Written examination in Computer Networks

MOCK EXAM

Last name: _____

First name: _____

Student number: _____

Result:

Question:	1	2	3	4	5	6	7	8	9	10	Σ	Grade
Maximum points:	10	7	14	11	15	11	9	14	10	10	111	—
Achieved points:												

1.0: 111.0-105.5, **1.3**: 105.0-100.0, **1.7**: 99.5-94.5, **2.0**: 94.0-89.0, **2.3**: 88.5-83.0,
2.7: 83.0-77.5, **3.0**: 77.5-72.0, **3.3**: 72.0-66.5, **3.7**: 66.5-61.0, **4.0**: 61.0-55.5, **5.0**: <55.5

Task 1)   Points: ....

Maximum points: 10

Decide whether the following statements are correct or wrong and explain shortly why.

   a) IEEE 802.11 (WLAN) uses a deterministic MAC protocol.

   b) HTTP uses TCP instead of UDP because it is more secure.

   c) The maximum goodput of a network is always limited by the data rate on the data link layer.

   d) If you update the specification of a transport layer protocol you must also adapt the network layer protocol accordingly.

   e) Accessing a web page via HTTPS takes more time than accessing the same page via HTTP.

f) With IPv6 I do not need a transport layer protocol because it has so many addresses that I can assign one address for each network service.

g) You can use NDP to find the MAC address for a given IPv4 address.

h) When you try to access an e-mail server via SMTP your operating system will know the port automatically.

i) Broadcasting video streams via the Internet makes efficient use of the networks' resources.

j) When sending and receiving e-mails over TLS there is no need to encrypt the content of the e-mails themselves.

Task 2)   Points: ....

Maximum points: 3+3+1=7

a) An image has a size of 5120×2880 pixels (5K) with true color (3 Bytes per pixel are used for the color information). How long does it take to transmit the uncompressed image via a $2.5\,\text{Gb/s}$ ($= 2.5 * 10^9$ bits per second) Ethernet connection?

b) Name the topology that is used by ...

modern Ethernet standards	
Thin Ethernet and Thick Ethernet	
WLAN without an Access Point	
WLAN with an Access Point	
Token Ring	
mobile phones (GSM standard)	

c) Mark the label of Twisted Pair Cables that have no cable and no pair shielding.
☐ *ATP*   ☐ *FTP*   ☐ *STP*   ☐ *UTP*   ☐ *XTP*   ☐ *ZTP*

Task 3)   Points: . . . .

Maximum points: 14

For the network devices, protocols, transmission units, line codes and addressing schemes in the table, mark the corresponding layer of the hybrid reference model. *(1 stands for bottom layer and 5 for top layer in the hybrid reference model. If more than just a single layer are a correct answer, it is sufficient to select at least <u>one</u> correct layer.)*

	Hybrid reference model layer				
	1	2	3	4	5
ALOHA					
Congestion control					
Differential Manchester-Code					
Dynamic Host Configuration Protocol (DHCP)					
Ethernet					
Flow control					
Frame					
Hub					
Hypertext Transfer Protocol (HTTP)					
ICMP					
Internet Protocol (IP)					
Internet Message Access Protocol					
Intermediate System to Intermediate System (IS-IS)					
Link state routing protocol					
Logical address					
Media access control					
Network Time Protocol (NTP)					
Non-Return to Zero (NRZ)					
Open Shortest Path First (OSPF)					
Packet					
Physical address					
Port number					
Repeater					
Spanning Tree Protocol (STP)					
Secure Shell (SSH)					
Transmission Media					
Non-Return to Zero Invert (NRZI)					
User Datagram Protocol (UDP)					

Task 4)   Points: ....

Maximum points: 2+4+2+3=11

For a given network connection you know the following properties:

- The channel *bandwidth* is *4 kHz (= 4000 Hz)*
- The *signal power* is *1 mW (= 0.001 W)*
- The *noise* on the channel has a maximum power of *5 μW (= 0.000005 W)*
- Each *symbol* can encode *16 bit*
- A line encoding scheme with 100 % efficiency is used

a) What is the symbol rate of the network?

b) What is the maximum data rate of this network? (*Hint: Maybe more than one limit applies.*)

c) What is the maximum data rate if each symbol can encode *32 bit*?

d) What is the maximum data rate if the noise increases to a peak value of *50 μW (= 0.00005 W)*? (For the original *16 bit* per symbol.)

Task 5)   Points: ....

