Exercise 7. Answer Sheet

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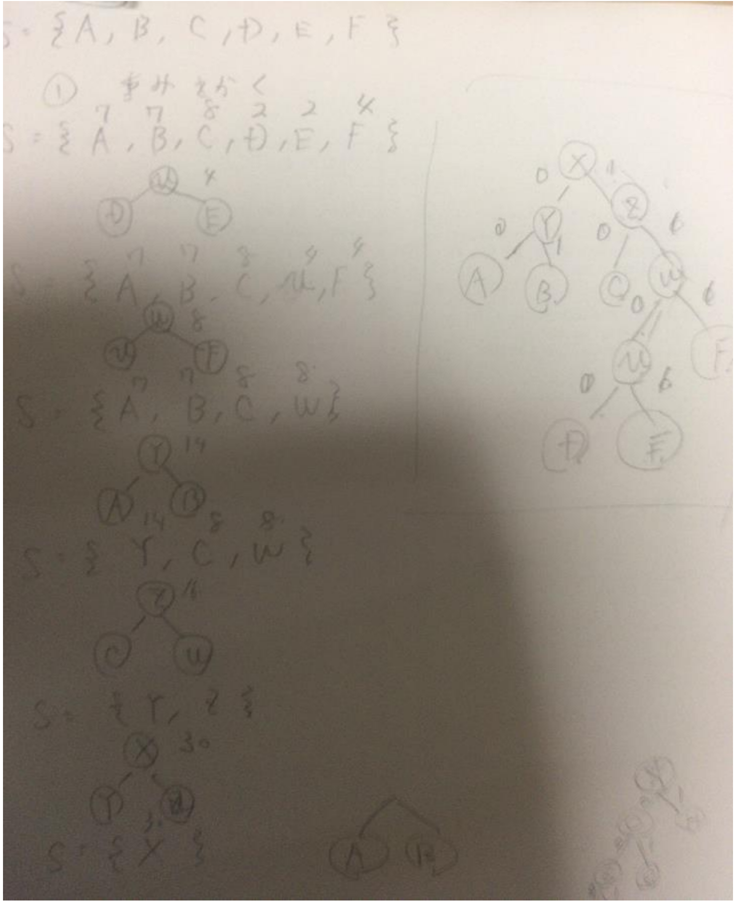
Problem 1. (20 point) Consider following sequence of letters:

ABBCACCEACBCCFABCDAFEABFFADBBC

a) (10 points) Construct Huffman encoding tree for the above sequence and show it below

Put your answer here



b) (10 points) What is the code for each letter:

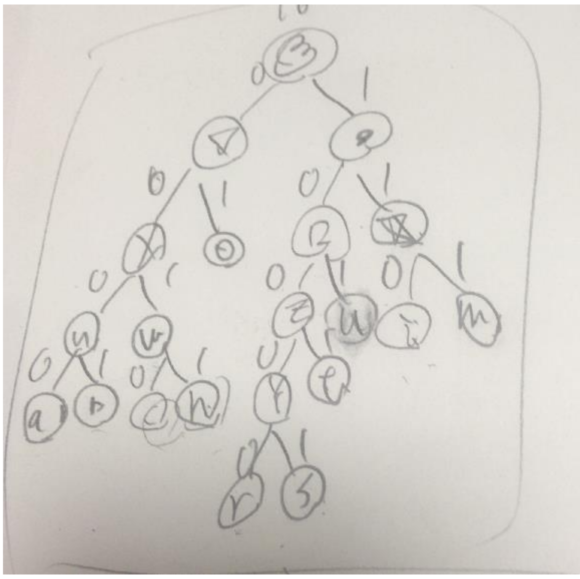
A: 00
B: 01
C: 10
D: 1100
E: 1101
F: 111

Problem 2. (25 points) What is the Huffman code for the following set of frequencies, based on the first 8 Fibonacci numbers?

A: 1,   B: 1,   C: 2,   D: 3,   E: 5,   F: 8,   G: 13,   H: 21

A: 0000000
B: 0000001
C: 000001
D: 00001
E: 0001
F: 001
G: 01
H: 1

Problem 3. (15 points) Write your name in English letters and construct Huffman tree and code for it. Show your tree and code below.
tomonori masubuci
a: 1
b: 1
c: 1
n: 1
r: 1
s: 1
t: 1
i: 2
m: 2
u: 2
o: 3



a: 0000 b: 0001 c: 0010 n: 0011 r: 10000 s: 10001 t: 1001 u: 101 i: 110 m: 111

Problem 4. (40 points) Make a program implementing Huffman encoding. Upload your code with usage example.

