University of Washington – Computer Science & Engineering

Winter 2020 Instructor: Justin Hsia 2020-02-14

CSE333 MIDTERM

Last Name:		
First Name:		
Student ID Number:		
Name of person to your Left | Right		
All work is my own. I had no prior knowledge of the exam contents nor will I share the contents with others in CSE333 who haven't taken it yet. Violation of these terms could result in a failing grade. **(please sign)**		

Do not turn the page until 5:00.

Instructions

- This exam contains 10 pages, including this cover page. Show scratch work for partial credit, but put your final answers in the boxes and blanks provided.
- The last page is a reference sheet. Please detach it from the rest of the exam.
- The exam is closed book (no laptops, tablets, wearable devices, or calculators). You are allowed one page (US letter, double-sided) of *handwritten* notes.
- Please silence and put away all cell phones and other mobile or noise-making devices. Remove all hats, headphones, and watches.
- You have 70 minutes to complete this exam.

Advice

- Read questions carefully before starting. Skip questions that are taking a long time.
- Read *all* questions first and start where you feel the most confident.
- Relax. You are here to learn.

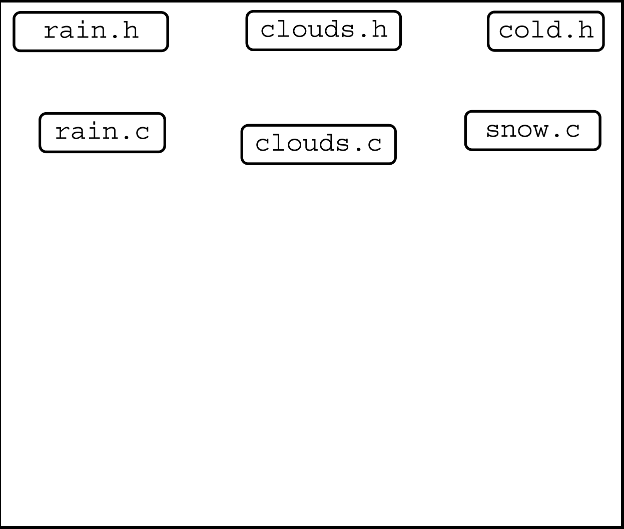
Question	1	2	3	4	5	Total
Possible Points	19	10	24	32	19	**104**

Question 1: You MAKE Me Whole [19 pts]

Let `CFLAGS = -Wall -g -std=c11`. The symbol "`$^`" means all sources.

(A) Complete the corresponding directed acyclic graph for the `Makefile`. [5 pt]

```
winter: rain.o snow.o clouds.o
   gcc $(CFLAGS) $^

snow: snow.o
   gcc $(CFLAGS) -o snow $^

rain.o: rain.c rain.h clouds.h
   gcc $(CFLAGS) -c rain.c

clouds.o: clouds.c clouds.h
   gcc $(CFLAGS) -c clouds.c

snow.o: snow.c clouds.h rain.h cold.h
   gcc $(CFLAGS) -c snow.c

clean:
   rm -f rain.o clouds.o winter snow
```



(B) Starting with only the source files (`.c` and `.h`) and `Makefile`, what should happen to the following files if we run "`make`" followed by "`make clean`"? Use "**C**" for created, "**CD**" for created and then deleted, and "**U**" for untouched (*i.e.* unchanged or not created). [4 pt]

`rain.o` _____ `clouds.o` _____ `snow.o` _____ `winter` _____

(C) Do we need a phony `all` target in `Makefile`? *Briefly* justify your response. [2 pt]

Yes / No

(D) [1] We run "`make`". [2] We modify `rain.h`. [3] What should happen to the following files when we run "`make`" again? Use "**M**" for modified and "**U**" for untouched. [4 pt]

`rain.c` _____ `clouds.o` _____ `snow.o` _____ `snow` _____

(E) Assuming that the two executables do different things, it turns out that there is something inherently wrong with our project setup that will cause 1 of 2 possible compilation errors. Identify the compilation errors and which target will cause them. Hint: what does *every* C executable need? [4 pt]

Possible error:	Target:
Possible error:	Target:

SID: ______________

Question 2: PREPROCESS This! [10 pts]

Suppose we have the following files:

`twoface.h`:

```
#ifdef  DSWITCH
#define FACE(f) NULL
#else
#define FACE(f) (f * -2)
typedef int my_type;
#endif
```

`twoface.c`:

```
#include <stdio.h>
#define f 2.0
#include "twoface.h"
int main(int argc, char** argv) {
  printf("%ld\n", (long) FACE(f) );
  return 0;  // EXIT_SUCCESS
}
```

(A) The header file is missing a header guard! Following the style guide for this class, what name should we use for the guard macro? [2 pt]

