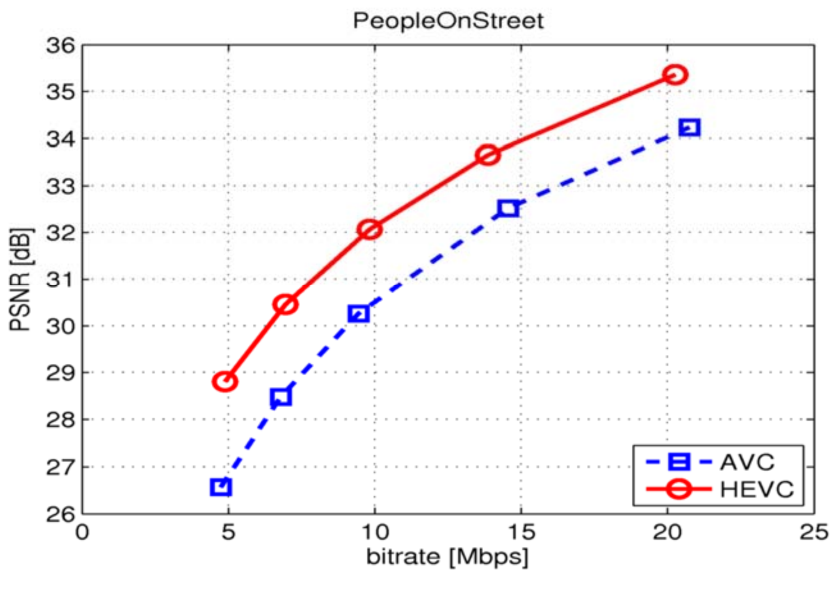
Concordia University
Department of Electrical & Computer Engineering
ELEC 6831 – Digital Transmission Systems
Thursday December 8, 2016
Duration: 180 minutes

You are allowed two 8.5*11 inch formula sheet. Anything may be written on this sheet. Non programmable calculators, pens, pencils and straightedges are also allowed.

If you have a difficulty you may try making REASONABLE assumptions. State the assumption and how that assumption limits your answer. Show all your work and justify all your answers. Marks are given for how an answer is arrived at not just the answer itself.

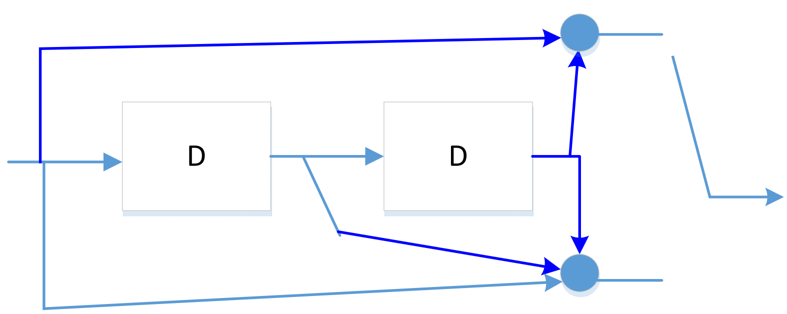
1) The following curves show the performance of a typical video clip in terms of Peak-Signal-to-Noise-Ratio (PSNR) as a function of the bit rate for two standards: Advance Video Coding (AVC) and High Efficiency Video Coding (HEVC). Assume that a TV station has 6 MHz. of bandwidth.
   a. What type of modulation should be used if the roll-off factor is 0.1, a PSNR of 32 dB or better is required and HEVC encoder is used? (3 Marks)
   b. What would be PSNR if your design in part (a) is used with an AVC encoder? (2 Mar)
   c. How much more bandwidth do you require if to get the same performance as part (a) but using an existing AVC encoder? (2 Marks)
   d. Repeat part (a) assuming that rate ¾ convolutions coding plus standard RS coding is used. (3 Marks)



2) A technician measures the received power of a mobile receiver as -95 dBm and the bit error rate as 10^{-5}.
   a. Assuming that the bit rate is 1 Mbps and QPSK modulation is used find the overall receiver noise temperature (5 Marks)
   b. Find the noise figure (2 Mark).

c. What would be the bit error probability if the bit rate is increased to 2 Mbps? (3 Marks)

3) The encoder of a convolutional code is shown below.
   a. Draw the state diagram (1 Mark) and the trellis diagram (3 Marks) for this code.
   b. Derive the transfer function (5 Marks) and find the free distance (1 Mark).



4) A communication system uses QPSK modulation and the $\frac{E_b}{N_0} = 5$ dB.
   a. Find the BER (1 Mark).
   b. Find the BER if a (31, 26) Hamming code is used (4 Marks).

