

### Exercise 4.3

a) Algorithm: We choose most frequent letters with codewords of length which costs less time and less length

For example, "."  $\Rightarrow$  0, "-"  $\Rightarrow$  1

time(2)  $\Rightarrow$  0

time(4)  $\Rightarrow$  00, 1

time(6)  $\Rightarrow$  000, 01, 10

time(8)  $\Rightarrow$  0000, 001, 010, 100, 11

time(10)  $\Rightarrow$  00000, 0001, 0010, 0100, 1000, 011, 101, 110

time(12)  $\Rightarrow$  ... 0011, 0101, 0110, ~~1001~~, 1010, 1110, 111

Therefore, the order is 0, 1, 00, 01, 10, 000, 11, 001, 010, 100, 0000, 011, 110, 0001, 0010, 0100, 1000, 00000, 111, 0011, 0101, 0110, 1001, 1010, 1110

b). After calculating the result, we get average time 9.7140

c). After calculating the result, we get average length:  $\frac{4}{1} 4.84$  bits

$$H(x) = 3.90 \text{ bit}$$

$$H(x) < \text{expected average length} < H(x) + 1$$

Therefore, it is optimal

d). Prefix code:

