1. An information source has its output from alphabet set {A, B, C, D} with probabilities $P_r(A) = 1/8$, $P_r(B) = 1/4$, $P_r(C) = 1/2$, and $P_r(D) = 1/8$.
   (a) Determine the entropy of this source. (4%)
   (b) A general encoding scheme uses two bits 00, 01, 10, and 11 to represent A, B, C, and D, respectively. What is the coding efficiency of this scheme? (2%)
   (c) For part (b), if the unipolar NRZ baseband modulator of 100 kbps is used to transmit the bits 0 (amplitude = 0V) and 1 (amplitude = +10V) through an AWGN channel with power gain = -20dB and two-sided PSD of noise = -30dBm/Hz, show the structure of optimal receiver and determine the impulse response of the receiver's filter as well as the value of optimal threshold. Also determine the bit-error-rate of this system in Q-function (or erfc function). (10%)
   (d) To increase the coding efficiency, design a Huffman code for this information source. What are the average codeword length and the coding efficiency? (5%)

2. The parity-check matrix of a linear (n, k) block code is

$$\mathbf{H} = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

   (a) What are the values of n and k of this code?(2%)
   (b) Show the generator matrix G.(3%)
   (c) If the message vector $\underline{m} = (1001)$. What is the corresponding code vector $\underline{u}$? (3%)
   (d) Determine d_{min}, error-detecting capability, and error-correcting capability of this code. (3%)
   (e) If the received vector $\underline{r} = (1001011)$, what is the decoded message $\underline{m}$? (3%)

3. (a) Show the 16-QAM signal constellation. (2%)
   (b) Draw the modulator and the demodulator of 16-QAM. (8%)
   (c) If 16-QAM signal is transmitted through a channel of raised cosine spectrum with roll-off factor $\alpha = 25\%$ and bandwidth = 100KHz, determine the data rate. (5%)

4. (a) Compare the relative advantages and disadvantages of double-sideband/ suppressed carrier (DSB-SC) with vestigial sideband (VSB). (3%)
   (b) Explain the "threshold effect" in an AM receiver under interference environment. (5%)
   (c) Why is preemphasis/deemphasis used in broadcast FM systems? (4%)

5. (a) Assume that an AM system operates with an index of 0.3 and that the message signal is $20\cos 10\pi t$. Compute the power efficiency, the detection gain in dB, and the output signal-to-noise ratio in dB relative to the baseband performance P_T/N_oW. (6%)
   (b) Compare the improvement (in decibels) in the output SNR of a linear envelope detector over a square-law detector for a high-predetection SNR as the modulation index is unity and a sinusoidal message signal is assumed. (8%)

6. A mixer is used in a short-wave superheterodyne receiver. The receiver is designed to receive transmitted signals between 5 and 10 MHz. High-side tuning scheme is used.
   (a) Determine the tuning range of the local oscillator for IF frequency fixed to be 200 KHz. (4%)
   (b) Determine the possible image signal frequencies that will mix into the same IF signal. (5%)
   (c) What is the best way to reject the above image signals: "Filtering at RF stage", "Filtering at IF stage", or "You cannot reject them at all"? (3%)

7. (a) There are 60 telephone channels to be multiplexed by the TDM (time- division multiplexing) and FDM (frequency-division multiplexing). Calculate the transmission bandwidths required for each of the two methods, showing clearly how your values were obtained. (6%)
   (b) Discuss the relative advantages of using one or other of the multiplexing methods both in the light of your bandwidth values and of other considerations. (6%)