

CPSC 457  
OPERATING SYSTEMS  
FINAL EXAM

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This is a CLOSED BOOK exam. Textbooks, notes, laptops, calculators, personal digital assistants, cell phones, and Internet access are NOT allowed.

It is a 120-minute exam, with a total of 100 marks. There are 18 questions, and 11 pages (including this cover page). Please read each question carefully, and write your answers legibly in the space provided. You may do the questions in any order you wish, but please USE YOUR TIME WISELY.

When you are finished, please hand in your exam paper and sign out. Good luck!

Student Name: \_\_\_\_\_

Student ID: \_\_\_\_\_

Score: \_\_\_\_\_ / 100 = \_\_\_\_\_ %

## Multiple Choice

Choose the best answer for each of the following 12 questions, for a total of 12 marks.

- 1 1. Three **file descriptors** associated with every Linux process are:
  - (a) standard input, standard output, and standard pipe
  - (b) standard input, standard output, and standard error
  - (c) standard input, standard output, and standard deviation
  - (d) standard input, standard output, and standard terminal
  - (e) standard input, standard output, and standard transmission
  
- 1 2. User Mode Linux (UML) is an example of a **virtual machine** environment in which:
  - (a) Linux runs on top of Windows
  - (b) Linux runs on top of Linux
  - (c) Windows runs on top of Linux
  - (d) Windows runs on top of Windows
  - (e) none of the above
  
- 1 3. During the **boot process**, a computer obtains its initial bootstrapping information from:
  - (a) a special “boot block” on disk
  - (b) the superblock in the root file system
  - (c) a pre-configured file `vmunix` within the file system
  - (d) the `/tmp` file system
  - (e) none of the above
  
- 1 4. The **copy-on-write** mechanism provides:
  - (a) an efficient way to create new processes
  - (b) a clever way to share virtual memory pages (at least temporarily)
  - (c) a way to avoid unnecessary page copying
  - (d) all of the above
  - (e) none of the above

- 1 5. In memory management, **global** page replacement is usually preferable to **local** page replacement because:
  - (a) most processes are well-behaved
  - (b) most processes have small working sets
  - (c) most processes have large working sets
  - (d) most processes are highly synchronized
  - (e) the set of pages from which to choose is larger
  
- 1 6. Implementing **LRU** precisely in an OS is expensive, so practical implementations often use an approximation called:
  - (a) MRU
  - (b) MFU
  - (c) LFU
  - (d) LFU with aging
  - (e) none of the above
  
- 1 7. For two processes accessing a shared variable, **Peterson's algorithm** provides:
  - (a) mutual exclusion
  - (b) progress
  - (c) bounded waiting
  - (d) all of the above
  - (e) none of the above
  
- 1 8. **Counting semaphores**:
  - (a) generalize the notion of a binary semaphore
  - (b) are used for managing multiple instances of a resource
  - (c) have increment and decrement operations
  - (d) can use queueing to manage waiting processes
  - (e) all of the above

- 1 9. The **Banker's Algorithm** is an example of a technique for:
- (a) deadlock prevention
  - (b) deadlock avoidance
  - (c) deadlock detection
  - (d) deadlock recovery
  - (e) stabilizing turbulent financial markets
- 1 10. With **asynchronous I/O**, file system changes will be committed to disk when:
- (a) the in-memory inode is updated
  - (b) the **sync** daemon runs
  - (c) the system administrator feels like doing it
  - (d) nightly file system backups are run
  - (e) the system is rebooted
- 1 11. The operation of **defragmenting** a hard disk:
- (a) uses compaction to combat internal fragmentation
  - (b) uses compaction to combat external fragmentation
  - (c) uses compression to combat internal fragmentation
  - (d) uses compression to combat external fragmentation
  - (e) all of the above
- 1 12. Which of the following is an **idempotent** request?
- (a) read the next byte from file **foople**
  - (b) read block 3 from file **foople**
  - (c) write this block to the end of file **foople**
  - (d) append file **foople** to file **boople**
  - (e) link file **foople** to file **boople**

## OS Concepts and Definitions

15 13. For each of the following pairs of terms, **identify** the context(s) in which they occur. Then **define** each term and **clarify** the key difference(s) between the two terms.

(a) (3 marks) “host OS” and “guest OS”

(b) (3 marks) “page” and “frame”

(c) (3 marks) “reference bit” and “dirty bit”

(d) (3 marks) “file” and “directory”

(e) (3 marks) “disk partition” and “file system volume”

## Processes

- 16 14. Answer the following questions about processes.
- (a) (4 marks) What is a **process**? What is a **thread**? How are they similar/different?
- (b) (6 marks) There are many **system processes** active on any Linux system. These are typically created at system startup, and operate in the background as daemon processes. Give **three examples** of system (daemon) processes in a Linux system, and briefly state their role in the operation of the system.
- (c) (6 marks) When multiple processes need to cooperate, there is a choice between **shared memory** and **inter-process communication (IPC)**. Compare and contrast these two techniques. Make sure to clarify the role of the operating system in each.

