P1- A nonreturn-to-zero data stream (of amplitude levels ± 1) is passed through a low-pass filter whose impulse response is defined by the Gaussian function

$$h(t) = \frac{\sqrt{\pi}}{\alpha} \exp\left(-\frac{\pi^2 t^2}{\alpha^2}\right)$$

where α is a design parameter defined in terms of the filter's 3-dB bandwidth by

$$\alpha = \sqrt{\frac{\log 2}{2}} \frac{1}{W}$$

(a) Show that the transfer function of the filter is defined by

$$H(f) = \exp(-\alpha^2 f^2)$$

Hence demonstrate that the 3-dB bandwidth of the filter is indeed equal to W. You may use Table A6.3 on Fourier-transform pairs.

(b) Show that the response of the filter to a rectangular pulse of unit amplitude and duration T centered on the origin is defined by Equation (6.135).

P2- Plot the waveform of a GMSK modulator produced in response to the binary sequence 1101000, assuming the use of a gain-bandwidth product $WT_b = 0.3$. Compare your result with that of Example 6.5.

P3- The binary sequence 1100100010 is applied to the DPSK transmitter of Figure 6.43*a*.

(a) Sketch the resulting waveform at the transmitter output.

(b) Applying this waveform to the DPSK receiver of Figure 6.43*b*, show that, in the absence of noise, the original binary sequence is reconstructed at the receiver output.

P4- The values of E_b/N_0 required to realize an average probability of symbol error $P_e = 10^{-4}$ using coherent binary PSK and coherent FSK (conventional) systems are equal to 7.2 and 13.5, respectively. Using the approximation

$$\text{erfc}(u) \simeq \frac{1}{\sqrt{\pi} u} \exp(-u^2)$$

determine the separation in the values of E_b/N_0 for $P_e = 10^{-4}$, using

(a) Coherent binary PSK and DPSK.

(b) Coherent binary PSK and QPSK.

(c) Coherent binary FSK (conventional) and noncoherent binary FSK.

(d) Coherent binary FSK (conventional) and coherent MSK.

P5- The *noise equivalent bandwidth* of a bandpass signal is defined as the value of bandwidth that satisfies the relation

$$2BS(f_c) = P/2$$

where $2B$ is the noise equivalent bandwidth centered around the midband frequency f_c, $S(f_c)$ is the maximum value of the power spectral density of the signal at $f = f_c$, and P is the average power of the signal. Show that the noise equivalent bandwidths of binary PSK, QPSK, and MSK are as follows:

Type of Modulation	*Noise Bandwidth/Bit Rate*
Binary PSK	1.0
QPSK	0.5
MSK	0.62

Note: You may use the definite integrals in Table A6.10. A discussion of noise equivalent bandwidth is presented in Appendix 2.