PHYS 391
Day 16

- Lab 4 tasks
- Fourier Series and Transform
- Sampling Basics

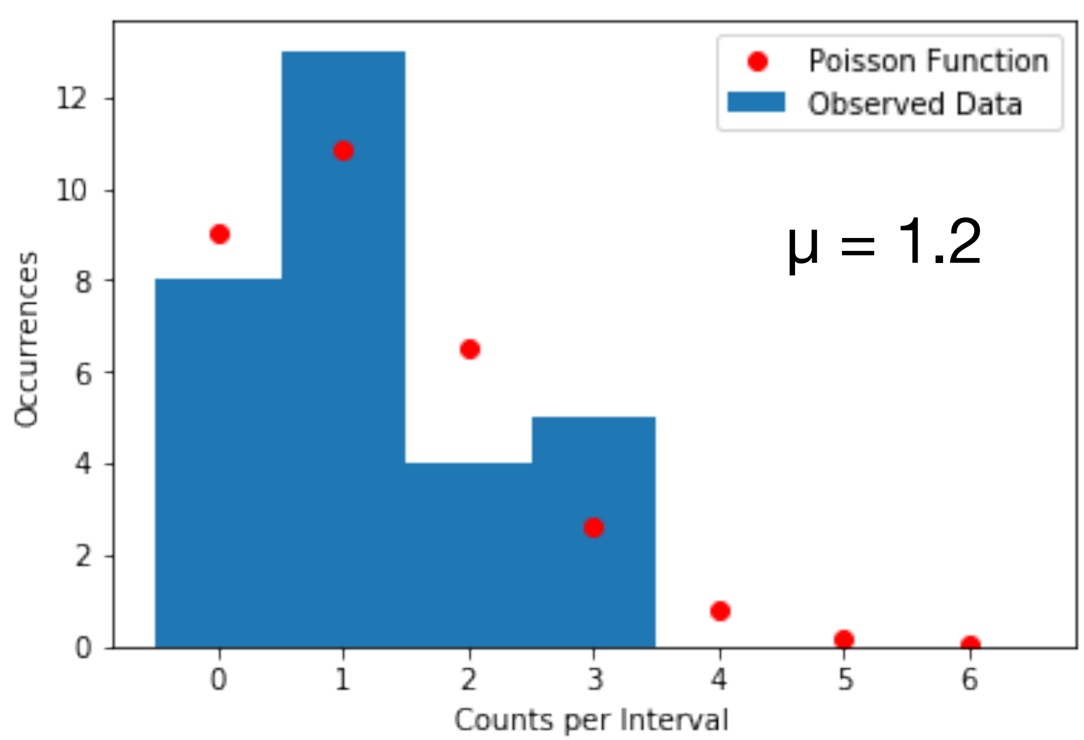
Lab 4

- 4.5 - Poisson Statistics
- 4.6 - Gaussian Statistics
- 4.7 - Inverse Square Law
- 4.8 - Attenuation Length

Don’t forget to describe (briefly) the data taking conditions
and also to provide some analysis of your results

4.5 Poisson Stats

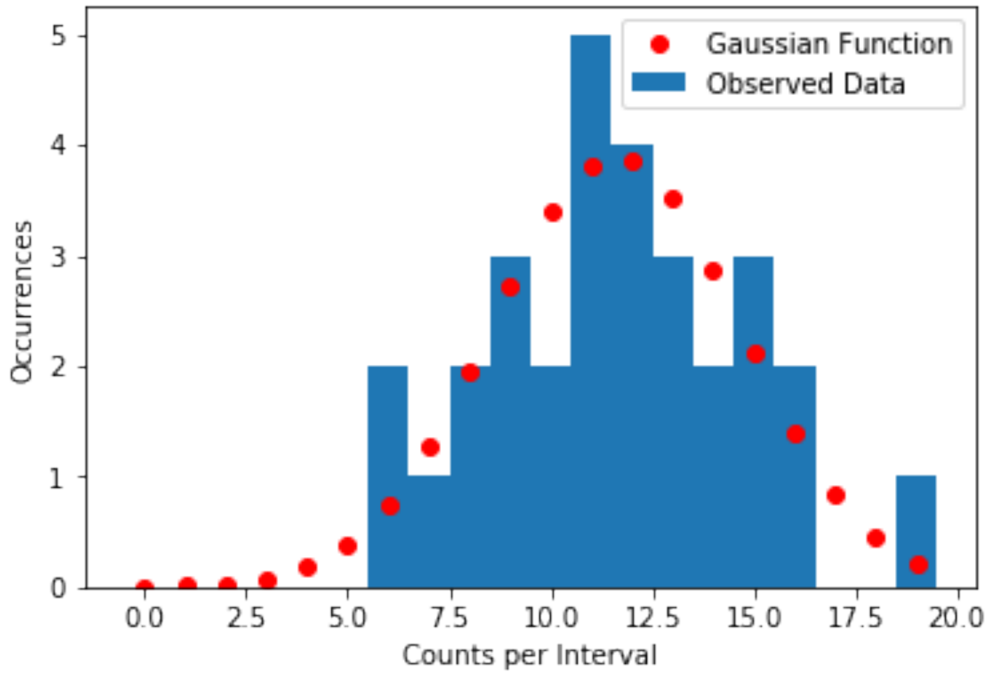
- Taking data with μ ~ 1
- Make histogram of events per interval
- Overlay with Poisson function with same μ
- Find background rate (used for remaining sections)



Challenge is really just making this plot…

4.6 Gaussian Stats

- Taking data with μ ~ 10
- Make histogram of events per interval
- Find mean and standard deviation
- Is $\sigma \sim \sqrt{\mu}$? Probably worth finding error on σ here…



Don't need to overlay Gaussian

4.7 Inverse Square Law

- Take data at different distances
- Subtract background and correctly propagate errors to get signal rate
- Expect $R(r) = R_0 / r^2$ -> want to fit to R_0 / r^n, is $n = 2$?
- Linearize this equation and perform a linear fit to your linearized data
- Don't need to include errors in the fit, but if you do, be careful with the errors on the linearized data…
- Need an uncertainty on n from your fit - present result with sig. figures…
- Discuss if there is evidence of deviations (particularly at short distances…)

4.8 Attenuation Length

- Take data at fixed distance, but varying thickness of Aluminum x
- Subtract background and correctly propagate errors to get signal rate
- Expect $R(x) = R_0 e^{-x/\lambda}$ -> fit for λ
- Linearize this equation and perform a linear fit to your linearized data
- Best to include errors in the fit, but must use correct uncertainty on ln(R), ask for help, or if you don't think you can to this correctly, use an unweighted fit…
- Need an uncertainty on λ from your fit
- Convert to λρ in units of g/cm^2 including error - present result with sig. figures
- From magnitude, is this more likely α, β, or γ radiation?

Fourier Transforms

Fourier Transform Notes:
https://pages.uoregon.edu/torrence/391/fftnotes.pdf

Note: I will not ask you to calculate analytic Fourier Transforms…

Complex Representation

- Can re-write Fourier Series as

$$f(x) = \sum_{n=-\infty}^{+\infty} c_n \, e^{inx}$$

where

$$c_n = \begin{cases} \frac{1}{2}(a_n - ib_n), & n > 0, \\ \frac{1}{2}(a_n + ib_n), & n < 0, \end{cases}$$

More compact notation, potentially more confusing
Closer to how the Fourier Transform is usually written

Fourier Transform

- Extending range from [-π, +π] to [-∞, +∞] changes:
  - sum ⇒ integral
  - c_n with spacing (π/L) ⇒ continuous function c(ω) = $\hat{f}(\omega)$

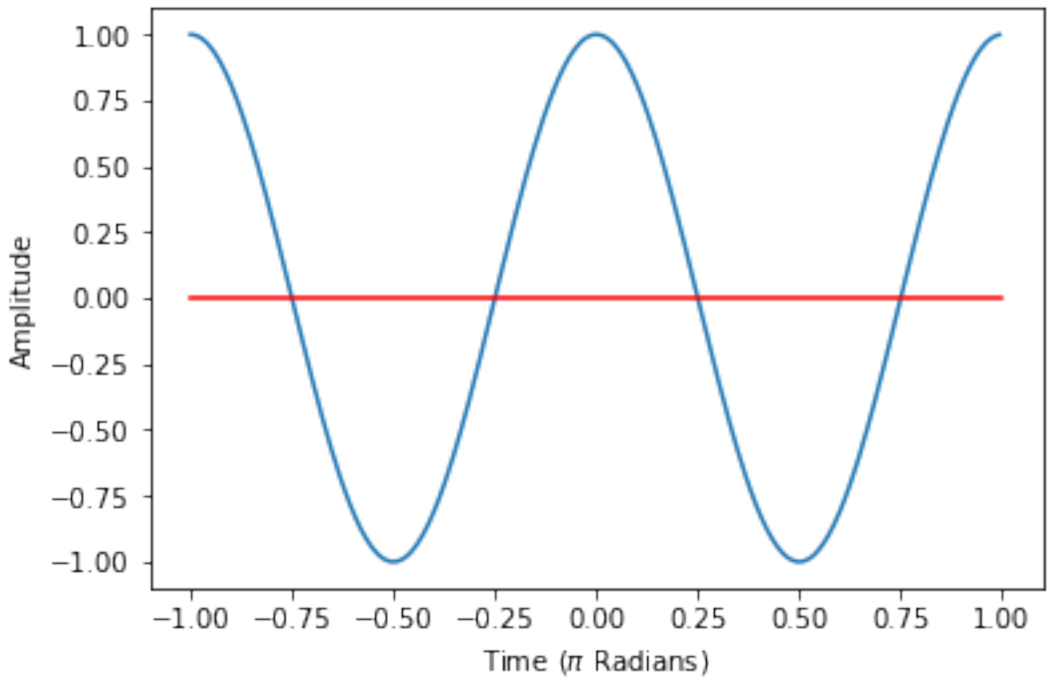
$$\hat{f}(\omega) \equiv \int_{-\infty}^{+\infty} f(x) e^{-i\omega x}\, dx,$$ [Fourier Transform]

$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \hat{f}(\omega) e^{i\omega x}\, d\omega.$$ [Inv. Fourier Transform]

