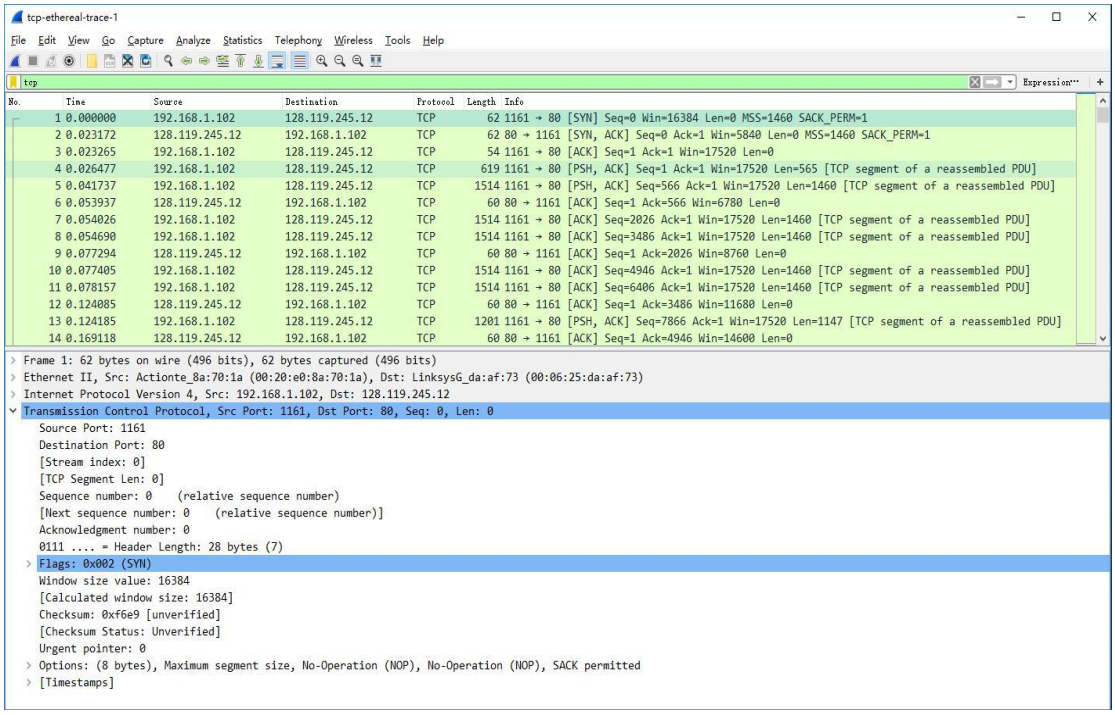
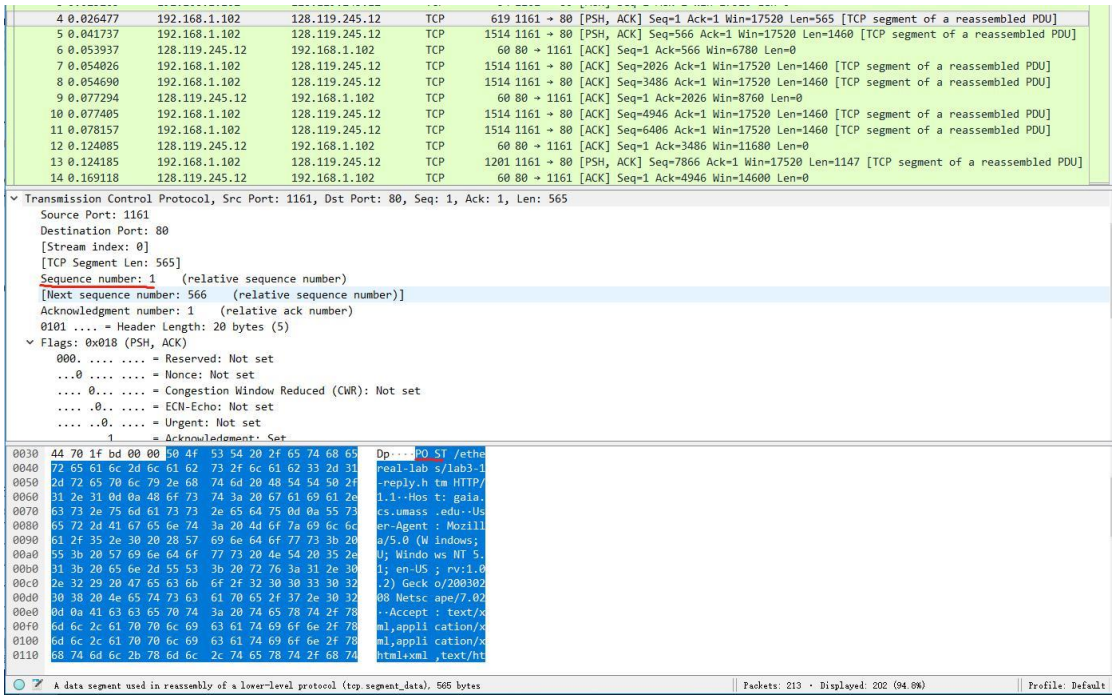
Exercise 1:

