ECE 453: Wireless Communication Systems **Fall 2026**
Problem Set #2 **Due Date: 5pm, Fri, Sept 18, 2026**

1. A band-limited approximation to a unit-amplitude square wave is a single-tone message $\cos(2\pi f_m t)$ frequency-modulates a carrier. The peak frequency deviation Δf_{max} is held constant while f_m is varied. The carrier spectral line is observed to vanish at f_m = 2.000 kHz and again at f_m = 3.133 kHz. Use the first four zeros of $J_0(x)$: 2.4048, 5.5201, 8.6537, and 11.7915.

   (a) Determine the peak frequency deviation Δf_{max} in kHz.

   (b) Give two additional positive tone frequencies that will also make the carrier component vanish.

2. Consider the following angle modulated signal: $s(t) = 5\sin(\omega_c t + 10\cos(2\pi\, 2500t))$

   a. Find the peak phase deviation of $s(t)$, in radians.

   b. Find the instantaneous frequency deviation.

   c. Find the peak frequency deviation. Express your result in kHz.

   d. Estimate the bandwidth, BW, of $s(t)$ using Carson's rule. Express your result in kHz.

   e. Suppose that $s(t)$ is passed through a bandpass filter that passes all frequencies within $\pm BW/2$ of the carrier frequency f_c without attenuation and rejects all other frequency components, i.e. the bandpass filter has a rectangular frequency response that is centered on fc with a bandwidth equal to BW found in part d. You may assume that any spectral lines that fall on the edge of the filter's passband are passed by the filter. Express the time-averaged power at the output of the filter as a percentage of the total time-averaged power in $s(t)$. You will want to use Mathematica, Matlab, or equivalent to obtain the numerical values of $J_n(\beta)$ that you will need for this part.