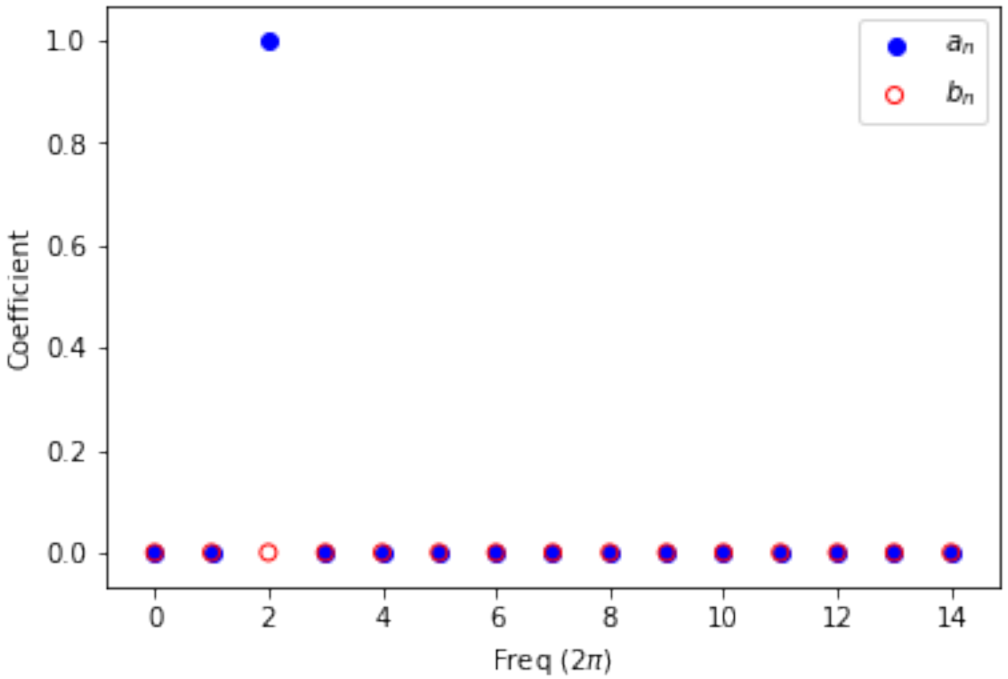
Simple Examples

- Will discuss code next week

$$f(t) = \cos[2(\pi t)]$$



Purely Even



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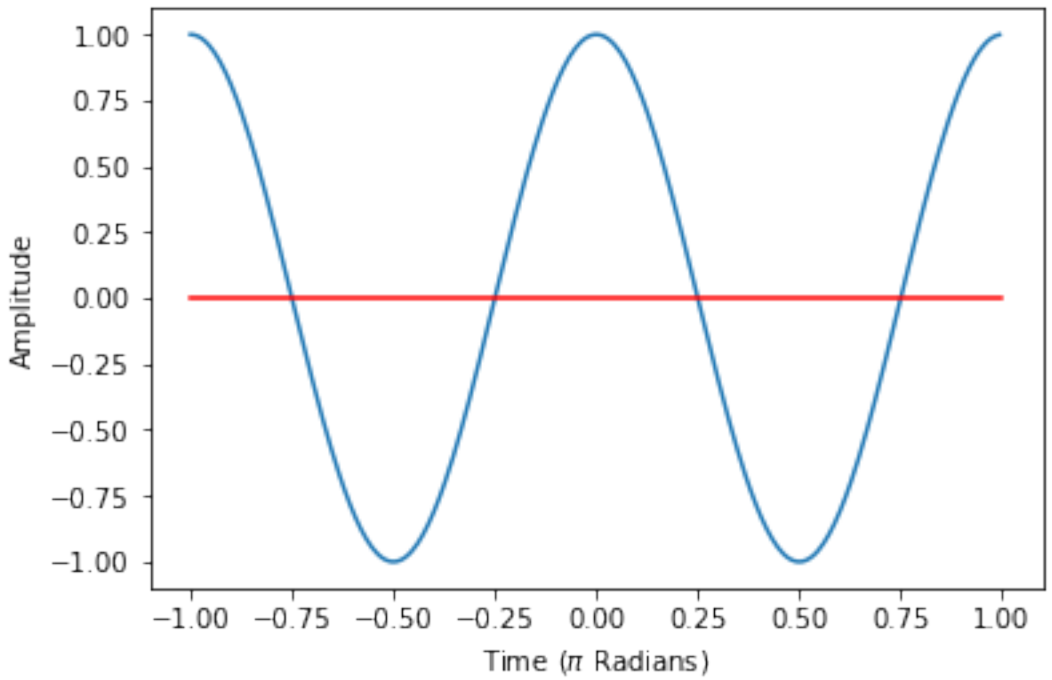
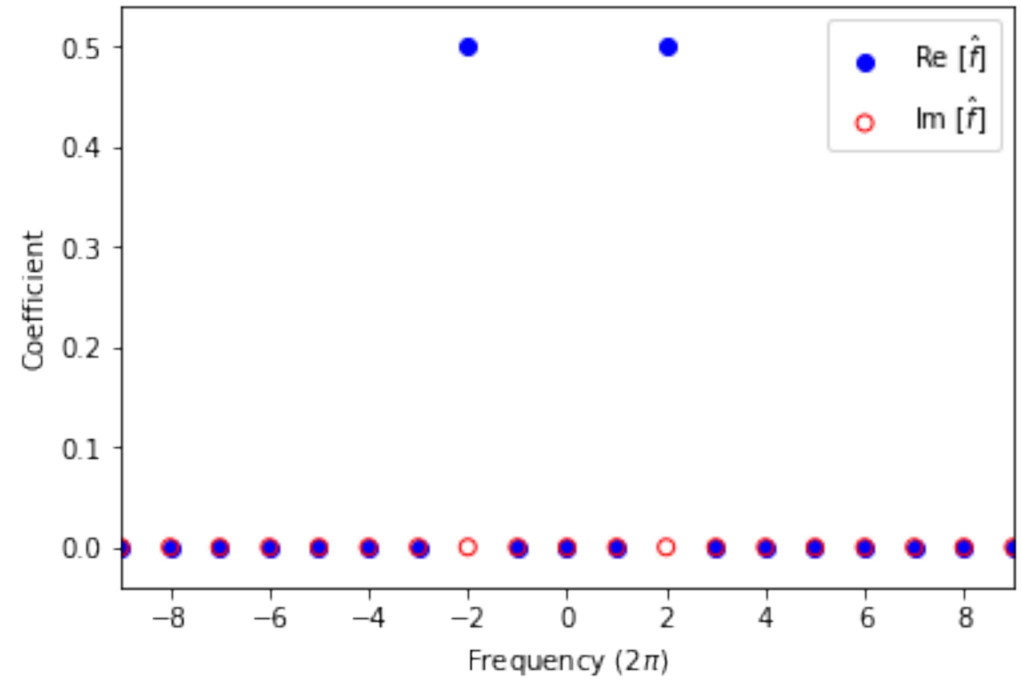


Complex form



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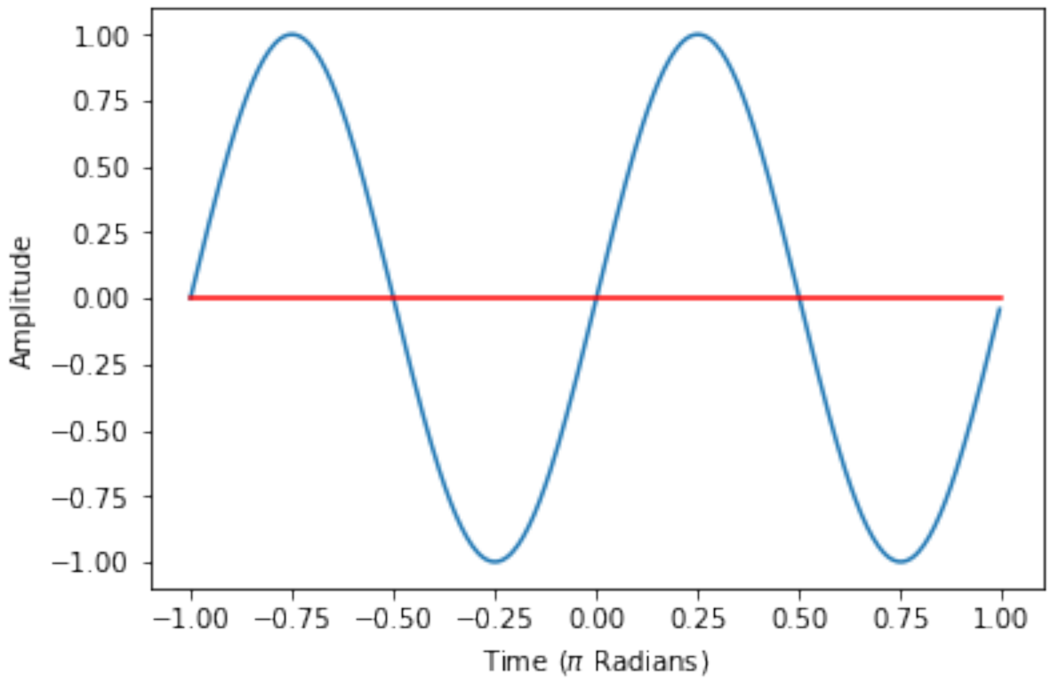

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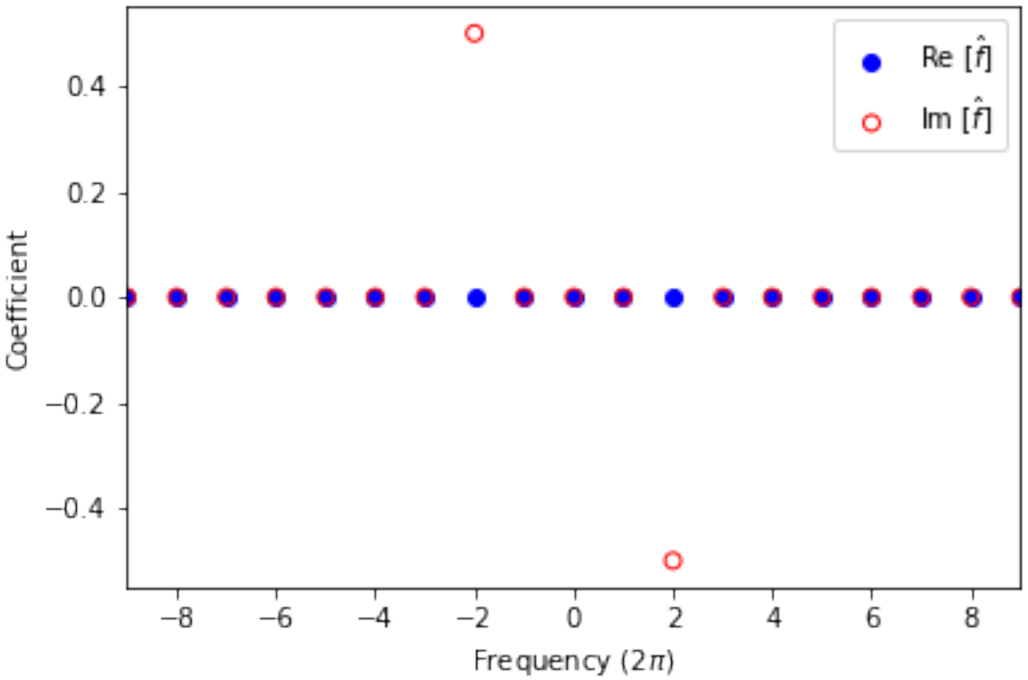
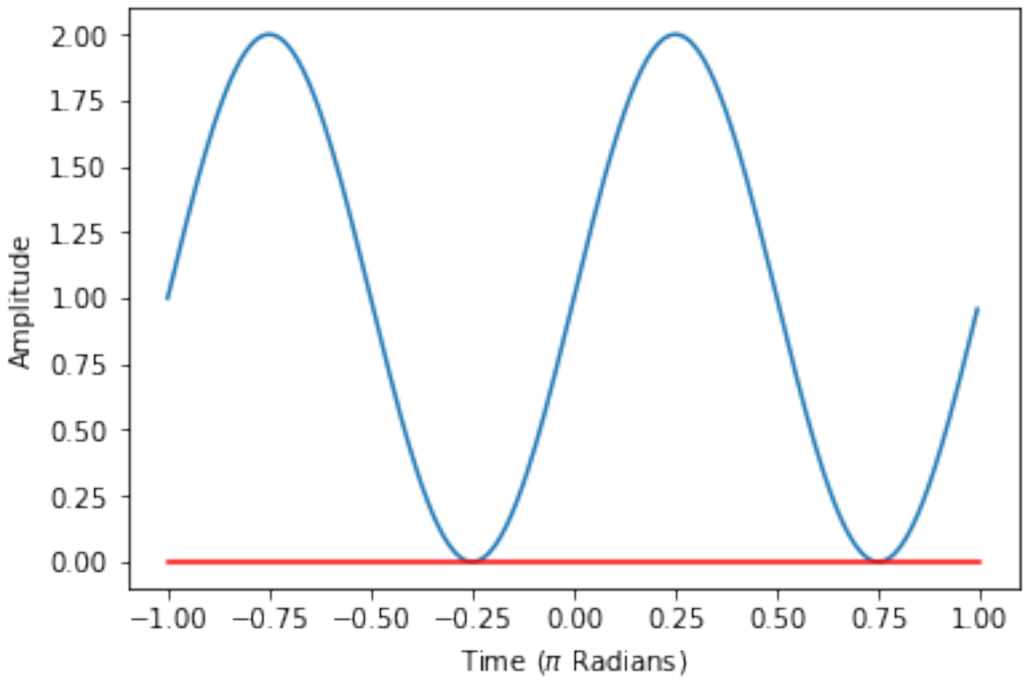


