CSM 61C Spring 2020

C Memory

Exam Question Compilation

This document is a PDF version of old exam questions by topic, ordered from least difficulty to greatest difficulty.

Questions:

- Fall 2015 Final MT1-1B
- Spring 2015 Final M1-1C
- Fall 2018 Quest Q3A
- Summer 2018 Midterm 1 Q2
- Fall 2019 Quest Q5
- Summer 2019 Midterm 1 Q2
- Fall 2018 Final M2 Part 2
- Spring 2018 Midterm 1 Q3
- Summer 2018 Final Q2

SID: _____

MT1-1: Potpourri – Good for the beginning… (8 points)

a. **Memory Management**

```
int global = 0;

int* func() {
     int* arr = malloc(10 * sizeof(int));
     return arr;
}

int main() {
     char* str = "hello world";
     char str2[100] = "cs61c";
     int* a = func();
     return 0;
}
```

In what part of memory are each of the following values stored?

*str:	_____	str2[0]:	_____
a:	_____	arr:	_____
arr[0]:	_____		

SID: _____

M1-1: *I smell a potpourri section covering midterm one…* (9 points)

c) Consider the C code below. Indicate where the values on the right live in memory (using **(S)**tack, **(H)**eap, s**(T)**atic, or **(C)**ode). Assume no registers are used:

```
#define a 10
int b = 0;

int main(int argc, char** argv) {
   int c = a;
   char d[10];
   int* e = malloc(sizeof(int));
```

a:

b: _____

***d:**

***e:** _____

e:

Fall 2018 Quest

```
// My project partner wrote this code to duplicate some elements of orig into copy
      int orig[] = {1,2,3,4,5,6,7,8}; // ints are 4 bytes wide
      int main() {
            int *backup, *copy, **copyH;
            backup = copy = (int *) malloc (sizeof(int) * 100);
            copyH = &copy;

            for (int i = 0; i < 2; i++) {
                  *copy = orig[i];
                  *copyH = *copyH + 4;
            }
      }
```

Q3a) Right *before* the **for** loop, where in memory do the following **point**? (Select ONE per row)

	Code	*Static*	*Stack*	*Heap*
orig	○	○	○	○
backup	○	○	○	○
copyH	○	○	○	○

SID: _____

Question 2: C Memory Management (16 pts)

```
char *mood;
char *copy_message (char *msg) {
     char *x = malloc (sizeof (char) * (strlen (msg) + 1));
     strncpy (x, msg, strlen (msg));
     x[strlen (x)] = '/0';        / **** 6 ****/
     return x;
}
void print_int (int *p) {
     printf ("%d\n", *p);                /**** 7 ****/
}
void print_msg (char *str) {
     char *cpy = calloc (strlen (str) + 1, 1);
     strncpy (cpy, str, strlen (str));
     printf ("%s\n", cpy);          /**** 8 ****/
}
char *a () {
     char res[7] = " rules";
     return res;
}
char *b () {
     char *var = "cs 61c";
     return var;
}
void c () {
     printf ("%s\n", a ());       /**** 9 ****/
     printf ("%s\n", b ());      /**** 10 ****/
}
int main () {
     int y;
     mood = malloc (3);
     strcpy (mood, "hi");
     copy_message (mood);
     print_int (&y);
     print_msg (mood);
     c ();
}
```

SID: _____

Each of the following values below evaluates to an address in the C code on the previous page. Select the region of memory that the address points to (notice each function is called exactly once).

1. `mood`	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
2. `&mood`	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
3. `var`	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
4. `res`	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
5. `print_int`	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap

On the previous page there are comments on lines with numbers from 7-11. Each of these refers to a line of code that requires a dereference of a pointer to be performed. What we want to do is characterize if these memory accesses are legal c. We will use the following terminology

Legal: All addresses dereferenced are addresses that the program is allowed to read.

Initialized: Is there actual meaningful data in contents (data at each address) or is it garbage.

Always Illegal: This line will always dereference an address the program doesn't have explicit access to

Possibly Legal: The operation could result in only dereferences of legal addresses but it's also possible that in other runs on the program illegal accesses occur.

For each of lines that have the numbered comment select the best answer from

- A. Legal and Initialized
- B. Legal and Uninitialized
- C. Possibly Legal
- D. Illegal

For example for question 6 you should answer about the line with the /**** 6 ****/ comment from when the program runs.

6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

Q5) [10 Points] Each of the following evaluate to an address in memory. In other words, they "point" somewhere. Where in memory do they **point**?

