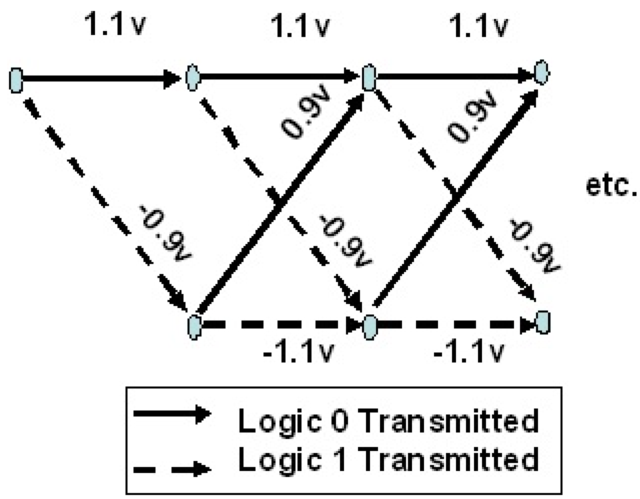
ECEN5533 Final Exam 9 December 2008 Name________________________________

1) In class and in the text, the use of trellis diagrams and the Viterbi algorithm for soft and hard decision decoding of convolutional codes has been discussed. Another use of the Viterbi algorithm is the decoding of a signal suffering Intersymbol Interference. The figure to the right shows a trellis diagram of the expected voltages out of a bit detector for a noise free binary data sequence. Suppose the first five bits of the actual received sequence, contaminated by noise, yield the voltages (+1.0, -0.3, -0.7, +0.5, 0).



[35] Use the Viterbi Algorithm and **determine the most likely transmitted sequence**. Show the minimum distance paths to each node and the distance measure for that surviving path at each node. Also clearly indicate what sequence the algorithm would have output after these five inputs have been processed, and what (if any) decision would still be up in the air and awaiting further inputs. [Answer: Most likely transmitted sequence is 0110. Minimum distances at this point are 1.5 on the top and 2.7 on the bottom. The fifth bit is still undecided as the paths have not yet merged. Minimum distances at the very end are 2.6 at the top and 2.4 at the bottom.]

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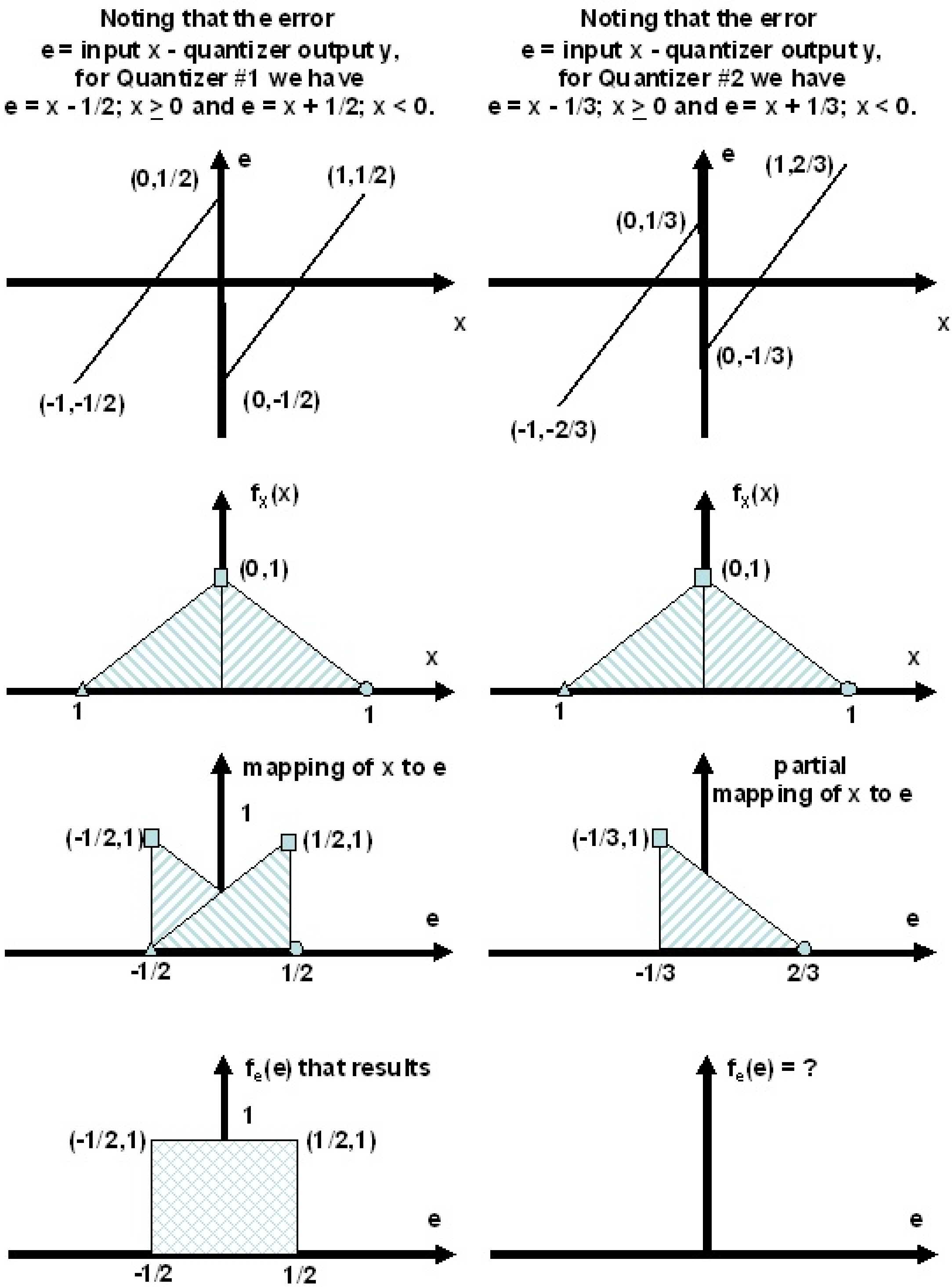
2) You are a Staff Engineer with the Quantizer Division at MegaMoron Communications, Inc. You have been tasked to evaluate the effectiveness of two different two-level quantizers. Quantizer #1 outputs y(t) = 1/2 volt for any input voltage $\geq$ 0 volts, and y(t) = -1/2 volt for any input voltage < 0 volts. Quantizer #2 outputs y(t) = 1/3 volt for any input voltage $\geq$ 0 volts, and y(t) = -1/3 volt for any input voltage < 0 volts. The input voltage x(t) for these is known to have a PDF $f_X(x) = 1 - |x|; |x| \leq 1$. The average power $E[X^2]$ is known to be 1/6 watts.