Simple Examples

- What if I add a constant?

$$f(t) = \sin[2(\pi t)] + 1$$



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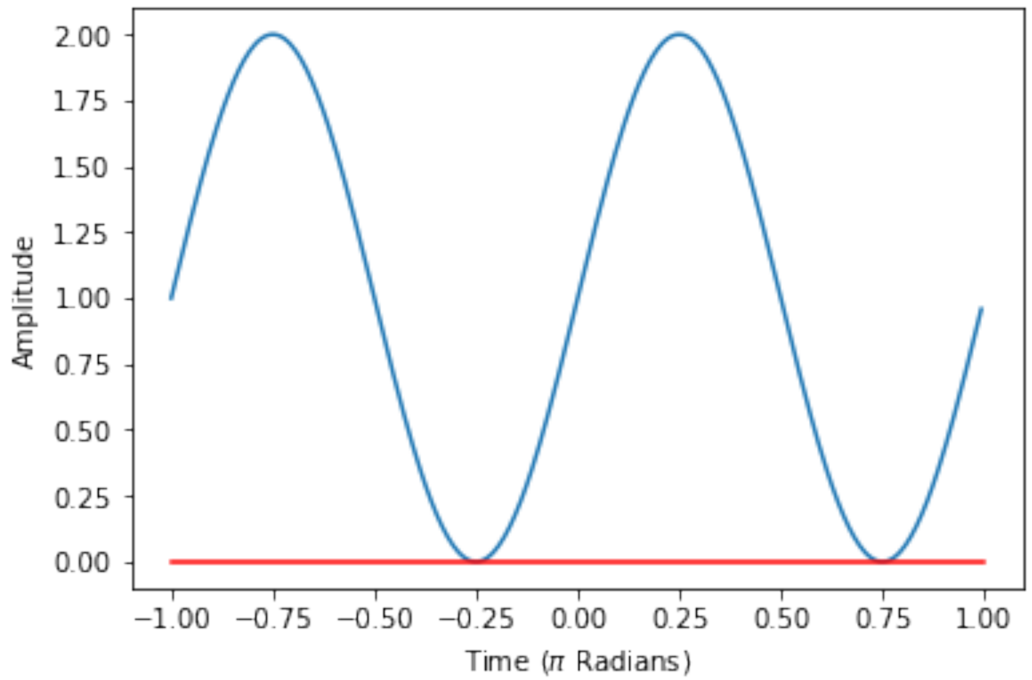

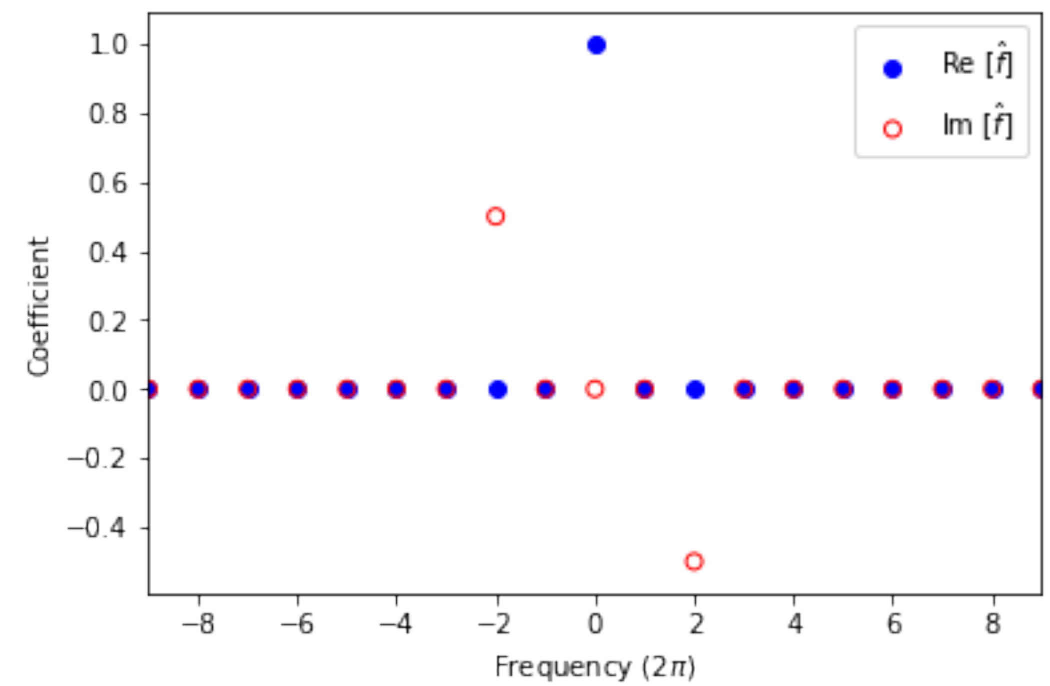

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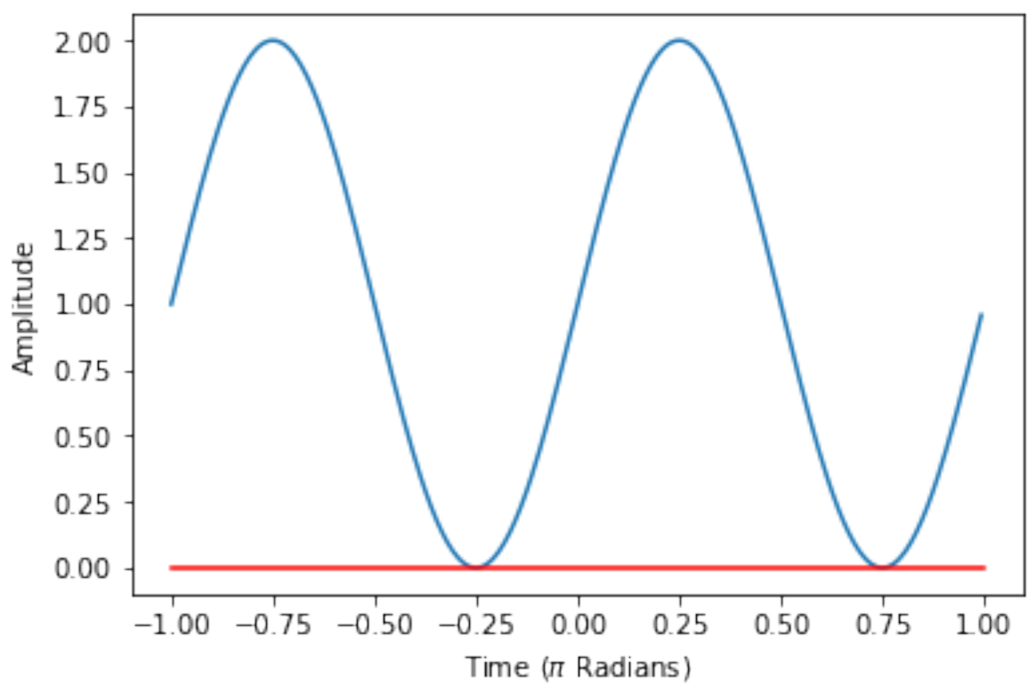
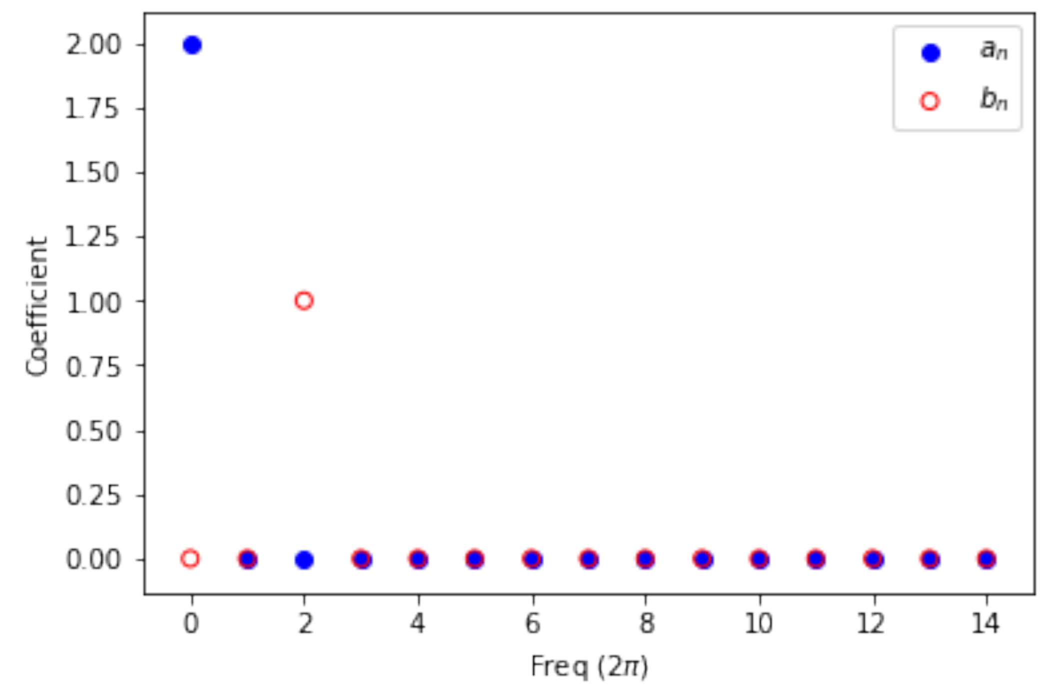
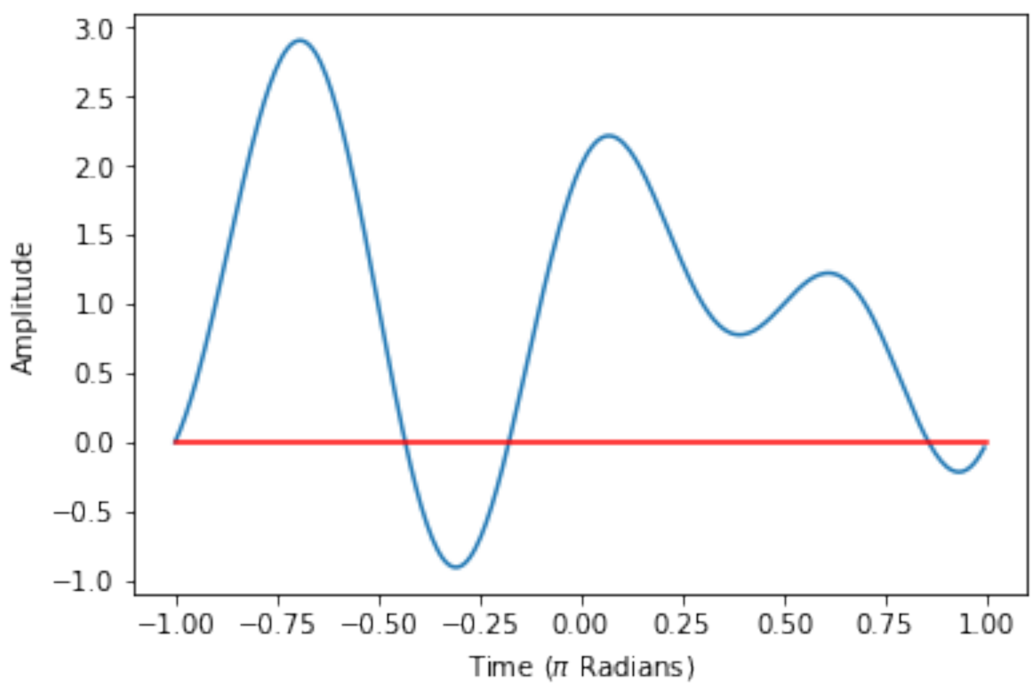




