Supp 5.1) A 5 kHz tone with an amplitude of $a = 1 \text{ V}$ is used to phase modulate a 100 MHz carrier. The PM modulation constant is $k_p = 2 \text{ V}^{-1}$.  

a) What are the maximum and minimum instantaneous frequencies?  
b) List all frequency components in the modulated carrier.  
c) What is the bandwidth of the modulated carrier?  
d) Is this narrowband or wideband phase modulation?

Supp 5.2) The instantaneous phase of a phase modulated carrier is equal to:

$$\theta(t) = 2\pi (10^8 t + 10 \sin(2\pi 10^4 t))$$

a) What is the instantaneous frequency of the transmitted signal?  
b) What is the bandwidth of the transmitted signal?  
c) Is this narrowband or wideband PM?  
d) What is the message signal, $s(t)$, if $k_p = 100 \text{ V}^{-1}$?

Supp 5.3) A binary signal is to be transmitted using PSK at a rate of $R_b = 100 \text{ kbps}$. a) What is the null-to-null spectrum width if binary PSK is used?  
b) What is the null-to-null spectrum width if QPSK is used?  
c) OQPSK?  
d) MSK?  
e) DPSK?

Supp 5.4) Binary PSK is being used to transmit a data signal with $\theta = \pi/2$ and $\Delta = \pi/2$. a) What is the power in the residual carrier component of the BPSK signal?  
b) What is the power in the modulated information component of the BPSK signal?  
c) What is the total power?

Supp 5.5) An NRZ-M digital waveform equal to 0 0 0 1 1 1 0 1 0 1 is received. Decode the waveform.

4.24)  
Modulate the second channel using a 56 kHz carrier instead of 38 kHz. Transmit a 56 kHz/2 = 28 kHz tone. Since $f_m = 71 \text{ kHz}$ and $\text{BW} = 2(\Delta f + f_m)$ then $\Delta f = 29 \text{ kHz}$.

4.44)  
Use a 48 kHz carrier for the second channel and transmit a 24 kHz tone. $\Delta f = 32 \text{ kHz}$

4.47)  
c) $A = 190.7 \text{ mV}$

Supp 5.1)  
a) $f_{(\text{min})} = 99.937 \text{ MHz}$, $f_{(\text{max})} = 100.063 \text{ MHz}$  
b) There are 29 frequencies spaced 5 kHz apart between 99.930 MHz and 100.070 MHz.  
c) $\text{BW} = 145.66 \text{ kHz}$  
d) Wideband
Supp 5.2)
   a) \( f(t) = 10^8 + 2 \pi 10^5 \sin(2 \pi 10^4 t) \)
   b) BW = 1.277 MHz
   c) Wideband
   d) \( s(t) = 0.0159 \sin(2 \pi 10^4 t) \)