1. *(10 points)* Consider the first network. An MTU of 1024 means that is the largest IP datagram that can be carried, so a datagram has room for $1024 - 20 = 1004$ bytes of IP-level data; because 1004 is not a multiple of 8, each fragment can contain at most $8 \times \lfloor 1004/8 \rfloor = 1000$ bytes. We need to transfer $1024 + 20 = 1044$ bytes of data when the TCP header is included. This would be fragmented into fragments of size 1000, and 44. Over the second network the 44-byte packet would be unfragmented but the 1000-data-byte packet would be fragmented as follows. The 576-byte MTU allows for up to $576-20 = 556$ bytes of payload, so rounding down to a multiple of 8 again allows for 552 byes in the first fragment with the remaining 448 in the second fragment. Thus:

| Fragment # | Size | Offset |
|---|---|---|
| 1 | 552 bytes | 0 |
| 2 | 448 bytes | 69 |
| 3 | 44 bytes | 125 |

2. *(15 points)*

(a)

| Information Stored at Node | Distance to Reach Node | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| A | 0 | ∞ | 3 | 8 | ∞ | ∞ |
| B | ∞ | 0 | ∞ | ∞ | 2 | ∞ |
| C | 3 | ∞ | 0 | ∞ | 1 | 6 |
| D | 8 | ∞ | ∞ | 0 | 2 | ∞ |
| E | ∞ | 2 | 1 | 2 | 0 | ∞ |
| F | ∞ | ∞ | 6 | ∞ | ∞ | 0 |

(b)

| Information Stored at Node | Distance to Reach Node | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| A | 0 | ∞ | 3 | 8 | 4 | 9 |
| B | ∞ | 0 | 3 | 4 | 2 | ∞ |
| C | 3 | 3 | 0 | 3 | 1 | 6 |
| D | 8 | 4 | 3 | 0 | 2 | ∞ |
| E | 4 | 2 | 1 | 2 | 0 | 7 |
| F | 9 | ∞ | 6 | ∞ | 7 | 0 |

(c)

| Information Stored at Node | Distance to Reach Node | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| A | 0 | 6 | 3 | 6 | 4 | 9 |
| B | 6 | 0 | 3 | 4 | 2 | 9 |
| C | 3 | 3 | 0 | 3 | 1 | 6 |
| D | 6 | 4 | 3 | 0 | 2 | 9 |
| E | 4 | 2 | 1 | 2 | 0 | 7 |
| F | 9 | 9 | 6 | 9 | 7 | 0 |

3. (10 points)

| Packet Destination Address | NextHop |
|---|---|
| (a) 128.96.39.10 | Interface 0 |
| (b) 128.96.40.12 | R2 |
| (c) 128.96.40.151 | R4 |
| (d) 192.4.153.17 | R3 |
| (e) 92.4.153.90 | R4 |

Apply each subnet mask and if the corresponding subnet number matches the Subnet Number column, then use the entry in Next-Hop. (In these tables there is always a unique match.)

(a) Applying the subnet mask 255.255.255.128 we get 128.96.39.0. Use interface0 as the next hop.

(b) Applying subnet mask 255.255.255.128, we get 128.96.40.0. Use R2 as the next hop.

(c) All subnet masks give 128.96.40.128 as the subnet number. Since there is no match, use the default entry. Next hop is R4.

(d) Next hop is R3.

(e) None of the subnet number entries match, hence use default router R4.

4. (10 points)

Giving each department a single subnet, the nominal subnet sizes are $2^7$, $2^6$, $2^5$, $2^5$ respectively; we obtain these by rounding up to the nearest power of 2. A possible arrangement of subnet numbers is as follows. Subnet numbers are in binary and represent an initial segment of the bits of the last byte of the IP address; anything to the right of the / represents host bits. The / thus represents the subnet mask. Any individual bit can, by symmetry, be flipped throughout; there are thus several possible bit assignments. The essential requirement is that any two distinct subnet numbers remain distinct when the longer one is truncated to the length of the shorter.

| Departments | Subnet ID | Subnet Mask |
|---|---|---|
| A: 75 hosts | 212.1.1.0 | 255.255.255.128 |
| B: 35 hosts | 212.1.1.0 | 255.255.255.192 |
| C: 20 hosts | 212.1.1.192 | 255.255.255.224 |
| D: 18 hosts | 212.1.1.224 | 255.255.255.224 |

5. (5 points)

| Destination Address | Nexthop |
|---|---|
| C4.5E.13.87 | B |
| C4.5E.22.09 | A |
| C3.41.80.02 | E |
| 5E.43.91.12 | F |
| C4.6D.31.2E | C |
| C4.6B.31.2E | D |

6. (20 points)

| step | confirmed | tentative |
|---|---|---|
| 1 | (A,0,-) | |
| 2 | (A,0,-) | (D,2,D) (B,5,B) |
| 3 | (A,0,- ) (D,2,D) | (B,4,D) (E,7,D) |
| 4 | (A,0,- ) (D,2,D) (B,4,D) | (E,6,D) (C,8,D) |
| 5 | (A,0,- ) (D,2,D) (B,4,D) (E,6,D) | (C,7,D) |
| 6 | (A,0,- ) (D,2,D) (B,4,D) (E,6,D) (C,7,D) | |

7. Experimental Results (5 points)