Tutorial 1: Introduction to Error Control Coding

Question 1:

Consider voice transmission over a telephone line. Each channel has a bandwidth $B = 3kHz$. We assume the analogue channel distorted by AWGN noise. If the power signal-to-noise ratio is 30 dB

1. What is the channel capacity?
2. What is the required signal-to-noise ratio, if this channel transmit at 19200 bits/sec with an M-ary signal?

Question 2:

1. Consider Wideband Code Division Multiple Access (W-CDMA). Given bandwidth $B = 5Mhz$, but only transmit data at 12.2k bits/sec, what is the required the signal-to-noise ratio?
2. On the basis of the above result, explain why the signal power is much weaker than the background noise in spread-spectrum communications.

Question 3:

In Information Theory, the channel capacity C of a channel with input U and output V is defined as the maximum mutual information between U and V.

1. Assume the input of the channel has a zero-mean and variance σ_u^2 and the channel is AWGN with variance σ_n^2. We have
$$C = 1/2 \log_2(1 + \frac{\sigma_u^2}{\sigma_n^2}). \quad (1)$$
On the basis of this result, derive the Shannon limit (possible maximum error-free transmission rate).
2. For a binary symmetric channel, the channel capacity is given by
$$C = 1 + p \log_2 p + (1 - p) \log_2(1 - p). \quad (2)$$
Show the steps to derive the minimum signal-to-noise power ratio per bit (E_b/N_0) for a coded system with code rate R. (Hints: Assume a modulation scheme, *e.g.*, BPSK. Then $p = Q(\sqrt{2E_s/N_0})$ and $E_s = RE_b$)(E_b/N_0 does not have a closed form)