Exercise 1:

Question 1. What is the IP address of gaia.cs.umass.edu? On what port number is it sending and receiving TCP segments for this connection? What are the IP address and TCP port numbers used by the client computer (source) that is transferring the file to gaia.cs.umass.edu?

The IP address of gaia.cs.umass.edu should be the destination IP address which is given by 128.119.245.12. The corresponding port number is used for this connection is 80.

The IP address of client computer is the source address which is given by 192.168.1.102 this is a private IP address, and the corresponding port number used is 1161.

Question 2. What is the sequence number of the TCP segment containing the HTTP POST command?

The fourth segment of the trace is the first TCP segment containing the HTTP POST command where you can find in the right.

The sequence number is 232129013

Question 3. Consider the TCP segment containing the HTTP POST as the first segment in the TCP connection.

(a) What are the sequence numbers of the first six segments in the TCP connection (including the segment containing the HTTP POST) sent from the client to the webserver (Do not consider the ACKs received from the server as part of these six segments)?

Packet list (Panel 1)

Source	Destination	Protocol	Length Info
192.168.1.102	128.119.245.12	TCP	62 1161 → 80 [SYN] Seq=0 Win=16384 Len=0 MSS=1460 SACK_PERM
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
192.168.1.102	128.119.245.12	TCP	54 1161 → 80 [ACK] Seq=1 Win=17520 Len=0
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]
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [PSH, ACK] Seq=566 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=566 Win=6780 Len=0
192.168.1.102	128.119.245.12	TCP	1514 80 → 1161 [ACK] Seq=2026 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
128.119.245.12	192.168.1.102	TCP	1514 1161 → 80 [ACK] Seq=3486 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=2026 Win=8760 Len=0
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=4946 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=6406 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=3486 Win=11680 Len=0
192.168.1.102	128.119.245.12	TCP	1201 1161 → 80 [PSH, ACK] Seq=7866 Ack=1 Win=17520 Len=1147 [TCP segment of a reassembled PDU]
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=4946 Win=14600 Len=0
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=6406 Win=17520 Len=0
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=7866 Win=20440 Len=0
128.119.245.12	192.168.1.102	TCP	60 80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=9013 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=10473 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
192.168.1.102	128.119.245.12	TCP	1514 1161 → 80 [ACK] Seq=11933 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]

Detail pane (Panel 1)

```
Protocol: TCP (6)
Header Checksum: 0x9f66 [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.1.102
Destination Address: 128.119.245.12
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 2026, Ack: 1, Len: 1460
  Source Port: 1161
  Destination Port: 80
  [Stream index: 0]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 1460]
  Sequence Number: 2026    (relative sequence number)
  Sequence Number (raw): 232131038
  [Next Sequence Number: 3486    (relative sequence number)]
  Acknowledgment Number: 1    (relative ack number)
  Acknowledgment number (raw): 883061786
  0101 .... = Header Length: 20 bytes (5)
  Flags: 0x010 (ACK)
  Window: 17520
  [Calculated window size: 17520]
  [Window size scaling factor: -2 (no window scaling used)]
  Checksum: 0xb98e [unverified]
  [Checksum Status: Unverified]
  Urgent Pointer: 0
  [Timestamps]
    [Time since first frame in this TCP stream: 0.054076000 seconds]
```

Detail pane (Panel 2)

```
Protocol: TCP (6)
Header Checksum: 0x9f65 [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.1.102
Destination Address: 128.119.245.12
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 3486, Ack: 1, Len: 1460
  Source Port: 1161
  Destination Port: 80
  [Stream index: 0]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 1460]
  Sequence Number: 3486    (relative sequence number)
  Sequence Number (raw): 232132498
  [Next Sequence Number: 4946    (relative sequence number)]
  Acknowledgment Number: 1    (relative ack number)
  Acknowledgment number (raw): 883061786
  0101 .... = Header Length: 20 bytes (5)
  Flags: 0x010 (ACK)
  Window: 17520
  [Calculated window size: 17520]
  [Window size scaling factor: -2 (no window scaling used)]
  Checksum: 0xdd01 [unverified]
  [Checksum Status: Unverified]
  Urgent Pointer: 0
  [Timestamps]
    [Time since first frame in this TCP stream: 0.054600000 seconds]
```

