CSE 2431 **HOMEWORK 2** **SPRING 2025**

Electronic Submission: 11:59 pm, Thu Feb 13, 2025
Point: 25 points (5% of total grade)

Notes:
K = 2^{10}; M=2^{20}; G=2^{30}; index always starts from 0 (e.g. page 0 is the first page)

Question 1: Free Space Management [8 points]
Suppose the malloc library is using the mechanism described in our lecture (**Slide 31-38** of **SP25_CSE2431_Topic_5b_Virtual_Memory_Dynamic_Relocation** to manage free space. Assume that **base address is 0 (note that here we start from 0, different from your lecture slide)**, and virtual memory is **given from 0 up to max**. Assume the header **takes 8 bytes**.

1) At the beginning, we have 1KB of empty memory space. Draw the memory layout diagram. 1KB = 1024 Bytes – 8 bytes (for header) = 1016.
2) Following 1), suppose the user calls **`malloc(20)`.** Draw the memory layout diagram. (Clearly state all the pointers)
3) Following 2), suppose the user **continue** by calling **`malloc(120)`**. Draw the memory layout diagram. (Clearly state all the pointers)
4) Following 3), suppose the user **frees** the block from 2). Draw the memory layout diagram.

Question 2: Memory Allocation [6 points]
Suppose we have 1000K of memory where the first 100K is reserved. Also suppose that the system uses contiguous allocation, and the following processes have been allocated memory in the following order:

P1: 100K, P2: 100K, P3: 25K, P4: 200K, P5: 200K, P6: 75K, P7: 100K.

Create a diagram of memory (ignore header information to maintain free space).

Suppose that P2, P4, and P6 finish, and the following processes are on the queue waiting for memory (assume FIFO):

P8: 150K, P9: 25K, P10: 50K, P11: 25K.

Create a diagram of memory for each of the following algorithms showing how the memory would be allocated:

a) **First-Fit Policy**
b) **Best-Fit Policy**
c) **Worst-Fit Policy**

Notes:

- ***Assume that the algorithm starts at the smallest address of memory to determine each new allocation for First-Fit.***
- ***If there is a 'tie', that is, two locations in memory where a process could be loaded, use the smaller address.***

Question 3: Address translation (Related to Question 2) [3 points]

Following Question 2, suppose the system uses Best-Fit, translate the following virtual addresses into physical addresses:

1) Address 1K of P1
2) Address 1K of P8
3) Address 50K of P9

Question 4: Paging (Basic) [8 points]

Suppose a process can have a max virtual memory of 4KB, and a machine has a physical memory of 64KB. Suppose page/frame size is 1KB.

1) What is the minimal number of bits for virtual address (VA) and for physical address (PA)?
2) For a virtual address, how many bits should be used as offset and how many are for virtual page number (VPN)?
3) For physical address, how many bits should be used as offset and how many are for physical frame number (PFN)?
4) Suppose the following page table: page 0 -> frame 3; page 1 -> frame 4; page 2 -> frame 1; page 3 -> frame 10. Translate the following virtual addresses into physical addresses
    a. 0
    b. 1024
    c. 2000
    d. 4096