0001"] = "1";
    hexOf["0010"] = "2";
    hexOf["0011"] = "3";
    hexOf["0100"] = "4";
    hexOf["0101"] = "5";
    hexOf["0110"] = "6";
    hexOf["0111"] = "7";
    hexOf["1000"] = "8";
    hexOf["1001"] = "9";
    hexOf["1010"] = "A";
    hexOf["1011"] = "B";
    hexOf["1100"] = "C";
    hexOf["1101"] = "D";
    hexOf["1110"] = "E";
    hexOf["1111"] = "F";

}

string hex2bin(string s)
{
    // hexadecimal to binary conversion
    string bin = "";
    for (int i = 0; i < s.size(); i++)
        bin += binOf[s[i]];
    return bin;
}

string bin2hex(string s)
{
    // binary to hexadecimal conversion
    string hex = "";
    for (int i = 0; i < s.length(); i += 4)
    {
        string ch = "";
        ch += s[i];
        ch += s[i + 1];
        ch += s[i + 2];
        ch += s[i + 3];
        hex += hexOf[ch];
    }
    return hex;
}
```



```
string permute(string key, int *arr, int n)
{
    string ans;
    for (int i = 0; i < n; i++)
        ans += key[arr[i] - 1];
    return ans;
}

bitset<4> sBox(string inputString, int num)
{
    int sbox[8][4][16] = {
        {{14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7},
         {0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8},
         {4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0},
         {15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13}},

        {{15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10},
         {3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5},
         {0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15},
         {13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9}},

        {{10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8},
         {13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1},
         {13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7},
         {1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12}},

        {{7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15},
         {13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9},
         {10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4},
         {3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14}},

        {{2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9},
         {14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6},
         {4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14},
         {11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3}},

        {{12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11},
         {10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8},
         {9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6},
         {4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13}},

        {{4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1},
         {13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6},
         {1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2},
         {6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12}},
```

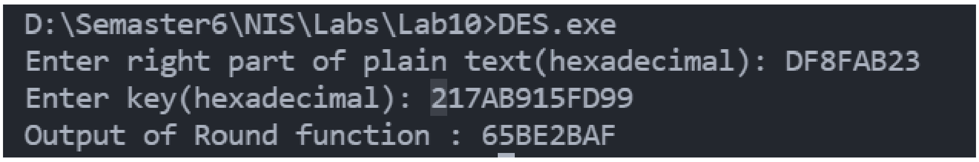


```
        {{13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7},
         {1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2},
         {7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8},
         {2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11}}};
    char rowBit[3] = {inputString[0], inputString[5], '\0'};
    int row = stoi(rowBit, 0, 2);
    char colBit[5] = {inputString[1], inputString[2], inputString[3],
inputString[4], '\0'};
    int col = stoi(colBit, 0, 2);
    bitset<4> res = sbox[num][row][col];
    return res;
}

bitset<32> roundFun(bitset<32> plainTeaxtRightPart, bitset<48> key)
{
    int pBoxExpansion[48] = {32, 1, 2, 3, 4, 5, 4, 5, 6, 7, 8, 9, 8,
9, 10, 11, 12, 13, 12, 13, 14, 15, 16, 17, 16, 17, 18, 19, 20, 21,
20, 21, 22, 23, 24, 25, 24, 25, 26, 27, 28, 29, 28, 29, 30, 31, 32,
1};
    string rightStr = permute(plainTeaxtRightPart.to_string(),
pBoxExpansion, 48);
    bitset<48> rightPartExp(rightStr);
    bitset<48> rightxorkey = rightPartExp ^ key;
    string inputString = rightxorkey.to_string();
    string outputSBox = "";
    for (int i = 0, k = 0; i < 48; i = i + 6, k++)
    {
        bitset<4> opsBox = sBox(inputString.substr(i, 6), k);
        outputSBox += opsBox.to_string();
    }
    int straightPermutation[32] = {16, 7, 20, 21, 29, 12, 28, 17, 1,
15, 23, 26, 5, 18, 31, 10, 2, 8, 24, 14, 32, 27, 3, 9, 19, 13, 30, 6,
22, 11, 4, 25};
    bitset<32> ans(permute(outputSBox, straightPermutation, 32));
    return ans;
}

int main()
{
    preload();
    string plainTeaxtRightPart;
    cout << "Enter right part of plain text(hexadecimal): ";
    cin >> plainTeaxtRightPart;
    string key;
```



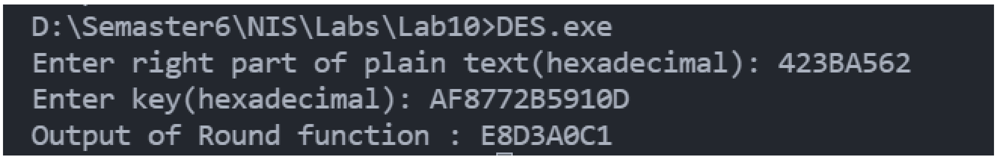
```
    cout << "Enter key(hexadecimal): ";
    cin >> key;
    bitset<32> rightPartBit(hex2bin(plainTeaxtRightPart));
    bitset<48> keyBit(hex2bin(key));
    bitset<32> op = roundFun(rightPartBit, keyBit);
    cout << "Output of Round function : " << bin2hex(op.to_string());
}
```

- **Test Case – 1:**



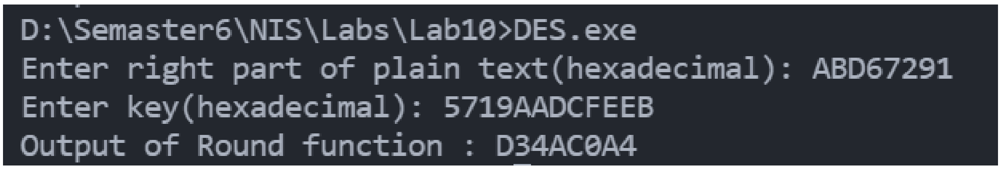
```
D:\Semaster6\NIS\Labs\Lab10>DES.exe
Enter right part of plain text(hexadecimal): DF8FAB23
Enter key(hexadecimal): 217AB915FD99
Output of Round function : 65BE2BAF
```

- **Test Case – 2:**



```
D:\Semaster6\NIS\Labs\Lab10>DES.exe
Enter right part of plain text(hexadecimal): 423BA562
Enter key(hexadecimal): AF8772B5910D
Output of Round function : E8D3A0C1
```

- **Test Case – 3:**



```
D:\Semaster6\NIS\Labs\Lab10>DES.exe
Enter right part of plain text(hexadecimal): ABD67291
Enter key(hexadecimal): 5719AADCFEEB
Output of Round function : D34AC0A4
```