B38CN: Introduction Communications and Networks
Tutorial 3 (Chapter 2) – Solutions

1. The Nyquist theorem is a property of mathematics and has nothing to do with technology. It says that if you have a function (signal) whose Fourier spectrum does not contain any sines or cosines above f, then by sampling the function at a frequency of 2f you capture all the information there is. Thus, the Nyquist theorem is true for all media.
2. Start with $\lambda f = c$. We know that c is 3×10^8 m/s. For λ =1 cm, we get 30 GHz. For λ = 5 m, we get 60 MHz. Thus, the band covered is 60 MHz to 30 GHz.
3. With 66/6 or 11 satellites per necklace, every 90 minutes 11 satellites pass overhead. This means there is a transit every 491 seconds. Thus, there will be a handoff about every 8 minutes and 11 seconds.
4. Like a single railroad track, it is half duplex. Oil can flow in either direction, but not both ways at once.
5. 1) There are four legal values per baud, so the bit rate is twice the baud rate. At 1200 baud, the data rate is 2400 bps.

   2) The phase shift is always 0, but two amplitudes are used, so this is straight amplitude modulation.

   3) If all the points are equidistant from the origin, they all have the same amplitude, so amplitude modulation is not being used. Frequency modulation is never used in constellation diagrams, so the encoding is pure phase shift keying.
6. Two, one for upstream and one for downstream. The modulation scheme itself just uses amplitude and phase. The frequency is not modulated.
7. Message switching sends data units that can be arbitrarily long. Packet switching has a maximum packet size. Any message longer than that is split up into multiple packets.
8. With circuit switching, at $t = s$ the circuit is set up; at $t = s + x/b$ the last bit is sent; at $t = s + x/b + kd$ the message arrives. With packet switching, the last bit is sent at $t = x/b$. To get to the final destination, the last packet must be retransmitted $k-1$ times by intermediate routers, each retransmission taking p/b sec, so the total delay is $x/b + (k - 1)p/b + kd$. Packet switching is faster if $s > (k - 1)p/b$.
9. Each cell has six neighbors. If the central cell uses frequency group A, its six neighbors can use B, C, B, C, B, and C respectively. In other words, only 3 unique cells are needed. Consequently, each cell can have 840/3=280 frequencies.
10. Frequencies cannot be reused in adjacent cells, so when a user moves from one cell to another, a new frequency must be allocated for the call. If a user moves into a cell, all of whose frequencies are currently in use, the user's call must be terminated.