INSTRUCTIONS:

(1) Answer all questions directly on the examination paper.
(2) No notes, books, or other aids are permitted. No electrically operated aid devices are permitted, including, but not limited to, computers, calculators, cellular phones, pagers, or PDA devices.
(3) If the space allotted for your answer is too small, continue your answer on the back of the page, clearly indicating your answer is continued overleaf.
(4) The exam has 19 questions on 6 pages, apart from this cover page.
(5) Attempt all questions: partial marks are given for incomplete but correct answers.
(6) Numbers beside questions in [] brackets denote number of points the question is worth. This exam is out of 88 total points.

Good luck!
Recall that \( c = 3 \times 10^8 \text{ m/sec} \) in vacuum, but only \( 2.1 \times 10^8 \text{ m/sec} \) in a wire or optical fiber.
You may find this table useful for the ASCII character set.

The table provides the hexadecimal character codes for characters in the character set. To generate the hex code for a character read down beside the row first, then add the column offset, e.g., the character code for ‘A’ is 40 + 1, hence 0x41.

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(1) [5] What odd-parity ASCII character is being communicated by the Manchester encoded signal shown? (bit 0 is sent first)? Each vertical division (every 0.5 ms) is a single bit-time.

(2) [3] One of the responsibilities of layer 3 of the OSI model is managing packet flow to minimize or avoid congestion. In a connectionless service, packets can be routed around congestion. Is this also true for connection-oriented service? why or why not?

(3) [3] A signal, arriving at the receiver, is only 1% as strong as when it was sent. What is the signal strength loss in dB?

(4) [4] In digitizing human speech for telephone transmission it is common to limit the high frequency components to 4,000 Hz and below. Suppose we represent each sample in an 8-bit byte. Show what the channel bandwidth must be to carry this digitized speech.
(5) [2] What is the Hamming distance between the even-parity encodings of the ASCII characters ‘A’ and ‘B’?

(6) [3] In transmitting data on a wire, the bits appear as state values of some signal on the wire. Suppose the receiver samples the wire k times per second. What is this rate of k samples per second called? What does knowing k tell you about the bit rate?

(7) [2] If an ISDN basic rate service has 2 B-channels and 1 D-channel, what would the aggregate total capacity of the basic rate service be if you could combine all three channels?

(8) [3] Some frame i has just been correctly received using a sliding-window protocol. Assume the window was empty, so now it contains the one frame, i. Suppose the receiver, which uses n-bit sequence numbers, wants to acknowledge that it has correctly received frame i. What sequence number value does the receiver send if (i) using Go-Back-N? (ii) Selective Repeat protocol?

(9) [2] Suppose you have a source of a single ‘pure’ audio frequency or tone (like a tuning fork) for 900 Hz. Given that $\lambda = \frac{v}{f}$, what is the length of one cycle of this tone in this room? (Hint: an acceptable approximation to $v_{\text{sound in this room}}$ is $3 \times 10^2$ m/sec). [Bonus [2]: what is the length of 1 cycle of this tone in a vacuum?]

(10) [3] Flooding may seem to be a drastic way to route packets, but it is effective. Flooding offers other advantages. Name and briefly describe one of these advantages.
(11) [5] Show what the LZ compressed version of the message “the one phone or the other” would look like — work only with groupings of 2 or more characters (as we did in class). For your convenience, the message is reprinted below, with the character positions numbered:

```
000000001111111112222222
12345678901234567890123456
the one phone or the other
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(12) [7] Suppose we work with frames of length 10 kbits and a channel capacity of 2 Mbps. The link is a copper wire connecting two machines that are 420 m apart, and is very reliable. Assuming that the processing times at either end are negligible, that the frame transmit times are the same at both ends (i.e., \( T_r = T_a \)), and there are no other delays of any kind, what would you suggest as a reasonable timeout value, e.g., for stop-and-wait with timeout to use?

(13) [4] When a node on a token-ring sends a frame, the A and C bits in the Frame Status field are both 0. When the frame returns to its originator, what does it mean if: (i) A and C are both 1? (ii) A is 1 but C is 0?

(14) [5] Assume a perfect link that carries data at 20.48 kbps. How long does it take to transmit a 50 kilobyte file?
(15) [2] If you could choose between using virtual circuit or datagram network models, why might you prefer datagrams if nodes in the network are known to be highly prone to failure?

(16) [10] Suppose \( F_T \) is a frame of bits to be transmitted over a link using CRC’s as part of its error handling mechanism. If the generator polynomial for the CRC system is \( x^4 + x^2 + x + 1 \), is the received frame \( F_R: 1110 \ 0010 \ 1110 \ 0101 \ 1101 \) correct or not? State how you know.

(17) [2] On some CSMA/CD link there have just been three consecutive collisions. Every time a collision is detected, each of the nodes waits some number \( j \) of time slots before attempting to send again. What is the range of values \( j \) may take on at this instant, just after the third consecutive collision?
(18) [7] The OSI 7-layer model is a classical model for the study of networks. Draw the seven layers, identifying each by its full name (i.e., not just with an acronym).

(19) [15] Fill in the blanks; each is worth 1 point.

(i) ________________ is always present in any communications medium.

(ii) ________________ and ________________ are two of many bodies that establish standards by which networks operate.

(iii) The kind of switching a network is using when an entire message transfer follows a single, fixed path through the network: ________________

(iv) Sine waves whose frequencies are multiples of a frequency \( f \), e.g., 2\( f \), 3\( f \), etc., are called ________________

(v) This kind of series can approximate any periodic function: ________________

(vi) A channel that picks up signal energy from other nearby signals is experiencing this kind of noise: ________________

(vii) Ensuring that unauthorized changes to a message in a network cannot go undetected is ensuring message ________________

(viii) Links become more susceptible to error as ________________ increases.

(ix) A connection-oriented service where packets are always provided in correct sequence is a ________________ delivery service.
(x) Two or more machines on a shared-resource link (like Ethernet) cause a ________________ if they begin transmitting packets at the same time.

(xi) The number of frames a node on a token-ring network can send if it does not have the token is ________________

(xii) The number of bits in a MAC address in 802.3 (e.g., in an Ethernet frame) is ________________

(xiii) Selecting a path for packets through a network from source to destination is called ________________

(xiv) A signal in a channel ranges from 1.5 kHz to 4.5 kHz has a bandwidth of ________________ kHz