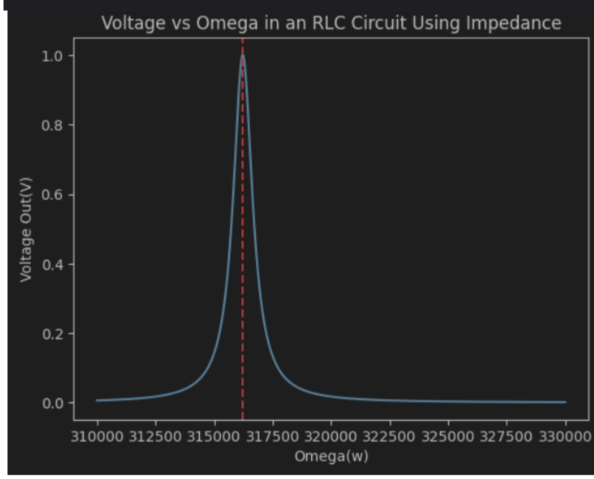
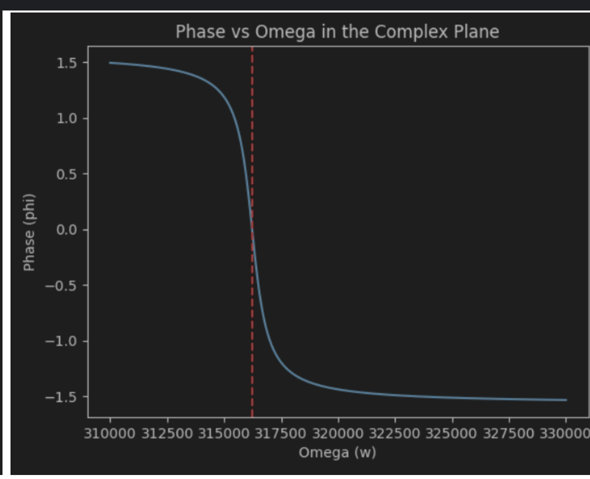
This is my code just in case my program doesn't compile correctly for some reason

Program 2:
Complex Impedance

```
#Problem 2
#Part a and b



import numpy as np
import matplotlib.pyplot as plt

#Initialize Variables
Vin = 1
L = 10e-6
R = 1e3
C = 1e-6


#Make an array of omega from 310000 to 330000 with 10,000 numbers in between
omega = np.linspace(310000, 330000, 10000)


#Voltage calculation function: Takes in omega array, L R and C of my circuit
and produces the Vout array which will then be used for plotting.
def V(omega, L, R, C):
   ZL = 1j*omega*L
   ZC = 1/(1j*omega*C)
   Zeff = (ZL*ZC)/(ZL+ZC)
   return Zeff/(R+Zeff)

#Just makes the output of V function as a variable
Vout = V(omega, L, R, C)


#Takes in both the real and complex parts of Vout and uses np.real() and
np.imag() to find the phase. I put both functions into the np.arctan function
to get the phase.
def phase_angle(Vout):
   #phase = np.angle(Vout, deg = True)
   phase = np.arctan(np.imag(Vout)/np.real(Vout))
   return phase

#Just makes the output of phase_angle as a variable
phase = phase_angle(Vout)



#Graphs both Omega vs Vout and Omega vs phase
```

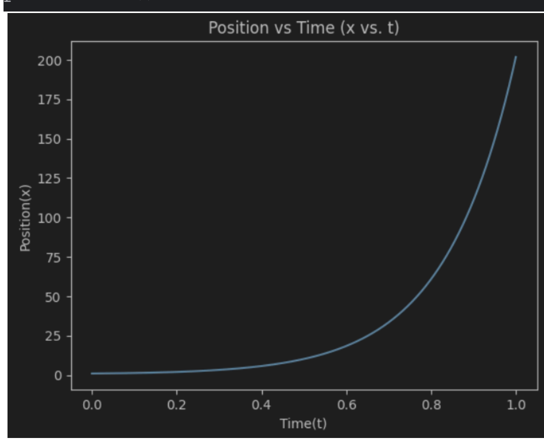
```
#### Note: Part B of my problem is answered using the red vertical line. This
red vertical line represents the resonant frequency. At this red line, in the
first graph, we can see that the Vout shoots up to 1 and immediately back down
at exactly the resonant frequency. In the second graph, my red vertical line
also represents my resonant frequency but at exactly this time, the shape of
the phase angle graph goes from concave down to concave up (also known as an
inflection point).
plt.plot(omega, Vout)
plt.xlabel('Omega(w)')
plt.ylabel('Voltage Out(V)')
plt.title('Voltage vs Omega in an RLC Circuit Using Impedance')
plt.axvline(x=1/np.sqrt(L*C), color='r', linestyle='--', label='Vertical Line')
plt.show()


plt.plot(omega, phase)
plt.xlabel('Omega (w)')
plt.ylabel('Phase (phi)')
plt.title('Phase vs Omega in the Complex Plane')
plt.axvline(x=1/np.sqrt(L*C), color='r', linestyle='--', label='Vertical Line')
plt.show()
```

