1. True or False

F F a. A socket is a protocol that defines messages exchanged between the application and the Network Operating System.

T T b. A web cache may be used to reduce response time as experienced by a user, reduce load on a link, and/or reduce load on a web server

T F T c. In broadcasting the ARP reply (instead of unicasting) may reduce the amount of ARP requests on the network.

F F d. In Persistent HTTP, a single TCP connection can transfer multiple images or other embedded objects in an HTML page regardless of whether they all come from the same server or not.

T T e. Queuing delays can be reduced by increasing the transmission bit rate and reducing the distance between the end hosts.

F T F f. SMTP is a protocol used by a mail client to retrieve mails from a mail server

F F g. The sequence number range must be at least twice the send window for GBN $SWS \leq 2^n - 1$

F F h. TCP, a Transport layer protocol, provides for guaranteed reliability, latency and bandwidth

T T i. GBN does not buffer out of order packets, so a receive buffer is not needed

F T F j. When a client send a UDP datagram to a server, the server use the source IP address, the source port number, the destination IP address and the destination port number to direct the UDP datagram to the appropriate Socket

T T k. A client process can open multiple TCP connections to the same server process.

l. In GBN, the longer the SWS is, the more frames need to be transmitted every time a frame get lost

m. In the absence of any frame loss or duplication, the stop and wait protocol would not need any sequencing of the frames.

n. Iterative DNS queries require shorter socket connections with DNS servers than recursive DNS queries

o. A machine can open more than one TCP socket on the same port

p. You are watching a real-time streaming Video. Chances are you have created a stream socket

q. A Process X running in a server machine has a port number of 40. Two hosts A and B each send a UDP datagram to the Server with destination port #40. Both of these datagram will be directed to the same socket.

r. To be able to recover the analog signal from its sample, the sampling period has to be at least twice the highest frequency component in the signal being sampled

s. If a computer has multiple Network Interface Cards, The DHCP process must occur separately over each interface to obtain a separate dynamically assigned IP address for each interface.

t. ARP is a protocol used to resolve the "next hop IP address" to its MAC address.

u. In cable access, several users share the same cable. Hence Medium Access Control procedures are required on both the uplink and the downlink to prevent collisions.

v. Statistical Multiplexing is more efficient when the Peak Rate is much higher than the average date rate.

T T w. In STDM, the number of time slots in each frame is less than the number of input lines to the MUX.

F F x. A DHCP server must be located on every network to assign IP addresses to DHCP clients on that network

F F y. The DNS server, a.k.a. the 'resolver", maps a host name address to an IP address.

Part 2: Quickies (every blank is worth 2 point)

1. Consider a link of length 1000 ~~miles~~ km with a 1 Gb/s data rate connecting a sending and receiving node. Assume a fixed packet length of 1250 bytes. Assume that the sender always has packets to send. Finally, assume that packets are never lost or corrupted. The utilization of this link for a stop-and-wait (SAW) protocol is 0.125 %. The necessary SWS to achieve the maximum utilization (~100%) in a sliding window ARQ is 801 frames.

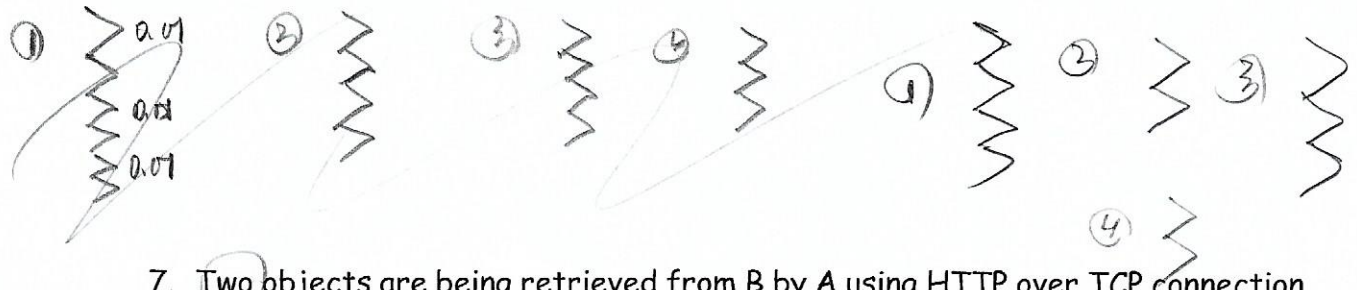
2. Four sources are multiplexed using FDM on a link that has a total bandwidth of 8 KHz. The maximum bandwidth for each source if there must be a 200 Hz guard band between the channels is 1850 Hz

