Question 1

(i) a) Frame time = 8000/50 = 160msec,
    Time interval(From and to): 3-0.16 to 3+0.16 i.e. 2.84 – 3.16
    b) Frame time = 160 msec; 5/sec = 5*0.16 = 0.8 frames/frame time
       G = 0.8, S = Ge^-2G = 0.8e^-1.6 = 0.162 frames/frame time
       Throughput = 50*0.162 = 8.076kbps
(ii) a) Slot start times are: 0,160, 320, 480, 640, 800, 960, 1120, i.e., So S0 can start at 1.12 sec
      b) S = Ge^G = 0.8e^-0.8 = 0.36, Throughput = 0.36*50 = 17.97 kbps

Question 2

(i)

Number of slots = 6
Slot 1 = [0, 4, 5]
Slot 2 = [0]
Slot 3 = [4, 5]
Slot 4 = [4, 5]
Slot 5 = [4]
Slot 6 = [5]

(ii)a)

Propagation Delay between S0 and S4 = 8/7*(1/160)*1000 = 50/7 micro sec
S0 transmission start time = 8 sec
S0 collusion detection time = 50/7 or 7.14 micro sec after starting
(ii)b) Throughput = \( \frac{8}{32} \times 1 \text{ Mbps} = 250 \text{ kbps} \)

(ii)c) Manchester encoding for Hexadecimal “AB”

![Manchester encoding diagram]

Question 3

(i) Routing table at R3:

<table>
<thead>
<tr>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>0</td>
</tr>
<tr>
<td>R1</td>
<td>1</td>
</tr>
</tbody>
</table>

Routing table at R4:

<table>
<thead>
<tr>
<th>IN</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2</td>
<td>0</td>
</tr>
<tr>
<td>R5</td>
<td>0</td>
</tr>
<tr>
<td>R6</td>
<td>0</td>
</tr>
</tbody>
</table>

(ii)a) Path A-F: F-B-A :8
Path A-G: G-C-B-A: 10

(ii)b) Entries in the routing table for nodes F and G

| 8 | B |
(ii)c) Protocol:

Send 100
RCV 100^+
Complete 100'''

A 100:
RCV:
C: <G, 10> D: <G, 7> B: <G, 7>

Complete: G [10, B]

A 200:

Send G: [10, B]

RCV:
C: <G, 10> D: <G, 13> B: <G, 13>

Complete: G [16, B]

A 300:

Send G: [16, B]

RCV:
C: <G, 17> D: <G, 13> B: <G, 13>

Complete: G [16, B]

Entries in routing table for node G:

At time T+200: G 16 B

At time T+300: G 16 B
Question 4

(i) Capacity of the bucket = 32 Mbits

1st burst: at time 0 (16 Mbps) ----> 5Mb transmitted ----> 11Mb left in bucket
2nd burst: at time 500 msec (16 Mbps) ----> 5Mb transmitted ----> 22Mb left in bucket
3rd burst: at time 1000 msec (16 Mbps) ----> 5Mb transmitted ----> 32-5=27Mb left (6Mb lost)
4th burst: at time 1500 msec (16 Mbps) ----> 5Mb transmitted ----> 32-5=27Mb left (11Mb lost)

At time 2000 msec 27Mb is left in the bucket which takes 2.7 seconds to be emptied.
So output of the leaky bucket is 10Mbps for 4.7 seconds. A total of 17Mb of data is lost.

Leaky bucket output

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10Mbps</td>
</tr>
<tr>
<td>4.7</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Token bucket output

ρ = 200/msec*2*8 = 3200 bits/msec = 3.2 Mbps

Time taken to discharge all tokens at 10Mbps = C/ (M - ρ) = 32/(10-3.2) = 4.7059 seconds

Total Input = 4*16=64Mbits

47.06 Mb transmitted at 10Mbps. Remaining data (64-47.06 = 16.94 Mb) is transmitted at the rate of the tokens i.e. 3.2 Mbps which lasts for 5.294 seconds.

Total time = 4.706 + 5.294 = 10 seconds
(iii) Fragment offset and MF fields for IP packets at R4:

1000 --- (400, 600)
400 --- (100, 300)
600 --- (350, 250)

100: <0, MF=1>
300: <100, MF=1>
350: <400, MF=1>
250: <750, MF=0>

(iv) Additional functions for C1 – C6 packet

**R1:**
- Replaces IPC1 with IP1
- Replaces Socket# with an index into its table
- Stores <IPC1, S1> in its table

**R4:**
- Finds entry using Socket#
- Replaces IP2 and Socket# with entries in its index table