

## Assignment 3

### Due October 22, 12:59pm

**NOTE:** Late submissions will **NOT** be accepted. Please put your solutions in the CENG 355 **drop-box** (ELW, second floor) – they will be collected at **13:00**.

**1.** [10 points] Assume a byte-addressable computer has 256-byte main memory and 128-byte cache with **eight blocks**, where each block has **four 32-bit words**. While executing some program, the CPU reads 32-bit words from the following sequence of 10 addresses:

**80    48    44    20    00    40    48    C0    2C    88**

Show the cache contents (e.g., **[00]** = contents stored at address **00**) at the end of this sequence and calculate the corresponding miss rate given that:

- (a) Cache is direct-mapped.
- (b) Cache is 4-way set-associative (4 blocks per set) with LRU replacement.
- (c) Cache is fully-associative with LRU replacement.

**2.** [10 points] Assume a byte-addressable computer has 4-KB main memory and 128-byte cache with **four blocks**, where each block has **eight 32-bit words**. While executing some program, the CPU reads 32-bit words from the following sequence of 10 addresses (in hexadecimal format):

**088    090    250    09C    240    200    220    210    230    080**

Show the cache contents (e.g., **[000]** = contents stored at address **000**) at the end of this sequence and calculate the corresponding miss rate given that:

- (a) Cache is direct-mapped.
- (b) Cache is 2-way set-associative (2 blocks per set) with LRU replacement.
- (c) Cache is fully-associative with LRU replacement.

**3.** [5 points] Assume a computer uses L1 and L2 caches for both instructions and data. The L1 access time is  $C_1 = 1\tau$  (L1 hit), the L2 access time is  $C_2 = 8\tau$  (L1 miss, L2 hit), and the main memory access time is  $M = 32\tau$  (L2 miss). Assume that for some given application the L1 hit rate is  $h_1 = 80\%$  (for both instructions and data). What is the minimum possible value of the average access time  $T_{ave}$  under these assumptions? What is the L2 hit rate  $h_2$  (for both instructions and data) such that  $T_{ave} = 4\tau$ ?