	Code	*Static*	*Stack*	*Heap*
arr	○	○	○	○
arr[0]	○	○	○	○
dest	○	○	○	○
dest[0]	○	○	○	○
&arrPtr	○	○	○	○

```
// The ASCII values for 'A', 'B', etc. are 65, 66,      <<<<<< Important
// The ASCII values for 'a', 'b', etc. are 97, 98,      <<<<<< Important


char *arr[] = {"Go", "Bears"};

int main() {
   char **arrPtr = arr;
   char *dest[2];
   int j;

   for (int i = 0; i < 2; i++) {
       char *currString = *arrPtr;
       dest[i] = (char *) malloc(strlen(currString) + 1);
       for (j = 0; j < strlen(currString); j++)
           dest[i][j] = currString[j] & ~(1 << 5); // Hint: Focus on this line!
       }
       dest[i][j] = '\0';
       arrPtr++;
   }
   printf("%s %s", dest[0], dest[1]);
}
```

Question 2: Remember remember the segments of memory. - 14 pts

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

bool fetch_data (char* buf);

char* receive_buffer;
bool is_complete = false;

int main(int argc, char* argv[]) {
      receive_buffer = malloc(100*sizeof(char));
      if (!receive_buffer) {
            return -1;
      }
      fetch_data(receive_buffer);
      free(receive_buffer);
      return 0;
}

/* Function that takes in a buffer for storing characters
 * and places data in the buffer by calling receive_data.*/
void fetch_data(char* buf) {
      int len = receive_data(receive_buffer);
      if (len == 0) {
            return; // HERE
      } else {
            fetch_data(buf + len);
      }
}
```

All of the following expressions **evaluate** to an address value. State in which region of memory each value corresponds to: stack, heap, static, or code. Assume we are about to execute the line marked HERE.

1.	receive_buffer	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
2.	&(receive_buffer[0])	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
3.	&receive_buffer	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
4.	&argc	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
5.	&is_complete	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
6.	&fetch_data	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap
7.	buf	Ⓐ Code	Ⓑ Static	Ⓒ Stack	Ⓓ Heap

Summer 2019 Midterm 1 (cont'd)

Now consider the following different program:

```
// function prototypes
int a(int x);
int b(int y);

int main(void) {
      a(3);
      return 0;
}

int a(int x) {
      return b(x - 1);
}

int b(int y) {
      if (y <= 1) {
            return 7; // HERE
      } else {
            return a(y - 1);
      }
}
```

Assume we are about to execute the line marked HERE. Label all the stack frames below with either the function that created the frame: a, b, or main, or with UNUSED if the frame is not in use.

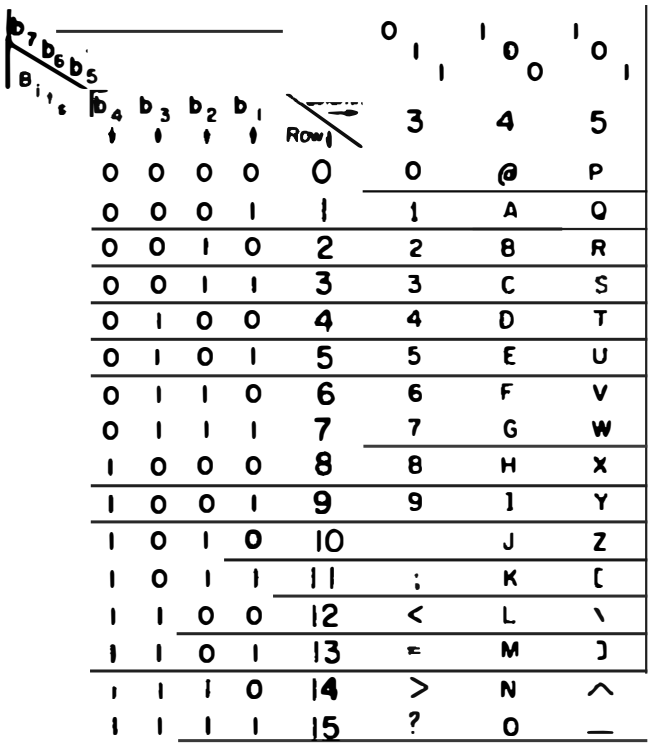
Memory	(Top)
1	
2	
3	
4	
5	
6	
7	

1. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
2. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
3. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
4. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
5. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
6. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED
7. Ⓐ a Ⓑ b Ⓒ main Ⓓ UNUSED

M2) *Floating down the C…, continued…* (8 points = 1,1,2,1,1,1,1,1, 20 minutes)

Consider the following code (and truncated ASCII table; as an example of how to read it, "G" is `0b0100 0111`):

