

### 1) Hardware support

- A. Give an example use for hardware interrupts.  
**Pressing a key on the keyboard or moving the mouse triggers hardware interrupts that cause the processor to read the keystroke or mouse position.**
- B. Give an example of what may generate a hardware trap.  
**Division by zero or invalid access to memory would generate a hardware trap.**

### 2) OS

- A. What are the responsibilities of an operating system?
- **Hiding the complexities of hardware from the user**
  - **Managing between the hardware's resources which include the processors, memory, data storage and I/O devices**
  - **Handling "interrupts" generated by the I/O controllers**
  - **Sharing of I/O between many programs using the CPU**
- B. Which POSIX system call creates a new process?  
**fork()**
- C. Which POSIX system call runs a new binary program over the current process.  
**exec()**
- D. What does SYSGEN do for Linux?  
**Configures the OS for a specific platform**

### 3) Threads

- A. What is the minimal number of threads in a traditional, heavyweight process?  
**1**
- B. Provide four benefits of multithreaded programming.
- **Resource sharing**
  - **Program structure simplification**
  - **Minimized system resource usage**
  - **Improved throughput**
- C. List three common ways of mapping user threads to kernel threads.
- **Many-to-one**
  - **One-to-one**
  - **Many-to-many**
- D. What is the PThread API for creating a thread?  
**int pthread\_create(pthread\_t \*thread, const pthread\_attr\_t \*attr, void \*(\*start\_routine) (void \*), void \*arg)**

E. What is the PThread API for terminating a thread?

**void pthread\_exit(void \*retval)**

F. What are the five states a thread may be in?

- **New**
- **Ready**
- **Running**
- **Waiting**
- **Terminated**

#### 4) Synchronization

A. What is the term for describing the situation where shared data may be manipulated concurrently and the outcome of the execution depends on the order of access?

**Race condition**

B. What term describes the segment of code where shared data is accessed and possibly modified?

**Critical section**

C. What are the three requirements for a solution to the critical-section problem?

- **Mutual exclusion**
- **Bounded waiting**
- **Progress**

D. What are the two English operations on mutex locks?

- **acquire()**
- **release()**

E. What are the two single letter Dutch operations on a semaphore and give their longer English names?

- **P() --- wait**
- **V() --- signal**

F. Name one modern programming language that incorporates monitors.

**Java**

#### 5) CPU Scheduling

A. What type of job had a pattern of many short CPU bursts?

**I/O bound**

B. What type of job has a pattern of a few long CPU bursts?

**CPU bound**

C. List three different criteria for designing a CPU scheduling algorithm.

- **CPU utilization**
- **Throughput**
- **Turnaround time**

D. What scheduling algorithm assigns CPU to the process with the highest urgency?

**Priority scheduling**

- E. What scheduling algorithm assigns CPU to the process that first requests it?  
**First Come First Serve (FCFS)**
- F. What scheduling algorithm assigns CPU to the process for a time slice or quantum and treats the ready queue as a circular queue?  
**Round Robin (RR)**
- G. What scheduling algorithm assigns CPU to the process with the shortest burst?  
**Shortest Job First (SJF)**
- H. In a multilevel feedback queue scheduling algorithm, what may happen if a process uses too much CPU time or if it waits too long in a low-priority queue?  
**Migrate to a different queue**
- I. If a thread on Solaris exhausts its time quantum without blocking, will its priority go up or down?  
**Down**

## 6) Deadlocks

- A. What are the four conditions that must hold to allow deadlock?
- **Mutual Exclusion**
  - **Hold and Wait**
  - **No Preemption**
  - **Circular Wait**
- B. Other than ignoring deadlocks, name three approaches to handling deadlocks.
- **Prevention**
  - **Avoidance**
  - **Detection & Recovery**
- C. What is the name of Dijkstra's classic deadlock avoidance algorithm?  
**Banker's Algorithm**
- D. Name two methods for recovering from deadlock.
- **Abort all deadlocked processes**
  - **Abort one process at a time until deadlock cycle is eliminated**

