Midterm 2 Study Guide

- Heap & Memory Allocation
  - Heap Allocation Functions: malloc for allocating memory, calloc for allocating and initializing memory to zero, realloc for resizing allocated memory, and free for deallocating memory.
  - Posix Functions: brk to set heap end, sbrk to increment/decrement heap size.
- Allocator Design Goals
  - Maximize throughput: Increase the number of malloc and free operations over time.
  - Maximize memory utilization: Increase the percentage of heap memory used for storing user data.
- Memory Fragmentation
  - External Fragmentation: Available memory is split into small blocks.
  - Internal Fragmentation: Memory is wasted within allocated blocks due to overhead.
- Free Block Management
  - Explicit Free List: Links free blocks together, can be external (outside blocks) or internal (within blocks).
  - Implicit Free List: Uses block headers to manage free blocks, without separate data structures.
- Placement Policies
  - First Fit: Allocates the first block large enough for the request.
  - Next Fit: Similar to First Fit but starts searching from the last allocated block.
  - Best Fit: Chooses the smallest block that fits the request.
- Coalescing
  - Combines adjacent free blocks to mitigate fragmentation.
- Free Block Footers
  - Used to store size information for coalescing.
- Free List Improvements
  - Free List Ordering: Can be by address or last-in order.
  - Free List Segregation: Maintains separate lists for different block sizes.
- Cache Design & Operations
  - Cache Blocks: Unit of memory transfer between cache and main memory.
  - Address Breakdown: Includes bits for word/block selection, set index, and tag comparison.
  - Cache Types: Direct Mapped, Fully Associative, Set Associative.
  - Replacement Policies: Least Recently Used, Least Frequently Used, Random.
  - Writing to Caches: Write-through vs. Write-back, handling misses with no-allocate or write-allocate policies.
- Types of Cache Misses
  - Cold Miss: Occurs when the cache is empty.
  - Capacity Miss: Cache is full.
  - Conflict Miss: Two blocks map to the same cache line.
- Cache Performance
  - Impacted by data layout, cache size, block size, number of sets, and lines per set.
  - Memory Mountain: Illustrates the relationship between cache size, block size, and access patterns on performance.