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

```
#define MAXTREE 100

struct MinHeapNode
{
  char data;
  unsigned freq;
  struct MinHeapNode *left, *right;
};

struct MinHeap
{
  unsigned size;
  unsigned capacity;
  struct MinHeapNode** array;
};

struct MinHeapNode* newNode(char data, unsigned freq){
  struct MinHeapNode* temp= (struct MinHeapNode*)malloc
    (sizeof(struct MinHeapNode));
  temp->left = temp->right = NULL;
  temp->data = data;
  temp->freq = freq;
  return temp;
}

struct MinHeap* createMinHeap(unsigned capacity){
  struct MinHeap* minHeap= (struct MinHeap*)malloc(sizeof(struct MinHeap));
  minHeap->size = 0;
  minHeap->capacity = capacity;
  minHeap->array= (struct MinHeapNode**)malloc(minHeap->
                                              capacity * sizeof(struct MinHeapNode*));
  return minHeap;
}

void swapMinHeapNode(struct MinHeapNode** a, struct MinHeapNode** b);

void minHeapify(struct MinHeap* minHeap, int idx);

int isSizeOne(struct MinHeap* minHeap);

struct MinHeapNode* extractMin(struct MinHeap* minHeap)
{
  struct MinHeapNode* temp = minHeap->array[0];
  minHeap->array[0] = minHeap->array[minHeap->size - 1];
  --minHeap->size;
  minHeapify(minHeap, 0);
  return temp;
}

void insertMinHeap(struct MinHeap* minHeap,struct MinHeapNode* minHeapNode);

void buildMinHeap(struct MinHeap* minHeap);

void print_arr(int arr[], int n);
```

```
int isLeaf(struct MinHeapNode* root);

void cprint(struct MinHeapNode* root, int arr[], int top);

void doHuffman(char data[], int freq[], int size);

struct MinHeap* createAndBuildMinHeap(char data[], int freq[], int size){

  struct MinHeap* minHeap = createMinHeap(size);
  for (int i = 0; i < size; ++i)
    minHeap->array[i] = newNode(data[i], freq[i]);
  minHeap->size = size;
  buildMinHeap(minHeap);
  return minHeap;
}

struct MinHeapNode* buildHuffmanTree(char data[], int freq[], int size){
  struct MinHeapNode *left, *right, *top;
  struct MinHeap* minHeap = createAndBuildMinHeap(data, freq, size);

  while (!isSizeOne(minHeap)) {
    left = extractMin(minHeap);
    right = extractMin(minHeap);
    top = newNode('$', left->freq + right->freq);
    top->left = left;
    top->right = right;
    insertMinHeap(minHeap, top);
  }
  return extractMin(minHeap);
}

void cprint(struct MinHeapNode* root, int arr[], int top);

void doHuffman(char data[], int freq[], int size);

int main(){
  char arr[] = { 'A', 'B', 'C', 'D','E','F','G','H'};
  int freq[] = { 1, 1, 2, 3, 5, 8, 13, 21};
  int size = sizeof(arr) / sizeof(arr[0]);

  doHuffman(arr, freq, size);
  return 0;
}

void swapMinHeapNode(struct MinHeapNode** a, struct MinHeapNode** b)
{
  struct MinHeapNode* t = *a;
  *a = *b;
  *b = t;
}

void minHeapify(struct MinHeap* minHeap, int idx)
{
  int smallest = idx;
  int left = 2 * idx + 1;
  int right = 2 * idx + 2;

  if (left < minHeap->size && minHeap->array[left]->freq < minHeap->array[smallest]->freq)
    smallest = left;

  if (right < minHeap->size && minHeap->array[right]->freq < minHeap->array[smallest]->freq)  smallest
= right;
  if (smallest != idx) {
    swapMinHeapNode(&minHeap->array[smallest],&minHeap->array[idx]);
    minHeapify(minHeap, smallest);
  }
}

int isSizeOne(struct MinHeap* minHeap)
{
  return (minHeap->size == 1);
}


void doHuffman(char data[], int freq[], int size){
  struct MinHeapNode* root = buildHuffmanTree(data, freq, size);
  int arr[MAXTREE], top = 0;

  cprint(root, arr, top);
}

void insertMinHeap(struct MinHeap* minHeap,struct MinHeapNode* minHeapNode)
{
  ++minHeap->size;
  int i = minHeap->size - 1;

  while (i && minHeapNode->freq < minHeap->array[(i - 1) / 2]->freq){
    minHeap->array[i] = minHeap->array[(i - 1) / 2];
    i = (i - 1) / 2;
  }
  minHeap->array[i] = minHeapNode;
}

void buildMinHeap(struct MinHeap* minHeap)
{
  int i;
  int n = minHeap->size - 1;

  for (i = (n - 1) / 2;i >= 0; --i)
    minHeapify(minHeap, i);
}

void print_arr(int arr[], int n){
  int i;

  for (i = 0;i < n;++ i)
    printf("%d", arr[i]);
  printf("\n");
}

int isLeaf(struct MinHeapNode* root){
  return !(root->left) && !(root->right);
}

void cprint(struct MinHeapNode* root, int arr[], int top){

  if (root->left)
    {
      arr[top] = 0;
      cprint(root->left, arr, top + 1);
    }

  if (root->right)
    {
      arr[top] = 1;
      cprint(root->right, arr, top + 1);
    }

  if (isLeaf(root))
    {
      printf("%c: ", root->data);
      print_arr(arr, top);
    }
}
```

```
H: 0
G: 10
F: 110
E: 1110
D: 11110
C: 111110
A: 1111110
B: 1111111
```