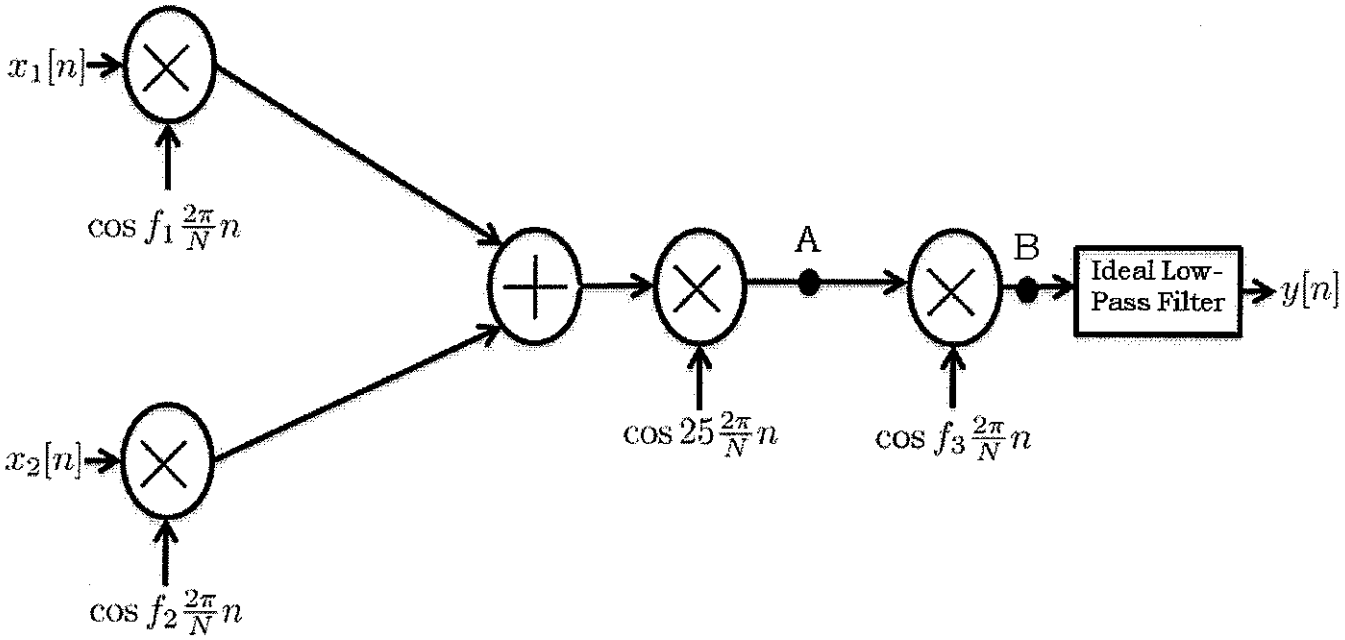
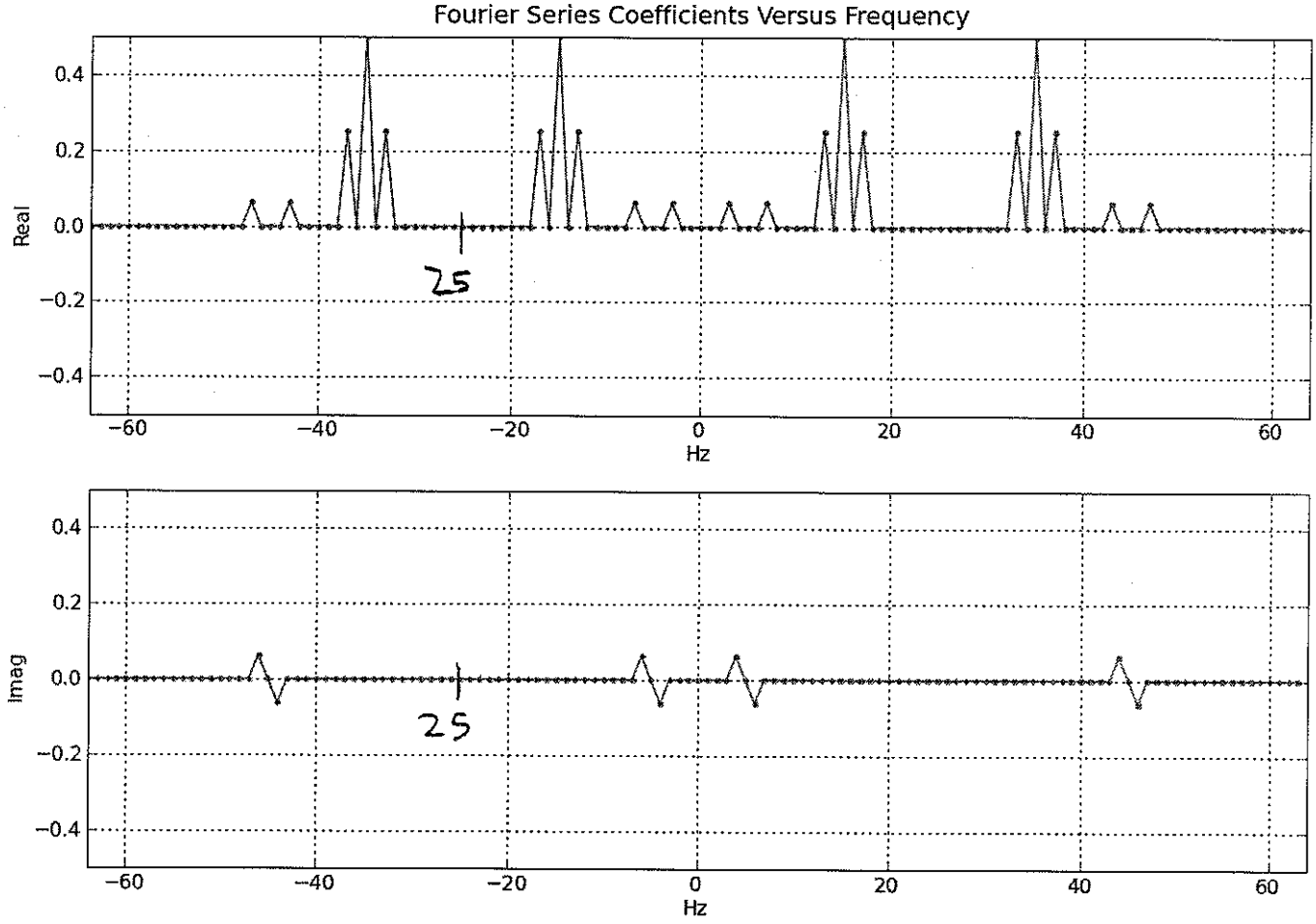
Problem 4. Modulation [35 Points]

