CSE 351 Summer 2021 – Unit Summary #3 – Task 3
Due Fri 8/20/21 8pm to Gradescope

Your Name:________________________

UWNet ID (email):________________________

Academic Integrity Statement________________________
All work on these questions is my own. I have not shared or discussed my answers with anyone else. (please sign) (1 point)

• To complete Task 3, please either:
  o print these THREE pages, fill them out and then scan and convert into a pdf
  o use digital ink or otherwise annotate the pdf electronically

• Gradescope requires you to upload a pdf

• Fill in your name and UW NetID above, then read the Academic Integrity Statement and sign your name indicating that you understand and will comply with the statement. If you are not printing this out or do not have access to digital ink, just type your full name.

• You may show scratch work for potential partial credit but showing work is not required. Be sure your final answer is placed in the blanks, boxes, or spaces provided.

• You may use your floorplan from Task 1, course lecture slides and Ed Lessons, and course textbooks while completing this task.

• Use of reference materials external to those listed above is not allowed (e.g., Stack Overflow, web searches, communicating with anyone other than the course staff, etc.)

• If you have questions, please ask on Ed! A private post is fine! Questions about the unit summaries will not be answered in office hours.

  Good Luck!
1. Cache parameters (3 points)

You have a byte-addressed machine with 64 KiB of Physical address space. You have a 2-way associative L1 data cache of total size 1024 bytes with a cache block size of 128 bytes.

a) [2 pt] Give the number of bits needed for each of these:

Cache Block Offset: _____________  Cache Tag: _____________

b) [1 pt] How many sets will the cache have? _____________

2. Structs (5 points)

For this question, assume x86-64 and the following C struct definition.

```c
typedef struct {
    char rating;
    char* name;
    char* ingredients[6];
    short servings;
    float cost;
} recipe;
```

a) [1 pt] What is the byte offset where `rating` begins? _____________


c) [1 pt] Is there any internal fragmentation? If so, how many bytes and where?

YES / NO  If yes, number of bytes ____________, where _________________________

d) [1 pt] Is there any external fragmentation? If so, how many bytes and where?

YES / NO  If yes, number of bytes ____________, where _________________________

e) [1 pt] Can the compiler reduce the amount of fragmentation? (circle one)?

YES / NO
3. Cache hit rate (12 points)

a) [4 pts] You have a direct mapped cache containing 256 bytes with a cache block size of 32 bytes. The cache uses LRU replacement and write-allocate and write-back policies. Assume i and j are stored in registers, and that the array happy starts at address 0x0. Give the hit rate (as a fraction or a %) for the following two loops. Assume the cache starts out empty.

```c
#define LEAP 4
#define SIZE 32
int happy[SIZE];
... // Assume happy has been initialized to contain values.
... // Assume the cache starts empty at this point.
for (int i = 0; i < SIZE; i += LEAP) {
    happy[i] = happy[i] + i * (i + 2);
}
for (int j = 1; j < SIZE; j += (LEAP * 2)) {
    happy[j] = happy[j] + j * 5;
}
```

Hit Rate for Loop 1: ___________  Hit Rate for Loop 2: ___________

b) [8 pts] For each of the changes proposed below, indicate how it would affect the hit rate of each loop above in part c) assuming that all other factors remained the same as they were in the original problem. Circle one of: “increase”, “no change”, or “decrease” for each loop.

<table>
<thead>
<tr>
<th>Change associativity from direct mapped to two-way:</th>
<th>Loop 1: increase / no change / decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loop 2: increase / no change / decrease</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Change LEAP from 4 to 8:</th>
<th>Loop 1: increase / no change / decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loop 2: increase / no change / decrease</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Change cache size from 256 bytes to 512 bytes:</th>
<th>Loop 1: increase / no change / decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loop 2: increase / no change / decrease</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Change block size from 32 bytes to 16 bytes:</th>
<th>Loop 1: increase / no change / decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loop 2: increase / no change / decrease</td>
</tr>
</tbody>
</table>
4. Processes (5 points)
The following function prints out numbers.

```c
void summer(void) {
    int x = 3;
    if (fork()) {
        if (fork()) {
            x += 7;
            fork();
        }
    } else {
        x += 2;
    }
    printf("%d ", x);
    if (fork()) {
        x -= 6;
    } else {
        x -= 1;
        printf("%d ", x);
        fork();
        printf("Bye ");
    }
    exit(0);
}
```

a. [1 pts] What is the total number of processes created (including the original process that called `summer`) by this function?

b. [1 pt] Is it possible for the numbers that are printed to appear in descending/non-increasing order (highest value to lowest value) in the output? YES / NO

c. [1 pt] How many times will “Bye” be printed?

d. [1 pt] What is the smallest number that will be printed?

e. [1 pt] What is the largest number that will be printed?