CPSC/ECE 3220 – Fall 2017 – Final Exam **Name: _____**

>>>> No calculators allowed. <<<<

Word Bank for Chapters 11-13

Write one of the words or terms from the following list into the blank appearing to the left of the appropriate definition. Note that there are more words and terms than definitions. (1.5 pts. each)

absolute path	device driver	home directory	path	sector
access control list	directory	inode	physical record	seek
capability list	extent	logical record	relative path	track
defragment	file	metadata	root directory	volume

1. _____ A circle of sectors on a disk surface.

2. _____ The string that identifies a file or directory.

3. _____ A named collection of data in a file system.

4. _____ The unit of data transfer for an application.

5. _____ Moving the disk arm over the desired track.

6. _____ The unit of data transfer for a physical device.

7. _____ A path name that is interpreted relative to the root directory.

8. _____ A list of (object, access rights) tuples held by a user or application.

9. _____ A path name that is interpreted relative to the current working directory.

10. _____ A collection of physical storage resources that form a logical storage device.

11. _____ A variable-size region of a file that is stored in a contiguous region on a disk.

12. _____ A list of human-readable names and a mapping from each name to a specific underlying file or directory.

13. _____ A list of (user, access rights) tuples held by an object, which may be stored explicitly or in a compressed format.

14. _____ Information about a file that is understood and managed by the operating system (e.g., the file size, the file owner, the file security information).

15. _____ Coalescing scattered disk blocks to improve spatial locality, by reading data from its present storage location and rewriting it to a new location.

16. _____ A process, thread, or procedure that translates between the high level abstractions implemented by the operating system and the hardware-specific details of I/O devices.

NOTE: In order to receive any credit for the short-answer questions, your explanations must go beyond generic, superficial answers such as "better", "efficient", "faster", etc. You must explain your reasoning.

Part 1: Objectives of an Operating System

17. The textbook describes the OS acting in three different roles. Identify at least two distinct actions, features, or services provided by the OS in the role of referee. (2 pts.)

Part 2: The Kernel

Kernel mode / User mode. Circle ***one or both*** of K and U, as applies. (1 pt. each)

18. K / U An add instruction is allowed to execute in this mode.
19. K / U A value from the user stack can be loaded in this mode.
20. K / U All physical memory locations can be accessed in this mode.
21. K / U Validation of the parameters to a system call is performed in this mode.
22. K / U In a paging system, the Page Table Base Register can be loaded in this mode.

23. Most processors define an interrupt return (iret) instruction that can be used to change from kernel mode back to user mode. Explain where in the OS this instruction would be used. (2 pts.)

Part 3: Programs, Process, and Threads

Program / Multithreaded Process / Thread. Circle ***only one*** of P, MTP, or T, as applies. (1 pt. each)

24. P / MTP / T The UNIX fork() system call creates an object of this type.
25. P / MTP / T This object has a scheduling state (e.g., running, ready, waiting).
26. P / MTP / T This object has a one-to-one association with a user SP (stack pointer).
27. P / MTP / T This object is the abstraction for protection provided by the operating system kernel.
28. P / MTP / T In a virtual memory paging system, this object has a one-to-one association with a page table.

29. What was the possible problem with this code pattern? (2 pts.)

```
If( !exists( file ) ){
        create( file );
}
open( file );
```

Part 4: Concurrency and Synchronization

30. Fill in the blanks. (1 pt. each blank)

a. A _____ condition occurs when the behavior of a program depends on the interleaving of operations of different threads.

b. Memory barrier instructions are needed since hardware can _____ load and store instructions.

c. Implementing a lock by disabling interrupts without taking any further actions is only appropriate on a _____ system.

d. A spin lock uses the _____ instruction to spin in a tight loop until some other thread releases the lock.

e. A Mellor-Crummey and Scott (MCS) lock implements a queue of waiting threads without using a spinlock. A waiting thread is atomically added to the tail of the queue using the _____ instruction.

f. Read-copy-update (RCU) provides high-performance synchronization for data structures that are frequently _____ and occasionally _____.

31. What synchronization actions are missing or performed incorrectly in the following two methods for the blocking bounded queue (BBQ)? (5 pts.)

```
int BBQ::remove(){
        int item;

        if ( front == nextEmpty ) {
                itemAdded.signal( & lock );
        }

        item = items[ front % MAX ];
        front++;

        itemRemoved.signal();

        lock.release();

        return item;
}
```

```
void BBQ::insert( int item ){

        while ( (nextEmpty – front) == MAX ) {
                itemRemoved.wait( & lock );
        }

        lock.acquire();

        items[ nextEmpty % MAX ] = item;
        nextEmpty++;

        itemAdded.wait();

}
```

Part 5: Deadlock

32. Give at least one deadlock prevention technique and explain which one of the four necessary conditions for deadlock is being prevented. (2 pts.)

Part 6: Scheduling

FIFO / RR / MFQ / SJF-preemptive. Circle ***one or more*** of F, R, M, S, as applies. (2 pts. each)

33. F / R / M / S Allows starvation.
34. F / R / M / S Uses future knowledge.
35. F / R / M / S Uses time quantums (i.e., time slices).
36. F / R / M / S Would not be the basis of the scheduling policy for a time-sharing system.

37. When would RR (round robin) produce the same exact results as FIFO? (1 pt.)

38. Some systems allow a signal operation to include a temporary scheduling priority boost. Explain the purpose of this boost. (2 pts.)

Part 7: Address Translation and Virtual Memory

Paging / Segmentation. Circle ***one or both*** of P or S, as applies. (1 pt. each)

39. P / S Can have external fragmentation.
40. P / S Requires loading of one or more privileged CPU registers on a process switch.

41. Explain what the term “superpage” means and how the concept helps improve TLB performance. (2 pts.)

One address translation scheme for the DEC Alpha used a 43-bit virtual address with three levels of page tables. The virtual address was divided into the following fields (the numbers are the field lengths in bits):

level 1	level 2	level 3	page offset
10	10	10	13

Answer questions 42-45 using powers of 2 for the address format above. Use bytes as the addressable units.

42. How big is a page in bytes? (2 pts.)

43. If a page table entry is 8 bytes in size, how big is a page table in bytes? (2 pts.)

44. If a page frame number within a page table entry is 32 bits, what is the maximum size of physical memory in bytes? (2 pts.)

45. Consider a data structure of 1 GB. How many level-2 page table entries do you need to map the structure? (2 pts.)

46. You want to implement zero-copy-I/O in a paged virtual memory. Explain the approach you need to take to implement this feature. (2 pts.)

Part 8: File, Directories, and Storage Devices

47. Label the following steps that occur in opening an existing file in their proper sequential order, 1-3. (1 pt. each)

____ Initialize the file position pointer in the per-open data structure to the first byte (or record) of the file.

____ Find the directory entry for the named file. Check the access permissions and return an error code if the requested access is not allowed.

____ Create a process-local per-open data structure and record the access permission under which the file was opened and the location of the file's inode (or other location information).

48. What is the purpose of the fsync() operation? (3 pts.)

49. Should you allow a user program to write bytes in a directory file? Give a justification for your answer. (3 pts.)

50. Why did we reject linked-list storage with links located in the disk blocks? (3 pts.)

Microsoft FAT, UNIX FFS, and Microsoft NTFS all uses links (i.e., pointers) for large files.

51. How does Microsoft FAT differ from linked-list storage with links located in the disk blocks? (3 pts.)

52. How does UNIX FFS differ from linked-list storage with links located in the disk blocks? (3 pts.)

53. How does Microsoft NTFS differ from linked-list storage with links located in the disk blocks? (3 pts.)