

You may discuss these questions with your classmates, as it may be helpful to gain a good understanding of the topic. Nonetheless you should always submit your own work!  
*Use a word processor to answer these questions, attach this questions page to your answers.*

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### **Question 1.**

In your own words explain what Direct Memory Access (DMA) is. Explain how it works, what are the characteristics (advantages and disadvantages) of DMA, potential complications of DMA. You may need to do some literature research to convey an answer.

*Direct memory access (DMA) is a feature of most computers that allows certain hardware submodules to access system the memory for reading and writing. The interaction between the subsystems and the memory is carried out independently of the CPU. Some systems that use DMA include disk drive controllers, graphics cards, network cards, sound cards, etc.*

*Advantages of DMA include: high transfer rates, fewer CPU cycles for each transfer. Some disadvantages include: DMA transfer requires a DMA controller to carry out the operation, hence more expensive system; synchronization mechanisms must be provided in order to avoid accessing non-updated information from RAM.*

*DMA transfers overcome the problem of occupying the CPU for the entire time it's performing a transfer. In DMA transfers, The CPU initiates the transfer, then it does other operations while the transfer is in progress, and it receives an interrupt from the DMA controller once the operation is finished. This is especially useful in real-time computing applications.*

*DMA can lead to cache coherency problems. If a CPU is equipped with a cache and an external memory, then the data the DMA controller has access to (stored in RAM) may not be updated with the correct data stored in the cache.*

**Question 2.**

Write the pseudo code that describes a “read routine” for a circular buffer.

Hint: You may want to consider the pseudo code of slide 9-27 of your notes as a starting point.

```
Err_Type Procedure read(data_type data);
    begin
        if empty_flag then return (ERR_BUF_EMPTY);
        else
            memory(read_ptr)=data;
            full_flag = false;
            read_ptr=((read_ptr-B)+1)mod N)+B;
            if (read_ptr==write_ptr) then empty_flag=true;
            endif;
            return(Err-OK);
        endif;
    end;
```

Question 3.

Explain what window-based flow control is.

*Flow control is the process of managing the rate of data transmission between two computers. Flow control mechanisms can be classified by whether or not the receiving node sends feedback to the sending node.*

*With this approach it is possible to send information at a faster rate than the destination computer can receive and process it. This occurs when the receiving computer has a heavy traffic load with respect to the sending computer, or if the receiving computer has less processing power than the sending computer.*

*The attributes of window-based flow control include:*

- *A method of flow control together with a mechanism for retransmitting lost messages, and detecting out-of-order and duplicate received messages.*
- *The sender tags its message with a sequence number 0, . . . , N-1 that is incremented after each message.*
- *The receiver acknowledges single messages or groups of messages by sending back the sequence of the last message that was correctly received in order.*
- *The sender is allowed to have up to  $W \leq N$  messages sent to the receiver but not yet acknowledged.  $W$  is the window size, which may be fixed or adjustable.*

*In any asynchronous data transmission it is possible for data packets to get lost*

- *they may get discarded because of detected errors*
- *they may get discarded because of buffer overflow*
- *they may get greatly delayed because of congestion*

*The window-based method follows these general two steps:*

- *The transmitter sends out  $W$  data packets, then it must stop and wait for an acknowledgement. But it should not wait forever.*
- *A timer is used to keep track of the time elapsed since each data packet was transmitted. If the elapsed time exceeds some value (e.g. twice the expected round trip delay), then the transmitter assumes that the data packet was lost, and then retransmits all unacknowledged packets.*

Question 4.

Explain the differences between actuators, relays, servos, and stepper motors.

- An **actuator** is a device that is used by a microcomputer to control an external physical quantity, such as position.
- A **relay** is a mechanical switch that is closed and opened by driving or not driving current through a magnetic coil.
  - Normally open (n.o.) relay: close switch by energizing.
  - Normally closed (n.c.) relay: open switch by energizing.
- A **servo** is an actuator that is used to cause mechanical rotation within some fixed range of angles ( $< 360$  deg.)
- A **stepper motor** is an actuator whose rotational position (360 deg.) and speed can be controlled by digital signals.