Name: _____

GTID: _____

ECE 6390: Satellite Communications and Navigation Systems
TEST 3 (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 75 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 (20 points)**

(a) _____

The idea of a rigorously-defined communications channel capacity was invented by *Answer*.

(b) _____

True or False: MPEG1, MPEG2, and MPEG4 are the moving pictures expert guild's protocol specifications for digital video modems.

(c) _____

Unlike Lempel-Ziv style compression protocols, the method for storing images in JPEG format is *Answer* compression.

(d) _____

Sets of optical spectra that result in the same perceived color in the human eye are called *Answer*.

(e) _____ (1) _____ (2)

The colors cyan, magenta, and yellow are *Answer 1* primaries while the colors red, green, and blue are *Answer 2* primaries.

(f) _____

True or False: the human eye contains a higher density of rods (intensity-sensing cells) than cones (color-sensing cells).

(g) _____

A *Answer* may be used to change the first-order statistics of an analog signal before sampling so that it is better suited for uniform quantization.

(h) _____ (1) _____ (2)

Adding forward error correction to a satellite link allows the spacecraft to travel farther from earth, and/or operate with less transmit *Answer 1*, and/or reduce the *Answer 2* in the received signal.

2. **Analog Video:** Terrestrial analog video relies on VSB analog modulation, while satellite analog video uses FM. Why? (**10 points**)

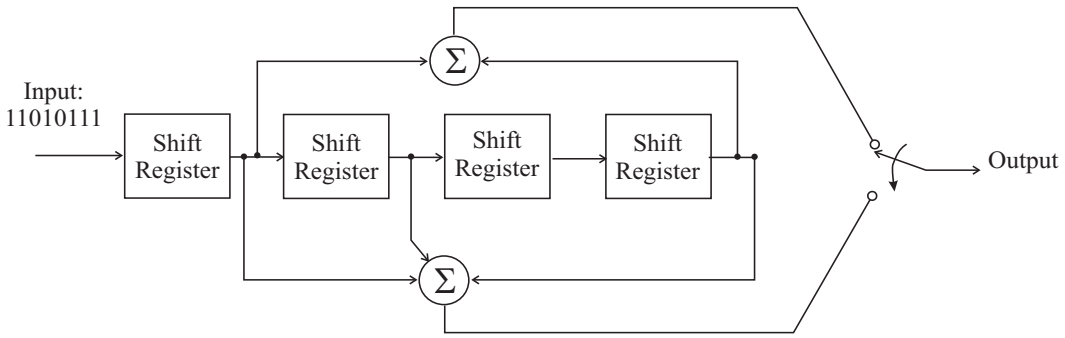
3. **Digital Video:** Terrestrial digital video relies on schemes such as 16-QAM and 8-VSB, while satellite digital video most commonly uses BPSK or QPSK. Why? (**10 points**)

4. **Pulse Shaping:** What is the maximum symbol rate for a QPSK communication link that uses an ideal raised-cosine pulse with roll-off factor $\kappa = 0.5$ that must fit within a 30 MHz RF channel? (**10 points**)

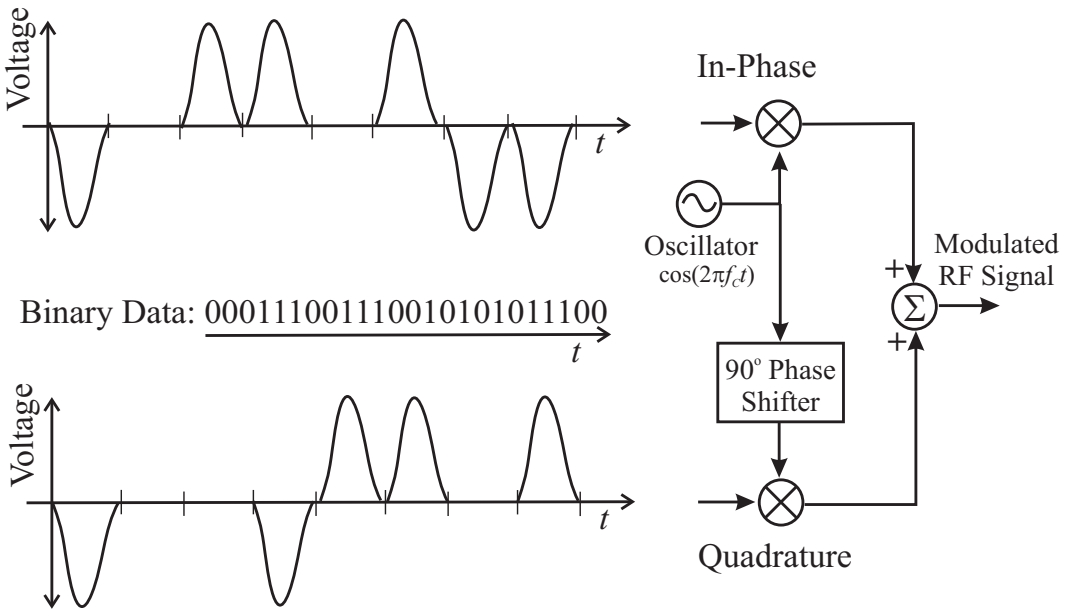
5. **Digital Transmission:** You are digitizing a 5-MHz baseband analog video signal. Your quantizer has 12-bits per sample, you use Lempel-Ziv compression to provide a 75% reduction on the bit stream (compressed rate is 1/4 of uncompressed rate), and you plan on using a rate 1/2-Turbo code for forward error correction coding. If your final transmitted symbol rate is 6 Mbaud, what is the minimum constellation size required by a system using M-QAM to transmit this signal. (**10 points**)

