

This exam is **closed book**. You can have **one sheet** (i.e., **two pages**) of notes.
Please answer every part of every question

1. Match each of the following UNIX features with the function it performs: (10×2 points)
(*Hint: Some of the choices offered are plain wrong.*)

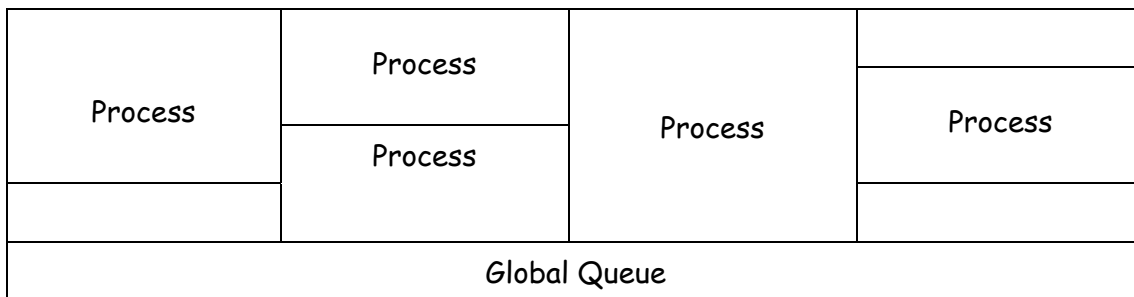
<i>pipe</i>	<u> l </u>	<i>fork()</i>	<u> d </u>
<i>i-node</i>	<u> b </u>	<i>exec()</i>	<u> k </u>
<i>special files</i>	<u> a </u>	<i>superblock</i>	<u> e </u>
<i>valid bit</i>	<u> j </u>	<i>lseek()</i>	<u> g </u>
<i>stream</i>	<u> i </u>	<i>indirect block</i>	<u> c </u>

- a) Allow programs to read from and write to physical devices.
 - b) Contains most file attributes.
 - c) Contains addresses of other blocks.
 - d) Creates a new process.
 - e) Describes the contents of a disk partition.
 - f) Implements a Windows NT 4.0 API.
 - g) Modifies the position of the next byte to be accessed in an opened file.
 - h) Provides a fast but unreliable method to transfer data over the Internet.
 - i) Provides a reliable method to transfer data over the Internet.
 - j) Sometimes used to simulate the page referenced bit.
 - k) Loads in memory the program to be executed by a given process.
 - l) Used to send the standard output of a program to the standard input of another one.
2. Assume that your are **doubling** the memory size of a workstation running Berkeley UNIX. How should that affect the **optimal angle** between the two hands of the UNIX page replacement policy? (5 points)

Keeping the angle constant would double the number of page frames included in that scan. Since there would be less pages being expelled, the two hands of the clock would also move more slowly. This means that keeping the angle unchanged would result in keeping unused pages for too long. I would thus halve the angle.

3. Describe in some detail the page replacement policy of VMS(10 points minus 4 points if no diagram) and explain its main respective advantage and disadvantage (2×5 points)

VMS page replacement policy combines some aspects of FIFO and least recently used. VMS assigns to each process a fixed size partition called the process' *working set* and uses a FIFO replacement policy to manage it. Pages that are expelled from a working set are put at the end of a large global queue of pages waiting to be expelled from main memory. These pages are also marked invalid in the page tables of their respective processes. Every time a page fault occurs, VMS scans first this global queue before attempting to bring the missing page from secondary storage.



Advantages: The mechanism approximates LRU quite well provided that (a) enough pages are allocated to the process working sets to keep the number of false page faults under control, and (b) the global queue is large enough to allow the rescue of pages that had been erroneously expelled from the working set of their process. In addition, it supports real-time processes.

Disadvantages: It does not work well if processes have memory requirements that change over time

4. Consider a Mach process consisting of a code segment, a data segment, a mapped file and a shared memory segment. What should be the inheritance attribute of
- its *code segment*? (5 points) _____ **share**
 - its *data segment*? (5 points) _____ **copy**
 - its *mapped file*? (5 points) _____ **share**
 - its *shared memory segment*? (5 points) _____ **share**

Assume now that we want to create another thread within the address space of that process. What do we need to change before forking that thread? (5 points)

Make the inheritance attribute of the data segment share.

5. Consider a clustered page table interacting with a TLB implementing subblocking. Assuming a *subblocking factor of 4* and *64 bit addresses*, what would be the size of the page table entry assuming that:

a) the TLB implements *full subblocking*? (5 points) _____ **6x8=48 bytes**
(one VPN, four PPN and one next pointer, all 8-byte long)

b) the TLB implements *partial subblocking*? (5 points) _____ **3x8=24 bytes**
(one VPN, one PPN and one next pointer, all 8-byte long; the valid bit vector is stored in the unused byte of the PPN)

6. Explain how Mach copy-on-write feature speeds up *fork()* system calls. (5 points)

Most *fork()* system calls are quickly followed by an *exec()* with only I/O redirection tasks being performed between the two. As a result, extremely few pages of the child process address space are modified. With copy-on-write, only these very few pages will be duplicated.

7. What is the main difference between *superpages* and *subblocks*? (5 points)

The main difference between *superpages* and *subblocks* is that all pages in a *subblock* do not need to be simultaneously present in main memory.

8. Why does the UNIX Fast File System subdivide each disk partition into *cylinder groups*? (5 points)

Partitioning each disk partition into *cylinder groups* allows UNIX to store most file blocks in the same *cylinder groups* as the file *i-nodes* thus reducing disk arm motions.