ECE 6390: Satellite Communications and Navigation Systems
Solutions to TEST 2 (Fall 2009)

1. **Dish Antennas and Noise:**

   (a) G/T = 2000 K^{-1} (antenna gain doubles)

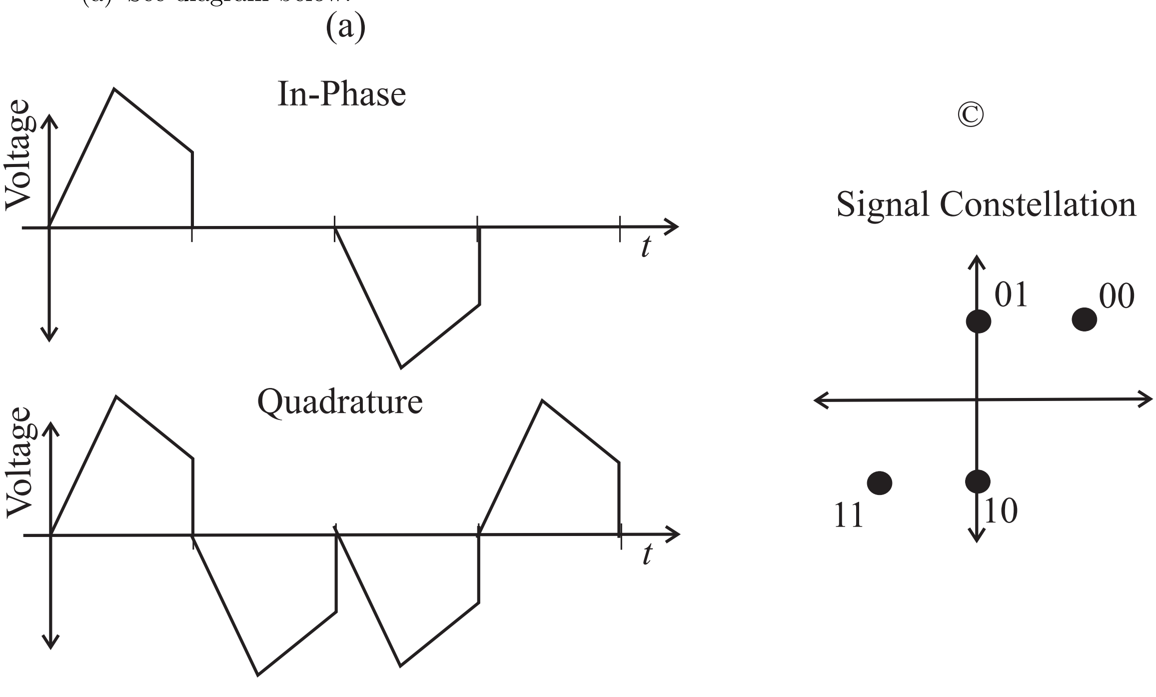
   (b) G/T = 794 K^{-1} (antenna gain reduces by 1 dB)

   (c) G/T = 1000 K^{-1} (increased bandwidth admits more noise, but does not influence system temperature)

2. **Doppler Shift:** An orbit around the moon at the specified radius requires about 1100 m/s of velocity, contributing about ±3600 Hz of Doppler for a 1 GHz signal. Rotation on the earth imparts a velocity of 460 m/s, contributing ±1500 Hz of Doppler. Thus, the full range should be approximately ±5 kHz from the main carrier frequency.

3. **Digital Transmissions:**

   (a) See diagram below:



   (b) This signal has sharp transitions, which makes for inefficient spectral use.

(c) The bit assignments in the constellation could be improved by ensuring the complementary pairs 00/11 and 10/01 are farther apart. An example of better bit assignments is shown in the diagram above.

(d) The speech would need to be sampled at 40,000 samples/sec and quantized at 10 bits/sample for a total of 400,000 bit/sec raw bit rate. The scheme transmits 2 bits/symbol for a total symbol rate of 200,000 sym/sec. Thus, the symbol period should be 5 μs.

(e) Lempel-Zhiv would likely be the best compression scheme, since we would not expect natural speech (from any civilization) to have long run-lengths inside their raw quantized data. Both are lossless compression techniques, so this was not a factor in your decision.

4. **Rain Fade:**

(a) 1.63 dB (the difference between pure vertical and pure horizontal polarizations for this link)

(b) 0.03%, from the table