Simple Examples

- What if I add a second function?

$$f(t) = \sin[2(\pi t)] + \cos[3(\pi t)] + 1$$



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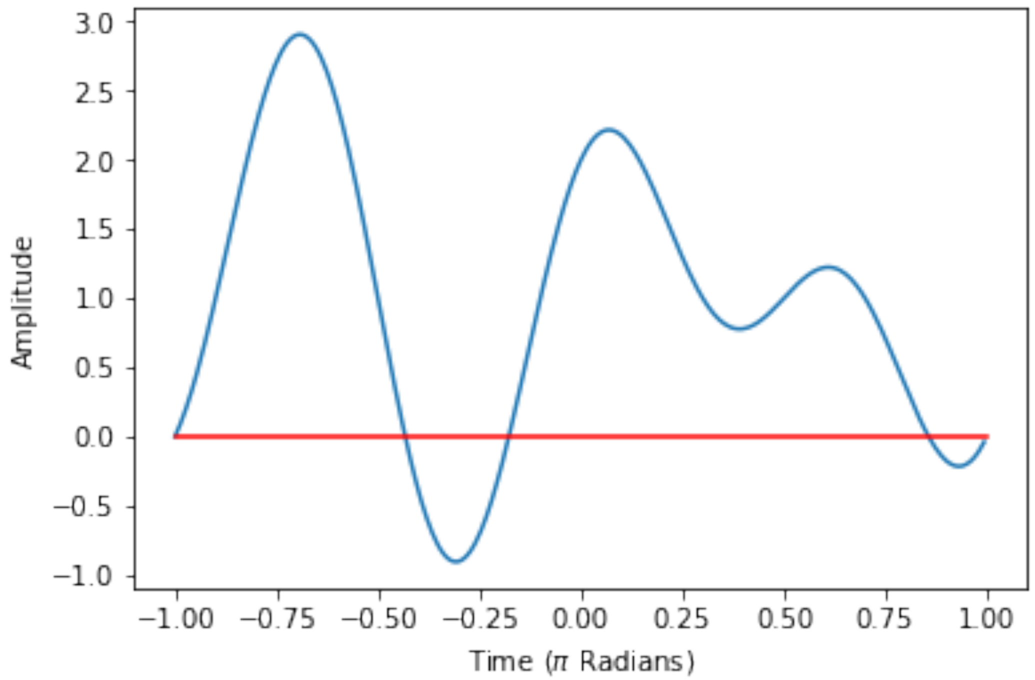
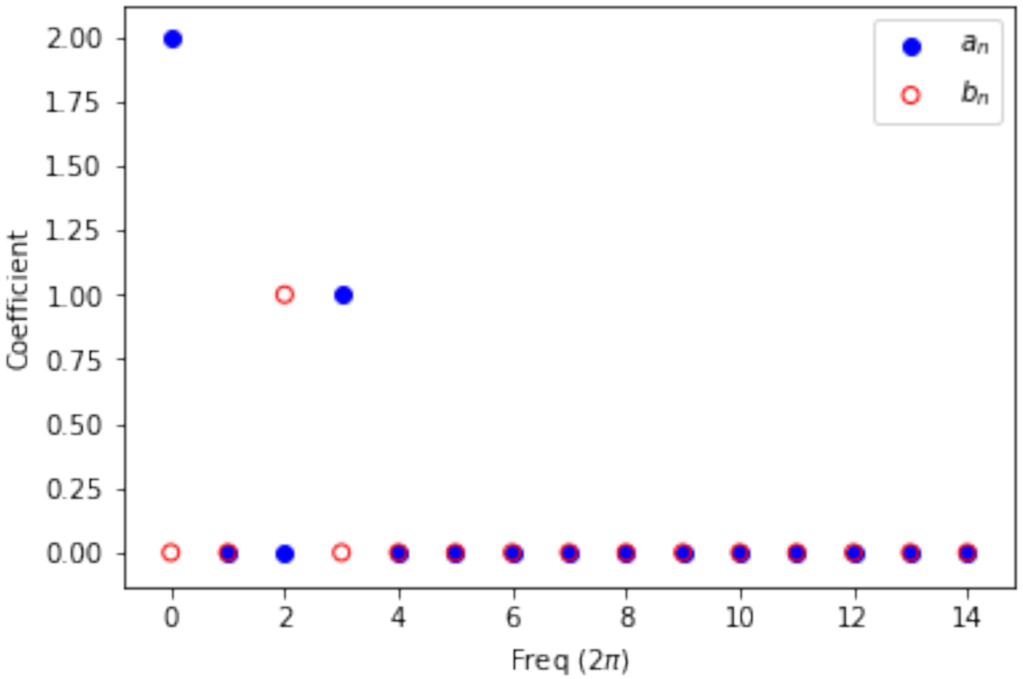
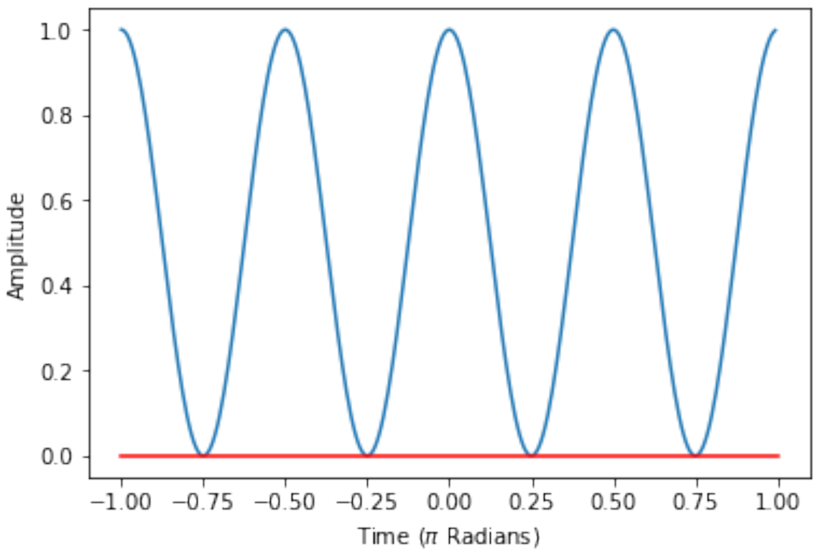


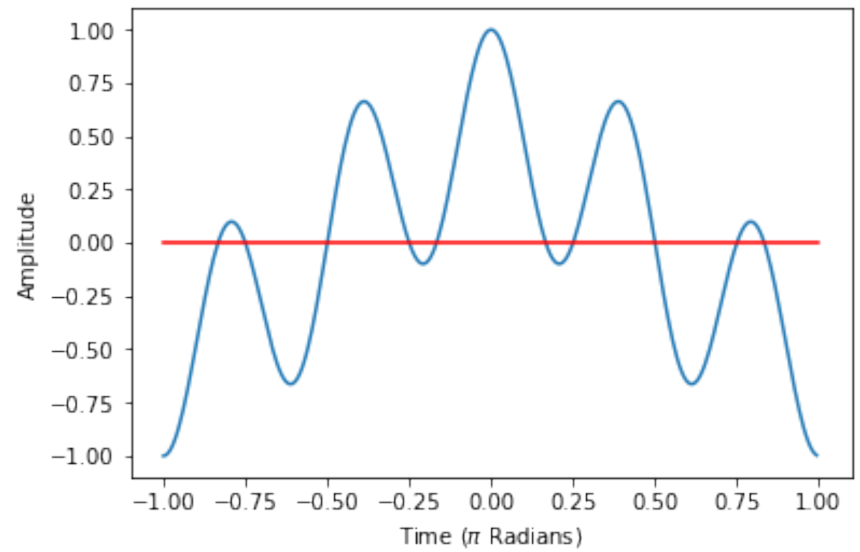


Match the Waveform

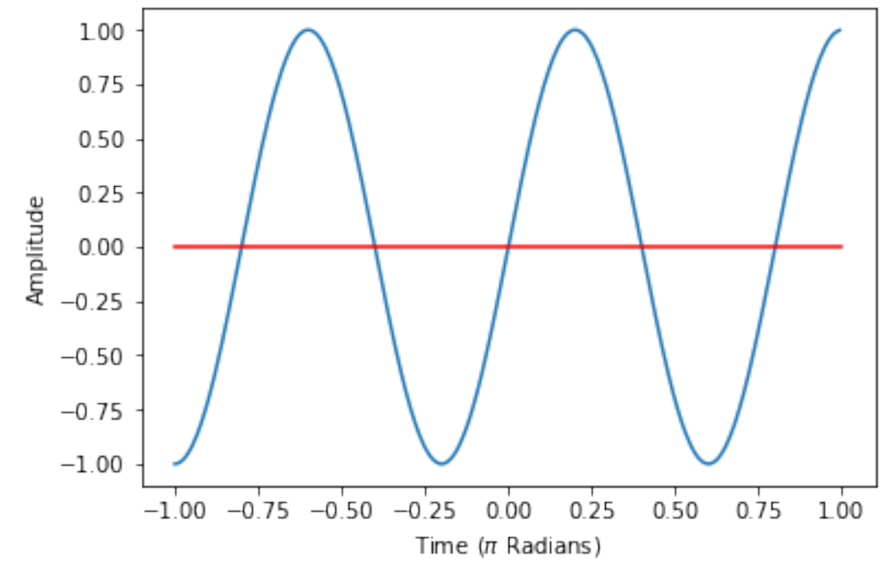
1)



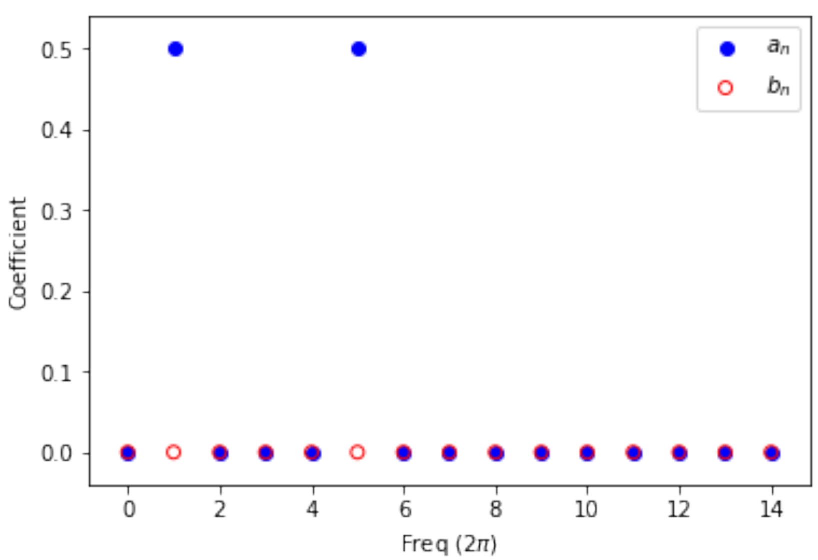
2)



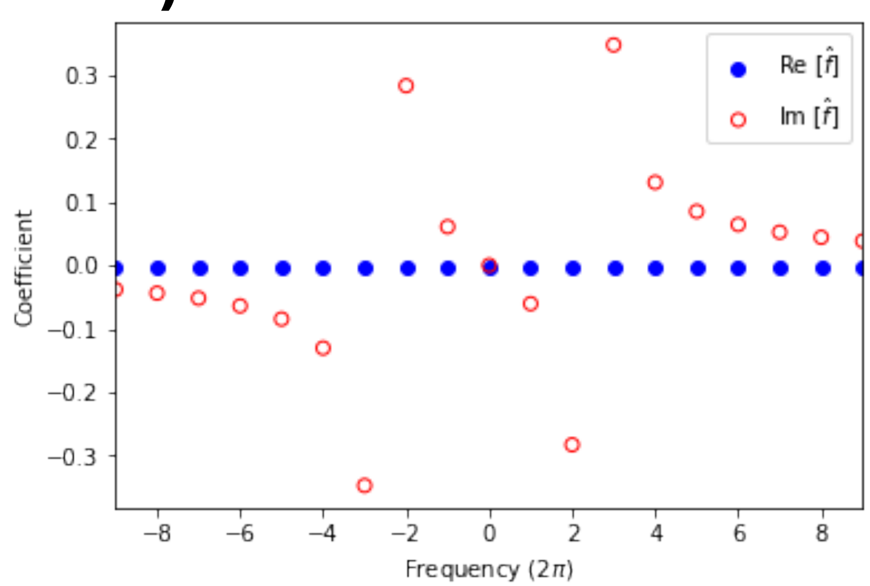
3)



