a) (0.4 pt.) What are five layers of operating system we discussed during the semester?
   a. Process & Thread Management
   b. Memory Management
   c. File Management
   d. Deadlock Management
   e. Input/Output Management

b) (0.4 pt.) A device controller is responsible for managing a specific type of I/O device. What is in charge of the device controller? **It is responsible for moving data between the physical devices and its local buffer storage, as well as sending signals to the OS to indicate readiness for data transfer.**

c) (0.4 pt.) What is Von Newmann Bottleneck? – **Since fetch cycle is much slower than execute cycle, there are bottleneck.**

d) (0.4 pt.) What is the reaction of operating system when the CPU is interrupted by any I/O devices?
- **OS stops what currently doing and immediately transfers execution to a fixed location where the service routine for the interrupt is located.**

e) (0.4 pt.) What is a role of interrupt-request line?
- **CPU detect interrupt from the interrupt-request line and it reads the interrupt number and jump to the interrupt handler routine**

f) (0.2 pt.) The form of interrupt-driven I/O is fine for moving small amounts of data but can produce high overhead when used for bulk data movement. What is the solution to reduce the overhead?
- **DMA**

g) (0.4 pt.) A CPU composed with several components: ALU, control unit registers. Program counter is one of registers in CPU. What is the role of program counter – **save the virtual address of the next instruction.**

h) (0.4 pt.) What is **Batch System** in the second-generation computer? – **similar job is collected and save in a magnetic tape and implement one by one sequentially.**

i) (0.4 pt.) What is **multiprogramming**? –several jobs are loaded into RAM and OS support pseudo-parallelism.

j) (0.4 pt.) A CPU is composed of several components: ALU, Control Unit, Cache, and Registers. Depending on the architecture, CPUs may have varying numbers and types of registers, such as General Registers, Program Counter, Stack Pointer, Program Status Word, and so on. What is the role of Stack Pointer? **Save the address of the top of the stack for the currently running process.**

k) (0.4 pt.) Why deadlocks between processes are necessary, if OS do not take care of deadlock? **Since limited number resources which must be shared between processes.**

l) (0.4 pt.) Microkernel is one of the operating system structures. Briefly explain the basic idea of the microkernel. –**to achieve high reliability, OS is broken into small well-defined module. Only one module (Microkernel) run in kernel mode and the rest run as user mode.**

m) (0.4 pt.) What are three main functions for OS to control each of I/O devices

- **Issue I/O command to devices**
- **catch interrupts from each I/O devices**
- **handle errors**

n) (0.4 pt.) What are four necessary conditions for a deadlock?

- **Mutual exclusion**
- **Circular Wait**
- **Hold and Wait**
- **No Preemption**

o) (0.4 pt.) Adding additional CPU to a multiprocessor system will increase computing power. Why adding many CPU will cause performance degrade?

- **Due to heavy data transfer, bus becomes a bottleneck.**

p) (0.4 pt.) What is the potential drawback in non-Uniform memory access in multi-processor system?

- **Increased latency when a CPU must access remote memory across the system interconnect, creating a possible performance penalty**

q) (0.4 pt.) What is **Spooling** ? – **jobs for processes (I/O jobs) are saved in a file and executed one by one (i.e. network printer)**

r) (0.4 pt.) An operating system keeps a process table for each process. Name three contents of process table – **process status, snapshot of CPU, scheduling information, memory management information I/O status information**.

s) (0.4 pt.) What are three main functions of OS for supporting multiprogramming?

a. **Protection between jobs**
b. **Job scheduling**
c. **virtual memory**

t) (0.4 pt.) Why a CPU performance can be improved by using pipelined design?
Sol) **Since instruction cycle are three steps: fetch, encoding, and execute**

u) (0.4 pt.) **Timesharing** – multiple terminals are connected to a host computer through networks and each user are shared system

v) (0.4 pt.) What are the three major activities of OS with regard to memory management?

- **Keep track of which parts of memory are currently being used by which process**
- **Allocate and deallocate memory space as needed for each process**
- **Decide which processes are to be loaded into memory when memory space become available.**

w) (0.4 pt.) An operating system for a computer is responsible for activities for secondary storage management. List five activities you can think of.

- **Mounting and unmounting a device.**
- **Free-space management**
- **Storage allocation**
- **Disk scheduling**
- **Partition**
- **Protection**

x) (0.4 pt.) Most CPUs feature two interrupt request lines: the non-maskable interrupt line (NMI) and the maskable interrupt line. Let's briefly explore both.

- **Non-maskable interrupt line – reserved for event such as unrecoverable hardware error.**
- **Maskable interrupt line – used by device controllers to request service.**

y) (0.4 pt.) What are three components for an I/O device? – **Mechanical component (device itself), electrical component (device controller) and device driver.**

z) (0.4 pt.) Explain briefly Asymmetric and Symmetric clustering

- **Asymmetric clustering**- one machine is in hot-standby mode. Hot-standby host machine does just monitoring the active server. If that server fails, the hot-standby host becomes the active server.
- **Symmetric clustering** – two or more hosts are running application and monitoring each other.