Ex. 1: Hamming Distance

Consider the following code:

0000 0000	A
0000 0111	B
0011 1000	C
1100 0001	D
0001 1110	E

1. What is the hamming distance between symbols A and E, what of the complete code?
2. What is the maximum number of bit errors such that every code word can still be decoded?
3. Assume a receiver gets the following code words:

   `11000001 00011000 00001110 00000111 00011100`

   Which characters are decoded?

Ex. 2: Error Detection and Recovery

1. Solve Ex 3a) of WS05/06!
   - i You want to encode 2048 code words, such that 1 Bit errors can be corrected. What is a lower bound for the required Bits per code word?
   - ii Now let us assume that we are sending 17 Bit code words (including the ability to **detect** 1 Bit errors). Also assume that on average every 1000th code word has a bit error. To repeat, the receiver sends a 3Bit NACK. For simplicity, you may assume that the NACK and the re-send is error-free. How many Bits are sent (on average) to transmit 1000 kBytes (2^{10}Bytes)?
   - iii For which use case is error correction useful?
2. Compute the CRC protected message-to-send with the following parameters

   $M(x)$: `110001010110101`
   $G(x)$: `10110`
3. What does the receiver need to know to verify the message?
4. Take the $T(x)$ computed above, flip bits 3 and 4 of the original message (`111101010110101`), and perform the verification process. What does it tell you?
5. **Optional** Implement a "literate" version of CRC checking in a programming language of your choice and run some random tests.

Ex. 3: Recovery / Flow Control Protocols

1. Sketch the sending of 5 Data Packets between two neighboring nodes following the stop-and-wait protocol with positive acknowledgements. Assume that Data Packet 2 has transmission errors.

2. What would change when using additional negative acknowledgements?

3. What would change when using sliding window with a window size of 5? What other protocol design question would we have to answer then with which consequences?

4. Assume a satellite link with 0.05s delay from earth to satellite, 10^6 Byte/s bandwidth, and a packet size of 2000 Bytes. What is the optimal size of the sliding window in packets, when one earth-bound station sends data to another? (ACK size is neglectable)