ASSIGNMENT 4 CMPT 300 SPRING 2014
PLEASE CHECK ASSIGNMENT WEB PAGE FOR DUE DATES

1 [38 points] Consider the following problem; there is a ferry dock on each side of a river. We will call this dock on this side of the river the ferry's home dock. We will call the dock on the other side of the river the ferry's destination dock. The ferry's destination dock is downstream of the ferry's home dock. At the ferry's home dock vehicles containing passengers load on the ferry to travel across the river. The ferry cannot leave the ferry's home dock until a full load of vehicles have been loaded. At the ferry's destination dock the vehicles unload from the ferry. The ferry cannot leave the unloading ferry dock until after all vehicles on the ferry have unloaded. The ferry needs to return to the ferry's home dock empty in order to make it upstream successfully. We need to consider vehicles traveling in one direction only from the ferry's home dock to the ferry's destination dock. All following conditions must be satisfied.

a) A vehicle is either a truck or a car. A vehicle is represented by a process.
b) The captain is represented by a process
c) Different waiting lines at the ferry dock should be represented in your program as different message queues. Message queues may hold messages from vehicles to the captain and messages from the captain to the vehicle or vehicles. You will need more than one message queue
d) Vehicles arrive at the home ferry dock at random times. In particular the time between the arrivals of two successive vehicles is taken from a uniform random distribution.
   A. The maximum length of time between the arrivals of two vehicles should be specified by the user of the program.
e) The user should specify the probability that the next vehicle to arrive will be a truck.
f) When a vehicle arrives at the ferry dock it sends a message to the captain indicating it is now waiting for the ferry
g) The ferry can take six cars (or equivalent) across the river each trip. One truck takes the same space on the ferry's deck as two cars.
h) On average trucks are heavier than two cars so the Ferry can carry a maximum of 2 trucks.
i) The ferry only makes a trip from the home dock to the destination dock when it is fully loaded (six cars, two trucks and two cars, one truck and four cars).
j) When the ferry arrives the home dock (or is ready to load for its first trip of the day) the captain will signal that the ferry is about to load
k) All vehicles presently in line when the captain signals that the ferry is about to load will be considered to be waiting vehicles.
l) Any vehicle not already in line when the captain signals the ferry is about to load will be told to wait in a separate lane (queue). Call any such vehicle a late arrival
m) To begin loading at the ferry's home dock the captain will signal enough vehicles for a full load. The following rules should be followed when determining which vehicles the captain should signal (which vehicles to load):
   A. Signal the first two waiting trucks. Here the first truck is the truck that arrived at the home ferry dock first (earliest).
      i. If there are less than three trucks waiting signal all waiting trucks,
   B. Signal enough waiting cars to fill the ferry.
   C. If there are not enough waiting cars to fill the ferry then consider the vehicles that

are late arrivals

i. If there is one or more trucks among the late arrivals, and there is room on the ferry for a truck or trucks, then signal the late arrival truck or trucks to load
ii. If there are no trucks (or the ferry is not full after trucks that fit have been loaded) then signal the late arrival cars

D. If there are presently no late arrivals that fit on the ferry, and the ferry is not yet full load each vehicle that fits on the ferry as it arrives, until the ferry is full.

n) The ferry cannot leave until a full load of vehicles has been loaded (both the captain and the vehicles themselves must know that they have been loaded. that is they must have receive and processed messages).

A. The vehicles the captain signalled in m) will load onto the ferry.
B. When a vehicle is loaded onto the ferry it will signal the captain that it has completed loading
C. When the captain knows all vehicles are loaded, the captain will tell vehicles that the ferry is about to sail
D. The ferry can sail

When the ferry arrives at the unloading ferry dock the vehicles will unload, as they unload they should signal the captain that they have unloaded. When all vehicles have unloaded the ferry returns to the loading ferry dock for the next load.

Your ferry simulation should end when the ferry arrives at the loading ferry dock for the 11^{th} load.

