3-1. Answer the following questions:

a. The following data fragment occurs in the middle of a data stream for which the byte-stuffing algorithm described in the text is used: A B ESC C ESC FLAG FLAG D. What is the output after stuffing?

3-1 (a)
A B ESC ESC C ESC ESC ESC FLAG
ESC FLAG D

b. You receive the following data fragment: 0110 0111 1100 1111 0111 1101. You know that the protocol uses bit stuffing. Show the data after destuffing.

(b)
011 0011111011110111111

3-2. A 12-bit Hamming code whose hexadecimal value is 0xE4F arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error. (p.s.: number the bits from left to right starting at bit 1)

3-2
0xE4F = 111001001111

对于1: 111001001111 1+1+0+0+1+1 = 0

对于2: 111001001111 1+1+1+1+1 = 1

对于4: 111001001111 0+0+1+0+1 = 0

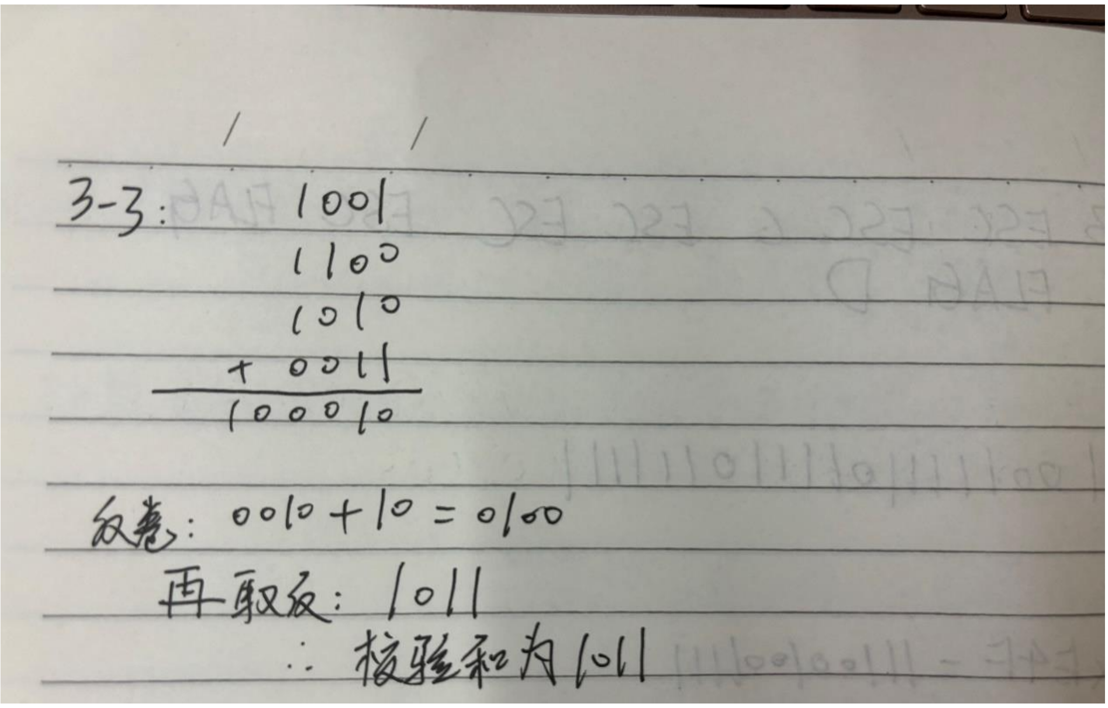
对于8: 111001001111 0+1+1+1+1 = 0

∴出错位: 0010 即2号位出错

∴原始值要去除1, 2, 4, 8号位

∴原始值为 0xA4F

3-3. Suppose that a message 1001 1100 1010 0011 is transmitted using the Internet Checksum (4-bit word). What is the value of the checksum?


3-3: 1001

1100

1010

+ 0011

100010

反码: 0010 + 10 = 0100

再取反: 1011

∴ 校验和为1011

3-4. A bit stream 10011101 is transmitted using the standard CRC method described in the text. The generator polynomial is $x^3 + 1$. Show the actual bit string transmitted. Sup pose that the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end. Give an example of bit errors in the bit string trans mitted that will not be detected by the receiver.

