TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

VICTORIA
UNIVERSITY OF WELLINGTON

EXAMINATIONS — 2008

FINAL EXAM

SWEN 201/COMP 206

PROGRAM AND DATA STRUCTURES

Time Allowed: 3 hours

Instructions:

- Attempt all questions.
- Write your student ID number at the top of each sheet.
- There are 180 possible marks on the exam.
- Make sure your answers are clear and to the point.
- Non-programmable calculators without full alphabetic keys are permitted.
- Non-electronic foreign language dictionaries are permitted.
- Refer to the Appendix.
- No other reference material is allowed.
- Answer in the appropriate heavily outlined boxes or follow the instructions given in the questions.

Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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Question 1. C Basics [14 marks]

(a) [2 marks] In the box below state the output of the following program.

The program uses `strcpy`, a function defined in `string.h`.

`strcpy(dst, src)` copies the string `src` to `dst` (including the terminating `'\0'` character).

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

#define SIZE 6

int main() {
  int i;
  char m[SIZE];

  strcpy(m,"ABC12");

  for(i=0 ; i<SIZE-1; i++) {
    printf("%d=%c\n", i, m[i]+2);
  }
  return 0;
}
```

0=C 1=D 2=E 3=3 4=4

(Question 1 continued on next page)

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(Question 1 continued)

(b) [12 marks] The C program below is supposed to read two integers from the terminal and print the list of integers from the lower to the higher.

```
#include <stdio.h>

int swap(int* x, int *y);

int main() {
  int i, x, y;

  printf("Value A?");
  scanf("%s", x);
  printf("Value B?");
  scanf("%s", y);

  if(x>y)swap(x, y);

  for(i=x, i<y, i++){
  printf("%d ", i)
  }
  printf("\n", i);

}

/* swaps the values of the two arguments */
int swap(int* x, int *y){
        int tmp;
        tmp=*y;
        *x=*y;
        *y=tmp;
}
```

It should behave like this:

```
%./a.out
Value A? 4
Value B? 9
4 5 6 7 8 9
%./a.out
Value A? 8
Value B? 5
5 6 7 8
```

(Question 1 continued on next page)

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(Question 1 continued)

Unfortunately this code contains several errors. In the box below identify the errors and provide corrections:

```
scanf("%d", &x);

scanf("%d", &y);

swap(&x, &y);

for(i=x, i<=y, i++)

tmp=*x;
```

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Question 2. Dynamic Data Structures [22 marks]

You have been employed as a C programmer on a corpus linguistics research project. Corpus linguists investigate language by studying the properties of a large body (a corpus) of text, almost always using a computer.

One statistic in which you are interested is how frequently each word in a text occurs. You decide to write a C program which will read words from a text file and will record how frequently each word occurs. You decide to use a binary search tree to record the data, where each node records a word and its frequency. You need functions to:

- print out a tree (showing the words in alphabetical order),
- insert a single word into a tree,
- read a file and insert all the words it contains into a tree, and
- open a file.

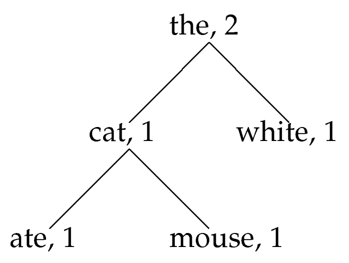
The method to insert a word to the tree can be described as follows:

- if the current node is `NULL` then add a new node containg the word with frequency 1;
- if the word is the same as the one at the current node, increment the frequency;
- if the word is less than the one at the current node, insert the data in the left subtree;
- if the word is more than the one at the current node, insert the data in the right subtree;

If the input file contains:

```
the cat ate the white mouse
```

then the following tree will be created:



(Question 2 continued on next page)

(Question 2 continued)

The header file for your program looks like this:

```
#define WORDSIZE 20
#define node_size sizeof(node)

struct treeitem {
       char word[WORDSIZE];
       int freq;
       struct treeitem* left;
       struct treeitem* right;
};

typedef struct treeitem node;

node* insert(node* tree, char* w);

void printtree(node* tree);

node* read_from_file(FILE* fp, node* tree);

FILE* openfile(FILE* fp, char* fname);
```

The `main` function looks like this:

```
int main(int argc, char* argv[])
{
   FILE *fp1;
   node* the_tree;

   fp1 = openfile(fp1, argv[1]);       /* Open the file. */

   the_tree=read_from_file(fp1, NULL); /* Build the tree. */

   printf("%s %s\n", "Frequency", "word");

   printtree(the_tree);                /* Print the tree. */

   return fclose(fp1);
}
```

(Question 2 continued on next page)

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(Question 2 continued)

(a) [8 marks] In the box below implement the `printtree` function, which will print the words out in alphabetical order. Given the tree above, this function will produce:

```
1 ate
1 cat
1 mouse
2 the
1 white
```

```
void printtree(node* tree){
   if(tree) {
      printtree(tree->left);
      printf("%9d %s\n", tree->freq, tree->word);
      printtree(tree->right);
   }
}
```

(Question 2 continued on next page)

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(Question 2 continued)

(b) [14 marks] In the box below, write a function `node* insert(node* tree, char* w)` which will add data about an occurence of a word to a tree, returning the updated tree. You may want to use `strcmp` and `strcpy`.

`strcmp` is a function defined in `string.h`. A call to `strcmp(s1, s2)` returns an integer greater than, equal to, or less than 0, according to whether the string `s1` is greater than, equal to, or less than the string `s2`.

`strcpy` is a function defined in `string.h`. A call to `strcpy(dst, src)` copies the string `src` to `dst` (including the terminating `'\0'` character).