Maximum points: 7+4+4=15

a) The following list contains the source and destination address of IP packets. Decide for each IP packet if a router in the Internet should forward the packet or not. If the packet should not be forwarded, explain briefly why.

Source: 160.45.170.10
Destination: 160.45.114.11

Source: 10.51.0.23
Destination: 35.163.72.93

Source: 192.109.234.218
Destination: 193.99.144.80

Source: 172.18.42.23
Destination: 172.20.8.15

Source: fd41:9312::beef:ea:ff:1927
Destination: 2001:67c:254:b0b0::1

Source: 2a01:4f8:151:64::10
Destination: 2a00:1450:400f:804::200e

Source: 2a02:2e0:3fe:1001:302::
Destination: fe80::3772:d265:966c:95e6

b) Split the class B network `183.126.33.0` for implementing 7 subnets. Calculate the subnet masks and answer the questions.

```
Network ID:    10110111.01111110.00100001.00000000    183.126.33.0
Number of bits for subnet IDs?
Subnet mask:   _____._____._____._____    ___.___.___.___
Number of bits for host IDs?
Number of host IDs per subnet?
```

c) Split the class C network `211.252.127.0` into subnets which contain 31 hosts each. Calculate the subnet masks and answer the questions.

```
Network ID:    11010011.11111100.01111111.00000000    211.252.127.0
Number of bits for host IDs?
Number of bits for subnet IDs?
Number of possible subnets?
Subnet mask:   _____._____._____._____    ___.___.___.___
```

Task 6)   Points: ....
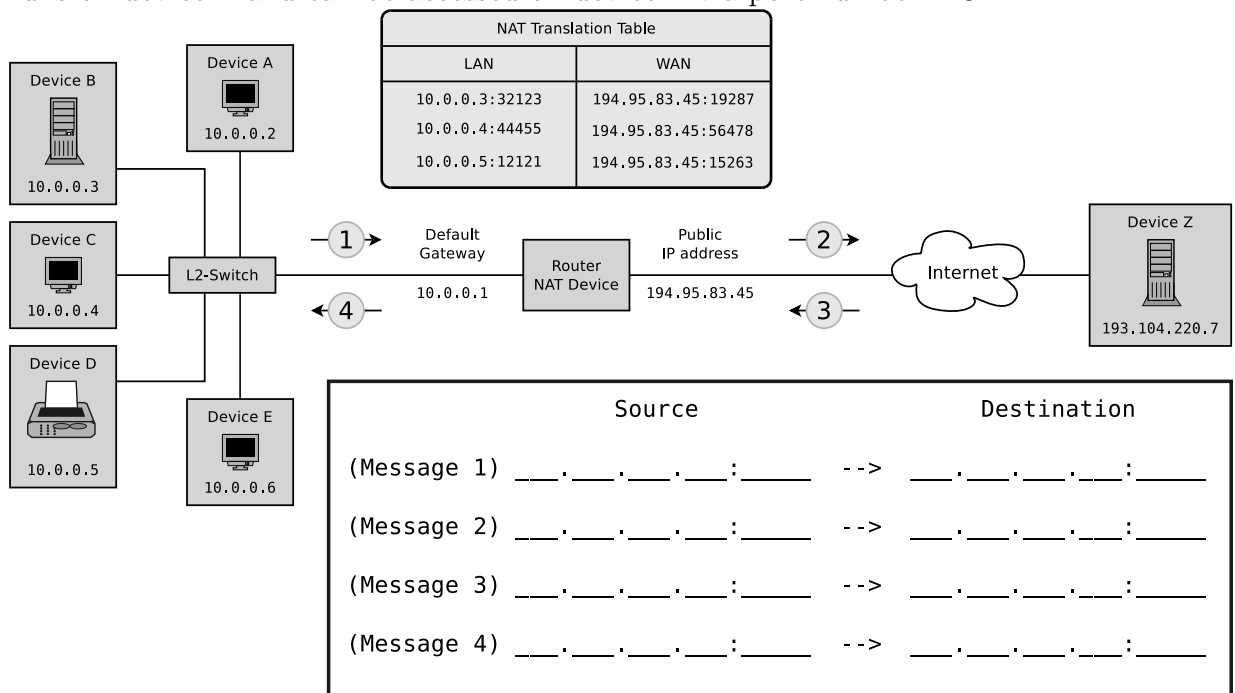
Maximum points: 8+3=11

a) Fill the missing IP addresses and port numbers into the figure that describes a NAT scenario where device C sends an HTTP request to a web server process that runs on device Z and can be accessed on device Z via port number 443.

