DISCO
(a) A major part of the Disco paper was hiding the NUMA-ness of FLASH from the commodity operating system. How does Disco achieve this?

(b) Disco uses direct execution (runs on the hardware without modification) for most operations to achieve reasonable performance. Unfortunately this cannot be done to some services. For example, to virtualize memory, Disco maintains a set of physical to machine address mappings and performs the necessary translation by changing the MIP's software TLB. Two problems that occur from this approach are:

- Some kernel segments on MIPS operating systems are traditionally direct mapped like KSEG0.
- TLB misses are now both more frequent and more expensive since the TLB must be flushed on virtual CPU switches.

XEN
(a) Louis Reasoner believes that he can use a lottery scheduler for CPU scheduling in XEN because he can implement the BVT with tickets. Louis believes he can simulate what BVT does when a process is unfairly scheduled, by temporarily removing tickets from that process. Is Louis correct? Explain.

(b) DISCO uses shadow page tables because of the software loaded TLB in MIPS. The shadow page tables kept track of physical addresses to machine addresses. Does XEN need a shadow page table to keep track of physical addresses to machine addresses like DISCO? Explain.

VMWare
(a) ESX goal is to run unmodified operating systems workloads that over-commit their memory. One way that they accomplish this is by using a idle memory tax to efficiently utilize memory. Does this remind you of another paper that we read? (HINT: Think about a paper that deals with utilizing idle memory)

(b) What is the double paging problem and why is it bad?