CSE4300 Homework 3 (Due on May 7th, 2019)

Q1. In a memory system, what is **fragmentation**? Discuss the difference between external fragmentation and internal fragmentation. **(5 points)**

Q2. Consider a paging hardware with TLB. Assume that the TLB has a hit ratio of 0.75. Searching TLB takes 30 ns and searching memory takes 200 ns in average. **(15 points)**
    a. What is the average cost to translate a virtual address to physical address?
    b. What is the cost if no TLB is used?

Q3. Consider virtual addressing of 32 bits. Assume that the page size is 8 KB. You have 16 GB of RAM. **(25 points)**
    a. How many **entries** do you need in the page table?
    b. How many bits are needed to **index** the page table?
    c. Assume that Table 1 lists all the virtual pages of process A that are currently in physical memory. If a virtual page is not listed in Table 1, it implies that any address in that range will result a page fault and will be a miss. **Translate** the following virtual addresses to physical address using the table below (if possible), and **mention** which will be hit and which will cause a miss: 13549, 45862, 38267, 144.

Virtual Page	Physical Page
1	4
5	7
3	12
0	9

Q4. Considering the following reference string:
3, 5, 0, 3, 0, 4, 3, 5, 1, 2, 4, 0, 3, 0, 2
for a memory with three frames, **illustrate** the following page-replacement algorithms and calculate **the number of page faults**. **(40 points)**
    a. FIFO
    b. OPT
    c. LRU
    d. Second-chance algorithm

Q5. What is Bélády's Anomaly and what property helps LRU avoid the anomaly? **(5 points)**

Q6. What is the cause of thrashing? How does the system detect thrashing? Once it detects thrashing, what can the system do to eliminate this problem? **(10 points)**