NAT Translation Table	
LAN	WAN
10.0.0.3:32123	194.95.83.45:19287
10.0.0.4:44455	194.95.83.45:56478
10.0.0.5:12121	194.95.83.45:15263

Device B
10.0.0.3

Device A
10.0.0.2

Device C
10.0.0.4

L2-Switch

Device D
10.0.0.5

Device E
10.0.0.6

(1) → Default Gateway

Router NAT Device
10.0.0.1   194.95.83.45

Public IP address

(2) →

(4) ←

(3) ←

Internet

Device Z
193.104.220.7

```
                    Source                          Destination

(Message 1) ___.___.___.___:_____   -->   ___.___.___.___:_____

(Message 2) ___.___.___.___:_____   -->   ___.___.___.___:_____

(Message 3) ___.___.___.___:_____   -->   ___.___.___.___:_____

(Message 4) ___.___.___.___:_____   -->   ___.___.___.___:_____
```

b) The sender transmits an IP packet to a receiver. Calculate the subnet ID of sender and re-
ceiver and specify whether the IP packet leaves the subnet during transmission or not.

```
Sender:        10000100.10011000.01010011.11111110    132.152.83.254
Subnet mask:   11111111.11111111.11111100.00000000    255.255.252.0


Receiver:      10000100.10011000.01010001.00000010    132.152.81.2
Subnet mask:   11111111.11111111.11111100.00000000    255.255.252.0


       Subnet ID of sender?
       Subnet ID of receiver?
       Does the IP packet leave the subnet [yes/no]?
```
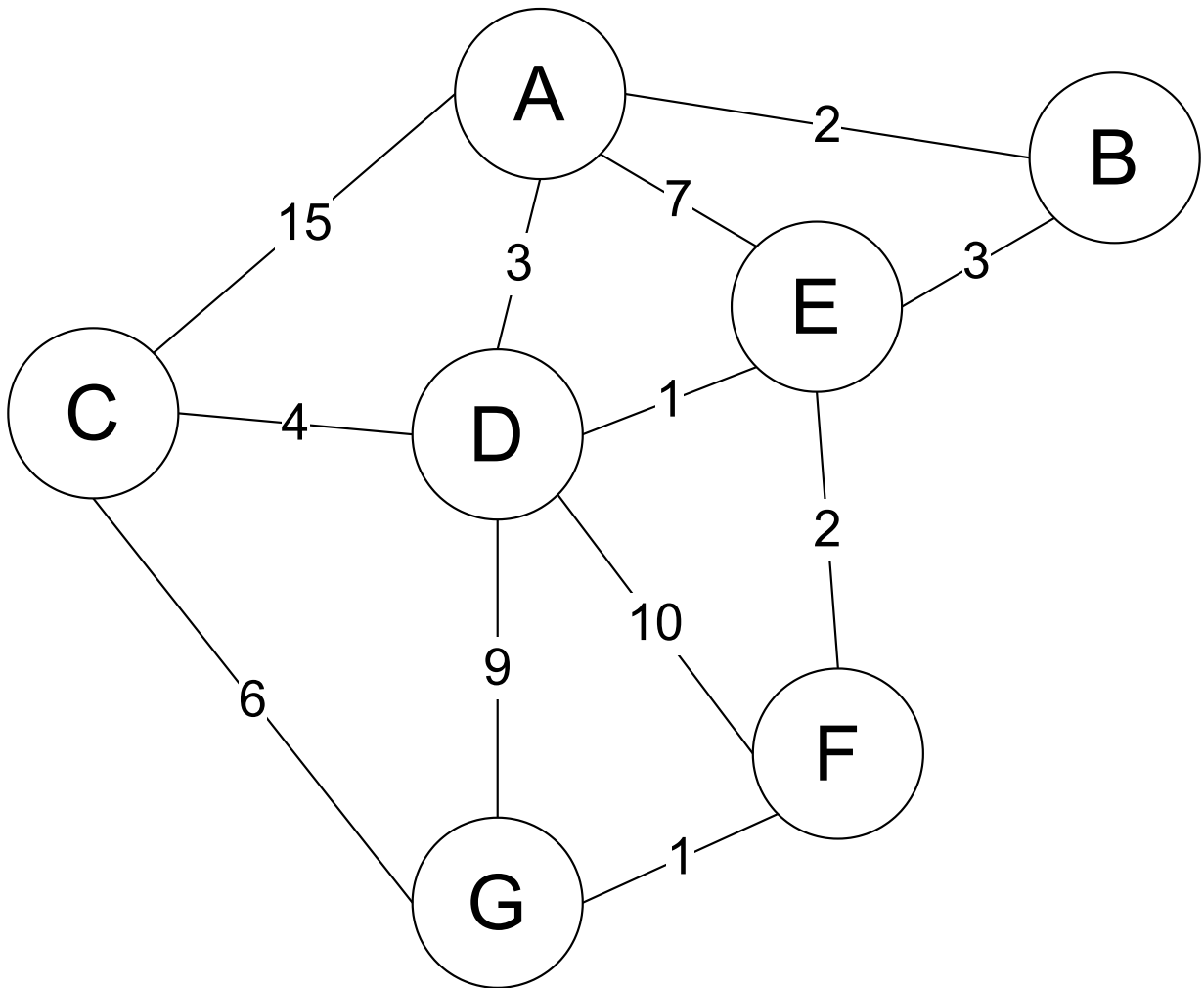
Task 7)   Points: . . . .