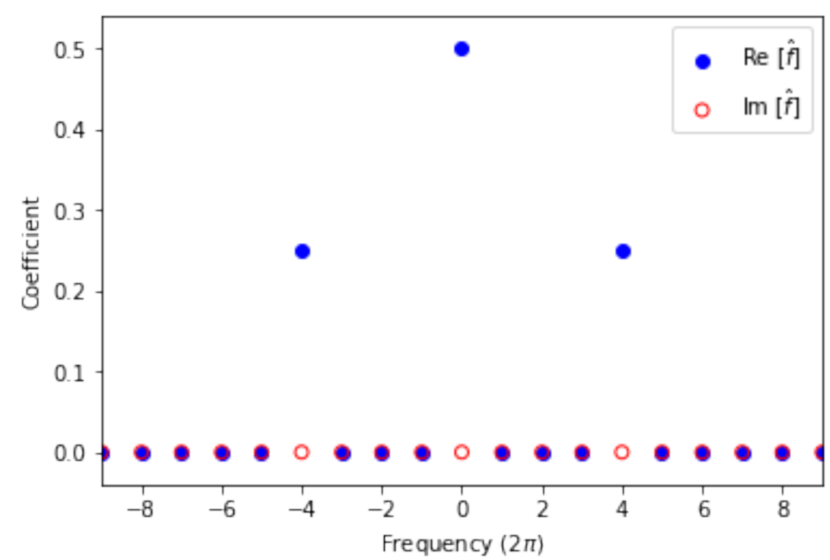
A)



B)



C)



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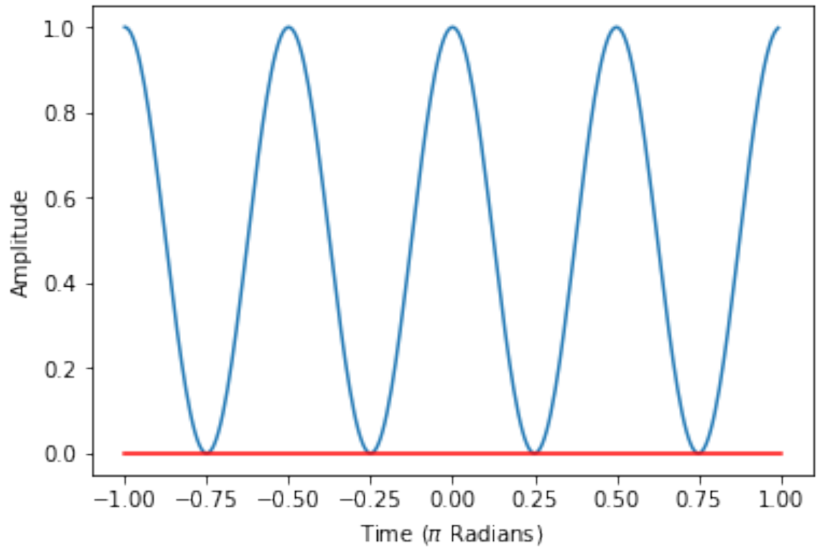
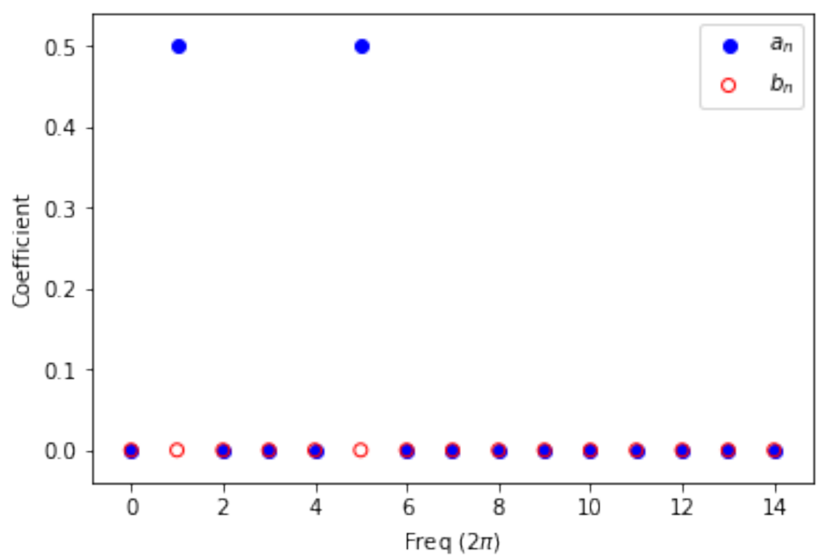


$$f(t) = \sin^2[2(\pi t)]$$

What features help you here?

A)



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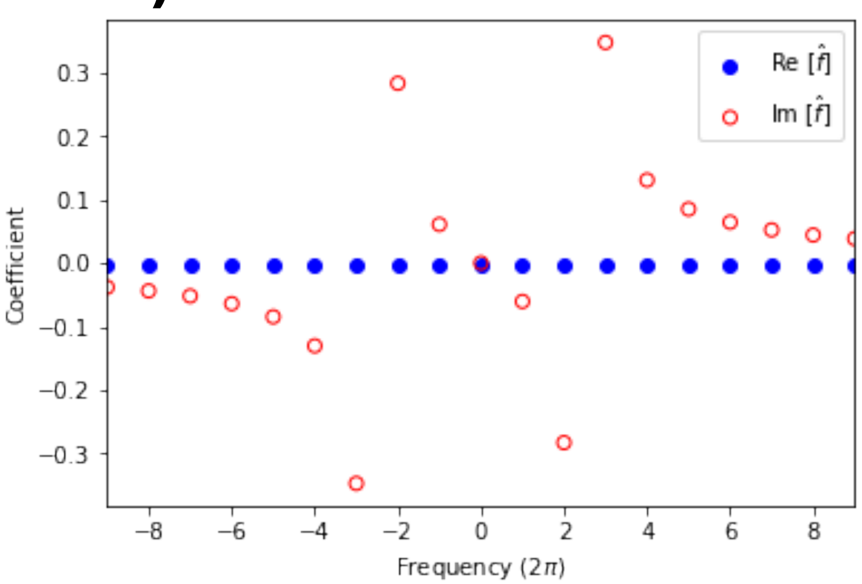

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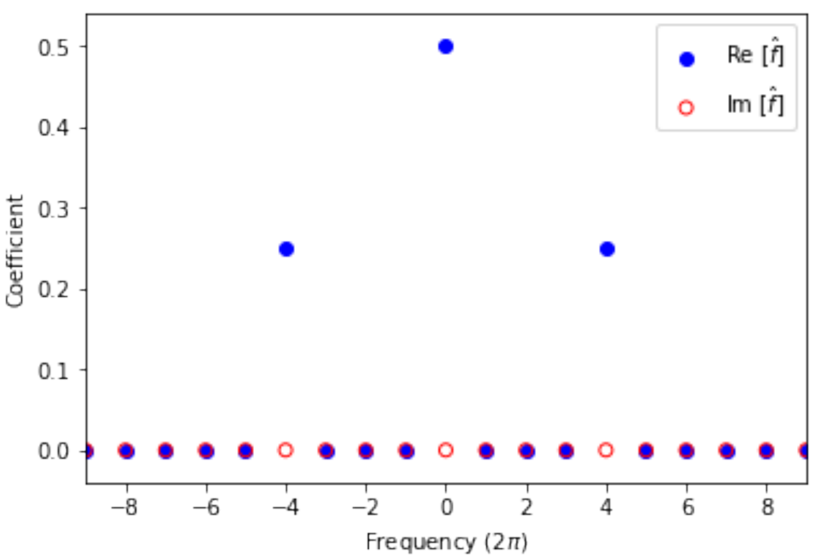

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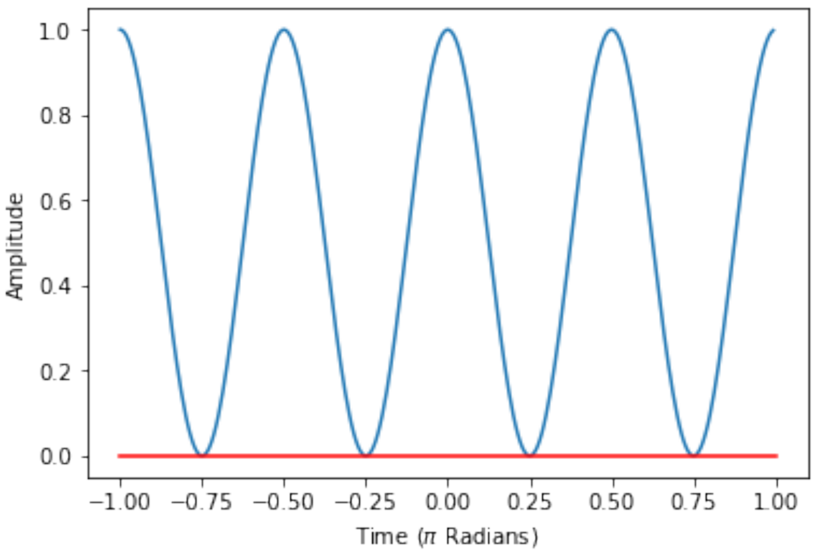

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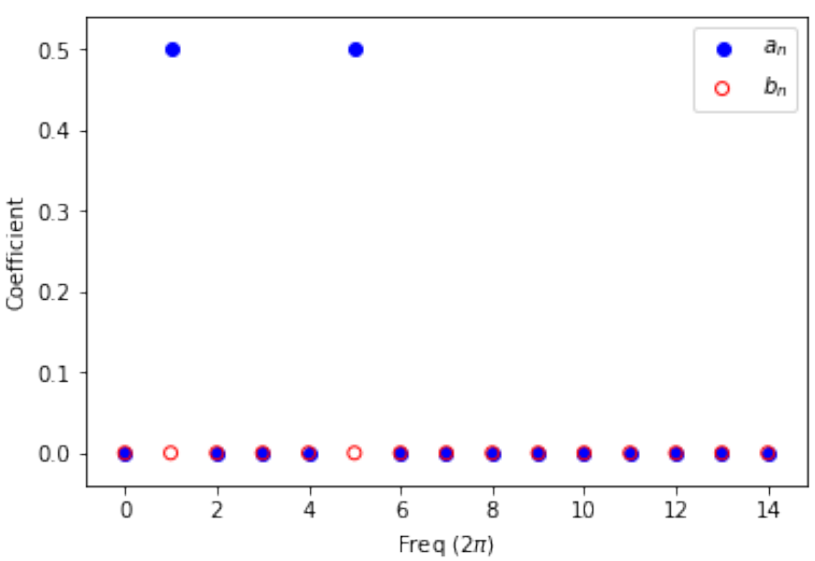

