Word Bank. 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 pt. each)

- asynchronous I/O
- hardware timer
- portability
- running list
- continuation
- host OS
- privileged instruction
- thread
- exception
- interrupt handler
- process
- thread context switch
- finished list
- interrupt masking
- ready list
- throughput
- green threads
- microkernel
- resource
- virtualization
- guest OS
- monolithic kernel
- response time
- waiting list

1. ________________ An operating system running in a virtual machine.
2. ________________ A kernel procedure invoked when an interrupt occurs.
3. ________________ The ability to temporarily defer any hardware interrupts.
4. ________________ Instruction available in kernel mode but not in user mode.
5. ________________ The ability of software to work across multiple hardware platforms.
6. ________________ A physical or virtual entity that can be assigned to a user or application.
7. ________________ A hardware device that can cause a processor interrupt after some delay.
8. ________________ A single execution sequence that represents a separately schedulable task.
9. ________________ Provide an application with the illusion of resources that are not physically present.
10. ________________ An OS design where most of the OS functionality is linked together inside the kernel.
11. ________________ A data structure used in event-driven programming that keeps track of a task’s current state and its next step.
12. ________________ A hardware event caused by the user program behavior that causes a transfer of control to a kernel handler.
13. ________________ The set of threads that are complete but not yet de-allocated, e.g., because a join may read the return value from the TCB.
14. ________________ The execution of an application program with restricted rights – the abstraction for protection provided by the operating system kernel.
15. ________________ A thread system implemented entirely at user-level without any reliance on operating system kernel services, other than those designed for single-threaded processes.

Kernel mode / User mode. Circle one or both of K and U, as applies. (2 pts. each)

16. K / U The interrupt masking can be changed in this mode.
17. K / U An add instruction is allowed to execute in this mode.
18. K / U Values can be loaded into the hardware timer in this mode.
19. K / U All physical memory locations can be accessed in this mode.
20. K / U A jump-to-subroutine instruction is allowed to execute in this mode.
**Process / Thread.** Circle **one or both** of P or T, as applies. (2 pts. each)

21. P / T Has a 1-to-1 association with a data segment.
22. P / T Has a 1-to-1 association with a stack segment.
23. P / T Has a 1-to-1 association with a PC (program counter).
24. P / T Has a scheduling state (i.e., READY, RUNNING, WAITING).
25. P / T Has a 1-to-1 association with a PSR (processor status register).

**True / False.** Circle **only one** of T or F. (2 pts. each)

26. T / F A user stack will always be in a valid state.
27. T / F An operating system kernel can use internal threads.
28. T / F Interrupt handlers are scheduled by the thread scheduler.
29. T / F The OS provides a common set of services in the role of referee.
30. T / F The OS manages resources and facilitates sharing in the role of referee.
31. T / F Threads created by a single program share the same memory address space.
32. T / F Asynchronous I/O requires that a running thread must create a separate I/O thread.
33. T / F Threads are less expensive for the operating system kernel to create than processes.
34. T / F To provide multiuser protection, hardware must have at least three execution modes.
35. T / F When a user attempts to execute a privileged instruction in user mode the CPU should halt.
36. T / F The interrupt vector table should be held in kernel memory and not arbitrarily changed by users.
37. T / F A loadable device driver means that the kernel does not have to be recompiled to use the device.
38. T / F In a typical modern OS, each schedulable unit of execution needs to have its own protection domain.
39. T / F The producer-consumer communication pattern allows two-way communication between processes.
40. T / F fork() in UNIX creates a new process, which then executes the function that is passed as an argument.

**Short Answer.** To receive credit, your answers must be specific and go beyond aspirational/warm-fuzzy words or terms such as efficiency, performance, protection, reliability, and security. (5 pts. each)

41. Why is a normal subroutine call not appropriate to invoke and interact with the operating system kernel?
42. The four generic actions that hardware performs in response to an interrupt are:

43. If the hardware provides separate user and kernel stacks, at what point must the action of switching to the kernel stack occur in the sequence of generic actions you listed in question 42 above, or does the exact timing of the switch between stacks not matter? Explain your answer.

44. How does the kernel periodically regain control of the processor?

45. The textbook states that there are many possible design approaches to the internal program structure within a monolithic kernel but that there have been two common structuring concepts used. Identify them.
46. What are two advantages of kernel-buffered writes for the producer-consumer communication pattern?

47. What is the benefit of having device drivers run in user mode?

Extra credit. (Not applicable for Spring 2020 since the UNIX paper was assigned earlier in the semester for Fall 2019.)

XC-1. What is considered to be the universal interface for program I/O for Unix?

XC-2. Define filter in the context of a Unix system.

XC-3. Name two common Unix filter programs.