

Bonus Question

A.

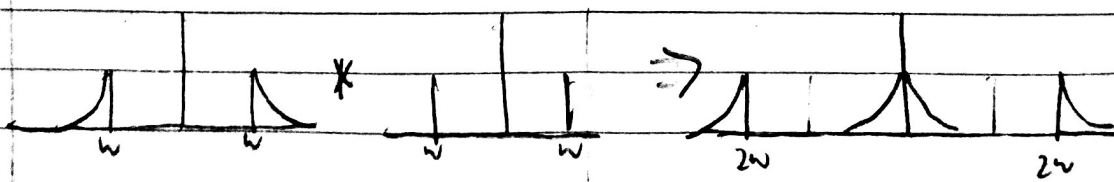
- a) In order to double the frequency of a signal using AM is to multiply the signal with a cosine wave of the same frequency as the fundamental of the signal.

With a cosine waves:

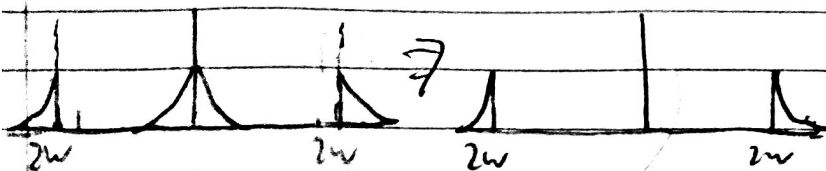
$$\begin{aligned} e(t) &= s(t) \cdot m(t) = \cos(2\pi f_c t) \cdot \cos(2\pi f_c t) \\ &= \frac{1}{2} [\cos(2\pi(f_c - f_c)t) + \cos(2\pi(f_c + f_c)t)] \\ &= \frac{1}{2} [1 + \cos(2\pi \cdot 2f_c \cdot t)] \\ &= \boxed{\frac{1}{2} \cos(2\pi \cdot 2f_c \cdot t)} : \text{Doubled Frequency} \end{aligned}$$