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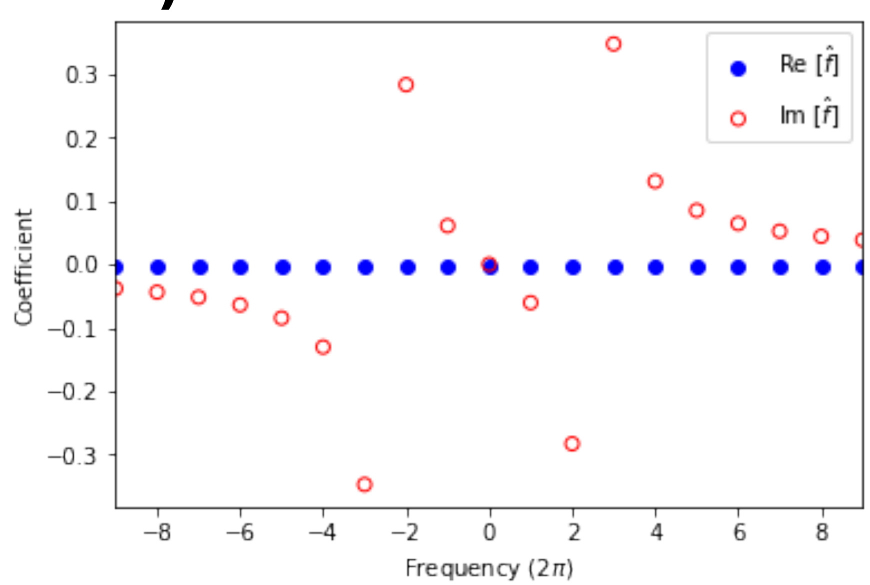

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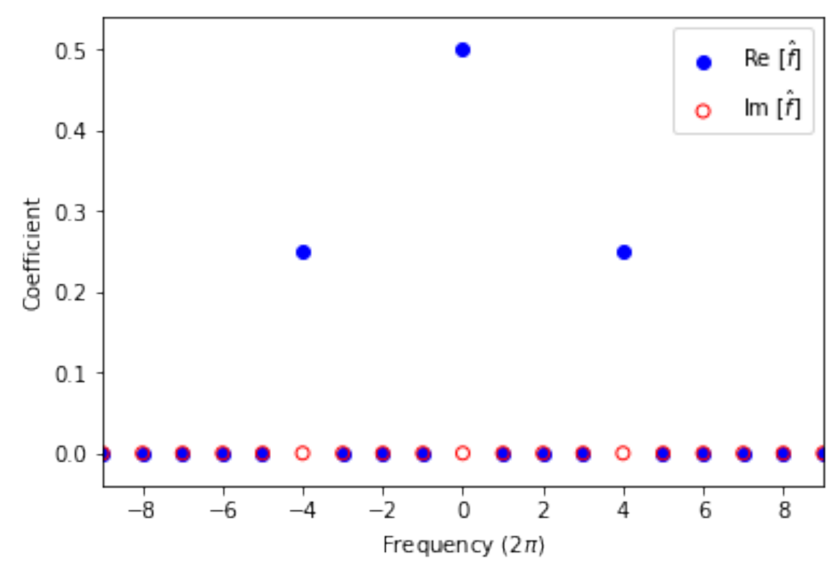

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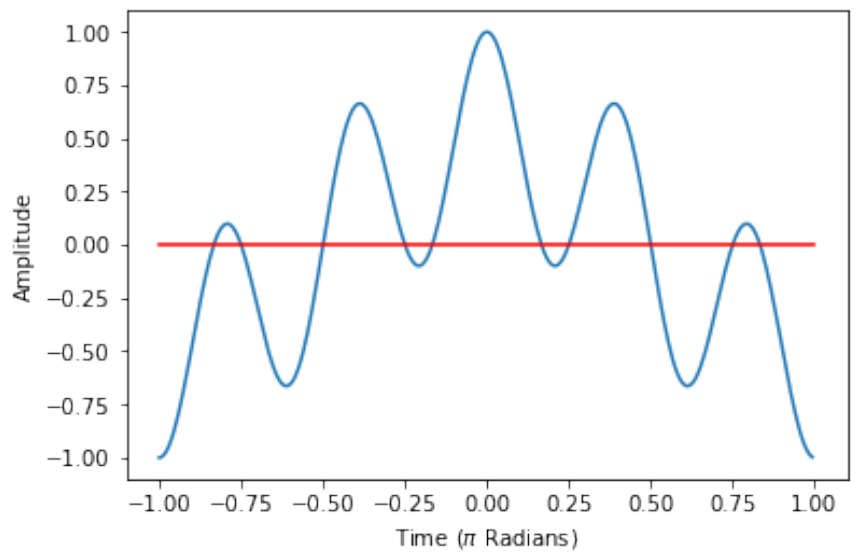
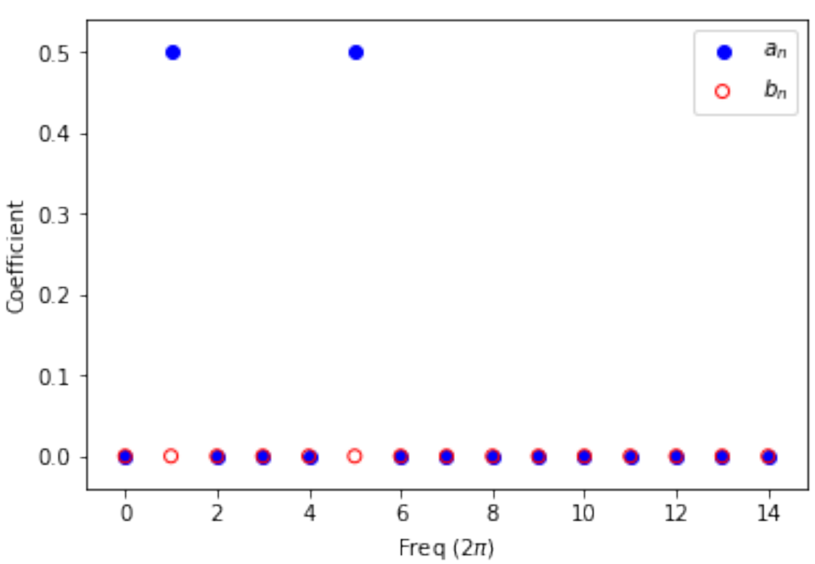
2)



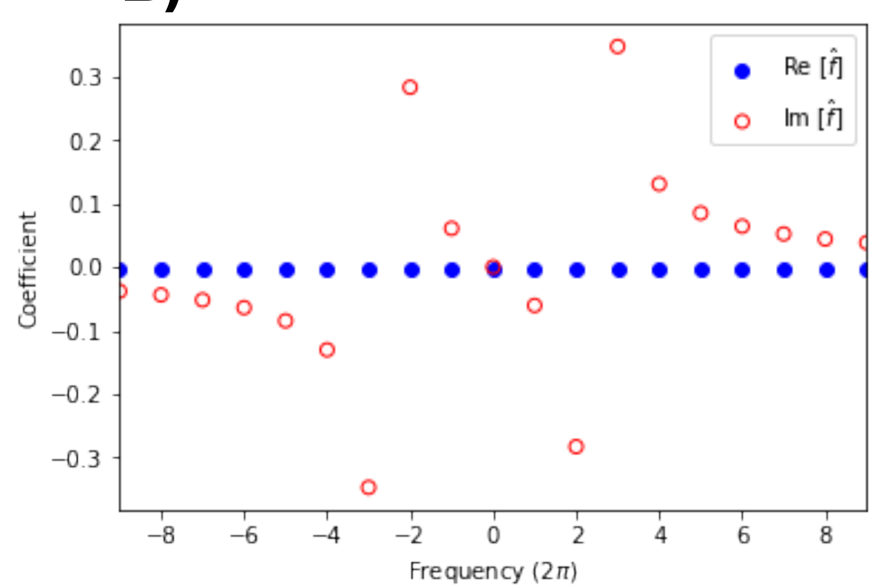
$$f(t) = \cos[2(\pi t)] \cos[3(\pi t)]$$

"Beat Frequency"

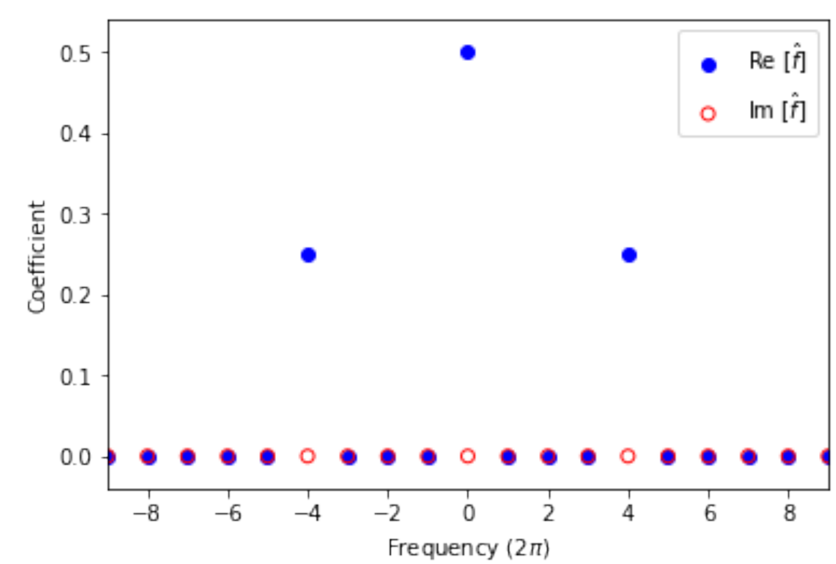
A)



B)



C)



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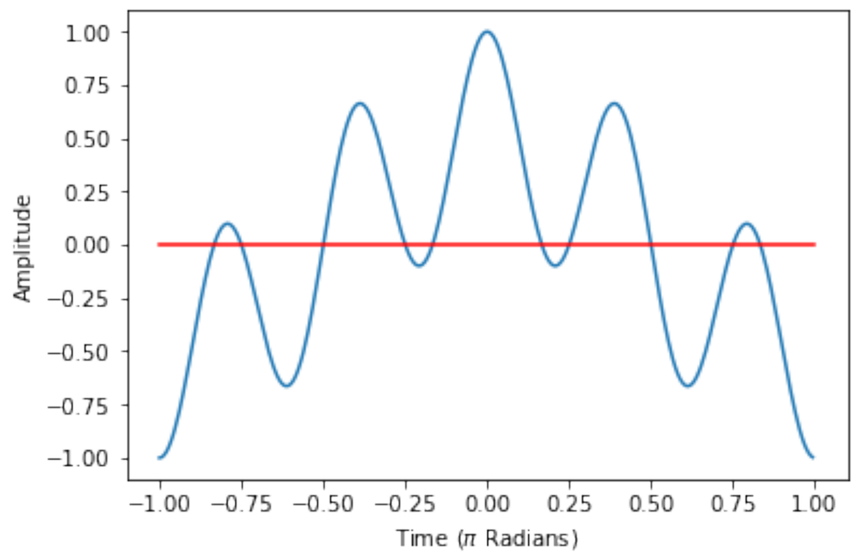

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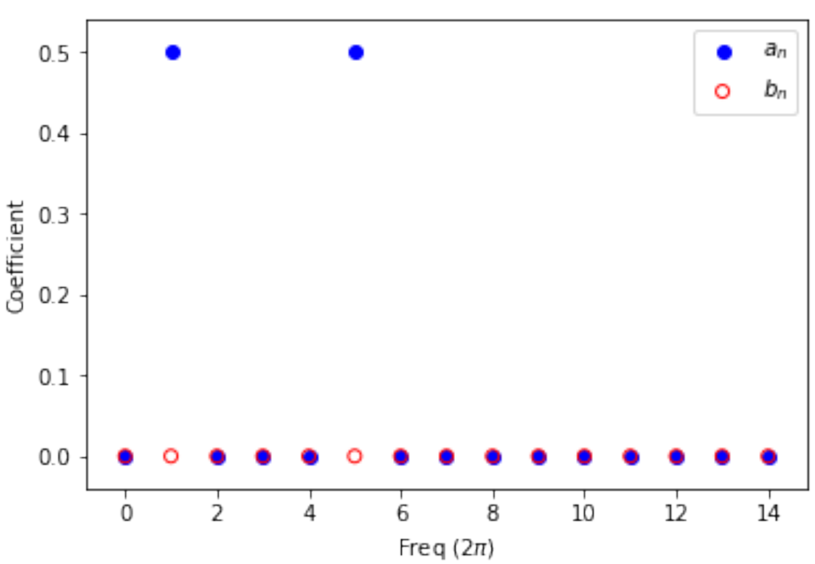