2a) [20] **Compute** the #1 Quantizer SNR. [SNR = 2]

2b) [20] **Compute** the #2 Quantizer SNR. (Hint on next page.) [SNR = 3.001]

Hint: Problem 2b requires a *Transformation of one Random Variable* to another, which you should've learned how to do as an undergrad and/or a grad student. In case the diagrams below don't trigger your memory, you can ask the instructor to explain what's going on at a cost of 5 points, or you can ask the instructor to sketch in the Quantizer #2 error PDF for 10 points.



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3) Voyager II is currently 12.63 Billion Km from Earth. Suppose a 21.3 watt BPSK signal at 8 GHz is fed to Voyager's 3.7 m diameter parabolic (η = 0.55) and received on Earth by a *single* 70 m diameter parabolic with an efficiency η of 0.60. Other losses Lo = 1.2 dB and Tsys = 22.3° K.

A maximum P(BE) = 0.00001 is desired. Note Q(4.264) = 0.00001.

3a) [20] **Compute** the maximum data bit rate that can be supported if no FEC is used. [R = 25.35 dB or 343.1 bps]

3b) [20] **Compute** the maximum *data* bit rate that can be supported on this link if MegaMoron Communications' Extra Sensory Perception FEC coder is used. Recall that this device increases the transmitted bit rate (data + parity bits) by a factor of 1.51, and that the Coding Gain for this device is = 0.81 dB + 0.93* Eb/*No* dB, using the Eb/*No* value obtained with the increased bit rate. (Holler if you want Design Problem #2 shown on the front video screen). [Rdata = 28.61 dB = 725.0 bps]

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4) A channel has an impulse response $h(t) = .1\delta(t) + .7\delta(t-0.2)$.

4a) [10] If a pulse $x(t) = 1;\ 0 \leq t \leq 1$ is input, **sketch the output** y(t). [You should sketch $y(t) = 0.1,\ 0 \leq t \leq 0.2;\ 0.8,\ 0.2 \leq t \leq 1.0;\ 0.7,\ 1.0 \leq t \leq 1.2$]

4b) [5] **Calculate the energy** in the input pulse x(t). [1.0 joule]

4c) [5] **Calculate the energy** in the output pulse y(t). [0.614 joules]

4b) [15] If White Gaussian Noise n(t) with Power Spectral Density 0.05 watts/Hertz is input, **find the output autocorrelation** $R_{NN}(\tau)$. [$0.025\delta(\tau) + 0.0035\delta(\tau - 0.2) + 0.0035\delta(\tau + 0.2)$]

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