- b) With other signals, harmonics will be reproduced in the bass, because

$$e(t) = s(t) \cdot m(t) = S(\omega) * m(\omega) =$$

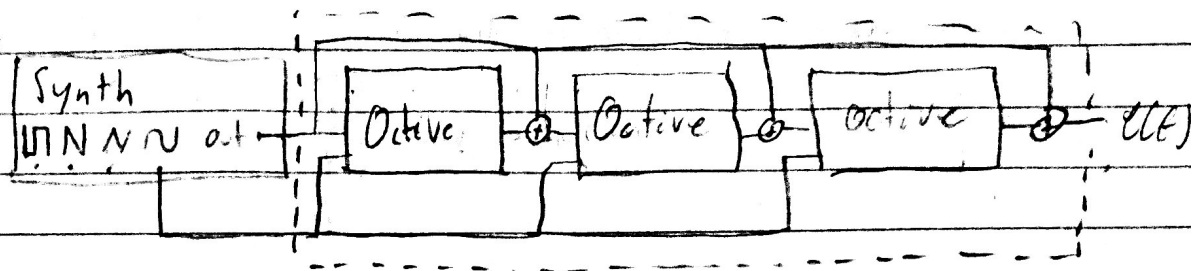


So a highpass filter with a cutoff frequency at 2ω should be used,



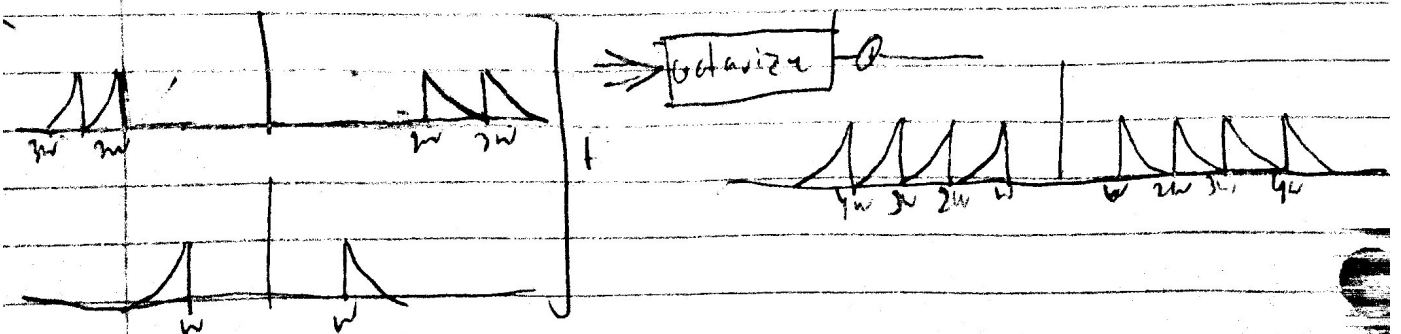
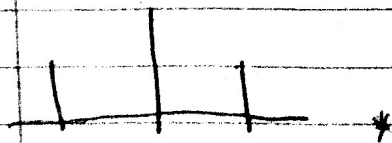
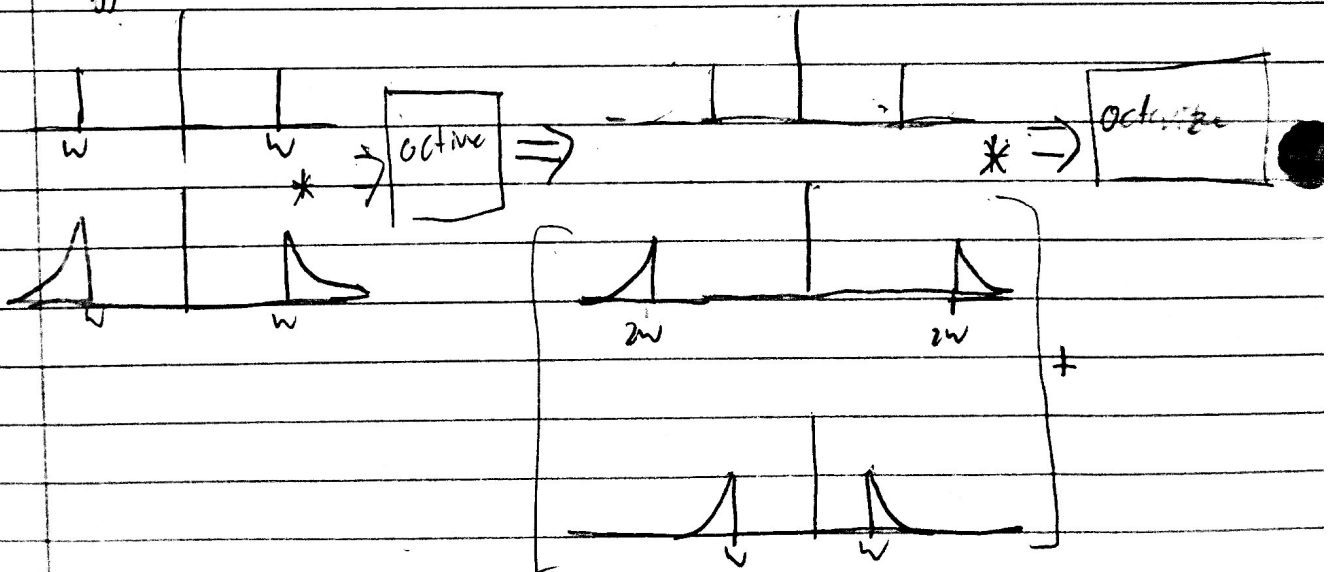
B.

a)



An octavizer will continue shifting the signal one harmonic up, so shifting and adding the original signal will result in adding harmonics to the original as an effect. Thus, harmonics are created.