```
uint8_t mystery (uint8_t *A) {
   return *A ? (*A & mystery(A+1))   0xFF;
}
```



b_7 b_6 b_5 / Bits	0 0 0	0 0 1	0 1 0	0 1 1
b_4 b_3 b_2 b_1 / Row ↓	0	1	2	3
0 0 0 0	0	SP	@	P
0 0 0 1	1	!	A	Q
0 0 1 0	2	"	B	R
0 0 1 1	3	#	C	S
0 1 0 0	4	$	D	T
0 1 0 1	5	%	E	U
0 1 1 0	6	&	F	V
0 1 1 1	7	'	G	W
1 0 0 0	8	(	H	X
1 0 0 1	9	)	I	Y
1 0 1 0	10	*	J	Z
1 0 1 1	11	+	K	[
1 1 0 0	12	,	L	\
1 1 0 1	13	-	M	]
1 1 1 0	14	.	N	^
1 1 1 1	15	/	O	_

d) Where is **A** stored? (*not* what it points to, ***A**)
◯code ◯static ◯heap ◯stack

e) What is **(char)mystery("GROW")**? _____

f) A two-character string is passed into **mystery** that makes it return the **uint8_t** value **0** (not the character "**0**"). The first character is "**M**", the second character is a number from 1-9. Which?
◯1 ◯2 ◯3
◯4 ◯5 ◯6
◯7 ◯8 ◯9

Problem 3 ***C Analysis*** **(10 points)**

The CS61C Staff is creating songs in preparation of the grading party. Consider the following program:

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

typedef struct Song {
     char *title;
     char *artist;
} Song;

Song * createSong() {
     Song* song = (Song*) malloc(sizeof(Song));
     song->title = "this old dog";
     char artist[100] = "mac demarco";
     song->artist = artist;
     return song;
}


int main(int argc, char **argv) {
     Song *song1 = createSong();
     printf("%s\n", "Song written:");
     printf("%s\n", song1->title); // print statement #1
     printf("%s\n", song1->artist); // print statement #2

     Song song2;
     song2.title = malloc(sizeof(char)*100);
     strcpy(song2.title, song1->title);
     song2.artist = "MAC DEMARCO";
     printf("%s\n", "Song written:");
     printf("%s\n", song2.title); // print statement #3
     printf("%s\n", song2.artist); // print statement #4

     return 0;
}
```

(a) What type of address does each value evaluate to? Fill in the entire bubble.

i. `song1`

- ○ Stack address
- ○ Static address
- ○ Heap address
- ○ Code address

ii. `song1->title`

- ○ Stack address
- ○ Static address
- ○ Heap address
- ○ Code address

iii. `song1->artist`

- ○ Stack address
- ○ Static address
- ○ Heap address
- ○ Code address

iv. `&song2`

- ○ Stack address
- ○ Static address
- ○ Heap address
- ○ Code address

v. `song2.title`

- ○ Stack address
- ○ Static address
- ○ Heap address
- ○ Code address

(b) Will all of the print statements execute as expected?

- ○ Yes
- ○ No

If you answered yes, leave this blank. If you answered no, write the number(s) of the print statement(s) which will not execute as expected.

_____

Question 2: Main [Memory] Stacks Management (8 pts)

In this question, we will continue the Stack implementation from Question 1, assuming it functions correctly. Consider the following program (and feel free to draw the stack in the space to the right :D):

```
StackNode *sp = NULL;
int main(int argc, char *argv[]) {
      push("main", &sp);
      push("foo", &sp);
      push("bar", &sp);
      StackNode *fork = sp;
      push("orig", &sp);
      push("split", &fork);
      return 0;
}
```

Each of the following values on the next page evaluate to an address in the C code above. Select the region of memory that these addresses point to right before the `main` function returns.

1. `main`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
2. `&sp`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
3. `sp`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
4. `*sp`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
5. `sp->func_name`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
6. `&fork`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code
7. `argv`	Ⓐ Stack	Ⓑ Heap	Ⓒ Static	Ⓓ Code

Suppose we had a simple recursive function defined as follows:

```
long factorial(long n):
    if (n == 1):
        return 1;
    else:
        return n * factorial(n-1)
```

Assume that function frames only require space for the local variables (i.e. the return value of `frame_size("factorial")`). You are given the following specifications:

Stack and Heap: 16 KiB
Static: 12 KiB
Code: 4 KiB

```
frame_size("factorial") = 8
sizeof(StackNode) = 56
```

Suppose we call the `factorial` function on some number N **using our Stack data structure from Question 1** (note: we allocated data for our `StackNode` structs):

```
StackNode *sp = NULL;
int main () {
      push("factorial", &sp);
      push("factorial", &sp);
      push("factorial", &sp);


      // the N'th call to factorial
      push("factorial", &sp);

      // the first return from factorial
      pop(&sp);

}
```

What is the smallest value of N that will cause a maximum recursion depth error (meaning no more function frames can be created)? Ignore the stack space required for the `main` function. If convenient, put your answer as a power of 2.

N = _____