Maximum points: 9

Calculate the shortest path from node A to all other nodes using Dijkstra's algorithm. Denote for each note the path cost and the predecessor node.

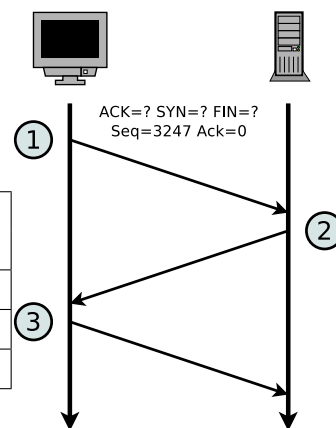## Task 8)   Points: . . . .
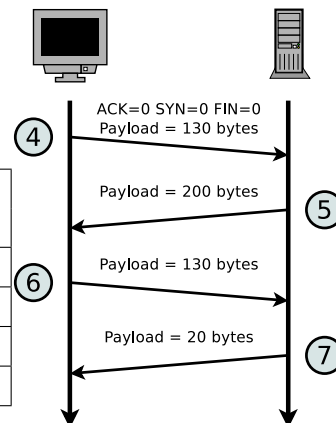
Maximum points: 4+5+5=14

a) The diagram shows the establishment of a TCP connection. Complete the table.

| Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
1					3247	0
2					7	
3						

ACK=? SYN=? FIN=?
Seq=3247 Ack=0

b) The diagram shows an excerpt of the transmission phase of a TCP connection. Complete the table.

Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
4				130	50	500
5				200		
6						
7						

ACK=0 SYN=0 FIN=0
Payload = 130 bytes

Payload = 200 bytes

Payload = 130 bytes

Payload = 20 bytes

c) The diagram shows the termination of a TCP connection. Complete the table.

Message	ACK flag	SYN flag	FIN flag	Payload length	Seq number	Ack number
8				0	1	2342
9				0		
10				0		
11				0		

ACK=0 SYN=? FIN=?
Seq=1 Ack=2342
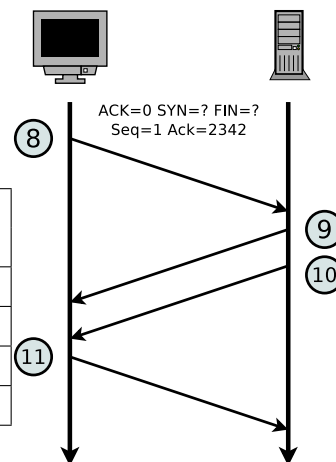
Last name: First name: Student number:

Task 9) Points: ....

Maximum points: 10

a) Explain the **differences** between TCP and UDP.

b) Describe what the Seq number in an TCP segment specifies.

c) Describe what the ACK number in an TCP segment specifies

d) Describe the functioning of **silly window syndrome avoidance**.

e) Why does the sender maintain **two windows** when using TCP and not just a single one?

Task 10)   Points: ....

Maximum points: 3+3+1+1+2=10

a) Describe the steps to generate a digitally signed message.
   The following objects and methods are available:

   - Plaintext message: P
   - Hash algorithm: $H()$
   - Private key of the sender: K_A^-
   - Cipher code: $E()$

b) Describe the steps to verify a digitally signed message.
   The following objects and methods are available:

   - Received, potentially tampered message: P'
   - Received, potentially tampered signature: VC_A'
   - Hash algorithm: $H()$
   - Public key of the sender: K_A^+
   - Decryption code: $D()$

c) Which of the following security goals can be addressed with digital signatures?

