

# CS 520: Introduction to Operating Systems

## Homework Assignment #5 (due November 28, 2019)

Read Chapters 9, and 10 and make sure that you understand everything covered in Lectures 6 and 7—leave no rock unturned!

1. Write a program that implements the Buddy System algorithm for memory management. For input the program accepts 1) the amount of total available memory and 2) the sequence of integers with allocation (+) or return (-) requests. As output, the program must print the table showing the state of the memory (in the same way it is demonstrated in Lecture 6 after each allocation or return. Test the program with the following input parameters: Two megabytes of available memory and the following sequence: (A: +20K), (B: +35K), (C: +90K), (D: +40K), (E: +240K), (D: -40K), (A: -20K), (C: -90K), (B: -35K), (E: -240K). Turn in the listing of the program and the printout. **(35 points)**
2. A computer with a 32-bit address uses a two-level page table. Virtual addresses are split into a 9-bit top-level page table field, an 11-bit second-level page table field, and an offset. How large are the pages and how many are there in the address space? **(15 points)**
3. Below is an execution trace of a program fragment for a computer with 512-byte pages:

Load word 8118 (a value of a procedure input parameter) into register 0  
 Push register 0 onto the stack  
 Call a procedure at 4120 (the return address is stacked)  
 Remove one word (the actual parameter) from the stack and  
 Compare the actual parameter to constant 7  
 If equal, jump to 5000

The values of *PC* and *SP* are, respectively, 2020 and 10192. (The stack growth down—toward 0.) Each instruction occupies four bytes. Produce the page reference string generated by this program. **(10 points)**

4. 1) Explain the value and drawbacks of “non-traditional” hardware architectures for supporting virtual memory (i.e., *inverted page table* and *TLB-only*).
- 2) Using the *inverted* page table below,

0 | 2 | Process 11 | 3 | Process 22 | 1 | Process 13 | 0 | Process 24 | 0 | Process 1

give the physical page frame number corresponding to virtual page numbers 0, 1, and 2 of *Process 1*. (15 points)

4 2 0

5. Provide a proof that, with three-frame memory, MRU will result in  $3(l+1)$  page faults, and LFU will result in  $3[\min(k,l)+1]$  page faults, but FIFO and LRU will result only in six page faults on a reference string  $\omega = (1,2,3)^k (4,5,6)^l$ . (25 points)