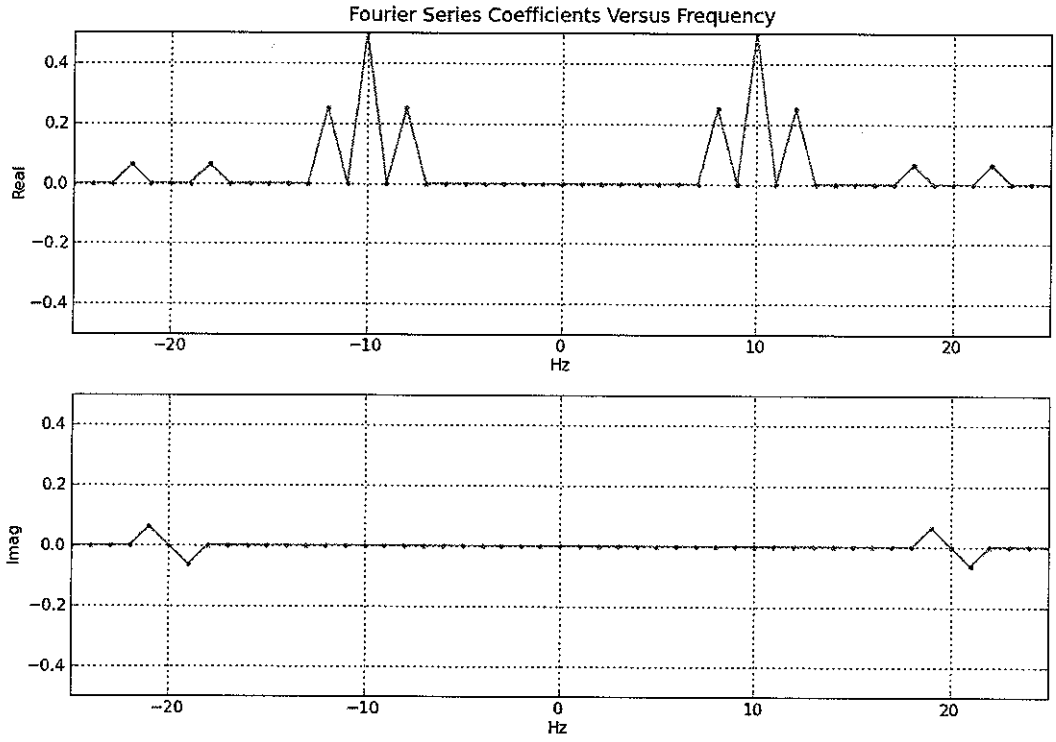
In answering the four parts of this question, please refer to the modulation-demodulation system below. For this problem, please assume $N = 128$ and that the sampling frequency, f_s, is 128 samples per second.