## 7) Mass Storage Structure

- A. True or False? Magnetic disks provide the bulk of secondary storage for modern computer systems.  
**True**
- B. True or False? Solid state disks have the same characteristics as traditional hard disks.  
**False**
- C. What is the term for the smallest unit of transfer between a disk?  
**Logical block**
- D. What are the two ways a computer can access disk storage?
- **Host-attached**
  - **Network-attached**

- E. List the three general disk scheduling algorithms.
- **First Come First Serve (FCFS)**
  - **Shortest Seek Time First (SSTF)**
- F. What disk scheduling algorithm is typically used with solid state disks?  
**First Come First Serve (FCFS)**
- G. What must be done to a disk before it can be used for storage?  
**Physical formatting**
- H. Where does the Windows system place its boot code?  
**Master Boot Record**
- I. True or False? Most modern systems swap entire processes to swap space.  
**False**
- J. What are the two main improvements of using RAID?
- **Improved Performance**
  - **Reliability**
- K. What are the three possible outcomes when writing to disk?
- **Successful completion**
  - **Partial failure**
  - **Total failure**

## 8) File System Interface

- A. List at least five attributes of a file.
- **Name**
  - **Location**
  - **Size**
  - **Protection**
  - **Last modification date**
- B. List five common operations that may be performed on a file.
- **Read**
  - **Write**
  - **Create**
  - **Delete**
  - **Truncate**
- C. What are the two fundamental ways of accessing a file?
- **Sequential Access**
  - **Direct Access**
- D. What is a volume?  
**An entity containing a file system**
- E. What is the most common way of structuring directories?  
**Tree structured**
- F. True or False? UNIX systems allow acyclic-graph directories.  
**True**

G. If a mount point is /home and the device jane/programs is mounted on the mount point, what is the complete path name to access the programs directory?

**/home/jane/programs**

H. Name one type of remote file system.

**Distributed file system**

I. Name one example of a distributed information system.

**Domain Name System (DNS)**

J. What are the three general classifications of users in connection with each file in Linux?

- **Owner**
- **Group**
- **Everyone**

9) Consider the following page reference string:

e, c, b, e, a, g, d, c, e, g, d, a

With 4 frames, how many page faults would occur with the following page replacement algorithms? Fill in the tables accordingly.

RS: reference strings; F0: frame 0, F1: frame 1, etc.

*Hint: all frames are initially empty, so your first unique pages will all cost one fault each.*

1) Optimal

Time	1	2	3	4	5	6	7	8	9	10	11	12
RS	e	c	b	e	a	g	d	c	e	g	d	a
F0	e	e	e	e	e	e	e	e	e	e	e	a
F1		c	c	c	c	c	c	c	c	c	c	c
F2			b	b	b	g	g	g	g	g	g	g
F3					a	a	d	d	d	d	d	d
Page fault?	Y	Y	Y	N	Y	Y	Y	N	N	N	N	Y

Total page fault:

2) LRU

Time	1	2	3	4	5	6	7	8	9	10	11	12
RS	e	c	b	e	a	g	d	c	e	g	d	a
F0	e	e	e	e	e	e	e	c	c	c	c	a

F1		c	c	c	c	g	g	g	g	g	g	g
F2			b	b	b	b	d	d	d	d	d	d
F3					a	a	a	a	e	e	e	e
Page fault?	Y	Y	Y	N	Y	Y	N	Y	N	N	N	Y

Total page fault:

### 10) Paging and TLB

A computer keeps its space tables in memory. The overhead required for reading a word from the page table is 3 microseconds. To reduce this overhead, the computer has TLB, which holds pairs (virtual page, physical page frame), and can do a lookup in 500 nanoseconds. What hit rate is needed to reduce the mean overhead to 1500 nanoseconds for reading a word from page table?

Units = nanoseconds,  $h$  = hit-rate

$$500h + 3000(1 - h) = 1500$$

$$500h + 3000 - 3000h = 1500$$

$$-2500h = -1500$$

$$h = 0.6 \text{ nanoseconds}$$