CSE 374 Final Exam 6/10/10

Name ________________________________

Do **not** write your id number or any other confidential information on this page.

There are 10 questions worth a total of 100 points. Please budget your time so you get to all of the questions. Keep your answers brief and to the point.

You may have a sheet of hand-written notes plus the notes from the midterm if you brought them. Other than that, the exam is closed book, closed notes, closed laptops, closed twitter, closed telepathy, etc.

Please wait to turn the page until everyone is told to begin.

Score ___________________ / 100

1. _______ / 8

2. _______ / 6

3. _______ / 6

4. _______ / 8

5. _______ / 12

6. _______ / 15

7. _______ / 12

8. _______ / 13

9. _______ / 12

10. _______ / 8

Question 1. (8 points) (testing) Suppose we are testing a list data structure implementation similar to a Java `ArrayList`. The list uses a fixed-size *array* as the underlying data structure to store the list elements. The available operations include `initialize()`, to create an empty list; `add(x)`, which adds `x` to the end of the list; `get(index)`, which returns the item at a given position; `set(index, x)`, which replaces the item at a given position; `size()`, which returns the number of items currently in the list; `capacity()`, which returns the maximum size the list can hold; `contains(x)`, which reports whether `x` appears in the list; and `remove(index)`, which removes the item at the given position.

(a) Describe three different **black-box** tests that you could use to test this data structure. The tests must check different things – you can't just describe the same test three times with different data.

(i)

(ii)

(iii)

(b) Describe three different **white-box** tests you could use to test this data structure. As before, the different tests must check different things.

(i)

(ii)

(iii)

Question 2. (6 points) (test coverage) Two of the ways we can measure the thoroughness of a set of tests are *statement coverage* and *path coverage*. How do these differ?

Question 3. (6 points) (debugging) You are trying to fix a C program that contains a single function `main`. During execution the program gets stuck in an infinite loop somewhere. From looking at the source code we can see that it contains 4 simple loops.

Describe how you would use a debugger like `gdb` to figure out where in the program the problem lies. You may not modify the source code (i.e., you can't insert print statements or anything like that – you have to work with the source code as it exists).

Question 4. (8 points) (a little preprocessor mischief) Suppose we have the following three C header and source files:

File `x.h`:

```
#ifndef X_H
#define X_H

#include "other.h"
#define XYZZY 42

#endif
```

File `other.h`:

```
#ifndef OTHER_H
#define OTHER_H

#define XYZZY 17

#endif
```

File `test.c`:

```
#include <stdio.h>
#include "x.h"
#include "other.h"

#define F(a,b) a*b

int main() {
   int a, b, c, d;
   a = 2;
   b = 3;
   c = 5;
   d = F(a+b,c);
   printf("xyzzy is %d\n", XYZZY);
   printf("d is %d\n", d);
   return 0;
}
```

What output is produced when we compile and execute `test.c`? (Assume that all three files are in the same directory. This program compiles and executes successfully.)

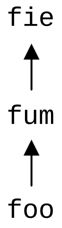
Question 5. (12 points) (strings and memory) The following program is supposed to read lines from `stdin`, store them in an array, then print the stored strings and delete them. It only needs to work as long as the input lines are under 500 characters. But even if the input lines are not too long, it produces the wrong output and tends to crash.

Without altering the basic organization of program and the specification of the functions in it, identify the problems and fix them. Write your corrections on the code below

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

#define MAX_LINES 100
#define MAX_LINE_LENGTH 500

char **text_lines;  /* input stored in text_lines[0..nlines-1] */
int    nlines;

/* initialize data structure */
void init_lines() {
   text_lines = (char**)malloc(MAX_LINES*sizeof(char*));
   nlines = 0;
}

/* store line in next entry in text_lines if room, else ignore */
void store_line(char * line) {
   if (nlines >= MAX_LINES) return;
   text_lines[nlines] = line;
   nlines++;
}

/* delete data structure */
void delete_lines() {
   int k;
   free(text_lines);
   for (k = 0; k < MAX_LINES; k++) {
      free(text_lines[k]);
   }
}

/* read stdin and store lines, print them, then delete */
int main() {
   char input_line[MAX_LINE_LENGTH];
   int k;

   init_lines();
   while (fgets(input_line, MAX_LINE_LENGTH, stdin)) {
      store_line(input_line);
   }
   for (k = 0; k < nlines; k++) {
      printf("%s", text_lines[k]);
   }
   delete_lines();
   return 0;
}
```

Question 6. (15 points) (make and svn) Suppose we have the following Makefile in the current directory.