```
node* insert(node* tree, char* w){
      int cond;

      if (!tree){
      if (!(tree = (node*)malloc(node_size))){
          printf("Cannot allocate memory. Last word was %s\n", w);
          exit(1);}
      strcpy(tree->word, w);
      tree->freq=1;
      tree->left=tree->right=NULL;

      }  else if ((cond = strcmp(w, tree->word)) == 0)
              tree->freq++;
         else if (cond < 0)
              tree->left=insert(tree->left, w);
         else
              tree->right=insert(tree->right, w);

      return tree;
}
```

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Question 3. C and C++ [18 marks]

(a) [6 marks] In the box below state the syntax of C's `struct` and `union` constructs and describe a situation when a `struct` would be used and a situation when a `union` would be used.

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(Question 3 continued)

(b) [6 marks] In the box below explain the two parameter passing mechanisms provided by C++.

(Question 3 continued on next page)

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(Question 3 continued)

(c) [3 marks] C provides `malloc` and `free` for memory management. Explain what these functions do.

(d) [3 marks] C++ provides additional constructs for memory management. State what these are and what advantages they have over the constructs offered by C.

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Question 4. C++ programming [30 marks]

You have been hired as a C++ programmer by a company which operates multi-storey car parks. They are not making as much profit as they would like, and they want to run some simulations to help them understand their business better.

You are just beginning to design the simulation, so you adopt a very simple model of a parking building. The information you need to record for a parking building are:

- its capacity;
- the number of cars it contains (never greater than its capacity);
- the income which the building has earned (it costs $1.00 to park a car in a building).

No vehicle can enter a building which is full, and, of course, no vehicles can leave an empty building.

You decide to use a C++ class, `Parking`, to represent a parking building. You realise that you can model the arrival a car at the building using the `++` operator and the exit of a car using the `--` operator.

You also decide to implement `>>` and `<<` operators for parking buildings. The `>>` operator will prompt the user for a capacity for the parking building, the `<<` operator will report the current state of the building.

For example, given the following `main` function:

```
int main(){
  int i;
  Parking p1;

  cin >> p1;  /* Get a capacity for p1 */

  Parking p2 = p1;  /* p2 is just like p1 */

  for(i=0; i<200; i++){p1++;} /* 200 attempted arrivals at p1 */
  for(i=0; i<100; i++){p2++;} /* 100 attempted arrivals at p2 */

  cout << "Building p1 -- " << p1 << endl;
  cout << "Building p2 -- " << p2 << endl;

  for(i=0; i<100; i++){p1--;}  /* 100 attempted exits from p1 */
  for(i=0; i<200; i++){p2--;}  /* 200 attempted exits from p2 */

  cout << "Building p1 -- " << p1 << endl;
  cout << "Building p2 -- " << p2 << endl;
}
```

(Question 4 continued on next page)

(Question 4 continued)

you should get the following behaviour:

```
Capacity? 150
Building p1 -- Current = 150 Capacity = 150 Income = $150
Building p2 -- Current = 100 Capacity = 150 Income = $100
Building p1 -- Current = 50 Capacity = 150 Income = $150
Building p2 -- Current = 0 Capacity = 150 Income = $100
```

(a) [5 marks] In the box below define a suitable C++ class `Parking`:

```
class Parking {
    friend ostream& operator<< (ostream&, const Parking&);
    friend istream& operator>> (istream&, Parking&);
    public:
      Parking(int c=0): capacity(c), current(0), income(0.00) {};
      Parking& operator= (const Parking&);
      Parking operator++(int);
      Parking operator--(int);
    private:
      int current;
      int capacity;
      double income;
};
```

(Question 4 continued on next page)

(Question 4 continued)

(b) [5 marks] In the box give C++ code (including comments) for the assignment operator for `Parking`:

```
Parking& Parking::operator= (const Parking& p){
    capacity = p.capacity;
    current = p.current;
    income = p.income;
    return *this;
};
```

(c) [5 marks] In the box give C++ code (including comments) for the post-increment operator for `Parking`:

```
Parking Parking::operator++(int){
  Parking temp = *this;
  if(current<capacity){
          current++;
          income+=1.00;}
  return temp;
}
```

(Question 4 continued on next page)

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(Question 4 continued)

(d) [5 marks] In the box give C++ code (including comments) for the post-decrement operator for `Parking`:

```
Parking Parking::operator--(int){
  Parking temp = *this;
  if(current>0) current--;
  return temp;
}
```

(e) [5 marks] In the box give C++ code (including comments) for the `<<` operator for `Parking`:

```
ostream& operator<<(ostream& ostr, const Parking& p){
    return ostr << "Current = " << p.current
                << " Capacity = " << p.capacity
                << " Income = $" <<  p.income;
}
```

(Question 4 continued on next page)

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(Question 4 continued)

(f) [5 marks] In the box give C++ code (including comments) for the `>>` operator for `Parking`:

```
istream& operator>> (istream& istr, Parking& p){
    cout << "Capacity? ";
    istr >> p.capacity;
    return istr;
}
```

Question 5. [18 marks]

C++ provides support for *polymorphism* in several ways. In the box below:

- state what forms of polymorphism C++ supports,
- explain how they are supported, and
- explain what advantages polymorphism gives to the programmer.

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