1. Physical layer (9%)

a) Shannons formula is $C=W \log_2(1+S/N)$ where C is data rate, W is bandwidth and S/N is signal to noise ratio. Here W=3 100Hz and S/N=30dB=1 000/1.* Then $C=3\,100 \log_2(1+1000) = 30\,894$bps.
*$30dB=10 \log_{10}(S/N) \Rightarrow 10^3=S/N$

b) Impairments:
Attenuation: The strength of the signal decreases with distance over the transmission medium.
Delay distortion: Occurs because the velocity of a signal over a guided medium varies with frequency.
Noise, four kinds:
Thermal noise, also called white noise: Due to thermal agitation of electrons in a conductor, function of temperature, independant of frequency.
Impulse noise: Irregular noise spikes or pulses of short duration and relatively high amplitude
Intermodulation noise: Nonlinearity in transmission components
Crosstalk: Electrical coupling between nearby cables, or other signals appearing where they are not supposed to.

c) Shannons formula considers thermal noise, also named white noise. See Stallings p. 62.

(Exam August 17 1998)

2. Network architecture (8 %)

5 A/D and 5 D/A conversions: Analog sound waves go into the microphone of Ronny's computer. An A/D conversion is performed in the computer. A D/A conversion is performed in the modem attached to Ronny's computer. An A/D conversion is performed as the signal enters the digital core of the telephone network and a D/A conversion is performed as it enters the analog access network to which ISP1 is connected. An A/D conversion is performed at the modem pool of ISP1. So far we have had 3 A/D and 2 D/A conversions. Similarily, from the modem pool of ISP2 to the speaker of Ragge's computer we will have 3 additional D/A conversions and 2 additional A/D conversions giving a total of 5 A/D and 5 D/A conversions.

(Exam March 10 1999)

3. Data link layer (12 %)

a) The one way propagation delay is 1,25 seconds ($3{,}75 \cdot 10^8 / 3 \cdot 10^8$)

b) Mission Control sends a request for the data; two propagation delays later, the first bytes of the picture arrive. It takes an additional 20 seconds to transfer 25 MB (200 Mbit), so the minimum time required is 22,5 seconds.

c) The sliding window should be large enough to keep the pipe full, i.e. the utilization should be 1. Using the formula $U = N/(1+2a)$ and solving for N we get $N = 1 + 2a = 1 + 2*(T_{pr}/T_{tr})$. We know from above that $T_{pr} = 1{,}25$ seconds. $T_{tr} = (8 * 10^3) / (10 * 10^6) = 0{,}8 * 10^{-3}$ Thus, we get $N = 1 + 2*(1{,}25/(0{,}8*10^{-3})) = 3126$. That is, we need 12 bits to store the sequence number ($2^{12} = 4096$).

(Exam March 10 1999)

4. Wide Area Networks (WANs) (10%)

Table 1:

Switch 1	Input port	Input VCI	Output port	Output VCI
A to B	0	0	1	0
C to G	3	0	2	0
D to B	2	1	1	1

Table 2:

Switch 2	Input port	Input VCI	Output port	Output VCI
C to G	0	0	2	0
E to I	2	1	3	0
D to B	1	0	0	1

Table 3:

Switch 3	Input port	Input VCI	Output port	Output VCI
C to G	0	0	3	0
E to I	1	0	0	1

Table 4:

Switch 4	Input port	Input VCI	Output port	Output VCI
E to I	1	0	0	0

(Exam March 10 1999)

5. ATM (Asynchronous Transfer Mode) (5%)

a) true
b) false
c) false
d) false
e) true

(Exam August 17 1998)

6. Local Area Networks (8%)

a) CSMA/CD:
Medium organised (logically) as a bus. Medium access protocol:
1. Listen on the medium (sense), if it is idle then transmit, otherwise go to 2.
2. If medium is busy, listen until idle then transmit.
3. If collision detected during transmission transmit jamming signal to assure all stations learn about collision.
4. After jamming, wait random time then go to 1.
Token ring:
Medium organised (logically) as a ring. Medium access protocol:
1. Token circulates in ring when idle.
2. Station that wants to transmit grabs token when it passes by, transforms it into start of frame marker and transmits data.
3. Transmitting station inserts a new token into the ring when it has finished transmission (or timer expires) and it has received the start of frame marker (after one circulation, i.e., only one frame may be on the ring).
4. Next station may seize token and transmit.

b) CSMA/CD handles collisions that occur, token ring avoids collisions altogether.

c) Token ring is the most fair protocol of the two. When all stations have data to transmit it behaves in a round robin fashion. In Ethernet there is no guarantee that a station will not be blocked forever.

(Exam August 17 1998)

7. Transport Protocols (9 %)

a) IP is a network level (OSI 3) datagram service that will route packets to the right host based on the IP address. UDP is a datagram service at the transport level (OSI 4) and can be used to direct the packets to different processes within the same host. To accomplish this, the UDP header includes a demultiplexing field (called port number) that is used to map the packet to the right process. (The UDP header also includes a checksum (optional) that covers the whole UDP-data as well as some fields in the IP header.)

b) TCP provides a reliable transfer from the sender to the receiver. To accomplish this the TCP header contains a sequence number, an acknowledgement sequence number and a checksum. Just as UDP, TCP is able to map packets to different processes by use of a demultiplexing field (called port number). (The TCP header also contains a window size field for the purpose of flow control and various flag bits.)

(Exam March 10 1999)

8. Networking (10 %)

a) 1: Eth-H, D-MAC=broadcast, S-MAC=l; No IP header
2: Eth-H, D-MAC=l, S-MAC=p; No IP header
3: Eth-H, D-MAC=p, S-MAC=l; IP-H, D-IP=o, S-IP=k
4: Eth-H, D-MAC=l, S-MAC=p; IP-H, D-IP=k, S-IP=o

b) Only two messages are seen (ICMP Echo Request and ICMP Echo Reply); no address resolution is performed as A and D has already cached each others MAC addresses in their respective ARP cache.
1: Eth-H, D-MAC=p, S-MAC=l; IP-H, D-IP=s, S-IP=k
2: Eth-H, D-MAC=l, S-MAC=p; IP-H, D-IP=k, S-IP=s

c) The Ethernet header contains multiplexing fields (SAP, Service Access Point) that tell what payload the Ethernet frame is carrying.

(Exam April 12 1999)

“Wrap-up” Recitation, Questions from previous exams

Solution to question 4

Name:

Person nummer:

Switch 1	Input port	Input VCI	Output port	Output VCI
A to B				
C to G				
E to I				
D to B				

Switch 2	Input port	Input VCI	Output port	Output VCI
A to B				
C to G				
E to I				
D to B				

Switch 3	Input port	Input VCI	Output port	Output VCI
A to B				
C to G				
E to I				
D to B				

Switch 4	Input port	Input VCI	Output port	Output VCI
A to B				
C to G				
E to I				
D to B				