Detail pane (Panel 3)

```
Protocol: TCP (6)
Header Checksum: 0x9f65 [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.1.102
Destination Address: 128.119.245.12
Transmission Control Protocol, Src Port: 1161, Dst Port: 80, Seq: 3486, Ack: 1, Len: 1460
  Source Port: 1161
  Destination Port: 80
  [Stream index: 0]
  [Conversation completeness: Incomplete, DATA (15)]
  [TCP Segment Len: 1460]
  Sequence Number: 3486    (relative sequence number)
  Sequence Number (raw): 232132498
  [Next Sequence Number: 4946    (relative sequence number)]
  Acknowledgment Number: 1    (relative ack number)
  Acknowledgment number (raw): 883061786
  0101 .... = Header Length: 20 bytes (5)
  Flags: 0x010 (ACK)
  Window: 17520
  [Calculated window size: 17520]
  [Window size scaling factor: -2 (no window scaling used)]
  Checksum: 0xdd01 [unverified]
  [Checksum Status: Unverified]
  Urgent Pointer: 0
  [Timestamps]
    [Time since first frame in this TCP stream: 0.054600000 seconds]
```

The sequence numbers are: 232129013 232129578 232131038 232132498 232133958 and 232135418

(b) At what time was each segment sent? When was the ACK for each segment received? Given the difference between when each TCP segment was sent and when its acknowledgement was received, what is the RTT value for each of the six segments?

The segments were sent at time 0.026477 0.041737 0.054026 0.054690 0.077405 0.078157

The ACKs were received at time 0.053937 0.077294 0.124085 0.169118 0.217299 0.267802

RTT value can be calculated by taking the difference shown in the following table

(c) What is the *EstimatedRTT* value (see relevant parts of Section 3.5 or lecture slides) after receiving each ACK? Assume that the initial value of *EstimatedRTT* is equal to the measured RTT (*SampleRTT*) for the first segment and then is computed using the *EstimatedRTT* equation for all subsequent segments. Set alpha to 0.125.

Round Trip Time for 192.168.1.102:1161 → 128.119.245.12:80

tcp-ethereal-trace-1
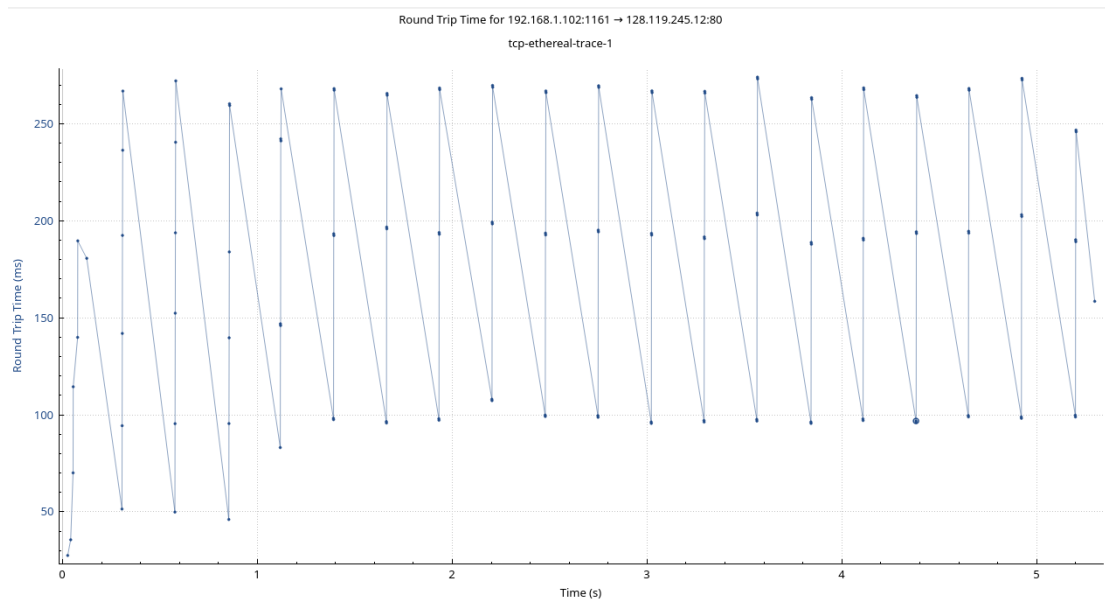
Sequence Number	Segment sent time	ACK receive time	RTT	EstimatedRTT	Length
232129013	0.026477	0.053937	0.027460	0.027460	565
232129578	0.041737	0.077294	0.035557	0.028472	1460
232131038	0.054026	0.124085	0.070059	0.033670	1460
232132498	0.054690	0.169118	0.114428	0.043765	1460
232133958	0.077405	0.217299	0.139894	0.055781	1460
232135418	0.078157	0.267802	0.189645	0.072514	1460