3. You are designing a Go-Back-N sliding window protocol to be used over a 1 Mbps link from a ground terminal to a geosynchronous satellite at a distance of 30,000 Km. Each frame carry 1 Kbyte of data. The speed of light is 3×10^8 m/sec. It is desired to keep the "pipe" full. The minimum number of bits you need for sequencing the frames is 5 bits.

4. Bit stuffing procedure is performed on the following binary sequence: 11011111011111110110101. The T/x pattern is 110111110011111010110101

5. We wish to send data at a rate of 8kbps through a 800Hz channel, The minimum SNR is 30.10 dB

6. Suppose that Alice wants to send an email message to Bob. This will involve four entities: Alice's mail client (for email composition and sending), Alice's outgoing mail server, Bob's incoming mail server, and Bob's mail client (for email retrieval and viewing). The number of times SMTP Protocol is used is 2

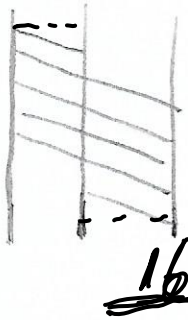


7. Two objects are being retrieved from B by A using HTTP over TCP connection. Each object is 1 Mbit in size. We assume all connection setup packets and HTTP request packets are negligible in size (which means ignore the transmission time for these packets, not the actual objects). Suppose the Round-Trip-Time (RTT) between A and B is 10 milliseconds and the bandwidth between the sites is 10 Mbits/s. In each of the following cases, how long will it takes for A to retrieve both objects under the following circumstances:

- Non-persistent connection: 0.24 sec
- Non-persistent, with Parallel connections: 0.12 sec
- Single Persistent connection: 0.23 sec
- Single Persistent connection with pipelining: 0.12 sec

8. A video signal is 4 MHz wide. It is sampled at the Nyquist sampling rate and then quantized using 64-levels and then encoded. The bit rate of the digital stream is 48M bps

9. A 32 Kbyte message is to be transmitted over a 2-hop packet network. The network limits the size of the packet to 2 Kbytes. The links are error free and each has speed of 50 Mbps. Each hop is 1000 Km long and the bits are transmitted at the speed of light of 2.5x108 m/sec. It will take 0.013444 seconds for the message to get from the source to the destination. Ignore processing and queuing delays.



10. Consider transmitting a packet from host A to host B via a router (i.e. hosts A and B are located on different networks). All ARP tables (in hosts and router) are empty. Let x denote the time (in seconds) to transmit the packet. Let y denotes the time (in seconds) elapsed from the beginning of transmitting an ARP query until receiving an ARP response. Ignoring propagation delay, the total time it takes to forward the packet from A to B is 2(x+y) sec.

3. An FCS error detection mechanism is used over a communications link. The message bit sequence is 101011. An FCS generator pattern of 1011 is used to generate the FCS sequence.

   a) How many FCS bits are generated? What are they? What is the transmitted bit sequence? Identify the FCS bits in that sequence. Show details of your work.
   b) Now suppose the received sequence is 010010111. Did errors occur? Will the receiver detect the errors? Prove your answer
   c) Now suppose the channel introduces the following error pattern 100010111. Will the receiver be able to detect the error? Prove your answer analytically.

a)

```
      100110
1011 | 101011000
       1011
       ----
        0011
        0000
        ----
         0111
         0000
         ----
          1110
          1011
          ----
           1010
           1011
           ----
            0010
            0000
            ----
             010
```

∴ 3 FCS bits are generated.
They are 010.
transmitted bit sequence:
101011010
↑ FCS bits

b) transmitted sequence: 101011010
received sequence: 010010111
so error occurred.

