CSC205 section 1 Spring 2015
Homework 10

How to Submit:
Please submit your solutions (parts A and B separately) through Blackboard. Remember to put your name and homework number on all the documents that you submit as attachments.

Total possible points in this homework: 10 for part B (+8 extra regular points if you get at least 5 points out of Q2)
(You receive 1 bonus point towards Part A if you get all Part A questions correct.)

Justification for allocation of extra points for part B:
Let X be in the set of students taking CSC205.
Let *a* be the event that X does well on the working set model.
Let *b* be the event that X does well on other homework (including the ones that cannot be assigned this year).

Given the following assumptions:
1. $P(a \wedge b) > P(a)P(b)$, that is events *a* and *b* are better than independent (that is, they are positively correlated);
2. $P(a \wedge b) > 0.5 * P(a)$, that is the probability that events *a* and *b* both happen is at least half as likely as event *a* happening;

(or equivalently, $P(a \wedge b) > P(a) * max(0.5, P(b))$).
It can be deduced that $P(b|a) > P(b|\sim a)$ *and* $P(b|a) > P(\sim b|a)$ where
$P(b|a) = P(a \wedge b)/P(a)$,
$P(\sim b|a) = 1 - P(b|a)$,
$P(b|\sim a) = (P(b) - P(a \wedge b))/(1 - P(a))$.
Statistics from past-year performance have firmly validated both assumptions 1 and 2. Therefore, for homework that cannot be assigned due to unforeseen circumstances, allocating those points to students who do well on this homework is the most reasonable meritocratic decision, compared to alternatives like assigning extra points uniformly to all (which is not meritocratic), or linearly scaling current grade (which does not provide a second chance for lost opportunities).

Part A

1. This problem explores the differences in memory utilization between paging and segmentation. Consider a system that has 64Kbytes of RAM dedicated to the storage of user programs during their execution. The following three programs are being run concurrently on the system. Program A: 20Kbytes; Program B: 31Kbytes; Program C: 17Kbytes.

    a. Scenario 1: The system implements virtual memory using paging. The page size is 16Kbytes. At a particular moment, the page tables of the 3 programs look like this:

Program A

Page	Frame
A0	0
A1	2

Program B

Page	Frame
B0	1
B1	-

Program C

Page	Frame
C0	-
C1	3

Compute the unused space in the RAM that is wasted to internal fragmentation.

b. Scenario 2: The system implements virtual memory using segmentation. At a particular moment, the segment tables of the 3 programs look like this:

Program A

Seg-ment	Size	Start location
A0	10K	0
A1	10K	40K

Program B

Seg-ment	Size	Start location
B0	24K	16K
B1	7K	-

Program C

Seg-ment	Size	Start location
C0	7K	53K
C1	10K	-

Compute the unused space in the RAM that is wasted to external fragmentation.

Part B

2. [10 pts] Read the article "The working set model for program behavior" by Denning 1968. (link: http://cs.gmu.edu/cne/pjd/PUBS/WSModel_1968.pdf) and answer the following questions.
   a. [0.5 pt] What is new in this work? (from *abstract*)
   b. [0.5 pt] What are the two constituents of the system demand of a *computation*? (from *1.Introduction*)
   c. [0.5 pt] What are the two reasons that a computer (operating system) cannot seek external help from the compiler when managing the system resources?
   d. [0.5 pt] Name four existing memory allocation strategies other than the one proposed by the author. (from *2.Background*)
   e. [0.5 pt] What is the meaning of the working set of a program? (from *3.Working Set Model*)
   f. [0.5 pt] When using the working set for memory allocation, what memory requirement must be met before a program can be run? (from the end of *3.Working Set Model*)
   g. [3 pts] Explain the definitions of the following symbols, either using the author's words, or using your own terminologies. Be as precise as possible.
      i. $W(t, r)$ and $\omega(t, r)$
      ii. $\{t_n\}_{n>=0}$ and $\{x_n\}_{n>=1}$
      iii. $F_x(\alpha)$
      iv. A, T and M
      v. $\lambda(r)$, $\varphi(r)$ and $\Phi(r)$
      vi. $\sigma(r)$

      Here are some examples:
      t denotes an instant of time
      r denotes the length of a time interval preceding t, over which the working set of a program is studied, and it is called the working set parameter
      x denotes the process-time interval between successive references to the same page.

h. [1 pt] At time t, suppose a process p has referenced pages 1, 2, 8, 12, 16 and 21 in the time interval r that just passed. Over the next time interval α, where $\alpha<r$, pages 1 and 8 are evicted and page 9 is loaded into the memory. Find $W(t, r)$, and $W(t+\alpha, r)$.
i. [2 pts] What are the four properties of a working set $W(t, r)$?
j. [1 pt] What choice of r does the author recommend? Why?