CS61C MIDTERM 1

After the exam, indicate on the line above where you fall in the emotion spectrum between “sad” & “smiley”...

<table>
<thead>
<tr>
<th>Last Name</th>
<th>Perfect</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Name</td>
<td>Petra</td>
</tr>
<tr>
<td>Student ID Number</td>
<td>0xDEADBEEF</td>
</tr>
<tr>
<td>CS61C Login</td>
<td>cs61c-zzz</td>
</tr>
</tbody>
</table>

The name of your SECTION TA and time

<table>
<thead>
<tr>
<th>Name of the person to your LEFT</th>
</tr>
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<tbody>
<tr>
<td>Name of the person to your RIGHT</td>
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</tbody>
</table>

All the work is my own. I had no prior knowledge of the exam contents nor will I share the contents with others in CS61C who have not taken it yet. (please sign)

Instructions (Read Me!)

- This booklet contains 6 numbered pages including the cover page.
- Please turn off all cell phones, smartwatches, and other mobile devices. Remove all hats & headphones. Place your backpacks, laptops and jackets under your seat.
- You have 80 minutes to complete this exam. The exam is closed book; no computers, phones, or calculators are allowed. You may use one handwritten 8.5”x11” page (front and back) crib sheet in addition to the RISC-V Green Sheet, which we will provide.
- There may be partial credit for incomplete answers; write as much of the solution as you can. We will deduct points if your solution is far more complicated than necessary. When we provide a blank, please fit your answer within the space provided.

<table>
<thead>
<tr>
<th>Points Possible</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>19</td>
<td>20</td>
<td>19</td>
<td>20</td>
<td>90</td>
</tr>
</tbody>
</table>

1/6
Q1: Back to the Base-ics (12 points)

a) Show how the binary string 0b1011 0110 can be interpreted and displayed as the following types:

- Hexadecimal: 0xB6
- Unsigned Decimal: 182
- Two's Complement Decimal: -74

b) What is the minimum number of bits needed to represent all the unsigned integer values that a three-digit base-7 number could encode? Your answer should be a simplified decimal value.

Powers of 7 are shown below for reference:

<table>
<thead>
<tr>
<th>$7^1$</th>
<th>$7^2$</th>
<th>$7^3$</th>
<th>$7^4$</th>
<th>$7^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>49</td>
<td>343</td>
<td>2401</td>
<td>16807</td>
</tr>
</tbody>
</table>

9

c) What bias should be added for a biased three-digit base-7 number to yield an equal number of positive and negative numbers? Your answer should be a simplified decimal value.

-171

d) Convert the unsigned number 0xDF to its base-7 equivalent (i.e. the base-7 number with the same decimal value). What is the resulting number? The prefix 0s is for base-7.

0s436
Q2: Thanks for the Memories (19 points)

```c
#define MAX_WORD_LEN 100
int num_words = 0;
void bar(char **dict) {
    char word2[] = "BEARS!";
    dict[num_words] = calloc(MAX_WORD_LEN, sizeof(char));
    strcpy(dict[num_words], word2);
    num_words += 1;
}
int main(int argc, char const *argv[]) {
    const int dict_size = 1000;
    char **dictionary = malloc(sizeof(char *) * dict_size);
    char *word1 = "GO";
    bar(dictionary);
    bar(dictionary);
    return 0;
}
```

Consider the program above. Based on what the given C expressions evaluate to, please select comparators to fill in the blanks (for 1-4) or the correct address type (for 5-7). As per the C standard, you cannot assume calls to malloc return heap addresses in a sequential order.

1. &dictionary ___ &num_words
   < > ==
   ○ >
   ○ <
   ○ ==
   ○ Can't tell

2. dictionary ___ &dict_size
   < > ==
   ○ >
   ○ <
   ○ ==
   ○ Can't tell

3. &word1 ___ &dict
   < > ==
   ○ >
   ○ <
   ○ ==
   ○ Can't tell

4. dictionary[1] ___ dictionary
   < > ==
   ○ >
   ○ <
   ○ ==
   ○ Can't tell

5. What type of address does word1 evaluate to?
   < > ==
   ○ Stack address
   ○ Heap address
   ○ Static address
   ○ Code address

6. What type of address does *(word2[1]) evaluate to?
   < > ==
   ○ Stack address
   ○ Heap address
   ○ Static address
   ○ Code address

7. What type of address does *dictionary evaluate to?
   < > ==
   ○ Stack address
   ○ Heap address
   ○ Static address
   ○ Code address
Q3: Put it in Reverse (20 points)