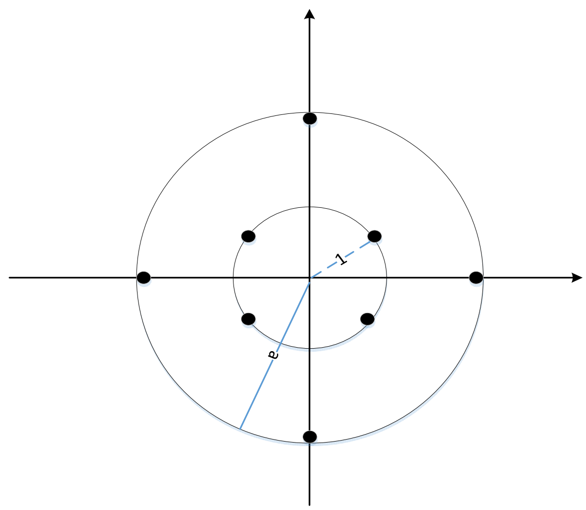
5) What is the output of the following program? (5 Marks)

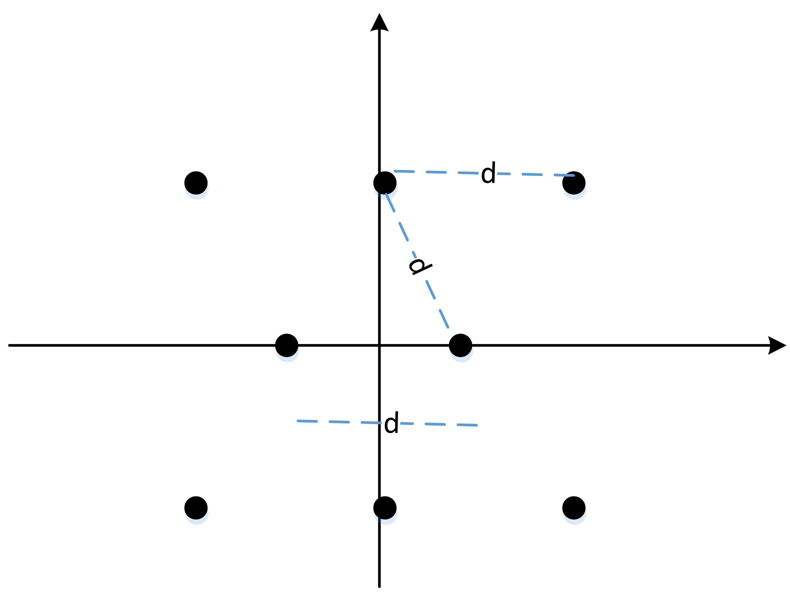
```
e=0;
n=1000000;
for i=1 to n
        if (normrnd(1, 0.25)<0)
                e=e+1;
        end (if)
end (for);
print (e/n);
```

Note: *normrnd*(μ, σ) is a Matlab function

6) Consider the following two signal constellations.
   a. For the first constellation, find *a* such that the probability of error for all symbols be roughly equal. (4 Marks)
   b. Find *d* for the second constellation such that the average power be the same for the two constellations (4 Marks).

c. Which of the two constellations result in lower BER? Why? (2 Marks).





7) In an application, packets of length 145 bits are to be transmitted. We use an RS code with $m = 5$.

   a. What is the number of parity bits (1 Marks)? What is the rate pf the code? (1 Mark)
   b. What would be the error correcting capability of this RS code? (1 Mark).
   c. What would be the bit error rate if the system uses QPSK with $\frac{E_b}{N_0} = 10\ dB$. (6 Marks).
   d. If the number of bits per packet was 120 bits and you had to keep the number of parity bits the same as (a) how would you modify the RS code? (1 Marks).

TABLE B.1 Complementary Error Function $Q(x) = \int_x^\infty (1/\sqrt{2\pi}) \exp(-u^2/2)du$

	Q(x)									
x	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3228	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2168	0.2148
0.8	0.2169	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.0099	0.0096	0.0094	0.0091	0.0089	0.0087	0.0084
2.4	0.0082	0.0080	0.0078	0.0075	0.0073	0.0071	0.0069	0.0068	0.0066	0.0064
2.5	0.0062	0.0060	0.0059	0.0057	0.0055	0.0054	0.0052	0.0051	0.0049	0.0048
2.6	0.0047	0.0045	0.0044	0.0043	0.0041	0.0040	0.0039	0.0038	0.0037	0.0036
2.7	0.0035	0.0034	0.0033	0.0032	0.0031	0.0030	0.0029	0.0028	0.0027	0.0026
2.8	0.0026	0.0025	0.0024	0.0023	0.0023	0.0022	0.0021	0.0021	0.0020	0.0019
2.9	0.0019	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015	0.0015	0.0014	0.0014
3.0	0.0013	0.0013	0.0013	0.0012	0.0012	0.0011	0.0011	0.0011	0.0010	0.0010
3.1	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008	0.0007	0.0007
3.2	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
3.3	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0094	0.0003
3.4	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002

$$\mathrm{erfc}(x) = 2Q(x\sqrt{2}) \tag{B.20}$$

$$Q(x) = \frac{1}{2}\,\mathrm{erfc}\left(\frac{x}{\sqrt{2}}\right) \tag{B.21}$$