Q1:



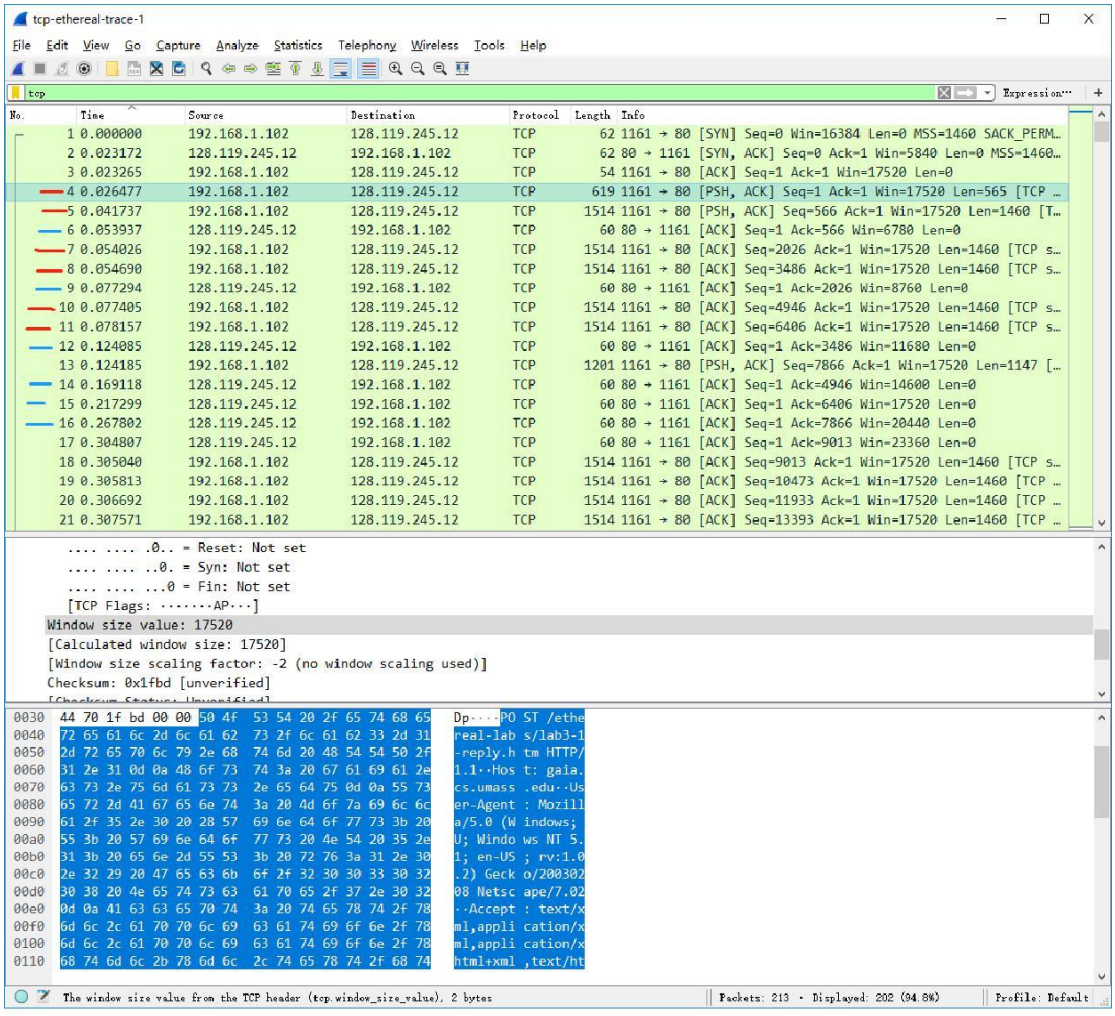
As is shown in above graph, the first SYN segment was sent by the host to the server(gaia.cs.umass.edu), thus, the IP address and port number are included in destination field, the IP address of gaia.cs.umass.edu is 128.119.245.12, the port number is 80. The information about the client computer is included in source field, thus the IP address of client computer is 192.168.1.102, the port is 1161.