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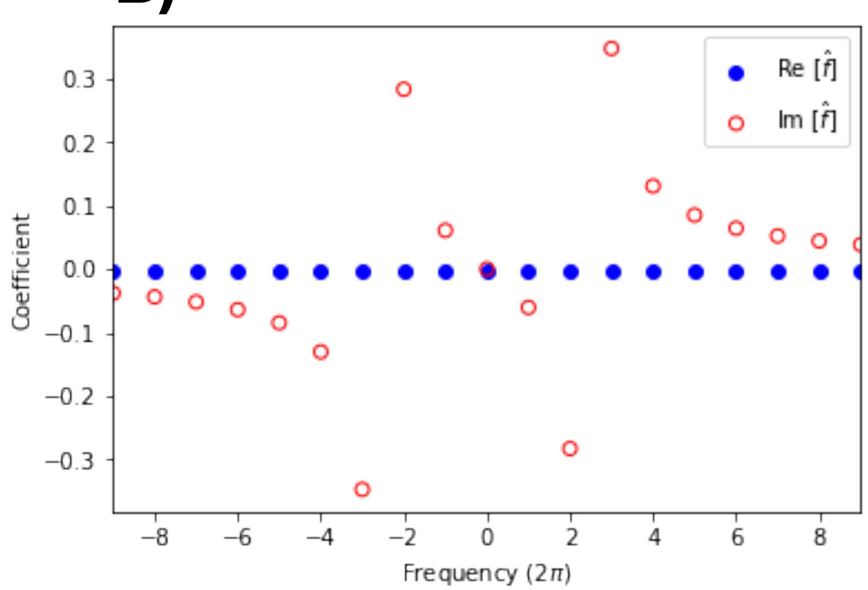

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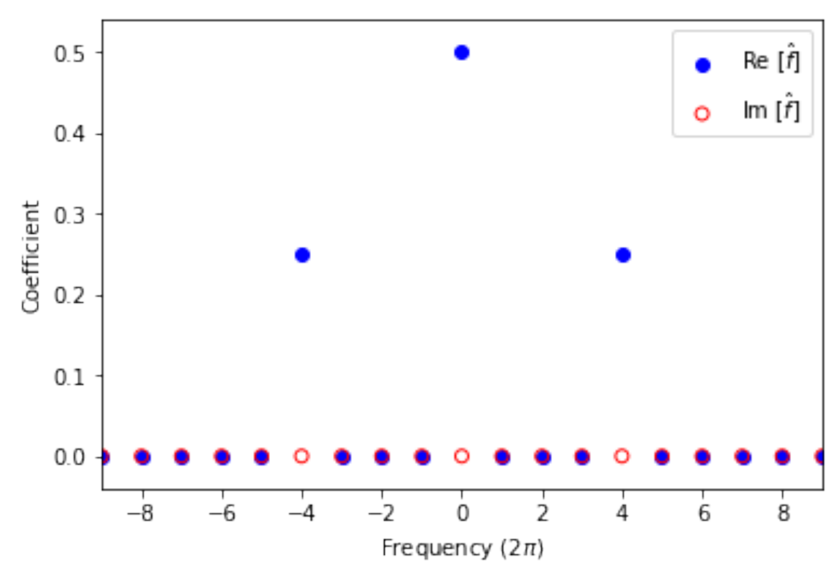
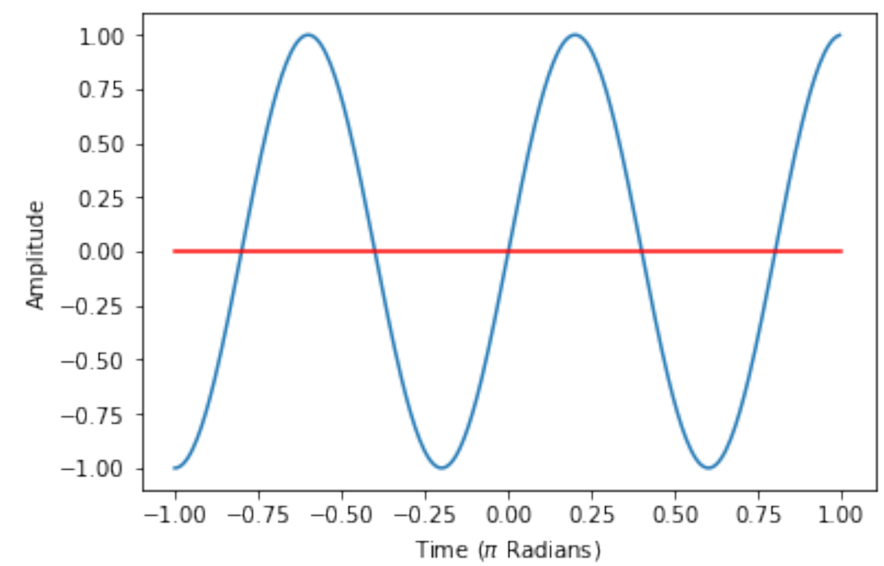


Match the Waveform

$$f(t) = \sin[2.5(\pi t)]$$

3)



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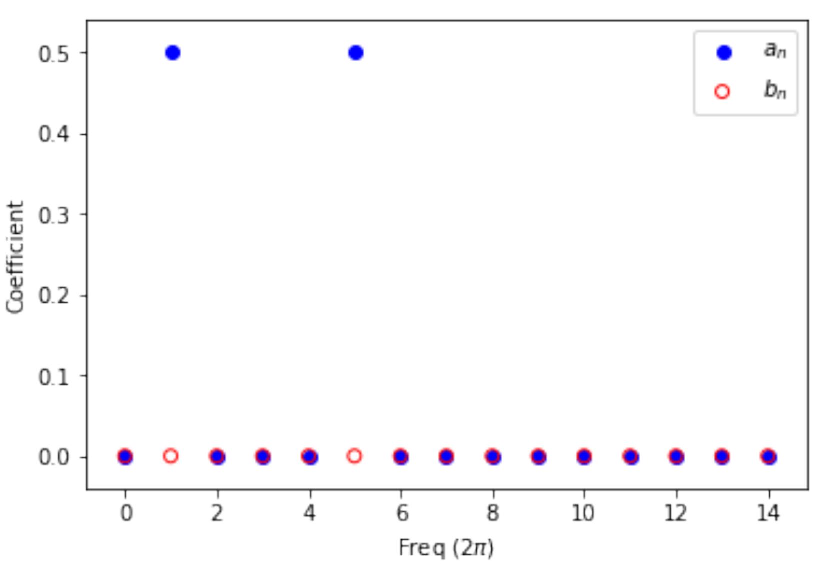

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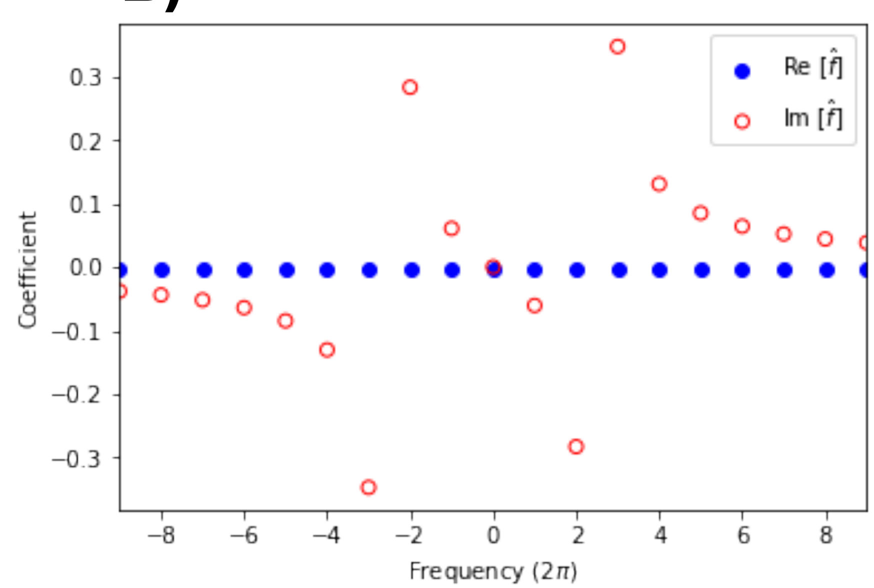

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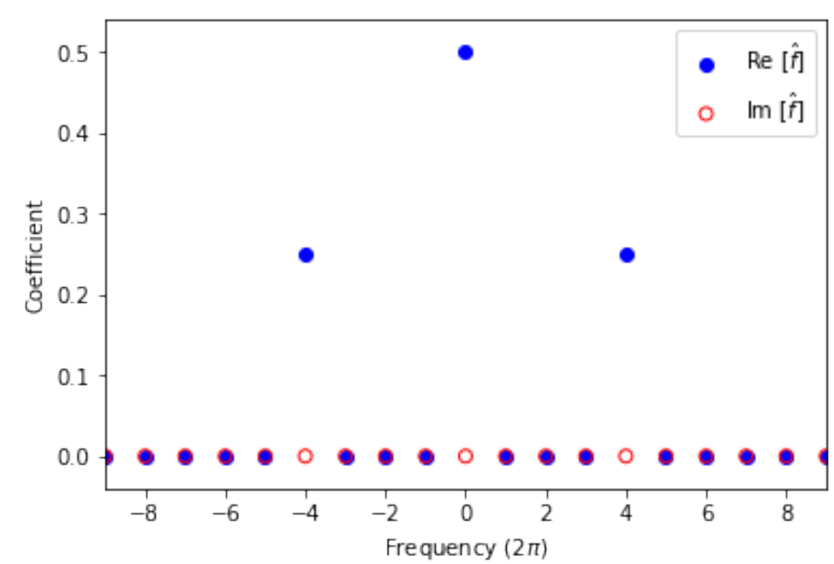
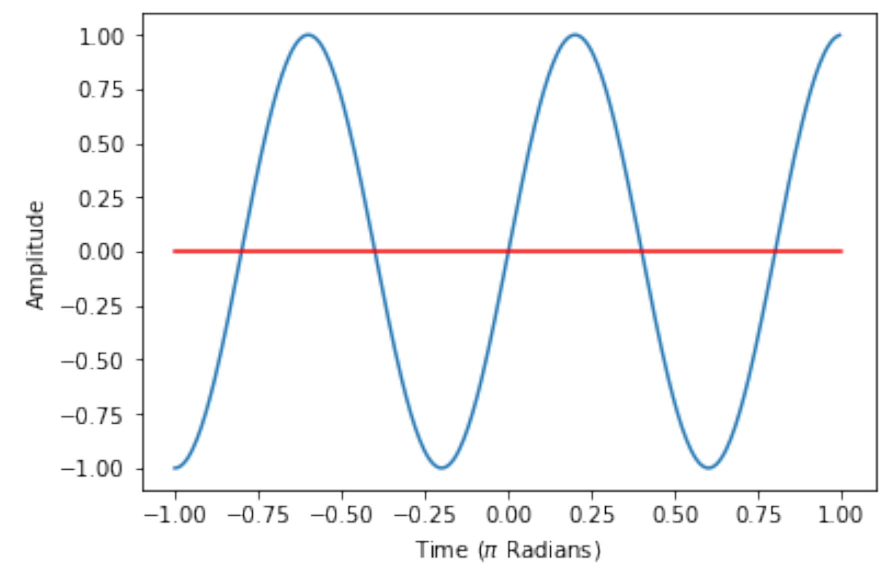


Match the Waveform

$$f(t) = \sin[2.5(\pi t)]$$

What is going on here?