☐ Confidentiality

☐ Privacy

☐ Integrity

☐ Authenticity

☐ Non-repudiation

☐ Availability

d) Explain whether the encryption for a digital signature uses a symmetric or asymmetric method.

e) How could a „Man in the middle" attack against this method look like? What has an attacker to accomplish beforehand? What can an attacker achieve with a successful attack?

Formulas, Definitions, Specifications

- You may need some of these formulas:
  - **Whittaker-Kotel'nikov-Shannon (WKS) sampling theorem**
    $f_S = 2 * f_{max}$
  - **Hartley's law**
    $C = 2 * H * log_2(V)$
  - **Shannon-Hartley theorem**
    $C = H * log_2(1 + S/N)$
  - **Latency**
    Latency = Propagation delay + Transmission delay + Waiting time
    $$\text{Propagation delay} = \frac{\text{Distance}}{\text{Speed of light} * \text{Velocity factor}}$$
  - **Change of logarithm base**
    $log_b(x) = \frac{log_d(b)}{log_d(x)}$

- Some line encoding schemes you may need:

  - **NRZ**
    A logical 0 is encoded with physical signal level 1, a logical 1 is encoded with level 2.

  - **NRZI**
    A logical 0 is encoded as missing signal level change, a logical 1 is encoded as signal level change.

  - **MLT-3**
    A logical 0 is encoded as no signal level change, a logical 1 is alternating encoded, according to the sequence `+, 0, -, 0`

  - **RZ**
    A logical 0 is encoded as low signal level for half a clock cycle before returning to the middle signal level. A logical 1 is encoded as high signal level for half a clock cycle before returning to the middle signal level.

  - **Unipolar RZ**
    A logical 0 is encoded as low signal level, a logical 1 is encoded as high signal level for half a clock cycle before returning to the low signal level.

  - **Manchester**
    A logical 0 is encoded with a **falling edge**, a logical 1 is encoded with a **rising edge**

  - **Differential Manchester**
    A logical 0 is encoded as a signal level change taking place at the beginning and the middle of a clock cycle. A logical 1 is encoded as a signal level change only in the middle of a clock cycle.

- Some IP address ranges:
  - IPv4
    * 127.0.0.1/32 is loopback (localhost)
    * Class A defines a /8 network with a prefix of 0.
    * Class B defines a /16 network with a prefix of 10.
    * Class C defines a /24 network with a prefix of 110.
    * Class D is reserved for multicast. The prefix is 1110.
    * 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16 are defined as private address range.
    * 169.254.0.0/16 is link-local
  - IPv6
    * ::1/128 is loopback (localhost)
    * fc00::/7 is unique-local
    * fe80::/10 is link-local
    * ff00::/8 is multicast
    * ff02::1:ff00:0/104 is solicited-node multicast

