Problem #1

a) \[ x_{FM}(t) = A \cos(2\pi f_c t + \beta \sin 2\pi ft) \]
   \[ = A \cos(\beta \sin 2\pi ft) \]
   \[ = A \cos(2\pi ft) \cdot \cos(\beta \sin 2\pi ft) \]
   \[ \approx A \cos(2\pi ft) \cdot \cos(\beta) \]

b) \( \Delta f = \frac{h A m}{\text{constant}} \)

c) \( V_{out}(t) = k \Delta F \cos 2\pi ft \)

d) If \( \beta = 3.3 \), \( J_c(\beta) = J_{-1}(\beta) = 0 \)

   There is only an unmodulated carrier which makes it through filter #2 - So - Output = 0

\( \text{(Unmodulated carrier = } k \cdot J_o(\beta) \cos 2\pi ft) \)

\( e) \ V_{out-ca}(t) = 0 \) the capacitor "gets rid" of DC term

\( \hat{f} \) \( V_{out-ps}(t) = k \cdot J_o(\beta)/2 \) (DC)

We have

\[ k \cdot J_o(\beta) \cos 2\pi ft \cdot \cos(\beta) \approx \text{after LPF} \Rightarrow k \cdot J_o(\beta)/2 \]
Problem #2

\[ S_{FM}(t) = A \cos \left( 2\pi F_c t + 2\pi h \int_s^t s(\tau) d\tau \right) \]

\[ = \frac{A e^{j \phi(t)} + e^{-j \phi(t)}}{2} \]

All of \( e^{j \phi(t)} \) are positive freqs
All of \( e^{-j \phi(t)} \) are negative freqs

\[ S_{FM}(t) = -J \text{sgn} F \left[ \frac{A e^{j \phi(t)} + e^{-j \phi(t)}}{2} \right] \]

\[ = \frac{A e^{j \phi(t) - \pi/2}}{2} - J \left( e^{-j \phi(t) - \pi/2} \right) \]

\[ S_{FM}(t) = A \sin \phi(t) \]

\[ X_{USB - SSB}(t) = A \cos \phi(t) \cos 2\pi F_0 t \]

\[ - A \sin \phi(t) \sin 2\pi F_0 t \]

\[ = A \cos \left( \phi(t) + 2\pi F_D t \right) \]

\[ X_{USB - SSB}(t) = A \cos \left( 2\pi (F_c + F_D) t + 2\pi h \int_s^t s(\tau) d\tau \right) \]
For an SSB-Signal, the lower sideband of \( \text{FFM} \) is cut off!

This is spectrum of original signal centered at \( (F_D + f_o) \).

\[
X_{\text{USB-SSB}}(t) = A \cos \left[ 2\pi (F_D + f_o) t + 2\pi f_o \int_{-\infty}^{t} \sin(2\pi f_o \tau) d\tau \right]
\]

After cutting off the lower sideband (LSB), we have the spectrum shown above and described by signal above, \( X_{\text{USB-SSB}}(t) \).