1. (7 pts) List in order from high-level to low-level the seven layers of the OSI networking model.

2. (2 pts each) Expand the following acronyms:
   (a) HTTP
   (b) SMTP
   (c) TCP/IP

3. (6 pts) Calculate the latency for a 2 MB message to travel from host A to host B through a router (C). The link from A to C is 100km long and has a bandwidth of 10 Mbps. The link from C to B is 400km and has a bandwidth of 1 Gbps. Assume that both links are fiber optic cable through which a signal can travel at $2.0 \times 10^8$ m/s. Also assume that there is a 5 ms queueing delay at the router. Express your answer in milliseconds and round your answer to the nearest millisecond. Show your work.

4. (3 pts each) Briefly define each term:
   (a) end system
   (b) protocol

5. (2 pts) For each abbreviation, give the long name and a definition:
   (a) µs
   (b) Mbps
   (c) ns

6. (4 pts) Which of the abbreviation(s) in problem 5 would be used as a measure of bandwidth? Which of the abbreviation(s) in problem 5 would be used as a measure of latency?

7. (4 pts) Briefly contrast time division multiplexing with frequency division multiplexing.

8. (4 pts) Explain the roles played by port numbers and by IP numbers.

9. (4 pts) Name two applications that use TCP as their transport layer protocol. Name two applications that use (typically) UDP as their transport layer protocol.

10. (2 pts) If SMTP supports only ASCII transmission, how is it that photos and other non-text documents can be sent using this mechanism?

11. (2 pts) Why are you able to receive email even if your computer is off?
12. (4 pts) What is the purpose of the POP3 and IMAP protocols?

13. Answer the following questions with regard to DNS.
   (a) (2 pts) In what layer of the OSI model does it operate?
   (b) (2 pts) What service does it provide?
   (c) (2 pts) What is an authoritative server?
   (d) (4 pts) Explain why the command `nslookup www.cnn.com` produces a rotating list of IP numbers. (i.e., why are there multiple numbers and why do they rotate?)

14. What port number is used for each protocol?
   (a) (2 pts) HTTP
   (b) (2 pts) SMTP

15. (3 pts) How is it possible to download files faster using bittorrent than when downloading from a high-performance server?

16. (3 pts) Briefly outline the architectural differences between Napster and Gnutella.

17. (4 pts) What problem with the Gnutella architecture do Distributed Hash Tables attempt to solve?

18. (14 pts) Recall that HTTP is based on a request/response protocol.

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<th>Requests are of this form:</th>
<th>Responses are of this form:</th>
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<td>version code phrase</td>
</tr>
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<tr>
<td>entity body</td>
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Write a simple HTTP client program in Java that given the name of a web server will retrieve the home page from that server and will display the entire response from the server. You may assume that the server does not use persistent connections and will disconnect from the client after the document is served.