1. Why do higher data rates require higher bandwidth for any given modulation scheme?

2. A frequency modulated wave has an angular carrier frequency ($\omega_c=2\pi f_c$) of 50000 radians/sec and a modulation index $\beta_f = 10$. For a modulation signal described by $m(t) = 20\cos(5t + \phi)$, what is the RF bandwidth and the upper and lower sideband frequencies?

3. A 2 MHz carrier with an amplitude of 4 volts is frequency modulated by a modulation signal $m(t)=A_m\sin(1000\pi t)$. The amplitude of the modulating signal is 2 volts and the peak frequency deviation was found to be 1 kHz. If the amplitude and frequency of the modulating signal are increased to 8 volts and 2 kHz respectively, write an expression for the new modulated signal $S_{FM}(t)$.

4. In the FM modulated AMPS system, the frequency deviation is 12 kHz and the modulation frequency is 4 kHz. What is the modulation index?

5. For AMPS FM transmission with a modulation index $\beta_f=3$ and an input SNR of 10 dB, what is the output SNR for the transmitter? If the input SNR increases by 10 dB, what is the corresponding increase in the SNR out of the detector?

6. A GSM mobile radio link uses 200 kHz of bandwidth and has a minimum SNR of 10 dB. What is the maximum possible channel capacity of this system? If the standard GSM data rate is 270.8 kbs, what percentage of the maximum possible data rate does the system utilize? If the SNR is increased to 20 dB, what data rate can be theoretically achieved by the GSM system?

7. In a digitally modulated system, define power efficiency.

8. In a digitally modulated system, define bandwidth efficiency.