Name: ______________________________

1. [5 pts] How many bits does a kilobyte contain?

2. [7 pts] Approximate $2^{18}$ in the form $x \times 10^y$, with $x$ and $y$ both being base-10 numbers. (Your answer need not be normalized.)

3. [8 pts] In the following function, you can assume that place is a power of two. Complete the function so that it returns 1 if the bit of that value in number is set, and 0 otherwise. For example, 
   \[ \text{isBitSet}(100, 4) \] should return 1, since $100_{10} = 1100100_{2}$, which has a 1 in the 4's place. 
   But 
   \[ \text{isBitSet}(27, 4) \] should return 0, since $27_{10} = 11011_{2}$.

   ```c
   int isBitSet(int number, int place) {
   }
   ```

4. [10 pts] What does the C program at right print when run?

   ```c
   #include <stdio.h>
   int main() {
   int i; int j;
   int *p; int *q;
   i = 2;
   j = 3;
   q = &i;
   p = &q;
   *q = 5;
   q = &j;
   **p = 7;
   printf("%d %d\n", i, j);
   printf("%d %d\n", **p, *q);
   return 0;
   }
   ```

5. [10 pts] Suppose we are using a HYMN computer, and the contents of registers and memory are as follows as it completes the execution of an instruction. (All numbers in the table are hexadecimal.)

<table>
<thead>
<tr>
<th>PC:</th>
<th>a M[a]</th>
<th>a M[a]</th>
<th>a M[a]</th>
<th>a M[a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>03</td>
<td>00 86</td>
<td>08 00</td>
<td>10 00</td>
<td>18 00</td>
</tr>
<tr>
<td>IR:</td>
<td>E5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC:</td>
<td>09</td>
<td>01 E5</td>
<td>02 0A</td>
<td>03 61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>04 00</td>
<td>05 01</td>
<td>06 0A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>07 00</td>
<td>08 00</td>
<td>09 00</td>
</tr>
<tr>
<td></td>
<td>00 BF</td>
<td>09 00</td>
<td>11 00</td>
<td>19 00</td>
</tr>
<tr>
<td></td>
<td>02 0A</td>
<td>09 00</td>
<td>12 00</td>
<td>1A 00</td>
</tr>
<tr>
<td></td>
<td>03 0B</td>
<td>09 00</td>
<td>13 00</td>
<td>1B 00</td>
</tr>
<tr>
<td></td>
<td>04 0C</td>
<td>09 00</td>
<td>14 00</td>
<td>1C 00</td>
</tr>
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<td>09 00</td>
<td>15 00</td>
<td>1D 00</td>
</tr>
<tr>
<td></td>
<td>06 0E</td>
<td>09 00</td>
<td>16 00</td>
<td>1E 00</td>
</tr>
<tr>
<td></td>
<td>07 0F</td>
<td>09 00</td>
<td>17 00</td>
<td>1F 00</td>
</tr>
</tbody>
</table>

   (The memory table at right lists each memory location’s memory address, followed by the data at the address. For example, the location with address 06_{16} holds 0A_{16}.) Modify the diagram to reflect how the registers and memory change during the fetch process.)
6. [10 pts] Give an example where the optimization of common subexpression elimination applies, and explain how it applies to your example. You can write your example in C/Java, or you can write it in x86/HYMN assembly.

7. [10 pts] Distinguish between the terms static linking (i.e., compile-time linking) and dynamic linking (i.e., load-time or run-time linking).

8. [10 pts] Suppose we have two threads using the code at right. One frequently calls advance to advance the computation of primes, while another frequently calls output to output the current information.

   a. Describe a situation in which output may display erroneous information.

   b. Edit the code at right to fix this. Your fix must allow a thread to execute output even when another thread is inside the isPrime method.

```java
public class PrimeCounter {
    private int last_checked = 1;
    private int primes_found = 0;

    public void advance() {
        if(isPrime(last_checked + 1)) {
            last_checked++;
            primes_found++;
        } else {
            last_checked++;
        }
    }

    public void output() {
        System.out.println(primes_found + " primes <= " + last_checked);
    }

    private boolean isPrime(int n) {
        for(int i = 2; i * i <= n; i++) {
            if(n % i == 0) return false;
        }
        return true;
    }
}
```
9. [10 pts] Describe the inputs and outputs of a (1-way) $2 \times 4$ demultiplexer, and explain how they relate.

10. [10 pts] Suppose we have a system using six-bit addresses which uses a direct-mapped cache with two lines, where each line has four bytes. And suppose the following sequence of accesses of one-byte accesses: M[0], M[2], M[5], M[11], M[2], M[7], M[12] (where the addresses are in base 10).

   a. Which of the accesses in the sequence hit the cache?

   b. Draw a picture of the contents of the cache after completing this sequence.

<table>
<thead>
<tr>
<th>line</th>
<th>tag</th>
<th>line data</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. [10 pts] Suppose we are using a FAT-16 filesystem in which each block takes two kilobytes. Recall that each directory entry in FAT-16 takes 32 bytes. How much total disk space does a directory and the 100 files in it consume, if each file contains precisely five bytes? Express your answer in kilobytes.

Enjoy the summer and the rest of your studies at CSB/SJU!