1. [10 points]

Advertised Window:

10^9 * 0.1 /8 bytes = 12500000 bytes = $2^{23.575}$ bytes in flight => 24 bit Advertised Window value

Sequence Number:

10^9 * 30 /8 bytes = 3.75 * 10^9 bytes = $2^{31.8}$ bytes in flight => 32 bit Sequence Number value

2. [10 points]

(a) 1:1 <- With round-robin service, we will alternate one telnet packet with each ftp packet, causing telnet to have dismal throughput.

(b) 13.5:1 <- With FQ, we send roughly equal volumes of data for each flow. There are about 552/41 ≈ 13.5 telnet packets per ftp packet, so we now send 13.5 telnet packets per ftp packet. This is better.

(c) 512:1 <- We now send 512 telnet packets per ftp packet. This excessively penalizes ftp.

3. [10 points]

First we calculate the finishing times F_i. We don't need to worry about clock speed here since we may take F_i = 0 for all the packets. F_i thus becomes just the cumulative per-flow size, ie $F_i = F_{i-1} + P_i$

Packet	Size	Flow	F_i
1	100	1	100
2	100	1	200
3	100	1	300
4	100	1	400
5	190	2	190
6	200	2	390
7	110	3	110
8	50	3	160

Step	Packet Number
1	1
2	7
3	8
4	5
5	2
6	3
7	6
8	4

4. [15 points]

(a) In slow start, the size of the window doubles every RTT. At the end of the *i*th RTT, the window size is 2^i KB. It will take 10 RTTs before the send window has reached 2^{10} KB = 1 MB.

(b) After 10 RTTs, 1023 KB = 1MB – 1KB has been transferred, and the window size is now 1MB. Although we have not yet reached the maximum capacity of the network, the sender's window size should not overwhelm the receiver's. So the window size will stay 1MB. It takes 10 more RTTs to transfer the remaining 9MB + 1KB. Therefore, the file is transferred in 20RTTs.

(c) It takes 2 seconds (20RTTs) to send the file. The effective throughput is (10MB/2s) = 40Mb/s = $40*2^{20}$ Mbps = 41.94 Mbps. This is only 4.2% of the available link bandwidth.

5. [10 points]

(a) We have

$$TempP = MaxP \times \frac{AvgLen - MinThreshold}{MaxThreshold - MinThreshold}$$

AvgLen is halfway between MinThreshold and MaxThreshold, which implies that the fraction here is 1/2 and so TempP = MaxP/2 = 0.005.

We now have P_{count} = TempP/(1 - count x TempP) = 1 / (1/TempP – count) = 1/(200-count). For count=1 this is 1/199; for count=100 it is 1/100.

(b) Evaluating the product $(1-P_1)$ x … x $(1-P_{50})$ gives

198/199 * 197/198 * 196/197 * .. * 150/151 * 149/150

which all telescopes down to 149/199, or around 0.7487.