Name: ______________________________

GTID: ______________________________

ECE 6390: Satellite Communications and Navigation Systems
TEST 1 (Fall 2008)

- 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** (**8 points**)

   (a) ________________ (1) ________________ (2)
   A drum-shaped *Answer 1* satellite uses gyroscopic forces of its own rotation to control attitude, while a box-shaped satellite typically uses internal *Answer 2*.

   (b) ________________
   The name of the first US-made satellite was *Answer*.

   (c) ________________
   One drawback of using *Answer* in space is that they typically require small, radioactive warming devices to keep active.

2. **Radar Detector:** A police radar gun operates at a carrier frequency of 10.525 GHz. If every commercial device manufactured in this application space uses a common 9.825 GHz local oscillator for first-stage mixing, what will the image frequency be for a radar detector detector detector detector? (**6 points**)

3. **Antenna Gains:** Explain the difference **concisely** between *gain* and *directivity*. (**6 points**)

4. **Look Angles:** We learned that one way to achieve good overhead satellite coverage of a high-latitude Earth station was to incline the orbit, maximize the eccentricity, and make the period 1 sidereal day. Presuming the satellite can approach no closer than an altitude of 1000 km to minimize atmospheric drag, calculate the maximum eccentricity that could be used in this type of orbit. (**20 points**)

5. **Transponder RF Chain:** In the space below, sketch the labeled RF block diagram for a simple bent-pipe transponder that converts an uplink signal with a 15 GHz carrier to a downlink signal that uses a 8 GHz carrier. (**20 points**)

6. **Link Budget for MEO Satellites:** A satellite with 500 Watt transmit power uses an electrically small antenna to broadcast to a mobile user on the surface of the earth. The mobile receiver also uses an electrically small antenna and requires -100 dBm received power for proper data reception. If the gains of the transmit/receive antennas are both 0 dBi (and independent of frequency) and the satellite is 10,000 km from the Earth's surface, what is the highest frequency that can be used in this link? (**20 points**)

7. **Antenna Coverage:** A satellite in circular orbit is using an electrically small dipole with gain pattern $G(\theta) = 1.5 \sin^2 \theta$ (linear scale). If all points on the Earth visible to the satellite must fall within the half-power beamwidth of this antenna, what is the minimum orbital radius of the satellite? (**20 points**)

Cheat Sheet

$$\lambda f = c \qquad c = 3 \times 10^8 \text{ m/s} \qquad \epsilon_o = 8.85 \times 10^{-12} \text{ F/m} \qquad \mu_o = 4\pi \times 10^{-7} \text{ H/m} \qquad k = \frac{2\pi}{\lambda}$$

$$\ddot{r} = r\dot{\theta}^2 - \frac{GM_P}{r^2} \qquad \ddot{\theta} = -\frac{2\dot{r}\dot{\theta}}{r}$$

$$T^2 = \frac{4\pi^2 a^3}{\mu} \qquad \mu = GM_p \qquad G = 6.672 \times 10^{-11} \text{ Nm}^2/\text{kg}^2 \qquad M_E = 5.974 \times 10^{24} \text{ kg}$$

$$b = a\sqrt{1 - e^2} \qquad \text{perigee} = (1 - e)a \qquad \text{apogee} = (1 + e)a$$

Circular Orbit: $V = \sqrt{\frac{\mu}{R}}$ **Earth Radius:** $R_e = 6378$ km **Sidereal Day:** $T_s = 86,164$ s

Logarithmic Link Budget: $P_R = P_T + G_T + G_R - 20\log_{10}\left(\frac{4\pi}{\lambda}\right) - 20\log_{10}(r)$