1 Some Hints

Your professor suggests the following preparation strategies:

- Be Sure that you have the correct exam (there is a 416 and 516 version).
- This exam is open book and open notes (your own books and notes that is!). Calculators are permitted, networked devices are not.
- Write neat clean answers, since if the grader cannot understand you on the real exam, it will go badly for you.
- Show your work, if you are guessing the grader will not give much credit (even if you get lucky and guess right).
- Define your notation (you can use tables like the lecture notes if you like).
- Set up the solution symbolically and simplify before plugging numbers in, it is easier to follow for the grader.
- You can solve problems out of order, but keep the work for each problem in one place, and mark it clearly.
2 The Problems

1. Multiple Access (15 Points):
   (a) What is multi-path interference? (5 points).
   (b) CDMA (10 Points): Suppose we have inputs $A, B, C, D$ in a direct sequence CDMA system with chip patterns:

<table>
<thead>
<tr>
<th>Input</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$B$</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>$C$</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$D$</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

   Assume that bipolar encoding of $V = +1, -V = -1$ is used for generating code words and that collisions are additive.
   i. Solve for $B \cdot (A + B + C + D)$, showing all your work (5 points).
   ii. Solve for $C \cdot (A + B + C + D)$, showing all your work (5 points).
   **Hint:** You may reuse work that is common with Problem 1(b)i.

2. ARQ (40 Points): Consider a system with a 100 Mbps connection between to end points with a 200μsec. end to end delay. Suppose that packets of 1300 bytes, with 50 bytes of header and trailer fields (the rest being user data).
   (a) What is the effective bandwidth of this connection if Stop-and-Wait ARQ is used (10 points)?
   (b) Suppose we want to use a window based form of ARQ, how large should the window size be (10 points)?
   (c) Suppose that the probability of a packet failing to transmit properly across the link is $10^{-4}$.
      i. What is the efficiency of the link using Go-Back-N ARQ with the optimal window size computed in Problem 2b (10 points)?
      ii. What is the efficiency of the link using selective repeat ARQ with the optimal window size computed in Problem 2b (10 points)?

3. Scheduling (25 points):
   (a) Max-Min Fair Share (5 points): Consider a system with 5 sources which demands of 5, 9, 7, 8, 13 respectively, and a channel with capacity of 40. If each source has equal weighting, what is the max-min fair share allocation to each channel (5 points)?
   (b) GPS and WFQ (20 points): Give the arrival times and service completion times of each packet in the system. Suppose that you have a scheduler managing connections $A, B, C$, with packets of size 30, 10, 40 respectively.
i. What is the GPS schedule of this system (5 points)?
ii. What is the WFQ schedule of this system assuming equal weights on each connection (5 points)?
iii. What is the WFQ schedule of this system assuming that the connections have weights of 1, 1, 2 respectively (10 points)?

4. Distance vector Routing (20 points): Consider the configuration shown in Figure 1, and recall the distance vector routing algorithm.

![Figure 1: Network in Problem 4](image)

(a) Show the initial condition of the system by giving each node's initial distance vector (5 points).
(b) Suppose that A gets the initial distance vector from B, show how A computes its updated distance vector (5 points).
(c) Suppose that A gets the initial distance vector from C, show how A computes its updated distance vector (5 points).
(d) Suppose that A has the distance vector computed in 4c and compute how A would update its distance vector after getting the vector from D which you computed in 4b (5 points).

5. Flow Control and Scheduling (10 Points):
   (a) How does TCP Reno differ from TCP Tahoe (5 points)?
   (b) What is the difference between work conserving and non work conserving scheduling disciplines (5 points)?