6. **Quantization:** The output of an MPEG codec is a raw 120 Mbit/sec bit stream that represents uncoded, uniformly-quantized RGB pixel levels. If the digital resolution is 500×400 pixels at 20 picture frames/sec, what is the quantization SNR of each pixel? (**10 points**)

7. **Forward Error Correction:** Below is a convolutional encoder with sample binary input. Write the binary output of this coder. Assume that the registers are all initialized with 0 before the data is sent. For this problem, read and write binary sequences with the rightmost bit being the earliest bit. What is the rate and constraint length of this encoder? (**10 points**)



8. **Constellations:** Based on the following in-phase and quadrature signals for the binary data sequence below, sketch the signal constellation in the space below, labeling the bits corresponding to each constellation point. (**10 points**)



9. **BER:** If CINR is 10 dB for the signal transmission in the previous problem, make a rough estimate of the BER of the demodulated, uncoded signal by approximating it as a generic form of M-QAM. Would you expect this BER approximation to be pessimistic (BER higher than actuality) or optimistic (BER lower than actuality). What is the drawback of using the above signal constellation? (**10 points**)

Cheat Sheet

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

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

$$N\text{-bit Uniform Quantization: } SNR = 6N$$

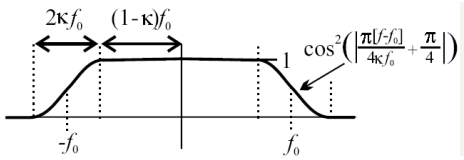
$$P_N = kTB \qquad k = 1.3807\times10^{-23}\ \mathrm{J\ K^{-1}}$$

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

$$\mathrm{sn}(x) = \frac{\sin(\pi x)}{\pi x}$$

Raised Cosine Pulse

$$\frac{2f_0\mathrm{sn}(2f_0t)\cos(2\pi\kappa f_0 t)}{1-(4\kappa f_0 t)^2}$$



x	Q(x)	x	Q(x)	x	Q(x)	x	Q(x)	x	Q(x)
0.00	0.5000	**1.00**	0.1587	**2.00**	0.02275	**3.00**	0.001350	**4.00**	0.00003167
0.05	0.4801	**1.05**	0.1469	**2.05**	0.02018	**3.05**	0.001144	**4.05**	0.00002561
0.10	0.4602	**1.10**	0.1357	**2.10**	0.01786	**3.10**	0.0009676	**4.10**	0.00002066
0.15	0.4404	**1.15**	0.1251	**2.15**	0.01578	**3.15**	0.0008164	**4.15**	0.00001662
0.20	0.4207	**1.20**	0.1151	**2.20**	0.01390	**3.20**	0.0006871	**4.20**	0.00001335
0.25	0.4013	**1.25**	0.1056	**2.25**	0.01222	**3.25**	0.0005770	**4.25**	0.00001069
0.30	0.3821	**1.30**	0.09680	**2.30**	0.01072	**3.30**	0.0004834	**4.30**	0.000008540
0.35	0.3632	**1.35**	0.08851	**2.35**	0.009387	**3.35**	0.0004041	**4.35**	0.000006807
0.40	0.3446	**1.40**	0.08076	**2.40**	0.008198	**3.40**	0.0003369	**4.40**	0.000005413
0.45	0.3264	**1.45**	0.07353	**2.45**	0.007143	**3.45**	0.0002803	**4.45**	0.000004294
0.50	0.3085	**1.50**	0.06681	**2.50**	0.006210	**3.50**	0.0002326	**4.50**	0.000003398
0.55	0.2912	**1.55**	0.06057	**2.55**	0.005386	**3.55**	0.0001926	**4.55**	0.000002682
0.60	0.2743	**1.60**	0.05480	**2.60**	0.004661	**3.60**	0.0001591	**4.60**	0.000002112
0.65	0.2578	**1.65**	0.04947	**2.65**	0.004025	**3.65**	0.0001311	**4.65**	0.000001660
0.70	0.2420	**1.70**	0.04457	**2.70**	0.003467	**3.70**	0.0001078	**4.70**	0.000001301
0.75	0.2266	**1.75**	0.04006	**2.75**	0.002980	**3.75**	0.00008842	**4.75**	0.000001017
0.80	0.2119	**1.80**	0.03593	**2.80**	0.002555	**3.80**	0.00007235	**4.80**	0.0000007933
0.85	0.1977	**1.85**	0.03216	**2.85**	0.002186	**3.85**	0.00005906	**4.85**	0.0000006173
0.90	0.1841	**1.90**	0.02872	**2.90**	0.001866	**3.90**	0.00004810	**4.90**	0.0000004792
0.95	0.1711	**1.95**	0.02559	**2.95**	0.001589	**3.95**	0.00003908	**4.95**	0.0000003711
1.00	0.1587	**2.00**	0.02275	**3.00**	0.001350	**4.00**	0.00003167	**5.00**	0.0000002867