CSCI-UA.0201
Computer System Organization
Homework Assignment 3

1. [5 points] Consider a computer system that has a cache with 4096 blocks. Each block can store 16 bytes. What will be the value stored in the \textit{TAG} field of the cache block that holds the memory block containing the address 0xABCDEF (This hexadecimal number gives you a hint on the address length):

(i) if it is a direct-mapped cache

(ii) if it is a 16-way set-associative cache

(iii) if it is fully associative

2. Consider a small 2-way set associative cache with a total of 32 blocks and a block size of 256 bytes. The cache uses LRU replacement policy. Assume that the cache is initially empty. The CPU accesses the following memory locations, in that order: 0x55c8, 0x55774, 0x5479c, 0x54c00, 0x55784, 0x56c80, 0x56718, 0x54738.

(a) [3 points] How the address is split to do cache lookup?

(b) [8 points] For each memory reference, indicate whether it will result in hit or miss and, if miss, indicate the type of miss (compulsory, capacity, or conflict)

(c) [1 point] From your solution in part (b) above, what is the hit rate of the cache?

(d) [3 points] Assume the memory access latency is 10 cycles and the cache, mentioned in this problem, has an access latency of 3 cycles. Also assume the hit rate you calculated in part (c) above. Did this system benefit from having a cache? Justify

3. Almost all programs need external libraries.

(a) [1 point] In how many places can needed libraries be added to your code?

(b) [3 points] What are these places?

(c) [6 points] For each one of those places, state one advantage and one disadvantage.
4. int array1[M][N];
   int array2[N][M];

   int copy(int i, int j)
   {
       array1[i][j] = array2[j][i];
   }

Suppose the above code generates the following assembly code (assume array2 and array1 are the base addresses of the corresponding arrays):

copy:
   movl %rdi, %ecx
   movl %rsi, %ebx
   leal (%ecx,%ecx,8), %edx
   sall $2, %edx
   movl %ebx, %eax
   sall $4, %eax
   subl %ebx, %eax
   sall $2, %eax
   movl array2(%eax,%ecx,4), %eax
   movl %eax, array1(%edx,%ebx,4)
   ret

What are the values of M and N (4 points)?
Show how did you reach your answer (6 points)
5. [4 points] Consider the two C functions fun1 and fun2. Which of these two functions compiled into the assembly code shown?

```c
int fun1(int a, int b) {
    if (a < b)
        return a;
    else
        return b;
}

int fun2(int a, int b) {
    if (b < a)
        return b;
    else
        return a;
}
```

6. [6 points] Fill the blanks of the following table:

<table>
<thead>
<tr>
<th>Hexadecimal</th>
<th>binary</th>
<th>Decimal (assuming unsigned)</th>
<th>Decimal (assuming signed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x8A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0x21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>