### Question 1. Identifying frame (20 pts)

**1.1 Why is a fixed-length frame not a good idea? Please list two reasons. (5 pts)**

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<thead>
<tr>
<th>Reason 1</th>
<th>Reason 2</th>
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**1.2 Why is a length-based frame (e.g. length of frame explicitly written in the header) not a good idea? Please list two reasons. (5 pts)**

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**1.3 Sentinel-based framing. Assuming the sentinel bit pattern is 01111110 (0X7E). Each of the following bit patterns arrived at an HDLC receiver. For each pattern, determine whether it is a valid bit pattern (i.e., after the sender performs stuffing)? If it is valid, please give the original, unstuffed version of the payload in the hexadecimal form. Append 0s at the end if there are not enough bits to form a hex representation. If it is not valid, please explain why—i.e., highlight any bits you believe to be in error. (The red bits represent the sentinels signaling the beginning and end of the frame.)**

#### 1.3.1 (5 pts)

```
0111 1110 0101 1101 1101 0111 1110
```

#### 1.3.2 (5 pts)

```
01 1111 10
```

```
0111 1110 0101 1111 0111 1100 1011 0111 1001 1111 10
```
Question 2 Error Handling

2.1 Hamming Distance (10 pts)

Consider a code on six-bit strings that contains (only) the following four codewords:

000000, 000011, 001111, 111111

2.1.1 What is the hamming distance of this code? (2 pts)

2.1.2 What is the rate of this code if we use it to encode two-bit strings? Is it efficient? If it is not efficient, please explain. (6 pts)

2.1.3 How many bit flips can be using this code detected? How many bit flips can be corrected? (2 pts)
2.2 CRC (10 pts)
Suppose a sender and a receiver are using the CRC generator polynomial \( x^4 + x^3 + 1 \).

2.2.1 The receiver receives the bit string 1010 1010 0101. Was the message received correctly? If so, what was it? If not, how do you know? Show your work. (5 pts)

2.2.2 The receiver receives the bit string 1010 0111 1110. Was the message received correctly? If so, what was it? If not, how do you know? Show your work. (4 pts)

2.2.3 What is the max bit flip that can be detected with generator \( x^4 + x^3 + 1 \)? (2 pt)
Question 3 Flow Control (15 pts)

A client and a server are transmitting data frames using the stop-and-wait ARQ protocol. Assume
- Round Trip Time (RTT) is 6 ms;
- The client timeout is 8 ms;
- The server drops every third transmission received from the client (server will not send an acknowledgment for that data frame);
- The sequence number is correctly encoded in every data and acknowledgment frame;
- The client transmits the first frame at time 0. (Here is a message exchange diagram for you to understand what is happening)

(Questions follows in next page)
3.1 Draw out the complete message exchange diagram until the client successfully communicates (i.e., receives explicit acknowledgments for) 7 frames. (10 pts)
3.2. How many frames has the client already transmitted, including retransmissions, when it receives an acknowledgment of the 7th frame from the server? (2 pts)

3.3. Compute the total time (in ms), including retransmissions, when the client receives an acknowledgment of the 7th frame from the server. (3 pts)
Question 4 Transfer Layer Protocols (10 pts)
4.1 Present an example of usage of UDP and explain the benefit of it. Why TCP might be a bad choice in this example? (5 pts)

4.2 Present an example of usage of TCP and explain the benefit of it. Why UDP might be a bad choice in this example? (5 pts)