Q2:



The sequence number of TCP segment containing the HTTP POST command is 1, as is shown in the above picture.

Q3 and Q4:



$$EstimatedRTT = (1- \alpha)*EstimatedRTT + \alpha*SampleRTT$$

Sequence Number	Segment sent time	ACK receive time	RTT	EstimatedRTT	Length
1	0.026477	0.053937	0.027460	0.027460	565
566	0.041737	0.077294	0.035557	0.028472	1460
2026	0.054026	0.124085	0.070059	0.033670	1460
3486	0.054690	0.169118	0.114428	0.043765	1460
4946	0.077405	0.217299	0.139894	0.055781	1460
6406	0.078157	0.267802	0.189645	0.072514	1460

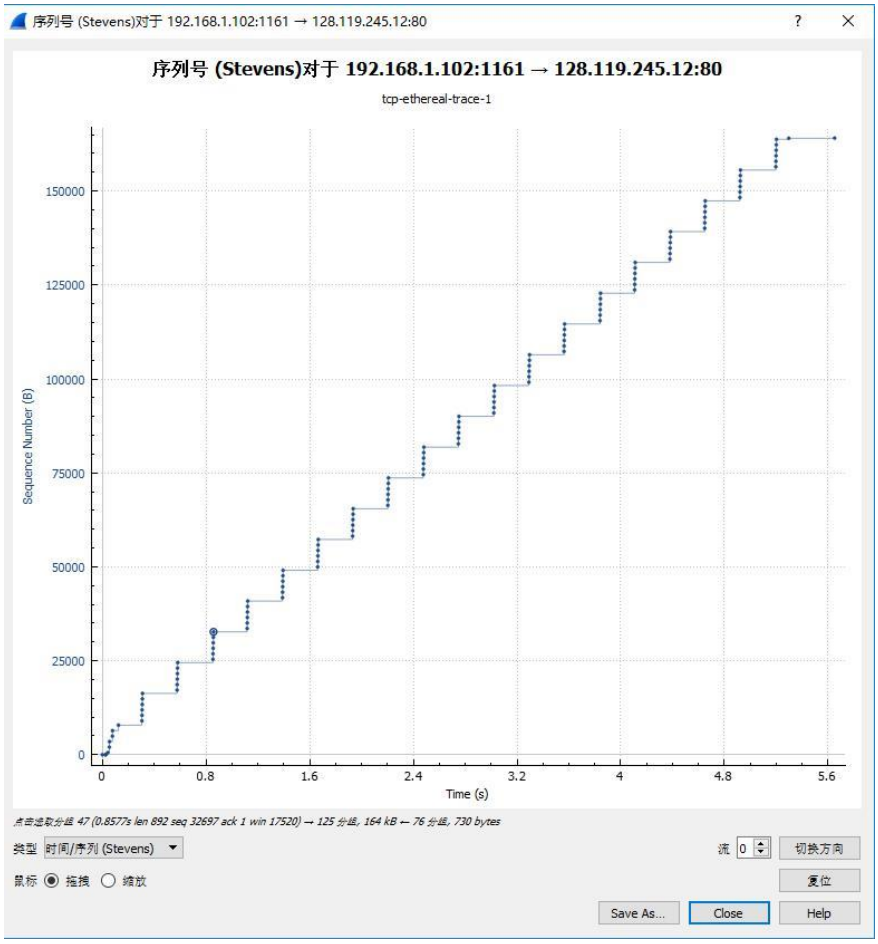
Alpha = 0.125

Q5:

1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_…
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565 [TCP segmen…
5	0.041737	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP seg…
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment…
58	1.121891	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=40889 Ack=1 Win=17520 Len=892 [TCP se…
59	1.200421	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=35049 Win=62780 Len=0
60	1.265026	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=37969 Win=62780 Len=0
61	1.362074	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=40889 Win=62780 Len=0
62	1.389886	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=41781 Win=62780 Len=0
63	1.390110	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=41781 Ack=1 Win=17520 Len=1460 [TCP segmen…
64	1.390824	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=43241 Ack=1 Win=17520 Len=1460 [TCP segmen…
65	1.391683	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=44701 Ack=1 Win=17520 Len=1460 [TCP segmen…

The minimum amount of available buffer space advertised at the receiver for the entire trace is 5840 bytes, and the maximum of that buffer space is 62780, so, it is not likely to throttle the sender, because the buffer space is always bigger than the segment size.

