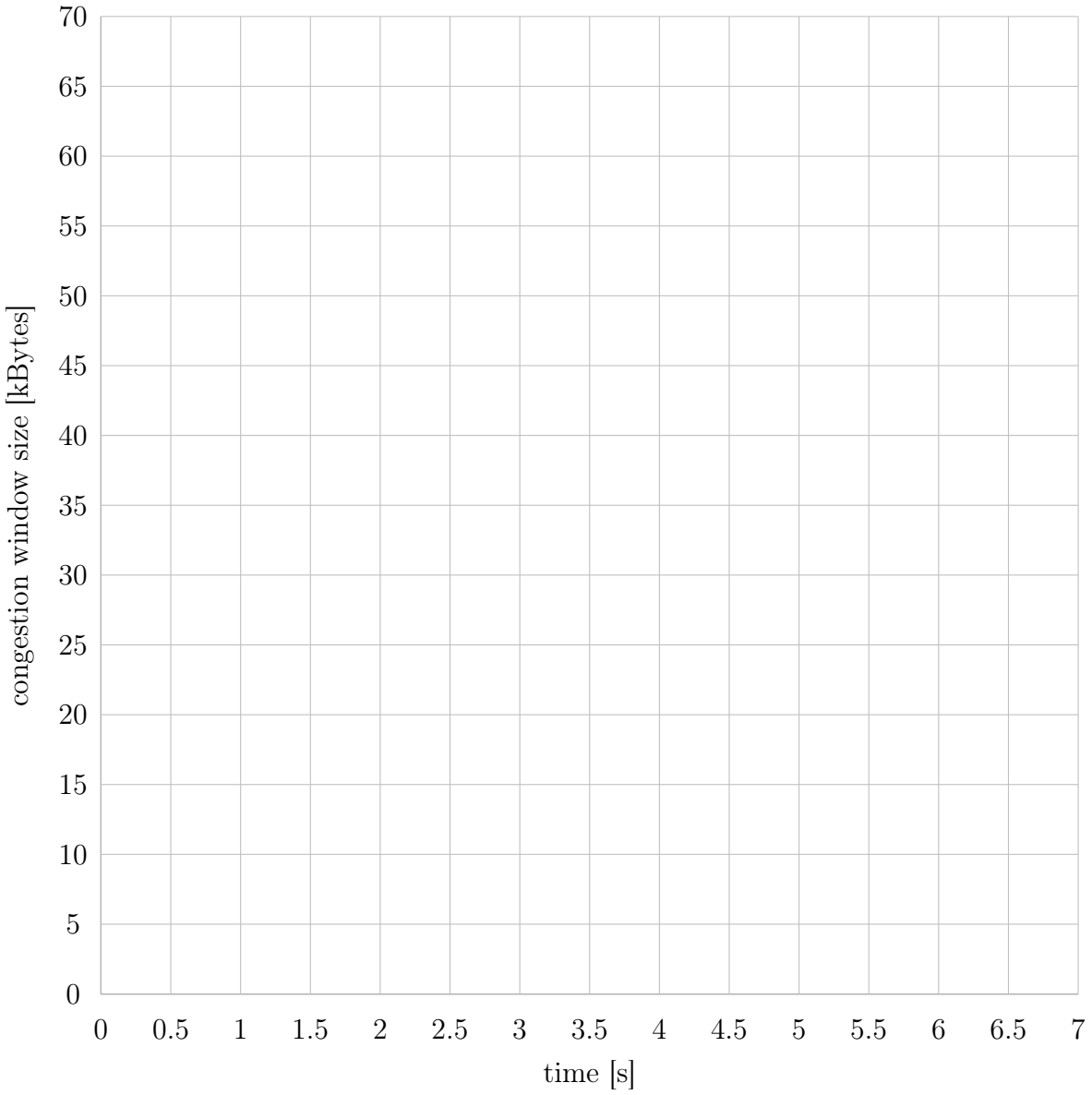
# 1 Congestion Control

1. What is the difference between flow control and congestion control?

2. What is the TCP slow start mechanism and why is it needed?

3. What is the main difference between the slow start and congestion avoidance phases?

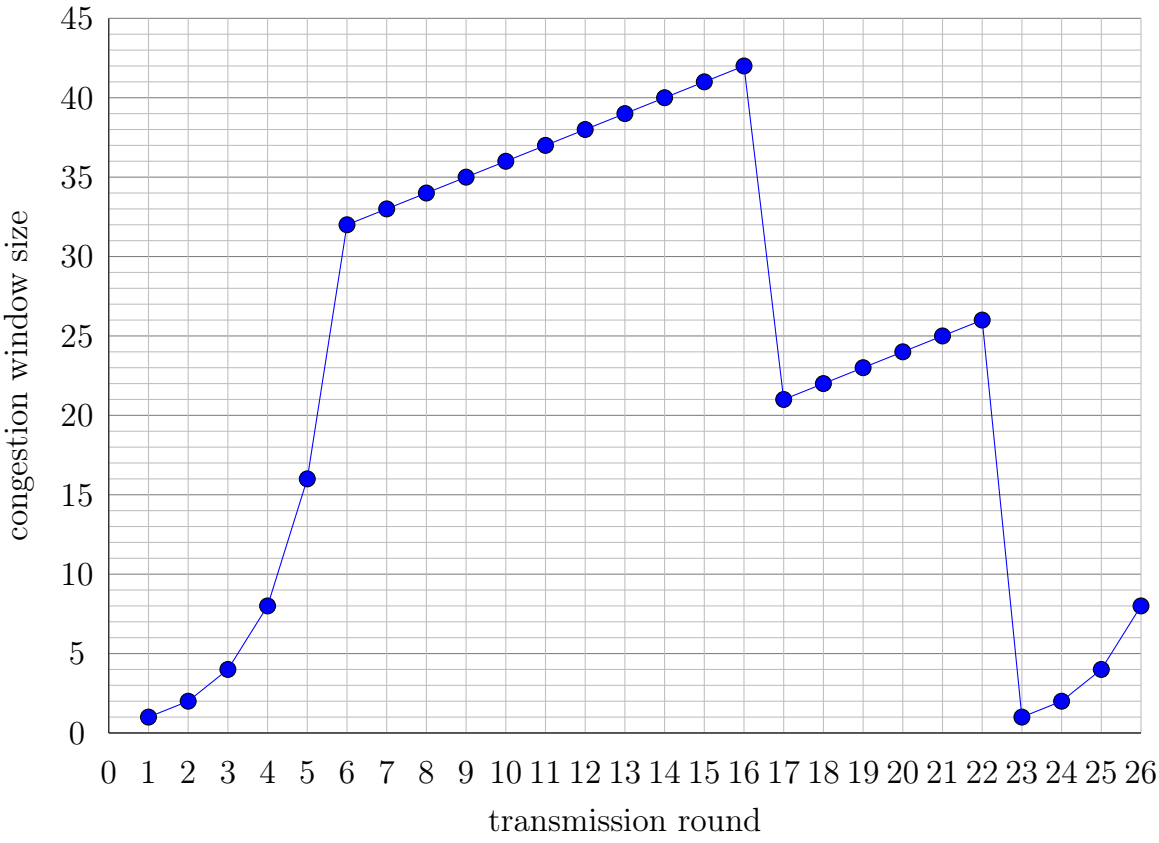
4. Consider a TCP Reno connection with $RTT = 200\,\text{ms}, MSS = 500\,\text{B}$ and a threshold of 64 kB. The congestion window size *cwnd* is initialized with 1 MSS. A segment loss is detected by a triple duplicate ACK after $t = 3\,\text{s}$ and by a timeout after $t = 4.4\,\text{s}$. Plot the congestion window size *cwnd* against time for the first 7 seconds.




5. For the above scenario, how many bytes were approximately transmitted during the first 15 RTTs?

# 2 TCP Reno

Consider the following plot of TCP window size as a function of time.




Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer.

1. Identify the intervals of time when TCP congestion avoidance is operating.
2. After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
3. After the 22nd transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
4. What is the initial value of threshold at the first transmission round?
5. What is the value of threshold at the 18th transmission round?
6. What is the value of threshold at the 24th transmission round?
7. During which transmission round is the 70th segment sent?

8. Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicated ACK, what will be the values of the congestion control window size and threshold?

# 3 TCP ARQ

1. ARQ can be implemented by both layer 2 protocols (Data Link Layer) and layer 4 protocols (Transport Layer). What is the difference between the 2 types of ARQ?

2. TCP can implement *go-back-N* ARQ with caching of out-of-sequence segments and *selective repeat* ARQ. What is the difference between these two options?

3. Consider a transmission using *go-back-N* ARQ (without caching of out-of-sequence segments) with a window size $N = 5$. The sender wants to send 8 packets as quickly as possible. The $4^{th}$ packet is lost on the way, and the acknowledgement of the $3^{rd}$ packet is also lost. Draw a sequence chart, and describe the events which will occur.

4. Consider a transmission using *selective repeat* ARQ with a window size $N = 5$. The sender wants to send 8 packets as quickly as possible. The $4^{th}$ packet is lost on the way, and the acknowledgement of the $3^{rd}$ packet is also lost. Draw a sequence chart, and describe the events which will occur. Assume, that each message is acknowledged individually and that no negative acknowledgement are used.