Think carefully about how to set up your queues so that all the required conditions are met, before you start programming. Use state diagrams to design program to implement a solution for this problem. Then implement your design using SYSV message queues (<linux/msg.h> <linux/ipc.h>). Make sure to hand in the state diagrams that you used to design your program. Make sure to use comments to explain how your program works (when your self documenting code does not make it obvious). A sample code (from http://www.linuxfocus.org/English/March2003/article287.shtml) using message queues is posted along with this assignment to give you a starting point.

DO NOT USE ANY SHARED MEMORY OR ANY SEMAPHORES OR MUTEXES

2 **[38 points]** Write a program to implement a solution for the problem described in problem 1. Use POSIX semaphores (semaphore.h) and threads (pthreads). Do not use shared memory. You must use pthread mutexes to protect critical sections not binary semaphores.

3 [12 points] Problem 28 (modified from text)

A computer has four page frames. The time of loading, time of last access, and the R and M bits for each page are as shown below. The times given in the tables are clock ticks, a larger number of ticks represents a later time. or each case explain why you think the page you chose should be the one that is replaced.

Page	Loaded	Last ref	R	M
0	106	340	1	0
1	172	199	0	0
2	229	288	0	1
3	10	370	1	1

(a) Which page will NRU replace?
(b) Which page will FIFO replace?
(c) Which page will LRU replace?
(d) Which page will second chance replace?

4 [12 points] modified from text

Suppose that a machine has 41 bit virtual addresses and 32 bit physical addresses.

(a) What is the main advantage of a multilevel page table over a single level one?
(b) Consider a two-level page table, using the minimum possible number of pages for the page table. The machine uses 64KB pages and 8 byte page table entries. For this machine how many page table entries can be placed on one page, how many pages of memory are needed to represent the whole virtual memory space, how many bits should be allocated for the second level page table, and how many bits should be allocated for the top level page table field? Explain how you determined each answer.

SUPPLEMENTAL PROBLEMS FOR REVIEW, solutions will be provided
(DO NOT HAND IN SOLUTIONS, THESE PROBLEMS WILL NOT BE GRADED)

5 **[12 points] (modified from text)**

In this problem you are to compare the storage needed to keep track of free memory using a bitmap versus using a linked list. The 64MB memory is allocated in units of n bytes. This means that there is one address for every n bytes of memory. For the linked list, assume that memory consists of an alternating sequence of segments and holes, each 16KB. This means that one link in the list will contain data and the next link will contain free blocks. Also assume that each node in the linked list needs a 32 bit memory address, a 16 bit length, and a 16 bit next node field. How many bytes of storage are required for each method? Which is better?

6 [12 points] (modified from text.)

Consider a swapping system in which memory consists of the following hole sizes in memory order: 3KB, 12KB, 4KB, 18KB, 11KB, 5KB, 16KB, 10KB. Which hole is taken for successive memory requests of (a) 14KB; (b) 10KB; and (c) 5KB for first fit? Now repeat the question for best fit, worst fit and next fit? At each step of each method explain why you chose the hole you did.

H1	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**
3KB	**12KB**	**4KB**	**18KB**	**11KB**	**5KB**	**16KB**	**10KB**

7 [12 points] (modified from text)

One way to use contiguous allocation of the disk and not suffer from holes is to compact the disk every time a file is removed. Since all files are contiguous, copying a file requires a seek time which on average will be 6msec, and a rotational delay which on average will be 3msec, a transfer rate of 4MB/sec. The average file size is 8 KB. How long does it take to read an average file into main memory and then write it back to the disk at a new location? Using these numbers, how long would it take to compact half of the 16-GB disk? Use 1GB=2^{30} bytes. In light of the the answers to the previous parts of this question, does compacting the disk ever make any sense?

8 [12 points] (from text)

Suppose that a system uses DMA for data transfer from disk controller to main memory. Further assume that it takes t1 nsec on average to acquire the bus and t2 nsec to transfer one word over the bus (t1>>t2). After the CPU has programmed the DMA controller, how long will it take to transfer 1000 words from the disk controller to the main memory, if

(a) Word at a time mode is used?

(b) Burst mode is used?

Assume that commanding the disk controller requires acquiring the bus to send one word and acknowledging a transfer also requires acquiring the bus to send one word.