Q6:

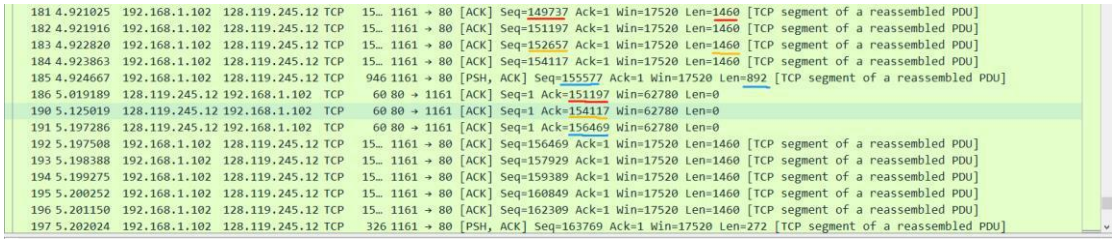


As it is shown above, the sequence number kept increasing, and there were no packets with the same sequence number but has different time stamps. This indicates that there

were no retransmit segments.

Q7:

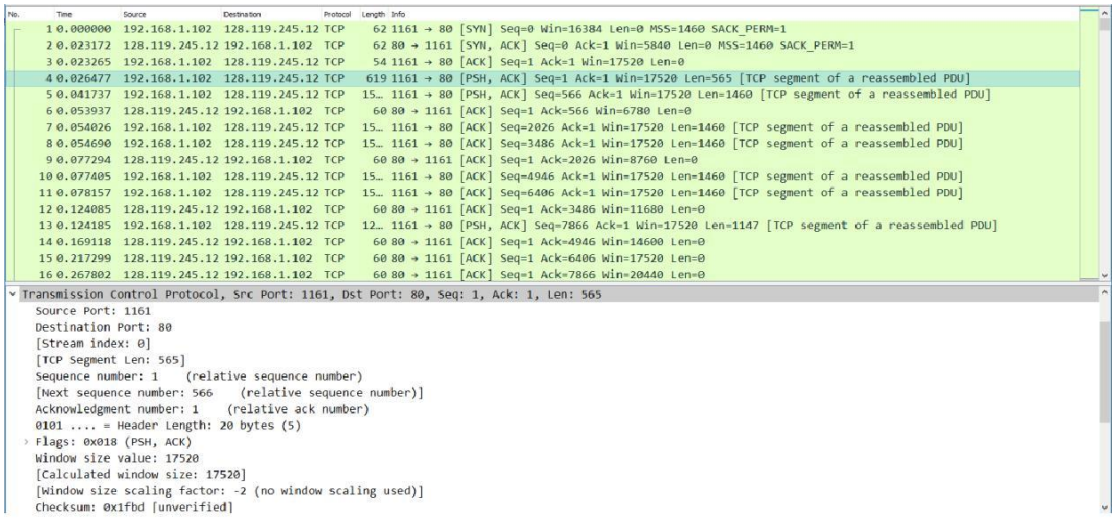
It is quite clear that the receiver typically acknowledges 1460 bytes of data in an ACK, it can be determined by investigating the increment of the ACK number.