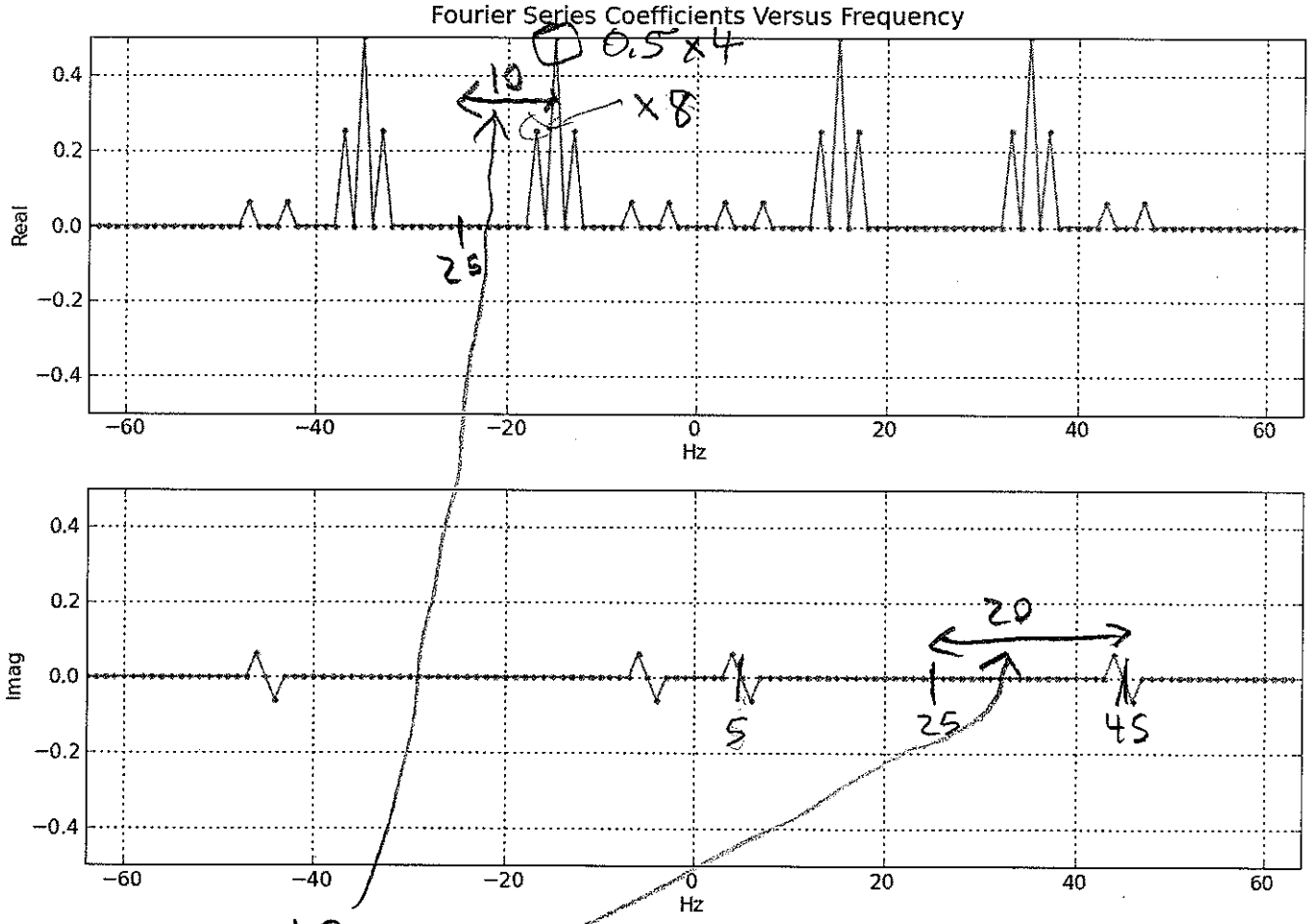
(A) Below are plots of the real and imaginary parts of the Fourier coefficients versus frequency for point **A** of the modulation-demodulation system. On the axes below, please plot the real and imaginary parts of the Fourier coefficients versus frequency for the signal at point **B**, assuming $f_3 = 25$. For this problem, you need only plot the Fourier Series coefficients for frequencies in the range -25 to 25. Please be sure to label critical frequencies and values in your graph