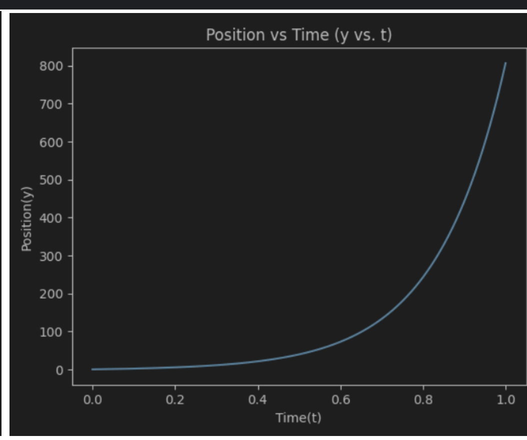




Program 3:
Coupled Oscillators

```
#Problem 3
#Coupled Oscillators

import numpy as np
import matplotlib.pyplot as plt

#Simply my explicit solutions from my work on paper
t = np.linspace(0, 1, 1000)
x = .5*np.exp(6*t)+ .5*np.exp(-2*t)
y = 2*np.exp(6*t) -2*np.exp(-2*t)

#Plots of x vs t and y vs t
plt.plot(t, x)
plt.xlabel('Time(t)')
plt.ylabel('Position(x)')
plt.title('Position vs Time (x vs. t)')
plt.show()

plt.plot(t, y)
plt.xlabel('Time(t)')
plt.ylabel('Position(y)')
plt.title('Position vs Time (y vs. t)')
plt.show()
```