No.	Time	Source	Destination	Protocol	Length	Info
181	4.921025	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=149737 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
182	4.921916	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=151197 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
183	4.922820	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=152657 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
184	4.923863	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=154117 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
185	4.924667	192.168.1.102	128.119.245.12	TCP	946	1161 → 80 [PSH, ACK] Seq=155577 Ack=1 Win=17520 Len=892 [TCP segment of a reassembled PDU]
186	5.019189	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=151197 Win=62780 Len=0
190	5.125019	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=154117 Win=62780 Len=0
191	5.197286	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=156469 Win=62780 Len=0
192	5.197508	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=156469 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
193	5.198388	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=157929 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
194	5.199275	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=159389 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
195	5.200252	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=160849 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
196	5.201150	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=162309 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
197	5.202024	192.168.1.102	128.119.245.12	TCP	326	1161 → 80 [PSH, ACK] Seq=163769 Ack=1 Win=17520 Len=272 [TCP segment of a reassembled PDU]

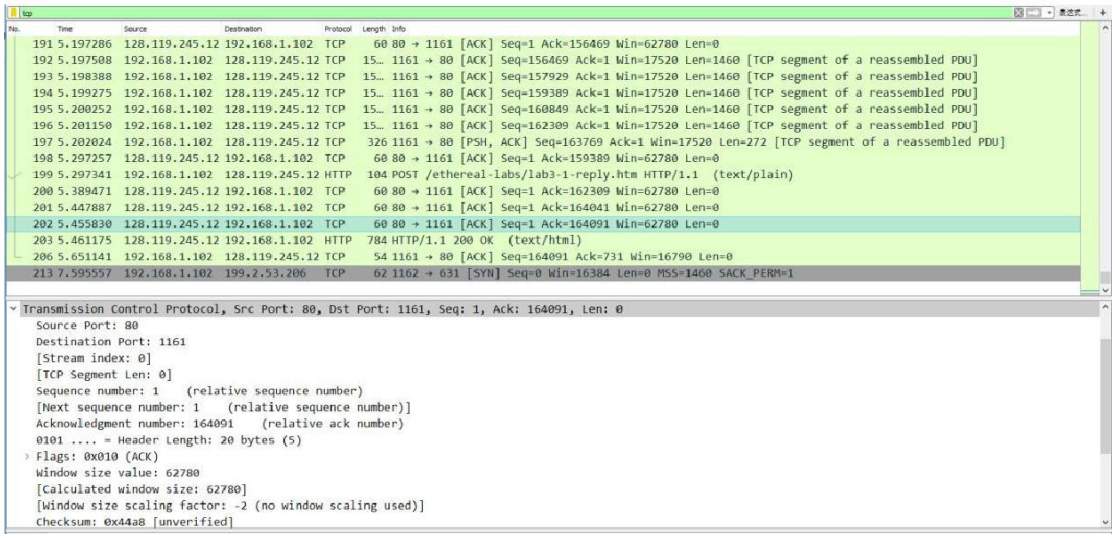
As we can see from the above picture, the receiver acknowledged 181, 183 and 185 segment. And there are more cases in this trace file.

Q8:



No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.1.102	128.119.245.12	TCP	62	1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1
2	0.023172	128.119.245.12	192.168.1.102	TCP	62	80 → 1161 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 SACK_PERM=1
3	0.023265	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=1 Ack=1 Win=17520 Len=0
4	0.026477	192.168.1.102	128.119.245.12	TCP	619	1161 → 80 [PSH, ACK] Seq=1 Ack=1 Win=17520 Len=565 [TCP segment of a reassembled PDU]
5	0.041737	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
6	0.053937	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
7	0.054026	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
8	0.054690	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
9	0.077294	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
10	0.077405	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
11	0.078157	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
12	0.124085	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
13	0.124185	192.168.1.102	128.119.245.12	TCP	12…	1161 → 80 [PSH, ACK] Seq=7866 Ack=1 Win=17520 Len=1147 [TCP segment of a reassembled PDU]
14	0.169118	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
15	0.217299	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
16	0.267802	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0

```
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 1, Ack: 1, Len: 565
    Source Port: 1161
    Destination Port: 80
    [Stream index: 0]
    [TCP Segment Len: 565]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 566    (relative sequence number)]
    Acknowledgment number: 1    (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x018 (PSH, ACK)
    Window size value: 17520
    [Calculated window size: 17520]
    [Window size scaling factor: -2 (no window scaling used)]
    Checksum: 0x1fbd [unverified]
```



