1. amplitude 2V at freq 5kHz
VCO frequency 10 kHz/V

(1) $\Delta f = k_f A_m$ (frequency deviation)

$10 \cdot 2 = 20$ kHz

(2) $\beta = \frac{k_f A_m}{f_m} = \frac{\Delta f}{f_m} = \frac{20\text{ kHz}}{5\text{ kHz}} = 4$, $\beta >> 1$: Wideband FM

(3) $BW \approx 2 f_m = 10$ kHz

$BW \approx 10$ kHz $\pm \approx 35\%$

2. $m(t) = \frac{1}{1+(t-10)^2}$, $M(f) = \pi e^{-j40\pi f} e^{-2\pi|f|}$, $0 \le t \le 20$sec

$B = \frac{\ln 10}{4\pi} = 0.1832$ Hz   90% of energy in $|f| \le B$

$\hat{m}(t) = \frac{t-10}{1+(t-10)^2}$, $v(t) = \int_{\tau=-\infty}^{t} m(\tau) d\tau = \frac{\pi}{2} + \tan^{-1}(t-10)$

$\tan^{-1}$ principal branch $\hookrightarrow -\pi/2, \pi/2$

$v(-\infty) = 0$,
$v(10) = \frac{\pi}{2}$,
$v(\infty) = \pi$

carrier freq $= f_c = 10$ Hz
$f_s = 100$ Hz

f) envelope of USSB, LSSB

$$= \sqrt{\left(\frac{1}{(1+(t-10)^2)}\right)^2 + \left(\frac{(t-10)}{(1+(t-10)^2)}\right)^2}$$

$$= \sqrt{\frac{1+(t-10)^2}{(1+(t-10)^2)^2}} = \sqrt{\frac{1}{1+(t-10)^2}} \quad (\sqrt{m(t)})$$

$$\text{envelope} = \sqrt{m(t)} = \sqrt{\frac{1}{1+(t-10)^2}}$$