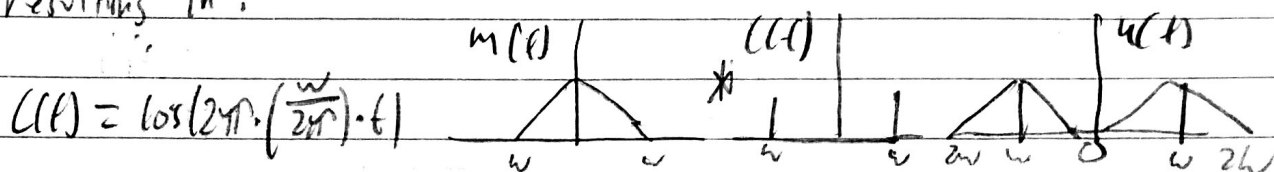
b)



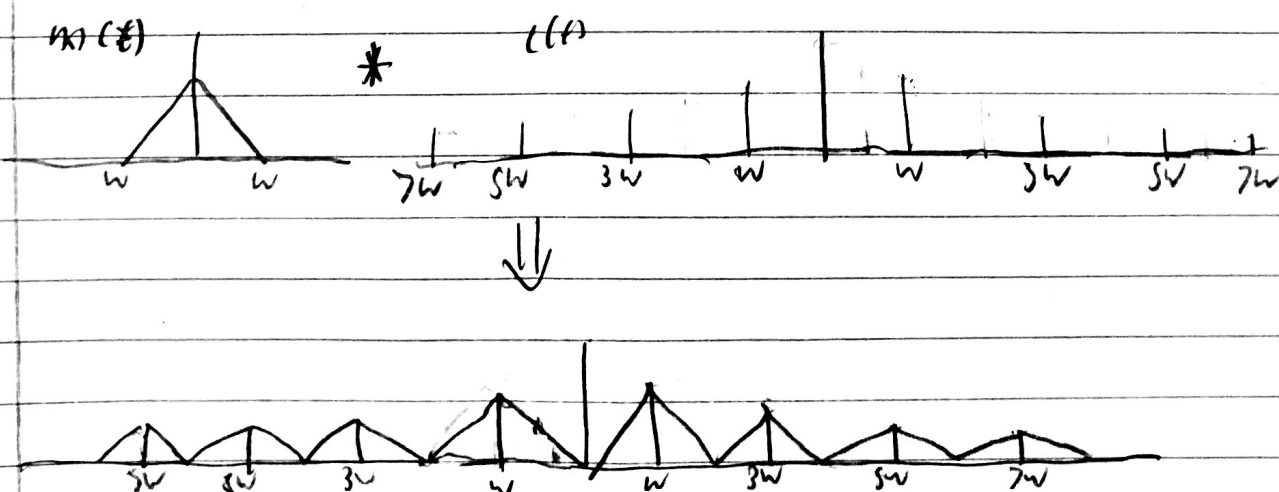
C.

- a) A Cosine wave with a frequency higher than the bandwidth of the music being sent is required, so a bandwidth of W results in a max frequency of $\frac{W}{2\pi}$.

Therefore, the carrier will have a frequency of $\frac{W}{2\pi}$, resulting in:



- b) If the student wants to broadcast on all frequencies, then a carrier with harmonics at every other harmonic must be selected. This is the case because the frequency domain convolution will require a difference of $2W$ in the harmonics in order to not have spectral overlap. With this in mind, a square wave should be used because the amplitude of the harmonics decreases the slowest. (We are limited to the synth).



$$C(f) = \frac{4}{\pi} \sum_{n=1,3,5,\dots}^{\infty} \frac{1}{n} \sin\left(\frac{n\pi x}{L}\right)$$

c) This signal is broadcast on all the other harmonics of the frequency ω . This means that ω or one of its harmonics must be isolated before it can be demodulated. Therefore, a bandpass filter must be applied to the incoming signal before it is demodulated. Then, a band of coded music can then be demodulated.