Estimated RTT = (1 - alpha) * Estimated RTT + alpha * SampleRTT

(d) What is the length of each of the first six TCP segments?

The lengths are: 565 1460 1460 1460 1460 1460 correspondingly

Question 4. What is the minimum amount of available buffer space advertised at the receiver for the entire trace? Does the lack of receiver buffer space ever throttle the sender?

```
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
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
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    1514 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    1514 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    1514 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    1514 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    1514 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    1201 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
17 0.304807   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=9013 Win=23360 Len=0
18 0.305040   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=9013 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
19 0.305813   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=10473 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
20 0.306692   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=11933 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
21 0.307571   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=13393 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
22 0.308699   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=14853 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
23 0.309553   192.168.1.102    128.119.245.12    TCP    946 1161 → 80 [PSH, ACK] Seq=16313 Ack=1 Win=17520 Len=892 [TCP segment of a reassembled PDU]
24 0.356437   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=10473 Win=26280 Len=0
25 0.400164   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=11933 Win=29200 Len=0
26 0.448613   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=13393 Win=32120 Len=0
27 0.500029   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=14853 Win=35040 Len=0
28 0.545052   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=16313 Win=37960 Len=0
29 0.576417   128.119.245.12   192.168.1.102    TCP    60 80 → 1161 [ACK] Seq=1 Ack=17205 Win=37960 Len=0
30 0.576671   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=17205 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
31 0.577288   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=18665 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
32 0.578329   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=20125 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
33 0.579195   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=21585 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
34 0.580149   192.168.1.102    128.119.245.12    TCP    1514 1161 → 80 [ACK] Seq=23045 Ack=1 Win=17520 Len=1460 [TCP segment of a reassembled PDU]
```

The minimum window size is 5840 bytes during the entire trace, the maximum buffer space is 62780 bytes. It is not likely to throttle the sender, as the buffer space is much bigger than the actual segment size.

