a) \( h(n) = \delta(n) + 2 \delta(n-1) + \delta(n-2) \Rightarrow \quad y(n) = x(n) + 2x(n-1) + x(n-2) \)

b) \( H(e^{j\omega_f}) = 1 + 2e^{j\omega_f} + e^{-j2\pi \frac{f}{F}} \)

\[
= e^{-j\omega_f} \left[ e^{j\omega_f} + 2 + e^{-j2\pi \frac{f}{F}} \right] = 2e^{j\omega_f} \left[ 1 + \cos 2\pi \frac{f}{F} \right]
\]

c) \( x(n) = \sin \pi n \frac{f}{F} \Rightarrow f = 0. \) \text{ Let } \ y(n) = \text{Im} [H(e^{j\omega_f})e^{j\frac{\tau n}{2}}]

\[
y(n) = \text{Im} \left[ 2e^{-j\pi \frac{f}{F}} \left[ 1 + \cos 2\pi \frac{f}{F} \right] e^{j\frac{\tau n}{2}} \right]
\]

\[
y(n) = 2 \left( 1 + \frac{n^2}{2} \right) \sin \left( \pi \frac{f}{2} \frac{f}{2} \right) = (2 + n^2) \sin \frac{\pi f}{2}(n-1)
\]

d) \( x(n) = s(n) \cos 2\pi fn \quad x(e^{j\omega_f}) = \frac{1}{2} \left[ s(e^{j\omega_f}f) + s(e^{j\pi + \omega_f}f) \right] \)

Because \( s(e^{j\omega_f}) \) is periodic, modulation by a cosine shifts the spectrum and aliases the spectrum. Trying to use a coherent demodulator won't work for the same reason. 

\text{Samantha is right.}

e) Note that \( s(n) \cos 2\pi fn + js(n) \sin 2\pi fn = s(n)e^{j2\pi fn} \)

To retrieve \( s(n) \), multiply by \( e^{-j2\pi fn} \)

\[
(s(n)e^{j2\pi fn}) e^{-j2\pi fn} = (s(n) \cos 2\pi fn + js(n) \sin 2\pi fn)(\cos 2\pi fn - jsin 2\pi fn)
\]

\[
= s(n) \cos^2 2\pi fn + s(n) \sin^2 2\pi fn
\]

\( \checkmark \)

The carrier frequency needs to be an integer number of \( \frac{1}{F} \), where \( F \) = bit interval duration. Data rate \( D = 44.1 \times 10^3 \times 16 = 705.6 \text{ Kbps} \)

\( \therefore f_c = \frac{1}{T} = 705.6 \text{ kHz} \) Pick \( n \) to be at least 3 (higher better)
b) Worst case occurs when \( b^{(1)}(n) = +1 \), \( b^{(2)}(n) = +1 \) and \( b^{(1)}(n+1) = -1 \), \( b^{(2)}(n+1) = -1 \). When \( b^{(1)}(n) = b^{(2)}(n) \),

\[
x(t) = A \cdot b^{(1)}(n) \left( \sin \omega c t + \cos \omega c t \right) \quad 0 \leq t \leq T
\]

\[
= A \cdot b^{(1)}(n) \left( \sqrt{2} \cos \left( \omega c t + \frac{\pi}{4} \right) \right)
\]

\[\therefore \text{Worst-case signal is a square wave of period } 2T \text{ modulated by } \sqrt{2} \cos \left( \omega c t + \frac{\pi}{4} \right). \text{ 90\% Bandwidth } = 2 \cdot \frac{3}{2T} = \frac{3}{T} = 3.7056 \text{ kHz} = 2.16 \text{ MHz}\]