1) i) $2RTT + RTT + (3 \times 9L/R + 2L/R) \div \frac{1}{2}$

$+2 \times 9Q$

$= 3RTT + 58\ L/R + 18Q$

ii) $11RTT + 58\ L/R + 18Q$

iii) $20RTT + 58\ L/R + 18Q$

iv) $12RTT + 34\ L/R + 9Q$

v) $8RTT + 22\ L/R + 5Q$

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2) i) linkrate: $\frac{375k}{6\ mil} = 0.0595$ seconds

T_B: $\frac{120}{60} \times 0.0595 = 0.119$

Avg access delay: $\frac{0.0595}{(1 - 0.119)} = 0.06754$

Total: $0.06754 + 2 + 4 = 6.06754$ seconds

2) ii) new link delay : $\frac{0.075}{1-(0.4)(0.15)} = 0.07979$ seconds

If miss ⇒ $0.07979 + 2 + 4 = 6.07979$ seconds,,

Total average time ⇒ $(0.6)(0) + (0.4)(6.07979) = 2.431916$ seconds,,

Reduced from 6.088235 seconds to 2.431916 seconds,,

iii)

$T = \frac{375}{5M} = 0.075$

$T_B = \frac{120 \times 0.3}{60} \times 0.075 = 0.045$

$delay = \frac{T}{1-T_B} = 0.07853$

$T = \frac{375}{10M} = 0.0375$

$T_B = \frac{120 \times 0.7}{60} \times 0.0375 = 0.0525$

$delay = \frac{T}{1-T_B} = 0.03958$

Total time $= 0.07853 \times 0.3 + 0.03958 \times 0.7 + 6$

$= 6.051265$,,

3) $12S/R > RTT > 4S/R$:

$2RTT + 4S/R$

$RTT + 4S/R$

$RTT + 16S/R + 28S/R$

$= 4RTT + 52S/R$

$RTT \geq 12S/R$:

$2RTT + 4S/R$

$RTT + 4S/R$

$RTT + 4S/R$

$RTT + 28S/R$

$= 5RTT + 40S/R$

4) i) Sender Events :

Send data octets 1-1000

Send data octets 1001-2300

Receive ack for 1000

Receive ack for 2300

Receiver Events :

advertise window = 2 300

ack up to 1000, window = 1000

ack up to 2300, window = 0

ii) Sender Events:

Send data octets 2501, 3500

Send data octets 3501, 4500

Receive ack for 3500

Receiver ack for 4500

Receiver ack for 4500

Receiver Events.

application reads 1500 octets

ackup to 2500, window = 2500

ackup to 3500, window = 1500

ackup to 4500, window = 500

application reads 1000 octets

ackup to 4500, window = 1506

5) i) TCP slow start is operating at [4, 7]
because the window sizes are doubling up.

ii) TCP congestion avoidance is operating at [1, 3] and [8, 16]
because of the linear increments to the window size

iii) After the 3rd transmission, packet loss is recognized by timeout and the window size is reset to 1.

iv) After the 16th transmission, segment loss is recognized by a triple duplicate Ack where window size is halved

v) Maximum possible initial size on first transmission round is 30, when TCP congestion avoidance started working.

vi) Since a timeout was detected, the congestion size of 32 was reduced to 1 at the 4th transmission round.
So the threshold becomes 16 //

vii) Since triple duplicate Ack was detected, the congestion size of 18 got reduced to 9 during the 11th transmission round.
So the threshold is 9 //

viii) The CWS will be 3 and threshold of 3 at 16th