Signal at Point **B** Fourier Series Coefficients:



(B) Repeated below are plots of the real and imaginary parts of the Fourier coefficients versus frequency for point **A** of the modulation-demodulation system (that is, the same plot as in part A). If $x_1[n] = \alpha + \beta\cos(2\frac{2\pi}{N}n)$ and $x_2[n] = \frac{1}{2}\cos(2\frac{2\pi}{N}n) + \frac{1}{2}\sin(\frac{2\pi}{N}n)$, please determine the two modulation frequencies, f_1 and f_2, and the two amplitudes, α and β.



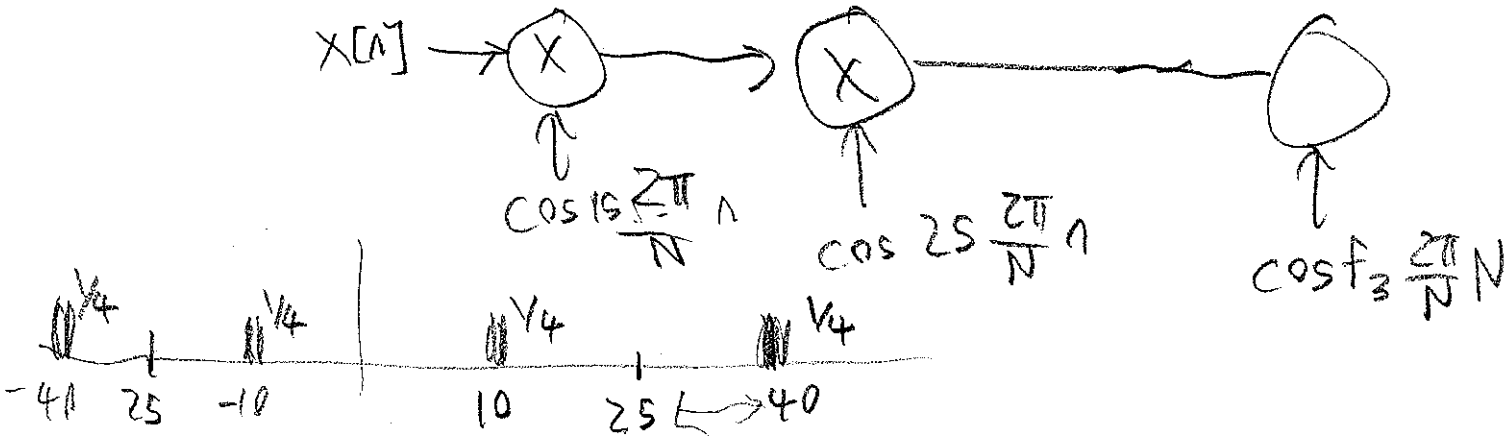
$f_1 =$ 10

$f_2 =$ 20

$\alpha =$ 2.0 (4 x 0.5)

$\beta =$ 2.0 (8 x 0.25)

(C) Now suppose $x_2[n] = 0$, $x_1[n] = \frac{1}{2}\cos(2\frac{2\pi}{N}n) + \frac{1}{2}\sin(\frac{2\pi}{N}n)$, and $f_1 = 15$ (not one of the answers to part B!). For what values of $f_3 < 64$ (there is more than one) will $y[n] = x_1[n]$, assuming the low-pass filter has been designed correctly. In addition, what should the magnitude be for the low frequency response of the low-pass filter? Please show your reasoning, with pictures if needed.



Values for f_3 = 10 and 40

Magnitude of the low-pass filter's low frequency response = 4

End of Quiz 2!