Question 1

(1) Idle BISYNC sender transmits SYN:

```
00010110 00010110 00010110 ...
```

(2) Transmitted frame is:

```
(SYN)  (SYN)  (DLE)  (SOH)
00010110 00010110 00010000 00000001
```

```
stuffed
```

```
01111110 00010000 00010000
```

```
Header
```

```
(DLE)  (STX)
00010000 00000010
```

```
stuffed
```

```
00000011 00010000 00010000 01111110
```

```
Message
```

```
(DLE)  (ETx)
00010000 00000011
```

```
NO need to stuff!!!
```

```
01111110 00010000
```

```
CRC
```
Question 2:

(1) 0111110 0111110 00001110

address  send

|-----------|   & data
0111110 0111111 & FCS.

0111110  & flag (ends frame).

(2) 0111110 0111110 00001110

|-----------|   
0111110  0111111 |

0111110
Question 3:

(1) Sender: $\text{seq}=1$

Receiver.

Correct

Receiver sends
ACK with recev. seq = 1.
back.

(2) Sender: $\text{seq}=1$

Receiver.

Frame received
in error.

Receiver does NOTHING!

(Sender will then time out
and retransmit the
frame !!!)
**Question 4:**

Frame exchange in Stop-and-Wait:

![Diagram of frame exchange](image)

1. **$T_1$: time to transmit a data frame**
   
   $T_1 = \frac{\text{10000 bits}}{64000 \text{ bits/sec}} = \frac{1}{64} \text{ sec} = 0.0015625 \text{ sec.}$

2. **$T_2$: one-way propagation delay**
   
   $T_2 = 5 \times 10^{-8} \text{ sec.}$
   
   $= 0.000005$

3. **$T_3$: time to transmit an ACK frame**
   
   $T_3 = \frac{80 \text{ bits}}{64000 \text{ bps}} = 0.00125 \text{ sec.}$
\[ T_L = \text{one-way propagation delay} \]
\[ = 5 \times 10^{-5} \text{ sec} = 0.00005 \text{ sec} \]

Su:

\[ 0.125 + 0.00005 + 0.00125 + 0.00005 \]

\[ = 0.12635 \text{ sec.} \]

Of the 0.12635 sec in the cycle, 0.125 sec is used to transmit data.

The fraction used to transmit data:

\[ = \frac{0.125}{0.12635} = 0.9893 \]

Effective Bandwidth Util =

\[ 0.9893 \times 64 \text{ kbps} = 63.3 \text{ kbps} \]
Part 2:

The end-to-end propagation delay does not change when bandwidth increases.

(End-to-end prop. delay delays are the speed of light only.)

Those changes:

\[ T_1 = \frac{8000 \text{ bits}}{100,000,000 \text{ bps}} = 8 \times 10^{-5} \text{ sec} \]

\[ = 0.00008 \]

\[ T_3 = \frac{80 \text{ bits}}{100,000,000 \text{ bps}} = 8 \times 10^{-7} \text{ sec} \]
Therefore:

\[ 8.10^{-5} \text{ sec} + 5.10^{-5} + 0.10^{-7} + 5.10^{-5} \]

\[ = 10.10^{-5} + 0.10^{-7} \]

\[ = 10.008 \cdot 10^{-5} \text{ sec} \]

Of the \( 10.008 \cdot 10^{-5} \text{ sec} \) in the cycle,

\( 8.10^{-5} \text{ sec} \) is used to transmit data.

Sv:

\[ \frac{0.10^{-5}}{10.008 \cdot 10^{-5}} = 0.44 \]

\( \text{is used for data} \)

Eff. BW with 1 = 0.44 \( \times \) 64 kbps

\[ = 28.3 \text{ kbps} \]

("over 80\%")
Question 5:

Sequence of events to send 1 frame:

1. Frame is sent.
2. Frame needs to travel to receiver.
3. Frame is received and checked (correct).
4. Receiver sends Ack frame.
5. Ack frame must travel to sender.
6. Ack frame is received.

→ Then sender can send next frame!
Timing of the events:

1. To send 10000 bits:
   
   \[ t_1 = \frac{10000}{10^9} \text{ sec} = 10^{-5} \text{ sec.} \]

2. To travel to receiver:
   
   \[ t_2 = \text{prop. delay} = 1 \text{ msec} = 10^{-3} \text{ sec.} \]

3. To send ACK (100 bits) frame:
   
   \[ t_3 = \frac{100}{10^9} \text{ sec} = 10^{-7} \text{ sec.} \]

4. ACK travels to sender:
   
   \[ t_4 = \text{propagation delay} = 1 \text{ msec} = 10^{-3} \text{ sec} \]
Total time to send 1 frame \( (= 10000 \text{ bits}) \)

\[= 10^{-5} + 10^{-3} + 10^{-7} + 10^{-3} \]

\[= 2.0101 \times 10^{-3} \text{ sec.} \]

This repeats until you sent all data:

\[1,000,000 \text{ bytes} = 8,000,000 \text{ bits} \]

\[= 800 \times 10,000 \text{ bits} \]

\[= 800 \text{ frames} \]

Total time to send the file of 1,000,000 bytes:

\[= 800 \times 2.01001 \text{ msec} \]

\[= 1.608008 \text{ sec} \]