## Memory Management

- 15 15. Answer the following questions about OS memory management.
- (a) (4 marks) One of the design decisions in OS memory management is the choice between **swapping** and **paging**. Define each of these terms, and clarify their respective roles in OS memory management.
- (b) (5 marks) Another key design decision in OS memory management is the choice between **paging** and **segmentation**. Compare and contrast these two approaches to memory management, making sure to identify the strengths and weaknesses of each.
- (c) (6 marks) In pure on-demand paging, a **page replacement policy** is used to manage system resources. Suppose that a newly-created process has 3 page frames allocated to it, and then generates the page references indicated below.
- (i) How many page faults would occur with **FIFO** page replacement?
- A B C B A D A B C D A B A C B D
- Circle** the references that would generate a page fault.
- (ii) How many page faults would occur with **LRU** page replacement?
- A B C B A D A B C D A B A C B D
- Circle** the references that would generate a page fault.
- (iii) How many page faults would occur with **OPT** page replacement?
- A B C B A D A B C D A B A C B D
- Circle** the references that would generate a page fault.





## File System Details

- 12 17. The following page shows some output from some file-system related commands on a local Linux system. Use this output and your knowledge of Linux file systems to answer the following questions.
- (a) (1 mark) **How many** different file systems are accessible on this Linux system?
  - (b) (1 mark) Which file system is the **fullest** (in terms of percent occupancy)?
  - (c) (1 mark) Which file system has the **largest** physical storage capacity?
  - (d) (1 mark) Which file system has the **fewest** bytes currently stored?
  - (e) (1 mark) Which disk partition (if any) is being used for **swap space**?
  - (f) (1 mark) What is the **type** of the `/tmp` file system?
  - (g) (1 mark) What is the **type** of the `/proc` file system?
  - (h) (1 mark) How many file systems are remotely mounted using **NFS**?
  - (i) (1 mark) Which file system is remotely mounted on server **nsh**?
  - (j) (1 mark) Is this NFS service provided using **UDP or TCP**?
  - (k) (2 marks) What **block sizes** are used for reading and writing via NFS?

```
[carey@csl]$ df
```

Filesystem	1K-blocks	Used	Available	Use%	Mounted on
/dev/sda2	20315844	7513824	11753380	39%	/
/dev/sda5	10581704	5181092	4854404	52%	/tmp
/dev/sda1	1019208	50356	916244	6%	/boot
tmpfs	1684784	77164	1607620	5%	/dev/shm
nsi:/export/research	247709760	203879488	31247360	87%	/home/research
nse:/export/scratch	3361364788	528637368	2661979928	17%	/home/scratch
nsj:/export/proj/dsl	485097928	184513976	275942416	41%	/home/dsl
nsg:/export/ug	381885660	79136396	283350608	22%	/home/ugc
nsf:/export/ug	381885660	88768580	273718424	25%	/home/ugb
nsh:/export/grads	789574392	507946744	241519616	68%	/home/grads
nsb:/export/ug	381885660	76958700	285528304	22%	/home/uga

```
[carey@csl]$ cat /etc/fstab
```

LABEL=/	/	ext3	defaults	1 1
LABEL=/tmp	/tmp	ext3	defaults	1 2
LABEL=/boot	/boot	ext3	defaults	1 2
tmpfs	/dev/shm	tmpfs	defaults	0 0
devpts	/dev/pts	devpts	gid=5,mode=620	0 0
sysfs	/sys	sysfs	defaults	0 0
proc	/proc	proc	defaults	0 0
LABEL=SWAP-sda3	swap	swap	defaults	0 0

```
[carey@csl]$ mount
```

```
/dev/sda2 on / type ext3 (rw)
proc on /proc type proc (rw)
sysfs on /sys type sysfs (rw)
devpts on /dev/pts type devpts (rw,gid=5,mode=620)
/dev/sda5 on /tmp type ext3 (rw)
/dev/sda1 on /boot type ext3 (rw)
tmpfs on /dev/shm type tmpfs (rw)
none on /proc/sys/fs/binfmt_misc type binfmt_misc (rw)
sunrpc on /var/lib/nfs/rpc_pipefs type rpc_pipefs (rw)
nsi:/export/research on /home/research type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nse:/export/scratch on /home/scratch type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nsj:/export/proj/dsl on /home/dsl type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nsg:/export/ug on /home/ugc type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nsf:/export/ug on /home/ugb type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nsh:/export/grads on /home/grads type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
nsb:/export/ug on /home/uga type nfs (rw,intr,tcp,rsize=32768,wsiz=4096)
```

## General Operating Systems Knowledge

- 15 18. Throughout CPSC 457 this year, there were several recurring **themes** (i.e., ideas that applied quite broadly across several topics).
- (a) (5 marks) One of these themes was **virtualization**. Identify **three** contexts in which virtualization was used as a solution technique. Briefly discuss the technical issues involved, and the benefits of the virtualization approach to the problem.
  
  - (b) (5 marks) A second theme was **hardware support**. Identify **three** contexts in which hardware support was used as a solution technique. Briefly discuss the technical issues involved, and the benefits of a hardware-based approach to the problem.
  
  - (c) (5 marks) A third theme was **caching**. Identify **three** contexts in which caching was used as a solution technique. Briefly discuss the technical issues involved, and the benefits of caching as a solution.

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