(B) Complete the result of `cpp -P -DSWITCH twoface.c` below. Ignore the output of the `#include <stdio.h>` directive. [5 pt]

```
int main(int argc, char **argv) {


}
```

(C) (Circle one) What will be happen when we try to compile `gcc -DSWITCH twoface.c` and run `a.out`? [3 pt]

compiler error	output -4	output 0	output 4

Question 3: ORDER Up [24 pts]

We're writing C software for restaurants to track orders using the following typedef-ed struct:

```
#define NUM_MENU_ITEMS 3

typedef struct order_st {
  int table;                     // table number
  char* server;                  // name of server
  int orders[NUM_MENU_ITEMS];    // # of each menu item ordered
  struct order_st* next;         // next order in linked list
} Order;
```

```
// order of 3 of menu item #0 for table 333, served by Justin
Order example = {333, "Justin", {3, 0, 0}, NULL};
```

We use `Order* head` to track *all* orders and `Order* curr` to track the current order. Assume both are defined in `main`. Because we cannot predict how many orders we will get, `Orders` must be allocated individually on the heap.

(A) Draw a memory diagram for a small linked list of two orders. The first order is for table 3, served by `"Andrew"`, and is for 1 of menu item #1. The second (and current) order is for table 7, served by `"Cheng"`, and is for 2 of menu item #0 and 4 of menu item #2. **Character arrays can be written as string literals. Don't forget to include variable and field names.** [8 pt]

Stack

Static Data / Literals

Heap

(B) Below, complete the helper function `CreateOrder()` that generates a new, empty order (*i.e.*, 0 quantity of all menu items) with some specified field values. Assume that `*server` doesn't need to be deep-copied. `NUM_MENU_ITEMS` is `#define`-d. [8 pt]

```
// Returns a pointer to an empty order, or NULL on error.
Order* CreateOrder(int table, char* server) {













}
```

(C) Recall that `head` and `curr` are local pointers in `main`. We are writing **`AddOrder`** that takes a specified heap-allocated `Order` (*e.g.* the return value from `CreateOrder`) and adds it to the end of the `head` list. If either `head` or `curr` is `NULL`, then they need to be updated to point to this new `Order`, meaning we may need to update the values of both `head` and `curr` in this function. Following good style guidelines, propose a suitable declaration: [4 pt]

`_________ AddOrder(_______________________________________________);`

(D) If we want to create a module for our `Order` system, indicate which file the following would go in (checkmark): [4 pt]

	`Order.h`	`Order.c`	`Restaurant.c`
`Order` typedef from problem description			
`CreateOrder()` definition from part B			
`CreateOrder()` declaration			
`main()`			

Question 4: Time to Get in SHAPE [32 pts]

Abbrev: constructor (**ctor**), copy constructor (**cctor**), assignment (**op=**), destructor (**dtor**).

```
struct Point {
  Point() : x(0), y(0) { }
  Point(int x, int y) : x(x), y(y) { }
  int x, y;
};  // struct Point

class Shape {
 public:
  Shape() : num_pts_(1), points_(new Point) { }
  Shape(const Shape& s);  // DEEP copies data members
  Shape& operator=(const Shape& rhs);  // DEEP copies
  ...  // other methods mentioned in this question

 private:
  Point* points_;     // array of num_pts_ points [Heap]
  size_t num_pts_;    // # of points in shape
  uint8_t color[3];   // RGB values of shape color
};  // class Shape
```

(A) Do we need accessor methods for `Point`? *Briefly* explain why or why not. [2 pt]

(B) Write out a line of code that will disable the cctor inside the definition `Point`. [2 pt]

(C) What does a default `Shape` describe? [2 pt]

(D) The member function **`Area`** returns the area of the `Shape` as a `double`. Propose a suitable function signature (for the *implementation* file): [3 pt]

____ {

(E) The member function **`ChangeColor`** sets the `Shape`'s color to specified red, green, and blue values. Propose a suitable function signature (for the *implementation* file): [3 pt]

____

____ {

(F) points_ points to an array on the heap. Define a Shape member function **Union()** that *appends* the points from a second Shape to points_ in this. Don't worry about duplicate points or self-unions. [10 pt]

```
void Shape::Union(const Shape& s) {










}  // many valid solutions exist
```

(G) The inline definition of the Shape destructor is given below, but leads to a memory error in our code! *Briefly* describe the issue and the fix (which may not be in the dtor): [4 pt]

```
~Shape() { delete[] points_; }
```

Issue:

Fix:

(H) Assume that the Shape cctor (definition not shown) does a *deep* copy of data members. If s is a Shape with 2 points, how many times are each of the following invoked (count *both* Shape and Point methods) during the execution of the friend non-member function **Reverse(s)**? [6 pt]

```
Shape Reverse(const Shape& s) {
  Shape out = s;
  for (size_t i = 0; i < s.num_pts_; i++) {
    out.points_[i] = s.points_[s.num_pts_-1-i];
  }
  return out;
}
```

ctor ________ cctor ________ op= ________ dtor ________

Question 5: INPUT and OUTPUT and ERRORS, oh my! [19 pts]