1. Fill in the blanks to complete the `reverse` function which takes in a `head_ptr` to the head of a linked list and returns a new copy of the linked list in reverse order. You must allocate space for the new linked list that you return. An example program using `reverse` is also shown below.

```c
struct list_node {
    int val;
    struct list_node* next;
};
struct list_node* reverse( ___struct list_node**___ head_ptr ) {
    struct list_node* next = NULL;
    struct list_node* ret;
    while (*head_ptr != NULL) {
        ret = malloc(sizeof(struct list_node))______;
        ret->val = (*head_ptr)->val______________;
        ret->next = next______________________;
        next = ret__________________________;
        *head_ptr = (*head_ptr)->next;
    }
    return ret________________________________;
}
/* Assume that NEW_LL_1234() properly malloc’s a linked list
* 1->2->3->4, and returns a pointer that points to the first
* list_node in the linked list. Assume that before test_reverse
* returns, head and ret will be properly freed. */
void test_reverse() {
    struct list_node* head = NEW_LL_1234();
    assert(head->val == 1); // returns True
    assert(head->next->val == 2); // returns True
    struct list_node* ret = reverse(&head);
    assert(head != ret); // ret is a new copy of the original list
    assert(ret->val == 4); // should return True
    ...
}
```

2. If the function `test_reverse` is called, there will be one error. This error will result due to one of the lines already given to you in `reverse()`, from part 1 above. In five words or less, what is the error? There are no syntax-related errors.

```c
memory leak
```
Q4: Ternary Search Tree Is Back (19 points)

Recall the Trie Tree and Ternary Search Tree from Homework #1. You’ve already implemented memory_trie_node, and now we ask you to provide the same feature for a Ternary Search Tree. Recall that the TSTnode structure needs to hold a char self, a char* word, and three TSTnode pointers to the left, right and sub trees.

1. First of all, please select all correct TSTnode structures from below. Please write your answer as letters in alphabetic order on the blank to the right:

   ____B____

   | A. struct TSTnode {
   |     char self;
   |     char* word;
   |     TSTnode* left, right, sub;
   | } | B. struct TSTnode {
   |     char self;
   |     char* word;
   |     struct TSTnode *left, *right, *sub;
   | } |
   |
   | C. struct TSTnode {
   |     char* self;
   |     char* word;
   |     TSTnode *left, *right, *sub;
   | } | D. struct TSTnode {
   |     char self;
   |     char *word;
   |     struct TSTnode* left, right, sub;
   | } |

2. How many bytes does a single TSTnode from HW1 take up in memory? Assume that we are working on a 32 bit word-aligned architecture, as we have normally in class.

   \[
   \text{sizeof(struct TSTnode)} = \underline{20} \text{ \underline{\text{___________}}}
   \]

3. Assume you have the TSTnode struct, as defined in the project. Fill in memory_tst_node to calculate the total amount of heap memory usage (similar to what you did in Trie Tree). You may or may not need to use all blanks;

   ```c
   int memory_tst_node( struct TSTnode* node ) {
       if (!node)
           Return 0;

       unsigned int bytes = sizeof(struct TSTnode);
       bytes += memory_tst_node(node->left);
       bytes += memory_tst_node(node->right);
       bytes += memory_tst_node(node->sub);
       If (node->word)
           bytes += (strlen(node->word)+1)*sizeof(char);
       return bytes;
   }
   ```
Q5: RISC-Y Business (20 points)

You wish to speed up one of your programs by implementing it directly in assembly. Your partner started translating the function is_substr() from C to RISC-V, but didn’t finish. Please complete the translation by filling in the lines below with RISC-V assembly. The prologue and epilogue have been written correctly but are not shown.

Note: strlen(), both as a C function and RISC-V procedure, takes in one string as an argument and returns the length of the string (not including the null terminator).

```c
/* Returns 1 if s2 is a substring of s1, and 0 otherwise. */
int is_substr(char* s1, char* s2) {
    int len1 = strlen(s1);
    int len2 = strlen(s2);
    int offset = len1 - len2;
    while (offset >= 0) {
        int i = 0;
        while (s1[i + offset] == s2[i]) {
            i += 1;
            if (s2[i] == '\0')
                return 1;
        }
        offset -= 1;
    }
    return 0;
}
```

1. `is_substr:
2.    mv s1, a0
3.    mv s2, a1
4.    jal ra, strlen
5.    mv s3, a0
6.    mv a0, s2
7.    jal ra, strlen
8.    sub s3, s3, a0
9.    Outer_Loop:
10.    __blt__ s3__, x0__, False
11.    add t0, x0, x0
12.    Inner_Loop:
13.    add t1, t0, s3
14.    add t1, s1, t1
15.    lbu t1, 0(t1)
16.    __add t2 s2 t0___________
17.    __lbu t2 0(t2)___________
18. __bne_t1, t2__, Update_Offset
19.    addi t0, t0, 1
20.    add t2, t0, s2
21.    __lbu t2 0(t2)___________
22.    beq t2, __x0__, ______True_____
23.    jal x0 Inner_Loop
24.    Update_Offset:
25.    addi s3, s3, -1
26.    __jal x0 Outer_Loop_________
27. False:
28.    xor a0, a0, __a0_____
29.    jal x0, End
30. True:
31.    addi a0, x0, 1
32. End: ....