Name: ______________________________

GTID: ______________________________

ECE 6390: Satellite Communications and Navigation Systems
TEST 3 (Fall 2009)

- Please read all instructions before continuing with the test.
- This is a **closed** notes, **closed** book, **closed** friend, **open** mind test. On your desk you should only have writing instruments and a calculator.
- Show all work. (It helps me to give partial credit.) Work all problems in the spaces below the problem statement. If you need more room, use the back of the page. DO NOT use or attach extra sheets of paper for work.
- Work intelligently – read through the exam and do the easiest problems first. Save the hard ones for last.
- All necessary mathematical formulas are included either in the problem statements or the last page of this test.
- You have 80 minutes to complete this examination. When the proctor announces a "last call" for examination papers, he will leave the room in 5 minutes. The fact that the proctor does not have your examination in hand will not stop him.
- I will not grade your examination if you fail to 1) put your name and GTID number in the upper left-hand blanks on this page or 2) sign the blank below acknowledging the terms of this test and the honor code policy.
- Have a nice day!

Pledge Signature: ____

I acknowledge the above terms for taking this examination. I have neither given nor received unauthorized help on this test. I have followed the Georgia Tech honor code in preparing and submitting the test.

1. **Short Answer Section (10 points)**

   (a) ________________
   A $\boxed{\textit{Answer}}$ coder folds redundancy into a *continuously* encoded bit stream.

   (b) ________________
   The mark of a good error correction code is that its performance approaches the $\boxed{\textit{Answer}}$ limit.

   (c) ________________
   The mark of a good position location system is that its performance approaches the $\boxed{\textit{Answer}}$ lower bound.

   (d) ________________
   A $\boxed{\textit{Answer}}$ is a fixed-location terrestrial transmitter that broadcasts a GPS L1 signal that is used for increasing the precision of nearby GPS receivers.

   (e) ________________
   True or False: the coding gain of a block code is solely a function of how many extra bits have been added to the original data.

2. **Short Discussion Section:** Answer the questions below with very concise, well-articulated answers. Verbosity will be penalized.

   (a) Forward error correction can be even more important to digital satellite communication radio links than digital *terrestrial* radio links. Why? (**10 points**)

(b) GPS uses spread spectrum in a code division multiple access scheme for its many satellites. Why is this preferable to either a TDMA or FDMA scheme for this particular application? (**15 points**)

(c) Would you expect GPS to work better at the North Pole or at the equator? Explain your reasoning. (**5 points**)

(d) Would you expect GPS to work better at night or during the day? Explain your reasoning. (**5 points**)

(e) Would you expect GPS to work better in midtown Atlanta or in Alpharetta? Explain your reasoning. (**5 points**)

3. **Radiolocation Analysis:** Use your knowledge of GPS to answer the following radiolocation questions about a *Time Difference Of Arrival* (TDOA) system for a terrestrial mobile wireless network. A TDOA system estimates the 2D position of a handset user by measuring the time it takes for the handset's signal to reach 3 different base stations that are carefully synchronized. Answer the questions below based on this scenario. (**50 points**)

   (a) In the space below, sketch the ideal position of the user relative to the 3 measuring base stations that minimizes the dilution of precision. (10 points)

   (b) If the mobile system is using GSM for its air interface (RF bandwidth of 200 kHz, symbol period $T_s = 3.7\mu$s) and the typical power from the handset measured at the base station is -80 dBm, what is the expected position standard deviation error for this system? Assume no dilution of precision and that the error is only due to noise/interference. Assume a system noise temperature of 200 K at the base station's measurement radio and that the typical in-band interference power received from nearby users is -95 dBm in total. Presume that the base station integrates over 1ms worth of digital symbols before making its estimate. (20 points)

   (c) List two other sources of location estimate degradation in this system. (10 points)

   (d) If this same location system were used on a CDMA air interface (3 measurement locations, average RF measurement CINR of -8 dB, $T_c = 1\mu$s, integration over 1ms), what factor of range improvement/degradation would you expect compared to the GSM system? (10 points)

Cheat Sheet

$$\sigma_r = cT_c\sqrt{\frac{N_{sat}T_b}{\left(\frac{C}{N}\right)_{\text{despread}} T_{int}}} \qquad c = 3.0 \times 10^8 \text{ m/s}$$

$$\left(\frac{C}{N}\right)_{\text{despread}} = M\left(\frac{C}{N}\right)_{\text{spread}} \qquad \left(\frac{C}{N}\right)_{\text{spread}} = \frac{C}{P_N + (Q-1)C} \approx \frac{1}{Q-1}$$

$$\text{Channel Capacity } = B\log_2\left(1 + \frac{C}{N}\right)$$

$$\text{BER for } M\text{-QAM} \approx 4\left(1 - \frac{1}{\sqrt{M}}\right)\mathrm{Q}\left(\sqrt{3\,\mathrm{CINR}/(M-1)}\right)$$

$$\text{m-sequence with } K \text{ shift registers: } M = 2^K - 1$$

$$P_N = kTB \qquad k = 1.3807 \times 10^{-23} \text{ J K}^{-1}$$

$$Q(x) \approx \frac{1}{x\sqrt{2\pi}}\exp\left(-\frac{x^2}{2}\right) \text{ for } x > 3$$