1. Show that the receivers in Figures 2.3 and 2.4 in Section 2.2 of the notes give the same decision statistic $z_k$ for the DS-SS signal defined in (2.13).

2. Show that the power spectra of the $M$-ary FSK fast and slow FH-SS signals defined in Section 2.3 ((2.27) and (2.28)) are given by (2.29) and (2.30), respectively.

3. Show that the power spectrum of the TH-SS signal defined in Section 2.4 ((2.33)) is given by (2.34).

4. Show that the power spectrum of the MC-SS signal defined in Section 2.5 ((2.37)) is given by (2.38).

5. Show that the power spectrum of the despread signal $z(t)$ in Section 2.6.1 ((2.44)) is given by (2.45).
6. **MATLAB Problem:**

The goal of this problem is to verify the mathematical development of the four spread spectrum techniques described in class by measuring the power spectral densities of computer generated spread spectrum signals. This is a good exercise which can help you understand the spreading schemes better. Follow the models in class to generate the data and spreading signals.

The problems below involve representing analog bandpass signals in discrete-time format. Feel free to employ the complex baseband representation and choose the carrier frequency you like. You are required to calculate (more precisely should be “estimate”) the power spectrum of the signal that you generate. You should sample at least 4 times faster the chip/symbol rate to see some sidelobes of the spectrum (assuming that the complex baseband representation is employed). You need to first estimate the auto-correlation function of the signal and then take Fourier transform to obtain the power spectrum. Of course you need to use FFT to do the job. In your plot, state your bit rate, chip rate (hopping rate), sampling frequency, and label the horizontal axis of your spectral plot in Hz (please don’t simply give me the FFT index). To shorten the run time, you can assume the spreading gain, number of frequency bins, number of time bins, and number of sub-carriers to be 8.

(a) Generate a BSPK signal. Find and plot the power spectrum of this signal. You will need at least a few hundred bits to get a relatively smooth spectrum.

(b) Spread the BPSK signal generated in part (a) using the direct-sequence technique. You can assume BPSK spreading. Find and plot the power spectrum of the direct-sequence spread spectrum signal.

(c) Repeat part (b) using the time-hopping technique.

(d) Repeat part (b) using the multicarrier technique.

(e) Generate a BFSK signal. Find and plot the power spectrum of this signal. You will need at least a few hundred bits to get a relatively smooth spectrum.

(f) Spread the BFSK signal generated in part (e) based on the slow frequency-hopping technique and plot the power spectrum of the frequency-hop spread spectrum signal.