1. Raise two main advantages of **packet switching**, compared to **message switching**.
   - In packet switching, break long messages into multiple packets so may lose or corrupt a subset of the message but do not discard the entire message as in message switching.
   - In packet switching, takes less time compare to message switching because this will allow each node to start transmission as soon as first packet of message has been arrived. This will save enormous amount of time, especially when number of hops between source and destination are more.

     In message switching takes more time compare to packet switching as entire message will be stored at each of the hop points till it is completely received.

2. Given a 20-bit frame and bit-error-rate p in communication. What is the probability that the frame has no error? What is the probability of 1-bit errors?

   For all of the bits to be correct, the probability of frame has no error :

   $$P = p^0 \text{x } (1-p)^{20-0} = (1-p)^{20}$$

   For the probability of one bit error :

   $$P = p^1 \text{ x } (1-p)^{20-1} = \text{p x } (1-p)^{19}$$

3. Give two features that the **data link layer** and **transport layer** have in common, and further give two features in which they differ.

   Similarities : these layers provide flow control, can provide recovery from transmission errors, and both layers can support multiplexing.

   Dissimilarities :
   - **The transport layer** is end to end and involves the interaction of peer processes across the network. **The data link layer** involves the interaction of peer-to-peer processes that are connected directly. In general, the time that elapses in traversing a data link is much smaller the time traversing a network, where packets can become trapped in temporary routing loops. Consequently, transport layer protocols must be able to deal with out-of-sequence PDUs and a much larger backlog of PDUs than data link layers.
   - **The data link layer** is concerned convert groups bits into frames and the transport layer is not.

- **The data link layer** may be concerned with medium access control, **the transport layer** does not have this concern.

4. Which OSI layer is responsible for (a) determining the best path to route packets; (b) providing end-to-end reliable communications; (c) providing node-to-node reliable communications?

   The network layer is concerned with the selection of paths across the network.

   The transport layer is concerned with providing reliable service on an end-to-end across network.

   The data link layer provides for the reliable transfer of information between adjacent nodes in a network.

5. How does **the network layer** in a connection-oriented packet-switching network differ from **the network layer** in a connectionless packet-switching network?

   The network layer in connection-oriented networks maintains state information about every connection. It can allocate resources at the switches through admission control. **The network layer in connectionless networks** has no knowledge of "connections", and instead deals independently with each packet.

   The network layer in connection-oriented networks performs routing on a per connection basis. Each packet is routed based on a connection identifier of some sort and packets of the same connection have the same identifier value. **In a connectionless network**, routing is performed on per packet basis; each packet is routed independently based on information carried in the packet header, for example, the destination address.

   In connection-oriented networks, the network layer forwarding table is set up by a signaling procedure during the connection establishment. **In connectionless networks**, the routers may execute a distributed algorithm to share network state information and dynamically calculate the routing table continuously.

   In case of failure, the connection must be re-established in connection-oriented networks, whereas in connectionless networks, the packets are re-routed. The network layer in connectionless networks is more robust against failures.

Connection-oriented	Connectionless
Maintain state information about every connection	No knowledge of the "connection"
Allocate resources to connections at switches	No resource allocation
Admission control	No admission control
Per connection routing	Per packet routing
Route packet based on identifier	Route packet based on destination address.
Forwarding table specifies the output port and outgoing identifier value as function of the incoming identifier value	Routing table specifies the output port depending on the destination address
Forwarding table set up by signaling during connection establishment.	Router executes distributed algorithm to share network state information and dynamically calculate the routing table
Connection must be re-established in cases of failure	Packets are rerouted around failures, robust against failures

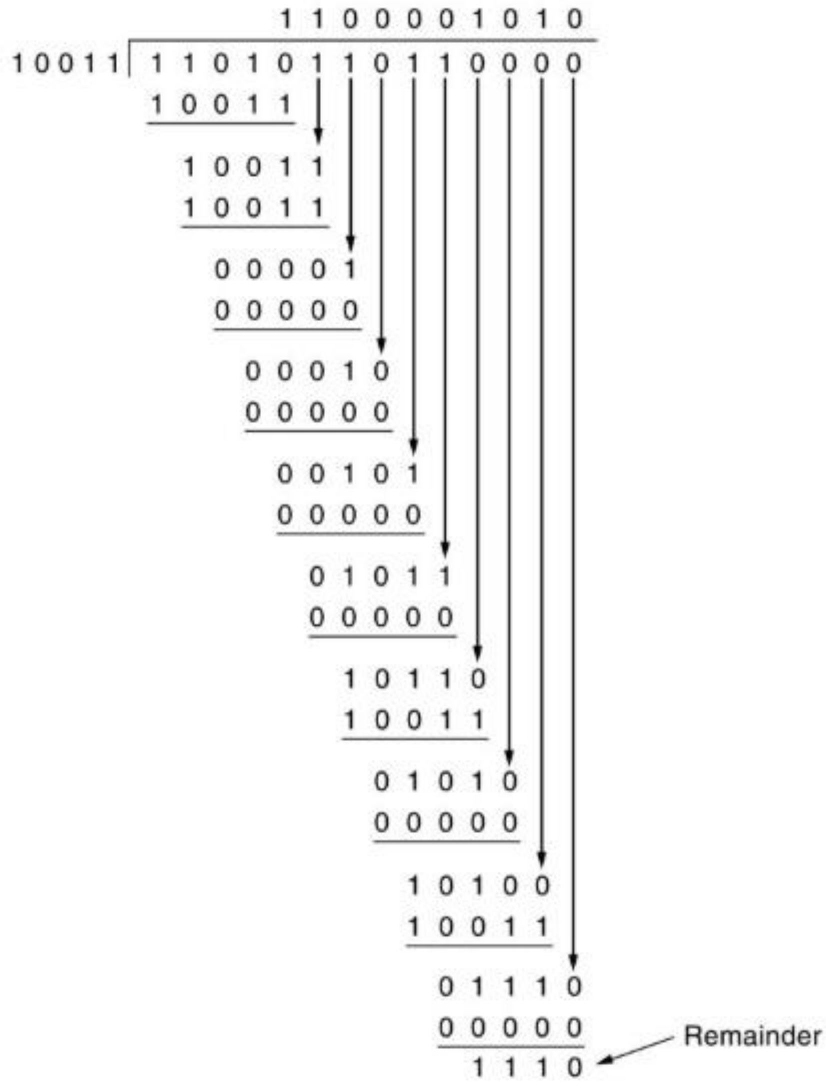
6. A bit stream 1101011011 is transmitted using the standard CRC method. The polynomial generator is x + x + 1. What is the actual bit string transmitted? Show the major steps to your answer.