3)



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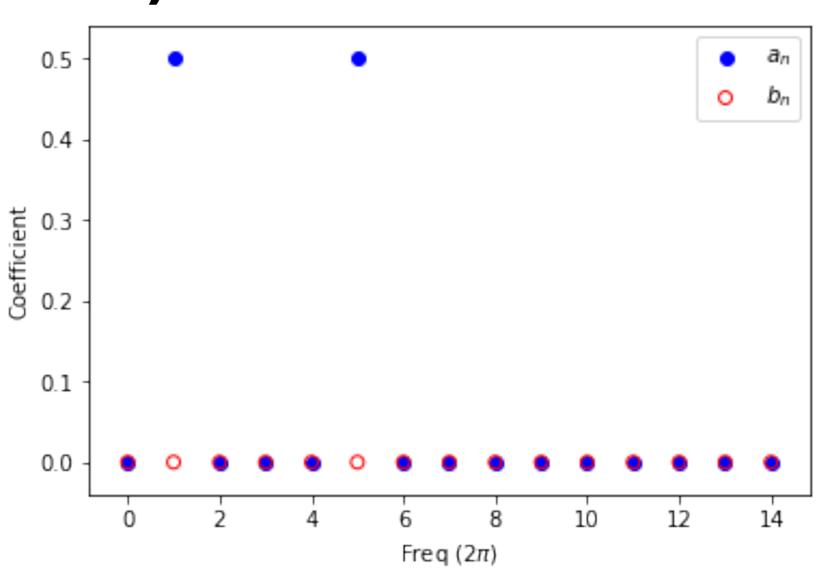

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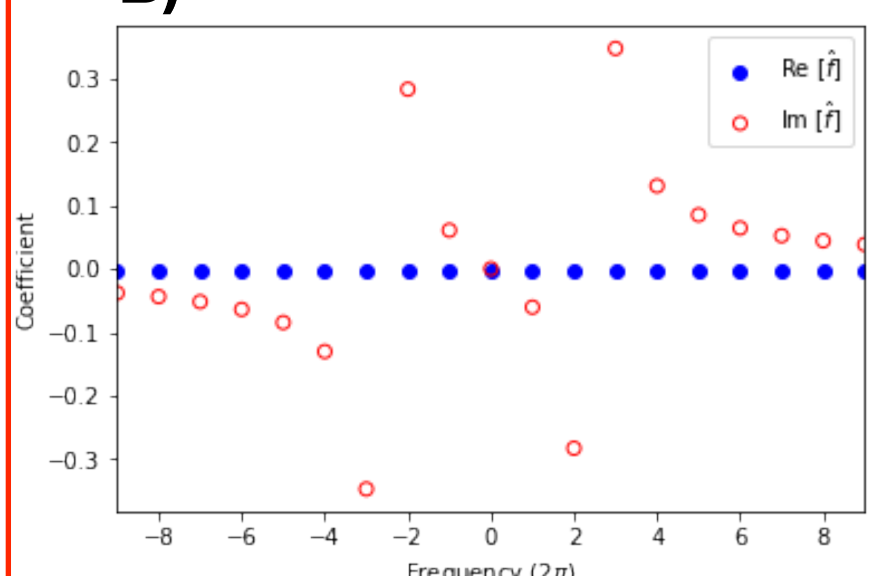

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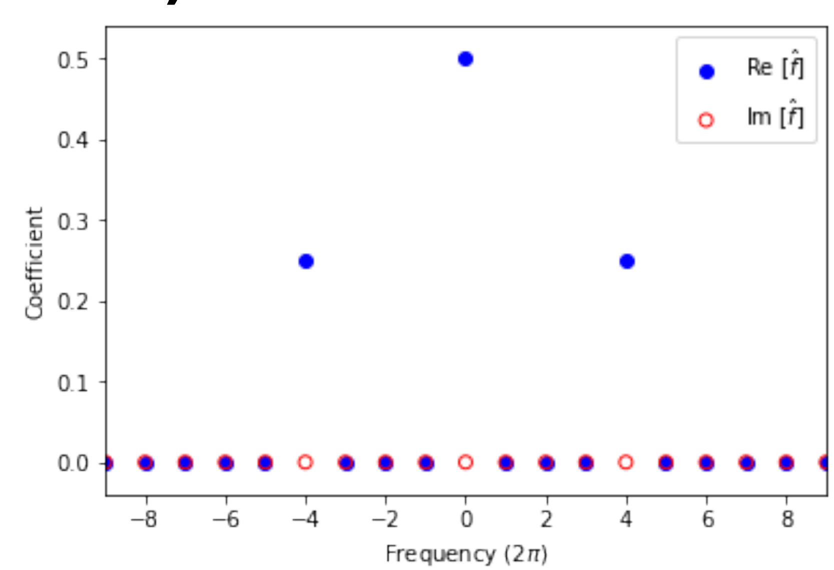

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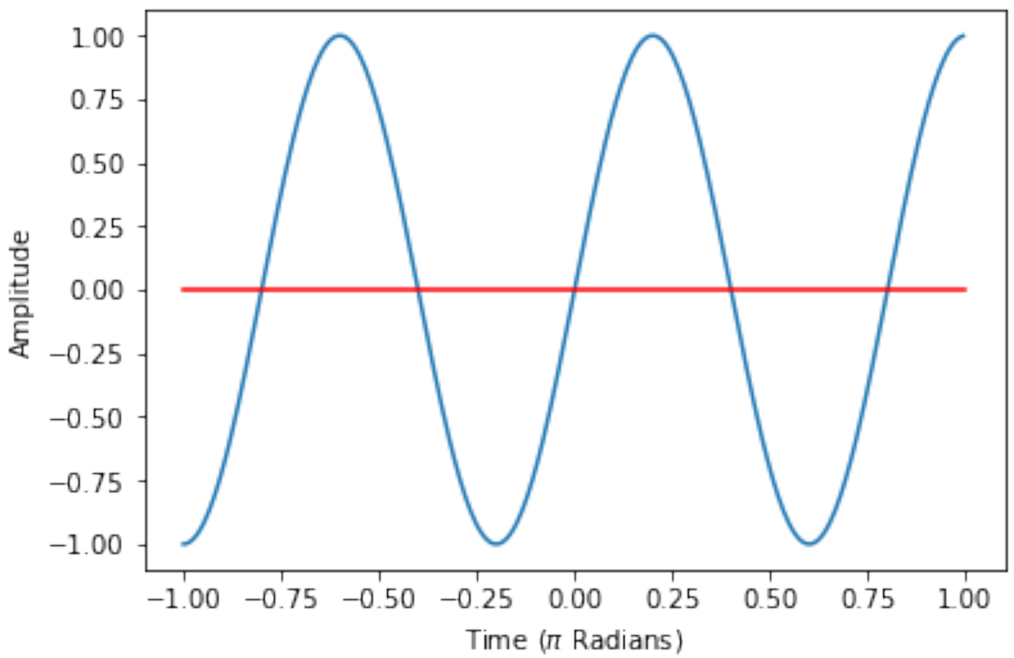
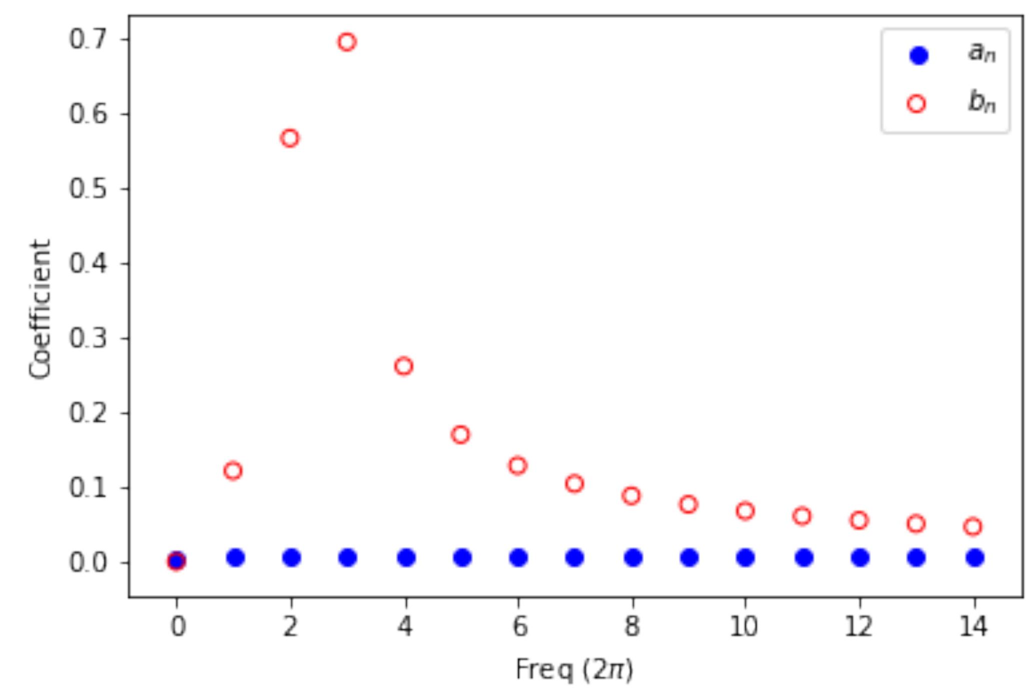
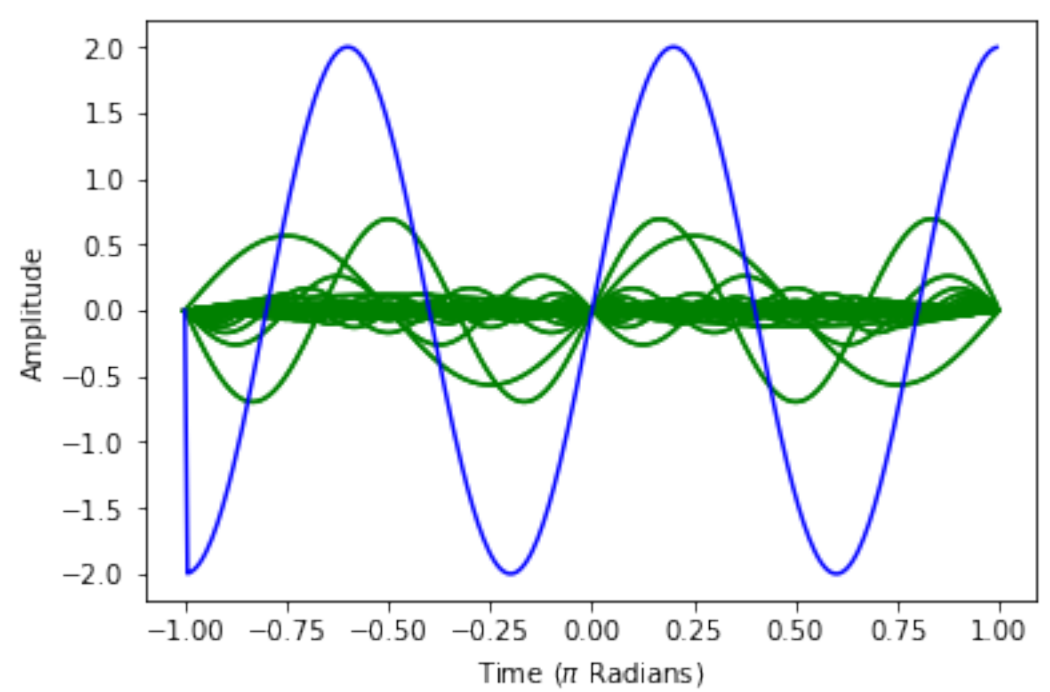




Function is not periodic across interval



Step Function