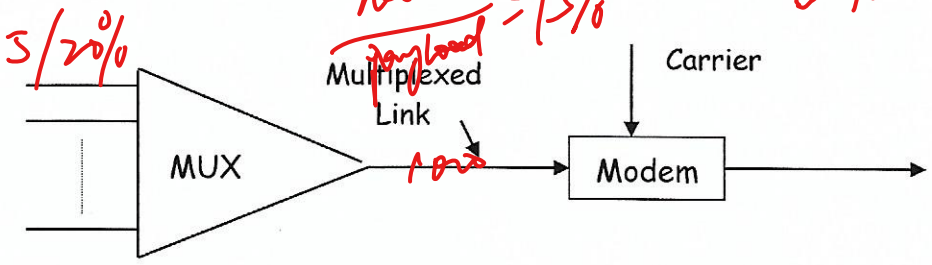
```
      01011
1011 | 010010111
       0000
       ----
        1001
        1011
        ----
         0100
         0000
         ----
          1001
          1011
          ----
           0101
           0000
           ----
            1011
            1011
            ----
             000
```

Since the remainder is 000,
the receiver will not detect
the errors

c) See Work Sheet #4

Part 4: Resource Sharing

Consider the following multiplexer



Assume that you have 4 input sources as follows:

Two sources generate 150bps (each), 75% of the time
One source generates 400bps, 50% of the time
One source generates 300bps bits/sec (each), 25% of the time

Part 1: Assume that the multiplexer is a synchronous TDM. What is the required data rate at the output of the MUX? What is the minimum number of time slots in such a frame and how are they assigned to each source? If each slot can support 8 bits, what is the frame duration? What is the frame rate? Assume that the modem is QPSK, what is the signaling rate (in Baud) at the output of the Modem?

Part 2: (unrelated to Part 1 but same diagram)

Now assume the MUX is a statistical MUX. You were given the following information:

- The capacity at output of the MUX is 100 Kbps.
- All terminals generate traffic at a rate of 5 Kbps when active. Terminals are active only 20% of the time.
- The ratio of the header bits to the payload bit in each time slot is 75%
- The link utilization at output of STDM is 80%

How many terminals can be supported? If the modem uses 16QAM, what is the signaling rate at output of Modem (in Baud)?

5. Consider a Data link that uses Go-Back-N ARQ with a sending window size of 4. Suppose the transmission time of a frame is 1 second. Assume the one-way propagation delay is 0.5 seconds. Neglect the transmission time of the Acknowledgements. Neglect processing delay. Assume station A begins sending with F_0. The **Timeout** for each frame is 2 seconds (The timer starts at the **end** of the transmission of each frame). Upon receiving a frame, the receiver decides to **wait** for 1 sec and send an ACK for all frames received with no errors detected up to that point in time. Assume all frames are of 1000 bits long.

   Draw the frame-exchange-timing diagram for the following sequence of events. Be sure to label each data frame and ACK frame with a sequence number for the following cases.

a) Station A sends 6 frames in a row, starting at t=0. Assume all frames are received with no errors. Calculate the throughput of the link assuming that station A has only those 6 frames to transmit.

b) Station A sends 6 frames in a row, starting at t=0. All frames are received without errors, except the frame with a sequence number 3 (i.e. F_3) which is "lost". Calculate the throughput of the link assuming that station A has only those 6 frames to transmit

c) Repeat part b **ONLY** assuming that Selective Repeat ARQ is deployed with the same SWS. Remember in SR, the receiver can't ACK out-of-order frames.