(A) Assume that the C std lib is using an internal write buffer of **1024 bytes** and we are trying to write 2048 bytes total in **256-byte chunks**. Assuming that all writes are successful (*i.e.* no partial writes or errors), how many system calls do we invoke using C std lib vs. POSIX? [4 pt]

`write()`	
`fwrite()`	

(B) Name a C function that we have used in this class that fits the descriptions: [4 pt]

Part of the C standard library, but doesn't invoke a system call.	
A POSIX system call that doesn't have a C std lib equivalent.	

(C) Convert the following two lines of C code into their C standard library equivalents. Do NOT add any other lines (*e.g.* error checking): [5 pt]

POSIX:
```
int fd = open("midterm.txt", O_RDONLY);
ssize_t n = read(fd, buf, 333*sizeof(int32_t));
```

C Std Lib: ____;

____;

(D) Before exiting/terminating a C program, name the three categories of *resources* that we have seen in this class that we need to make sure are cleaned up/closed: [3 pt]

(E) *Briefly* describe in what situations you prefer to use `perror` instead of `fprintf` to `stderr`. [3 pt]

CSE 333 Reference Sheet (Midterm)

C Library Header – stdio.h

```
FILE           // type of object containing info to control a stream

FILE*   fopen (const char* filename, const char* mode);
int     fclose (FILE* stream);
int     fprintf (FILE* stream, const char* format, ...);
char*   fgets (char* str, int num, FILE* stream);
size_t  fread (void* ptr, size_t size, size_t count, FILE* stream);
size_t  fwrite (const void* ptr, size_t size, size_t count, FILE* stream);
void    perror (const char* str);
int     ferror (FILE* stream);       // returns non-zero if error on stream
```

C Library Header – stdlib.h

```
EXIT_SUCCESS  // success termination code
EXIT_FAILURE  // failure termination code

void*  malloc (size_t size);
void*  calloc (size_t num, size_t size);  // zero-initialized block
void*  realloc (void* ptr, size_t size);  // change size of mem block *ptr
void   free (void* ptr);                  // does nothing when ptr = NULL
void   exit (int status);                 // terminate calling process
```

C Library Header – string.h

```
size_t strlen (const char* str);           // # of chars, not including '\0'

char*  strcpy (char* dst, const char* src);          // copy chars
char*  strcat (char* dst, const char* src);          // append chars
int    strcmp (const char* str1, const char* str2);  // compare strings
```

- Versions that take a third parameter `size_t num`: `strncpy()`, `strncat()`, `strncmp()`

C Library Header – math.h

```
INFINITY       // Infinity
NAN            // Not-A-Number

float  abs (float x);                 // absolute value
float  pow (float base, float exp);   // base raised to the power exp
float  sqrt (float x);                // square root
float  ceil (float x);                // round up (towards +∞)
float  floor (float x);               // round down (towards -∞)
```

- All of these functions are overloaded to work with `double`, too

POSIX Library Headers – fcntl.h, unistd.h, dirent.h

```
O_RDONLY      // read-only flag
O_WRONLY      // write-only flag
O_RDWR        // read-write flag
O_APPEND      // append (add to end) flag
DIR           // type representing a directory stream

int     open (char* pathname, int flags, ...);          // open a file
int     close (int fd);                                 // close a file
ssize_t read (int fd, void* buf, size_t count);         // read from file
ssize_t write (int fd, const void* buf, size_t count);  // write to file

DIR*    opendir (const char* dirname);                  // open a directory
int     closedir (DIR* dirp);                           // close a directory
struct dirent* readdir (DIR* dirp);                     // read a directory
```

Error Library – errno.h

```
errno         // # of the last error, usually checked against defined consts

EACCES        // permission denied
EBADF         // bad file/directory descriptor
EFAULT        // bad address supplied
EINTR         // interrupted function
EISDIR        // is a directory
ENOTDIR       // is not a directory
```

C++ Memory Allocation

```
new           // allocate space for type, return pointer
new[]         // allocate space for array of type, return pointer
delete        // deallocate space indicated by pointer
delete[]      // deallocate space of array indicated by pointer
```

Format Specifiers

Specifier	Type
`d / i`	signed decimal integer
`u`	unsigned decimal int
`x`	unsigned hexadecimal integer
`f`	decimal floating point
`c`	character
`s`	string of characters
`p`	pointer address

Streams

<stdio.h>	POSIX	<iostream>
`stdin`	0	`std::cin`
`stdout`	1	`std::cout`
`stderr`	2	`std::cerr`