3-4

x^3+1为1001

```
              100011
      ______________
1001 / 1001110000
       1001
       ---------
        01101
         1001
       ---------
          1000
          1001
       ---------
            100
```

∴实际传输的值为 1001110100

若第3位传出错，则传的值为 1011110100

对于接收方：

```
              10010010
      ______________
1001 / 1011110100
       1001
       ---------
        1000
        1001
       ---------
           1011
           1001
       ---------
             100
```

∴余数100，不能整除，检测成功

~~不会被检测到的例~~：

~~反例~~ 若所有位都变成了0（0整除任何数）

3-5. In the discussion of ARQ protocol in Section 3.3.3, a scenario was outlined that resulted in the receiver accepting two copies of the same frame due to a loss of acknowledgement frame. Is it possible that a receiver may accept multiple copies of the same frame when none of the frames (message or acknowledgement) are lost?

3-5. 仍有可能，接收方的确认帧如果传得太晚，超过了定时的时间，发送方就会重传（网络被别的进程占用）

3-6. A channel has a bit rate of 4 kbps and a propagation delay of 20 msec. For what range of frame sizes does stop-and-wait give an efficiency of at least 50%?

3-6. 设x为帧的字节数

$$\frac{\frac{8x}{4k}}{\frac{8x}{4k}+0.02\times 2} \geq 50\%$$

$$x \geq 20$$

$\therefore$ 至少20字节

3-7. A 3000-km-long T1 trunk is used to transmit 64-byte frames using protocol 5. If the propagation speed is 6 μsec / km, how many bits should the sequence numbers be?

3-7 总传播时延：$3000 \times 6\times10^{-6} \times 2 = \cancel{3.6\times10^{-2}}$ 36ms

而对于T1中继线，传输速率为 1.544Mbps

∴对于一个帧：$\frac{64\times8}{1.544M} \approx 0.3ms$

∴对于一个帧总时间为 $36+0.3=36.3ms$

$\frac{36.3}{0.3} = 121$个

∴能传121个帧

而 $2^7-1 = 127 \geq 121$

∴要7位

3-8. In protocol 6, when a data frame arrives, a check is made to see if the sequence number differs from the one expected and no_nak is true. If both conditions hold, a NAK is sent. Otherwise, the auxiliary timer is started. Suppose that the else clause were omitted. Would this change affect the protocol's correctness?

3-8 会，假设先传一个正常帧，接收方不启动辅助计时器且所有的确认帧都丢失了，下一次，发送方因为超时向接收方发送原样的帧，接收方收到后会返回NAK，若NAK也丢失(NAK只传一次)，那么发送方就会一直传之前传过的帧，而接收方只会丢弃，这样会死锁

3-9. Frames of 1000 bits are sent over a 1-Mbps channel using a geostationary satellite whose propagation time from the earth is 270 msec. Acknowledgements are always piggybacked onto data frames. The headers are very short. Three-bit sequence numbers are used. What is the maximum achievable channel utilization for

a. Stop-and-wait?

b. Protocol 5?

c. Protocol 6?

3-9 (a):

$$\frac{\frac{1000}{10^6}}{\left(\frac{1000}{10^6}+270\times10^{-3}\right)\times 2} \approx 0.1845\%$$

(b): $2^3-1=7$

$$\frac{\frac{1000}{10^6}\times 7}{\left(\frac{1000}{10^6}+270\times10^{-3}\right)\times 2} \approx 1.2915\%$$

(c): $2^{3-1}=4$

$$\frac{\frac{1000}{10^6}\times 4}{\left(\frac{1000}{10^6}+270\times10^{-3}\right)\times 2} \approx 0.7380\%$$

3-10. Compute the fraction of the bandwidth that is wasted on overhead (headers and retransmissions) for protocol 6 on a heavily loaded 50-kbps satellite channel with data frames consisting of 40 header and 3960 data bits. Assume that the signal propagation time from the earth to the satellite is 270 msec. ACK frames never occur. NAK frames are 40 bits. The error rate for data frames is 1%, and the error rate for NAK frames is negligible. The sequence numbers are 8 bits.

3-10 $\frac{4k}{50kbps}=8ms$ 而 $\frac{270\times 2+8}{8} < 2^{8}-1$

$\therefore$ 信道上充满了数据帧

而对于单个数据帧，头部+重传+NAK的部分浪费

$\therefore$ 1%重传率 $4000\times 1\% = 40$位要重传

NAK帧: $40\times 1\% = 0.4$位NAK帧

$\therefore$ 浪费率 $= \frac{40+40+0.4}{4000+40+0.4} \approx 1.99\%$