EECS 644 HW 3: due 10/02/2025 (by email)

1. Determine whether the following are *energy signals*, *power signals*, or *neither* (show work). When applicable, what is the energy or power of the signal?

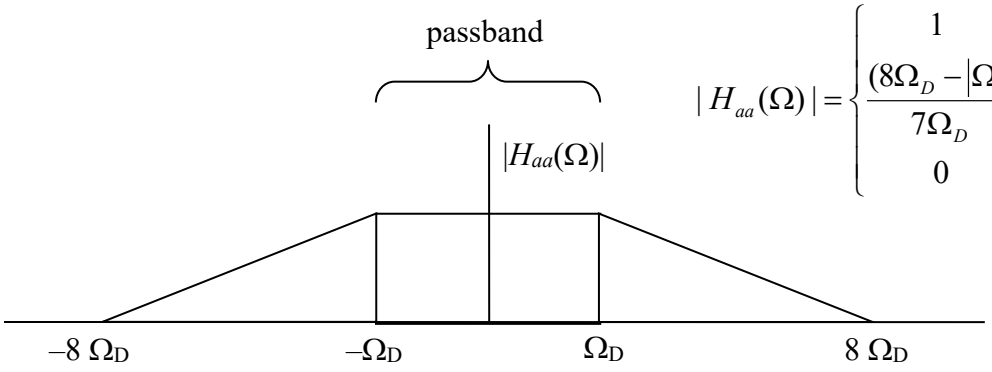
   a) $x(n) = \sum_{k=-\infty}^{k=\infty} \delta(n-2k)$

   b) $x(n) = a^n u(n) + b^n u(n)$ for $|a|<1$ and $|b|<1$, with a and b real-valued

2. Determine the cross-correlation $r_{xy}(\ell)$ between $x(n) = a^n u(n)$ and the finite-length sequence $y(n) = \{1, b, b^2\}$ for $0 < |a| < 1$. *Note: $y(n)$ is finite in time.*
   $\uparrow$

3. Using $x(n)$ and $y(n)$ from Prob. 3, determine the cross-correlation $r_{wy}(\ell)$ between $w(n) = x(-n)$ and $y(n)$.

4. A desired signal band-limited between $-\Omega_D$ and Ω_D is corrupted by noise that is constant over all frequencies (*i.e.* white noise). The frequency response (in absolute scale) of a hypothetical anti-aliasing filter is shown below. After filtering, what is the minimum sampling rate F_S such that <u>no additional</u> noise is aliased into the signal passband and why? (Be concise!)



$$|H_{aa}(\Omega)| = \begin{cases} 1 & \text{for } |\Omega| \le \Omega_D \\ \dfrac{(8\Omega_D - |\Omega|)}{7\Omega_D} & \text{for } \Omega_D < |\Omega| \le 8\Omega_D \\ 0 & \text{for } |\Omega| > 8\Omega_D \end{cases}$$

5. Given the signal

$$x(n) = \sum_{k=-\infty}^{\infty} \left[\delta(n-4k) + 7\delta(n-4k-1) - 7\delta(n-4k-2) - \delta(n-4k-3)\right]$$

how many bits are required to achieve an SQNR ≥ 28 dB if $X_m = 7$? What is the "optimal" value of X_m if the signal were Gaussian with the same signal power and how many bits does it require to achieve SQNR ≥ 28 dB?

6. For the polyphase decomposed components below, determine the original filter $h(n)$.

$$e_0(n) = \{a, b, c\}$$
$$e_1(n) = \{d, e, f\}$$
$$e_2(n) = \{g, h, i\}$$
$$e_3(n) = \{j, k, \ell\}$$