```
prattle.o:  prattle.h  prattle.c

     gcc -Wall -g -c prattle.c

complain.o: complain.h  complain.c  prattle.h

     gcc -Wall -g -c complain.c

annoy: annoy.o  prattle.o  complain.o

     gcc –Wall –g –o annoy annoy.o  prattle.o  complain.o

annoy.o:  annoy.c  prattle.h  complain.h

     gcc -Wall -g -c annoy.c
```



(a) In the space below, draw a dependency graph (diagram) showing the dependencies between the files as specified by the above Makefile. Your drawing should have an arrow from each file to the files that it depends on, as in the diagram to the left, where foo depends on fum, which depends in turn on fie.

(continued next page)

Question 6. (cont.) (b) If we just type "make" in the directory containing this Makefile, what happens? Assume that all of the source files (.c and .h) are present in the directory along with the Makefile, but that none of the other files (.o, etc.) named in the Makefile are present when we run make.

Now suppose we've been working on this program and want to add a new source file irritate.c along with an associated header file irritate.h. File irritate.c only includes the irritate.h header; it does not use any of the others. Files annoy.c and prattle.c have been modified to use the new functions defined in these new files, with the appropriate #includes and calls to the new functions.

(c) On the previous page, write in the modifications needed to the Makefile so these new files are included in the program and are correctly compiled (and recompiled) as needed when the program is built.

(d) Once the new irritate.h and irritate.c files have been tested and the Makefile updated in our working copy of the program, we need to be sure to update the svn repository. Write the necessary svn commands below to update the repository to reflect these additions and changes.

Question 7. (12 points) (memory management) One of the things that can go wrong with the memory manager is if the length (size) field in a block on the free list has a wrong value and is so big that the address of a free block plus its size gives an address that is is greater than the address of the next block on the free list. For this problem, complete the following function so that it returns 1 (true) if a free list block overlaps its successor and 0 (false) if overlap is not detected. You should assume that the following `struct` defines the layout of header part of each free list node.

```
struct free_node {
   int size;              /* number of bytes in this node, */
                          /*   including this header       */
   struct free_node *next; /* next node on the free list,   */
                          /*   or NULL if no more nodes.   */
};
```

Complete the following function to check for overlapping free-list blocks.

```
/* Return 1 (true) if a node on free_list overlaps its     */
/* successor (block address+size > successor address).     */
/* Return 0 if no overlap is detected.                     */
/* pre: assume freelist blocks have increasing addresses.  */

int overlap_found(struct free_node * free_list) {










}
```

Question 8. (13 points) (another trieing problem) Once the dictionary has been read by the text messaging program, all of the words and their synonyms are stored in the trie. For this problem, write a function that returns the length of the longest word (or words) in the trie – i.e., the longest string of digits that makes up a word. This is basically the height of the trie, except that links in the trie for synonyms ('#' links) should be ignored.

Assume that a trie node is defined as follows:

```
struct tnode {              // one node in the trie:
   char * word;             //  C-string if this node has a
                            //  word attached, otherwise NULL
   struct tnode *next[10];  //  Subtrees.  next[2] to next[9]
                            //  are subtrees for digits 2-9;
                            //  next[0] is the synonym ('#')
};                          //  link; next[i]==NULL if no child
```

(Note that you may not need to use all of the information attached to a node.)

Complete the following C function so it returns the length of the longest word (sequence of digits) in the trie with root r.

```
/* Return the length of the longest word in the trie r. */
int max_length(struct tnode * r) {










}
```

Question 9. (12 points) The ~~dreaded~~ ~~traditional~~ annoying C++ “what does this print” question. What output is produced when this program is executed? It does compile and execute with no warnings or errors using g++.

```
#include <iostream>
using namespace std;

class One {
 public:
   virtual void p() { q(); cout << "One::p" << endl; }
           void q() { r(); cout << "One::q" << endl; }
           void r() {      cout << "One::r" << endl; }
};

class Two: public One {
 public:
           void p() { q(); cout << "Two::p" << endl; }
           void r() {      cout << "Two::r" << endl; }
};

int main() {
   Two * creature = new Two();
   creature->q();
   cout << "----" << endl;
   creature->r();
   cout << "----" << endl;

   One * thing = creature;
   thing->p();
   cout << "----" << endl;
   thing->r();

   return 0;
}
```

Output:

Question 10. (8 points) (concurrency) (a) Why would anyone want to write a multi-threaded program?

(b) Give an example of a problem that can occur in a multi-threaded program that cannot occur in a program with a single thread.