Conversion table between decimal and binary representation

0 - 00000000	64 - 01000000	128 - 10000000	192 - 11000000
1 - 00000001	65 - 01000001	129 - 10000001	193 - 11000001
2 - 00000010	66 - 01000010	130 - 10000010	194 - 11000010
3 - 00000011	67 - 01000011	131 - 10000011	195 - 11000011
4 - 00000100	68 - 01000100	132 - 10000100	196 - 11000100
5 - 00000101	69 - 01000101	133 - 10000101	197 - 11000101
6 - 00000110	70 - 01000110	134 - 10000110	198 - 11000110
7 - 00000111	71 - 01000111	135 - 10000111	199 - 11000111
8 - 00001000	72 - 01001000	136 - 10001000	200 - 11001000
9 - 00001001	73 - 01001001	137 - 10001001	201 - 11001001
10 - 00001010	74 - 01001010	138 - 10001010	202 - 11001010
11 - 00001011	75 - 01001011	139 - 10001011	203 - 11001011
12 - 00001100	76 - 01001100	140 - 10001100	204 - 11001100
13 - 00001101	77 - 01001101	141 - 10001101	205 - 11001101
14 - 00001110	78 - 01001110	142 - 10001110	206 - 11001110
15 - 00001111	79 - 01001111	143 - 10001111	207 - 11001111
16 - 00010000	80 - 01010000	144 - 10010000	208 - 11010000
17 - 00010001	81 - 01010001	145 - 10010001	209 - 11010001
18 - 00010010	82 - 01010010	146 - 10010010	210 - 11010010
19 - 00010011	83 - 01010011	147 - 10010011	211 - 11010011
20 - 00010100	84 - 01010100	148 - 10010100	212 - 11010100
21 - 00010101	85 - 01010101	149 - 10010101	213 - 11010101
22 - 00010110	86 - 01010110	150 - 10010110	214 - 11010110
23 - 00010111	87 - 01010111	151 - 10010111	215 - 11010111
24 - 00011000	88 - 01011000	152 - 10011000	216 - 11011000
25 - 00011001	89 - 01011001	153 - 10011001	217 - 11011001
26 - 00011010	90 - 01011010	154 - 10011010	218 - 11011010
27 - 00011011	91 - 01011011	155 - 10011011	219 - 11011011
28 - 00011100	92 - 01011100	156 - 10011100	220 - 11011100
29 - 00011101	93 - 01011101	157 - 10011101	221 - 11011101
30 - 00011110	94 - 01011110	158 - 10011110	222 - 11011110
31 - 00011111	95 - 01011111	159 - 10011111	223 - 11011111
32 - 00100000	96 - 01100000	160 - 10100000	224 - 11100000
33 - 00100001	97 - 01100001	161 - 10100001	225 - 11100001
34 - 00100010	98 - 01100010	162 - 10100010	226 - 11100010
35 - 00100011	99 - 01100011	163 - 10100011	227 - 11100011
36 - 00100100	100 - 01100100	164 - 10100100	228 - 11100100
37 - 00100101	101 - 01100101	165 - 10100101	229 - 11100101
38 - 00100110	102 - 01100110	166 - 10100110	230 - 11100110
39 - 00100111	103 - 01100111	167 - 10100111	231 - 11100111
40 - 00101000	104 - 01101000	168 - 10101000	232 - 11101000
41 - 00101001	105 - 01101001	169 - 10101001	233 - 11101001
42 - 00101010	106 - 01101010	170 - 10101010	234 - 11101010
43 - 00101011	107 - 01101011	171 - 10101011	235 - 11101011
44 - 00101100	108 - 01101100	172 - 10101100	236 - 11101100
45 - 00101101	109 - 01101101	173 - 10101101	237 - 11101101
46 - 00101110	110 - 01101110	174 - 10101110	238 - 11101110
47 - 00101111	111 - 01101111	175 - 10101111	239 - 11101111
48 - 00110000	112 - 01110000	176 - 10110000	240 - 11110000
49 - 00110001	113 - 01110001	177 - 10110001	241 - 11110001
50 - 00110010	114 - 01110010	178 - 10110010	242 - 11110010
51 - 00110011	115 - 01110011	179 - 10110011	243 - 11110011
52 - 00110100	116 - 01110100	180 - 10110100	244 - 11110100
53 - 00110101	117 - 01110101	181 - 10110101	245 - 11110101
54 - 00110110	118 - 01110110	182 - 10110110	246 - 11110110
55 - 00110111	119 - 01110111	183 - 10110111	247 - 11110111
56 - 00111000	120 - 01111000	184 - 10111000	248 - 11111000
57 - 00111001	121 - 01111001	185 - 10111001	249 - 11111001
58 - 00111010	122 - 01111010	186 - 10111010	250 - 11111010
59 - 00111011	123 - 01111011	187 - 10111011	251 - 11111011
60 - 00111100	124 - 01111100	188 - 10111100	252 - 11111100
61 - 00111101	125 - 01111101	189 - 10111101	253 - 11111101
62 - 00111110	126 - 01111110	190 - 10111110	254 - 11111110
63 - 00111111	127 - 01111111	191 - 10111111	255 - 11111111

Units conversion table

Data units

```
1 B = 1 Byte = 8 bit = 8 b
1 kB = 1,000 B
1 MB = 1,000 kB = 1,000,000 B
1 GB = 1,000 MB = 1,000,000 kB = 1,000,000,000 B
```

Units of length

```
1 m = 1 meter
1 km = 1,000 m
1 cm = 0.01 m
1 mm = 0.1 cm = 0.001 m
```

Units of time

```
1 s = 1 second
1 min = 1 minute = 60 s
1 h = 1 hour = 60 min = 3,600 s
1 d = 1 day = 24 h = 1,440 min = 86,400 s
```