   The generator polynomial $G(x) = x^4 + x + 1$ is encoded as 10011.

   Clearly, the generator polynomial consists of 5 bits and degree 4.

   So, a string of 4 zeroes is appended to the bit stream to be transmitted.

   The resulting bit stream is 1101011011**0000**.



From here, CRC = 1110.

- The code word to be transmitted is obtained by replacing the last 4 zeroes of 1101011011**0000** with the CRC.
- Thus, the code word transmitted to the receiver = 1101011011**1110**.

7. Suppose a IP header consists of four 16-bit words: (11111111 11111111, 11111111 00000000, 11110000 11110000, 11000000 11000000). Please find the Internet checksum for the code ?

   L = 4

   Treating each 16-bit word as an integer
   b_0= 11111111 11111111 = 65535
   b_1= 11111111 00000000 = 65280

b_2= 11110000 11110000 = 61680
b_3= 11000000 11000000 = 49344

$x = b_0 + b_1 + b_2 + b_3$ modulo 65535 = 241839 modulo 65535 = 45234

The checksum is then given by: b_4= - x = - 45234

So the Internet checksum b_4 = 01001111 01001101

8. Suppose that a group of computers is connected to an Ethernet LAN. If the computers communicate only with each other, does it make sense to use IP protocol in the computers?

   So much software assumes the ubiquity of IP, but if you are not using any such software, there's no need for IP. You could not have any devices that expect anything but Ethernet frames between you and the computers.

   Should the computers run TCP directly over Ethernet?

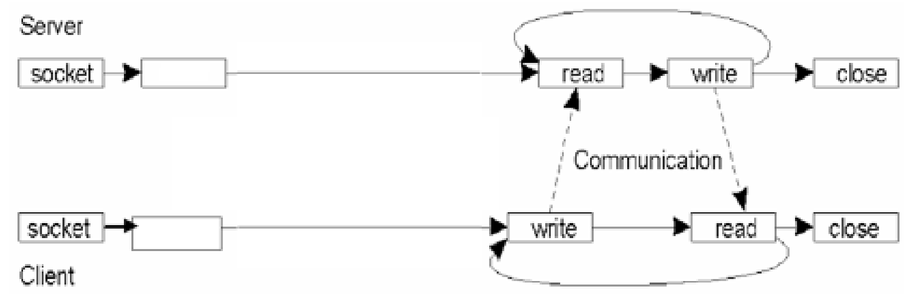
   You can't run standards-based TCP without IP, as TCP utilizes IP addresses. You would have to use your own custom streaming protocol that's based on Ethernet or other link layer as a lower layer.

   One thing IP does is abstract the link layer from upper levels of the stack - there was a time where it was possible you could have Ethernet or token ring, and there are things like PPP and HDLC, and also the loopback interface.

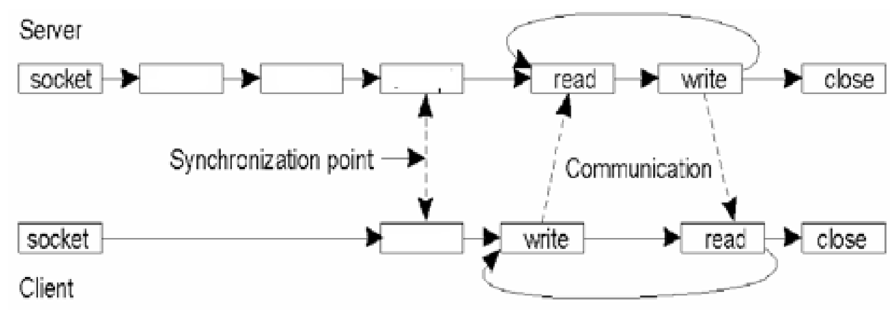
   How is addressing handled?

   This is something you get to decide when you create your custom protocol above. An option if you don't want to support routing at all is just using the MAC address. Non-IP protocols like IPX/SPX and AppleTalk had their own address schemes and methods to obtain host addresses.

9. (1) The figures below show the TCP/UDP communication pattern diagrams. Which diagram works for TCP? Why?
   (2) Fill the missing steps (blank boxes) in both diagrams for TCP/UDP correspondingly.



(a)



(b)

(1) Diagram works for TCP is diagram is (b) because in TCP, before sent and receive data, client establish connection with the server with function connect(). Therefor diagram (a) is UDP.

(2) In (a), blank boxes for server is bind().
In (b), blank boxes for server sequentially are bind(), listen(), accept() and for client is connect().