Question 5. Are there any retransmitted segments in the trace file? To answer this question, what did you check for (in the trace)?
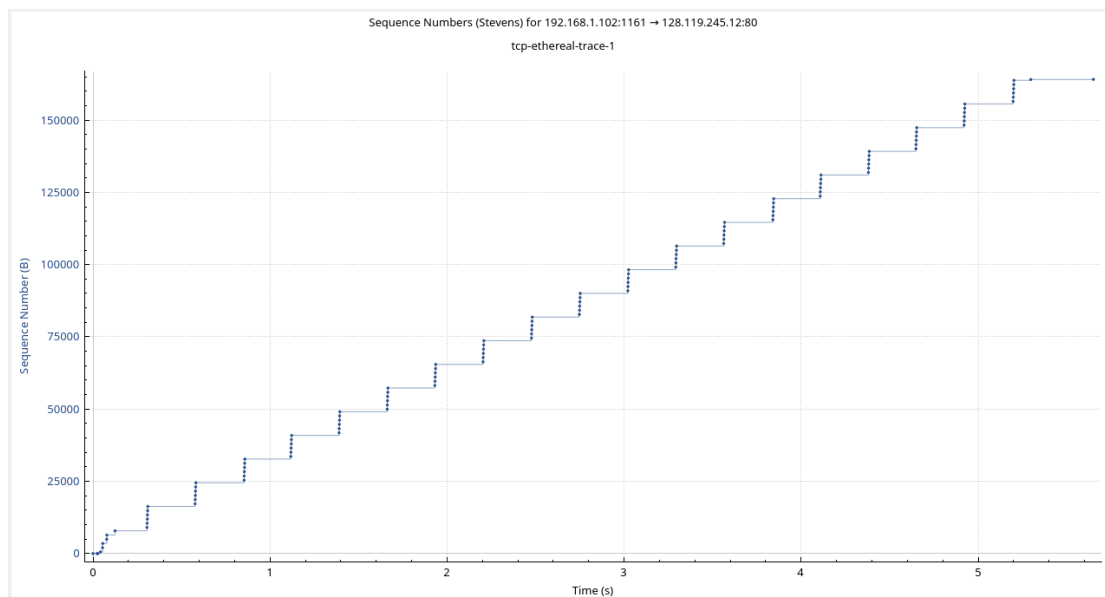
The sequence number kept increasing all the time, therefore, no retransmitted segments.

Question 6. How much data does the receiver typically acknowledge in an ACK? Can you identify cases where the receiver is ACKing every other received segment (recall the discussion about delayed acks from the lecture notes or Section 3.5 of the text)?

The receiver typically acknowledges 1460 bytes of data in an ACK, as we can see the length of the data sent by the sender is mostly 1460 bytes. In the picture above. We can find that Seq 95313 and seq 96773 are combined in the Acknowledgement 96773 sent from the receiver.

Question 7. What is the TCP connection's throughput (bytes transferred per unit of time during the connection)?

We can find that the total amount of data transmitted is 164090 bytes

Total time used to transfer the data is 5.455830-0.026477 = 5.429353s (from the HTTP POST request to the time finish the transmission)

Throughput = amount of data transmitted/ time used = 164090/5.429353 = 30222.75 bytes/s

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

Question 1 . What is the sequence number of the TCP SYN segment that is used to initiate the TCP connection between the client computer and server?

2818463618

Question 2. What is the sequence number of the SYNACK segment sent by the server to the client computer in reply to the SYN? What is the value of the Acknowledgement field in the SYNACK segment? How did the server determine that value?

Sequence number of the SYNACK segment sent by the server is 1247095790, the Acknowledgement field is 2818463619, which is the sequence number from the sender add 1 bit of SYN segment

Question 3 . What is the sequence number of the ACK segment sent by the client computer in response to the SYNACK? What is the value of the Acknowledgment field in this ACK segment? Does this segment contain any data?

Sequence number of the ACK segment sent by the client computer in response to the SYNACK is 2818463619, the value of the Acknowledgment field in this ACK segment is 1247095791. It contains 2818463652 – 2818463619 = 33 bytes of the data

Question 4 . Who has done the active close? Is it the client or the server? How you have determined this? What type of closure has been performed? 3 Segment (FIN/FINACK/ACK), 4 Segment (FIN/ACK/FIN/ACK) or Simultaneous close?

Both the client and server did the active close, in No 304 and 305, we can find both client and server sent a FIN ACK segment to other side while the sequence number and Ack number correspond to each other.

Question 5 . How many data bytes have been transferred from the client to the server and from the server to the client during the whole duration of the connection? What relationship does this have with the Initial Sequence Number and the final ACK received from the other side?

The amount of data transferred can be determined by the difference of first sequence number and the last ACK number.

Client: 2818463652 – 2818463619 = 33bytes

Server: 1247095831 – 1247095791 = 40 bytes

The Initial Sequence Number + 2 + total data transferred = final ACK received from the other side. Where the extra 2 is the SYN bit and FIN bit.