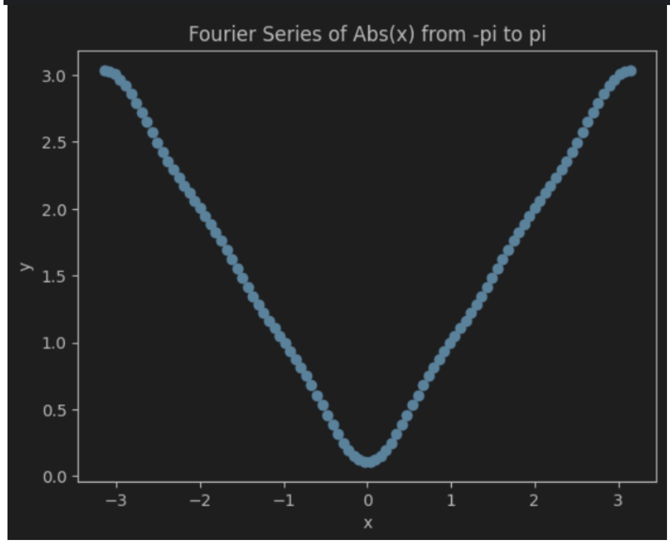




Problem 4:
Fourier Series

```
#Problem 4
#Part A, B, and C... D is in the block below
#Fourier Series
import numpy as np
import sympy as sym
import matplotlib.pyplot as plt


# initialize all of my variables
pi = sym.pi
nf = 5
T = sym.symbols('T', real = True, positive = True)
T = T.subs(T, pi)
x = sym.symbols('x')
n = sym.symbols('n', integer = True, positive = True)

function = sym.Abs(x)

#my a0 term that should be just pi/2
a0 = ((1/(2*T))*sym.integrate(function, (x, -T, T)))
print('a0 is:', a0, '\n')

#My an and bn terms just for printing out in pretty print
an = (1/T)*sym.integrate(function*sym.cos(n*x), (x, -T, T))
bn = (1/T)*sym.integrate(function*sym.sin(n*x), (x, -T, T))
print('My an term is:')
sym.pprint(an)
print('\n')
print('My bn term is:')
sym.pprint(bn)
print('\n')

#makes my *useful* an and bn terms used for calculating my fourier series
graphs
an = (1/pi)*sym.integrate(function*sym.cos(n*x), (x, -T, T))
bn = (1/pi)*sym.integrate(function*sym.sin(n*x), (x, -T, T))

#array of x values ranging from -pi to pi for graphing
x = np.linspace(-T, T, 100)


def fourier_series(x, pi, nf):
   #globalize these three terms
   global a0, an, bn

   #evaluates each fourier an and bn until n = 5
   an_fourier = [an.subs(n, i) for i in range(1, nf+1)]
   bn_fourier = [bn.subs(n, i) for i in range(1, nf+1)]
```

```
    f = a0
    for ni in range(1, nf+1):
        f += an_fourier[ni-1]*sym.cos(ni*x)+bn_fourier[ni-1]*sym.sin(ni*x)
    return f



#for every value in the x array, it makes the value of the fourier series with
the certain n and x value
fourier_list = [fourier_series(xi, pi, nf) for xi in x]

x_value_at_zero = fourier_series(0, pi, nf)
x_value_at_zero = x_value_at_zero.evalf()
print('The value of the fourier series with 5 non-zero terms is {:.3f} at x =
0.'.format(x_value_at_zero))


plt.scatter(x, fourier_list)
plt.title('Fourier Series of Abs(x) from -pi to pi')
plt.xlabel('x')
plt.ylabel('y')
plt.show()
```




```
######## Part D of Problem 4 #########
# This code can definitely be optimized, but I just didn't have the time. I
basically copied my code from above except I calculated the fourier series for
each n value until the fourier series <= .01. This code takes roughly 15
seconds to run... sorry! :( #



# initialize all of my variables
nf = 1
```

```python
x_value_at_zero = fourier_series(0, pi, nf)
while x_value_at_zero >= .01:
    nf += 1
    x_value_at_zero = fourier_series(0, pi, nf)


    pi = sym.pi
    T = sym.symbols('T', real = True, positive = True)
    T = T.subs(T, pi)
    x = sym.symbols('x')
    n = sym.symbols('n', integer = True, positive = True)

    function = sym.Abs(x)

    #my a0 term that should be just pi/2
    a0 = ((1/(2*T))*sym.integrate(function, (x, -T, T)))



    #makes my useful an and bn terms used for calculating my fourier series
graphs
    an = (1/pi)*sym.integrate(function*sym.cos(n*x), (x, -T, T))
    bn = (1/pi)*sym.integrate(function*sym.sin(n*x), (x, -T, T))

    #array of x values ranging from -pi to pi for graphing
    x = np.linspace(-T, T, 100)


    def fourier_series(x, pi, nf):
        #globalize these three terms
        global a0, an, bn

        #evaluates each fourier an and bn until n = 5
        an_fourier = [an.subs(n, i) for i in range(1, nf+1)]
        bn_fourier = [bn.subs(n, i) for i in range(1, nf+1)]


        f = a0
        for ni in range(1, nf+1):
            f += an_fourier[ni-1]*sym.cos(ni*x)+bn_fourier[ni-1]*sym.sin(ni*x)
        return f

print('The number of non-zero terms required for x = 0 to be <= .01 is:', nf)
```

```
The number of non-zero terms required for x = 0 to be <= .01 is: 63
```

Problem 5:
Surface Integral

```python
#Problem 5
#Surface Integral
import sympy as sym
import numpy as np
#First way to do the integral -- from class using F dot n ds

x = sym.Symbol('x', integer = True)
y = sym.Symbol('y', integer = True)
z = sym.Symbol('z', integer = True)


G = x
F = x**2 + z
n = [sym.diff(F, i) for i in (x, y, z)]

magnitude_n = 0
for j in n:
   magnitude_n += j**2
magnitude_n = sym.sqrt(magnitude_n)


Integral = sym.integrate(sym.integrate(G*magnitude_n, (x, 0, 1.4)), (y, 0, 4))

print(Integral)
```

```
8.42773651508637
```

or 26/3

```python
#Second way to do the integral-- from my textbook

#All I need to do is find the differential area ds and put it in terms of x,y

import sympy as sym
import numpy as np

x = sym.Symbol('x', integer = True)
y = sym.Symbol('y', integer = True)

function = x


#The differential area "dS" for my surface integral is the function below
#ds = sym.sqrt(1+4*x**2)*dA

#
ds = sym.sqrt(1+4*x**2)
```

```
function *= ds

#Do a double integral, integrate from x = 0 to sqrt(2) and y = 0 to y = 4. I
get these bounds from the graph given to us in the prompt.
Integral = sym.integrate(sym.integrate(function, (x, 0, sym.sqrt(2))), (y, 0,
4))

print('The value of the surface integral is:')
sym.pprint(Integral)
```