CS 61C Summer 2016
Guerrilla Section 5: Caches

You are given a MIPS machine with a single level of **2KiB direct-mapped** cache with **512B cache blocks**. It has **1MiB of physical address space**.

The function foo is ran on the system with a **cold** cache and as the only process:

```
#define ARRAY_LEN 4096
#define STEP_SIZE 64

// A starts at 0x10000
// B starts at 0x20000

foo( int* A, int* B ) {
      int total = 0;
      for ( int i = 0; i < ARRAY_LEN; i += STEP_SIZE ) {
            total += A[ i ];
            total -= B[ i ];
      }
}
```

1. Calculate the number of Tag, Index, and Offset bits for this cache.

Tag: 9
Index: 2
Offset: 9

2. Calculate the hit percentage for this cache after running foo.

0%

3. The cache is now cleared and the code is run again. This time, **A** and **B** are pointing to the same array, which starts at **0x10000**. Calculate the new hit percentage.

75%

4. Assume **A** and **B** starts once again at **0x10000** and **0x20000**. What is the new hit percentage if we ran foo on a fully associative cache, with all other parameters staying the same?

50%

Problem 2:

Question 1:

a. You are given a 16 KiB direct-mapped cache with 128 B blocks and a write-back policy. Assume a 64-bit address space and byte-addressed memory.

Tag: 50 Index: 7 Offset: 7

b. We have a 32-bit byte-addressed machine with an 8-way set-associative cache that uses 32 B blocks and has a total capacity of 8 KiB.

Tag: 22 Index: 5 Offset: 5

Problem 3:

a. Calculate the AMAT for a system with the following properties:

- L1 cache hits in 1 cycle with local hit rate 20%
- L2 cache hits in 10 cycles with local hit rate 80%
- L3 cache hits in 100 cycles with local hit rate 90%
- Main memory always hits in 1000 cycles

AMAT = 1 + (1 − 0.2)(10 + (1 − 0.8)(100 + (1 − 0.9)(1000))) = 41

b. How slow can you go? Your system consists of the following:

- L1 cache hits in 2 cycles with a miss rate of 20%
- L2 cache hits in 10 cycles
- Main memory always hits in 300 cycles

You want your AMAT to be <= 22 cycles. What does your **local** L2 miss rate need to be? What is the equivalent **global** miss rate?

AMAT = L1 Hit time + L1 Miss rate * (L2 Hit time + L2 Local Miss rate * L2 Miss penalty)
22 >= 2 + 0.2 * (10 + X * 300)
X = .3, or 30% local miss rate
Global miss rate = 30% * 20% = 6%

Q4:

1. 0xC5C8 -- binary decimal: 1111.001, mantissa 111001000, exponent is 3 + 31 = 34
2. 2^10 - 1 -- max is 1.111111111 and exponent of 2^9 -> 1111111111 which is 2^10 - 1
3. 2^15 - 2^9 - 1 -- We're basically looking for the number of positive norms and denorms. We have 6+9 bits of exponent and significand to set in any arrangement except those arrangements which represent zero, infinity, or NaN. So we have 2^15 - 2^9 (number of arrangements where exponent is 2^10 - 1 and significand is anything) - 1 (zero).