No.	Time	Source	Destination	Protocol	Length	Info
191	5.197286	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=156469 Win=62780 Len=0
192	5.197508	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=156469 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
193	5.198388	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=157929 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
194	5.199275	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=159389 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
195	5.200252	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=160849 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
196	5.201150	192.168.1.102	128.119.245.12	TCP	15…	1161 → 80 [ACK] Seq=162309 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
197	5.202024	192.168.1.102	128.119.245.12	TCP	326	1161 → 80 [PSH, ACK] Seq=163769 Ack=1 Win=17520 Len=272 [TCP segment of a reassembled PDU]
198	5.297257	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=159389 Win=62780 Len=0
199	5.297341	192.168.1.102	128.119.245.12	HTTP	104	POST /ethereal-labs/lab3-1-reply.htm HTTP/1.1 (text/plain)
200	5.389471	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=162309 Win=62780 Len=0
201	5.447887	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164041 Win=62780 Len=0
202	5.455830	128.119.245.12	192.168.1.102	TCP	60	80 → 1161 [ACK] Seq=1 Ack=164091 Win=62780 Len=0
203	5.461175	128.119.245.12	192.168.1.102	HTTP	784	HTTP/1.1 200 OK (text/html)
206	5.651141	192.168.1.102	128.119.245.12	TCP	54	1161 → 80 [ACK] Seq=164091 Ack=731 Win=16790 Len=0
213	7.595557	192.168.1.102	199.2.53.206	TCP	62	1162 → 631 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM=1

```
Transmission Control Protocol, Src Port: 80, Dst Port: 1161, Seq: 1, Ack: 164091, Len: 0
    Source Port: 80
    Destination Port: 1161
    [Stream index: 0]
    [TCP Segment Len: 0]
    Sequence number: 1    (relative sequence number)
    [Next sequence number: 1    (relative sequence number)]
    Acknowledgment number: 164091    (relative ack number)
    0101 .... = Header Length: 20 bytes (5)
  > Flags: 0x010 (ACK)
    Window size value: 62780
    [Calculated window size: 62780]
    [Window size scaling factor: -2 (no window scaling used)]
    Checksum: 0x44a8 [unverified]
```

Throughput = amount of data transmitted / time used to transfer data
Amount of data = 164090 bytes, time = 5.455830 – 0.026477 = 5.429353s.
Throughput = 164.090 / 5.429353 = 30.223 kBytes/sec.

Exercise 2:

No	Source IP	Destination IP	Protocol	Info
295	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [SYN] Seq=2818463618 win=8192 MSS=1460
296	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [SYN, ACK] Seq=1247095790 Ack=2818463619 win=262144 MSS=1460
297	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463619 Ack=1247095791 win=65535
298	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [PSH, ACK] Seq=2818463619 Ack=1247095791 win=65535
301	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [ACK] Seq=1247095791 Ack=2818463652 win=262096
302	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [PSH, ACK] Seq=1247095791 Ack=2818463652 win=262144
303	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463652 Ack=1247095831 win=65535
304	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [FIN, ACK] Seq=2818463652 Ack=1247095831 win=65535
305	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [FIN, ACK] Seq=1247095831 Ack=2818463652 win=262144
306	10.9.16.201	10.99.6.175	TCP	50045 > 5000 [ACK] Seq=2818463652 Ack=1247095832 win=65535
308	10.99.6.175	10.9.16.201	TCP	5000 > 50045 [ACK] Seq=1247095831 Ack=2818463653 win=262144

Q1:

The sequence number of the TCP SYN segment used to initiate the connection is 2818463618.

Q2:

The sequence number of the TCP SYNACK segment sent by the server to the client is 1247095790. The value of the Acknowledgement field is 2818463619, because the SYN segment does not have any data, so the server just adds 1 to the sequence number of the SYN segment, this initial increment of 1 on both host's sequence numbers occurs during the establishment of all TCP sessions.

Q3:

The sequence number of the ACK segment sent by the client computer in response to the SYNACK is 2818463619, the value of the Acknowledgement field in this ACK segment is 1247095790, and this segment contains 2818463652 – 2818463619 = 33 bytes data.

Q4:

Both the client and server did the active close, because according to segment 304 and 305, both client an server have sent a FIN ACK segment to the other side as their last sending-segment. It indicates that this is a simultaneous close.

Q5:

The amount of data transferred between the server and the client can be determined by the first file-sending sequence number and the last file-sending ACK for both sides. Thus, 2818463652 – 2818463619 = 33 bytes data was transferred from the client to the server. 1247095831 – 1247095791 = 40 bytes was transferred from the server to the client. The Ack numbers sort of keep track of the length of the data being transferred, so the result of having final ACK from the other side subtract the initial sequence number is the amount of data have been transferred. This result has excluded the SYN and FIN flag,

because these segments do not contain any data.