

Lab 5: NumPy and Basic Plotting

Name: _____

University Number: _____

Exercise 1: Chebyshev Polynomial of the First Kind

AIM:

Write a Python program that uses the NumPy `Polynomial` class to print a table of the first ten Chebyshev polynomials of the first kind. Here is the table generated by this program:

$$T_0(x) = 1$$

$$T_1(x) = x$$

$$T_2(x) = 2x^2 - 1$$

$$\vdots$$

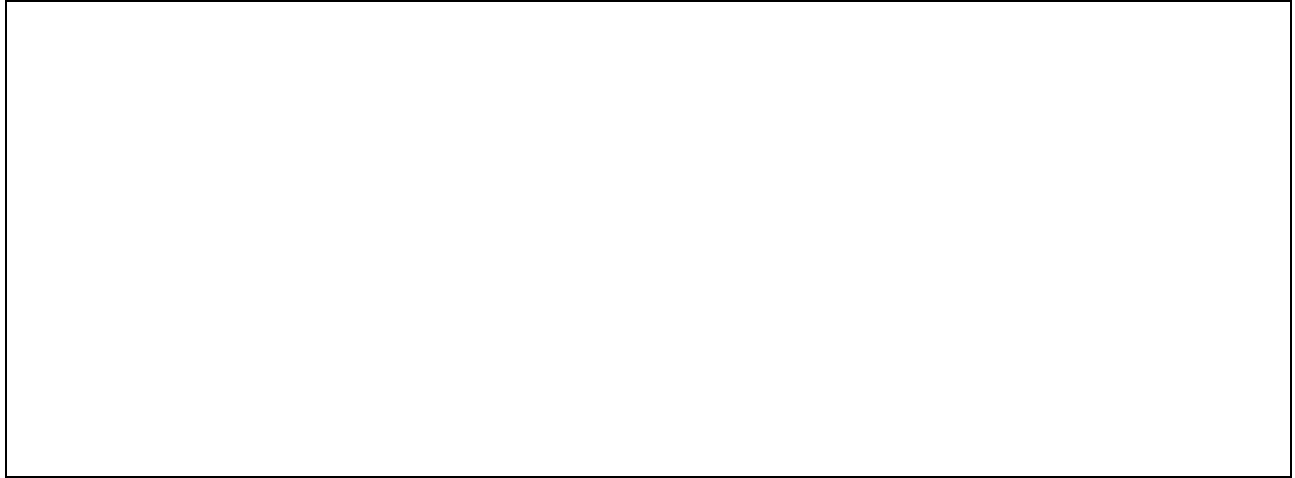
ALGORITHM:

PROGRAM:

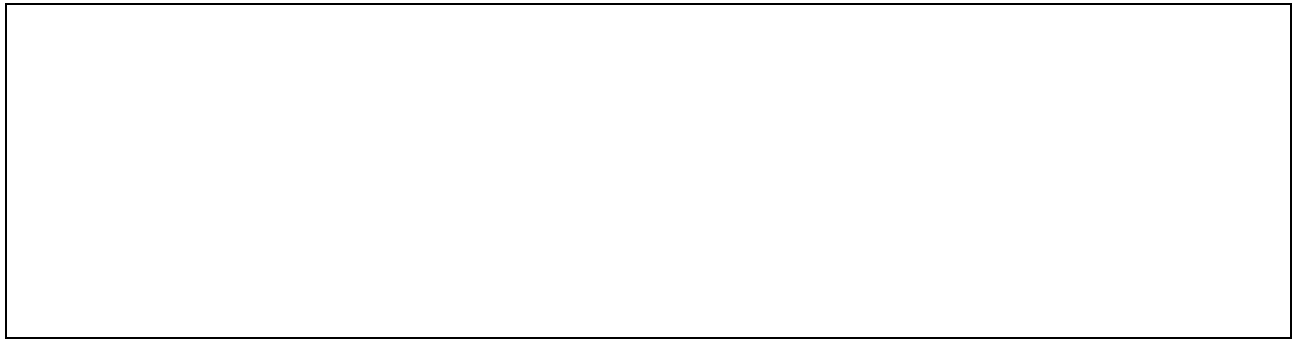
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OUTPUT:

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OUTPUT:



Exercise 3: Forced Vibration with Damping

AIM:

A small block of mass m suspended vertically by a spring with spring constant k is driven by an external force $F(t) = F_0 \cos(\omega t)$. The block is moving in a viscous medium with a damping force of the form $-bv$ where $b > 0$ is the damping constant and v is its instantaneous velocity. Taking downward as the positive direction, the vibration of the block is modeled by the differential equation:

$$m \frac{d^2 x}{dt^2} + b \frac{dx}{dt} + kx = F_0 \cos(\omega t)$$

where $x(t)$ is the displacement of the block from its equilibrium position at time t . It can be shown that the steady state solution (i. e. $x(t)$ when time $t \rightarrow \infty$) is

$$x_s(t) = (MF_0/k) \cos(\omega t - \phi)$$

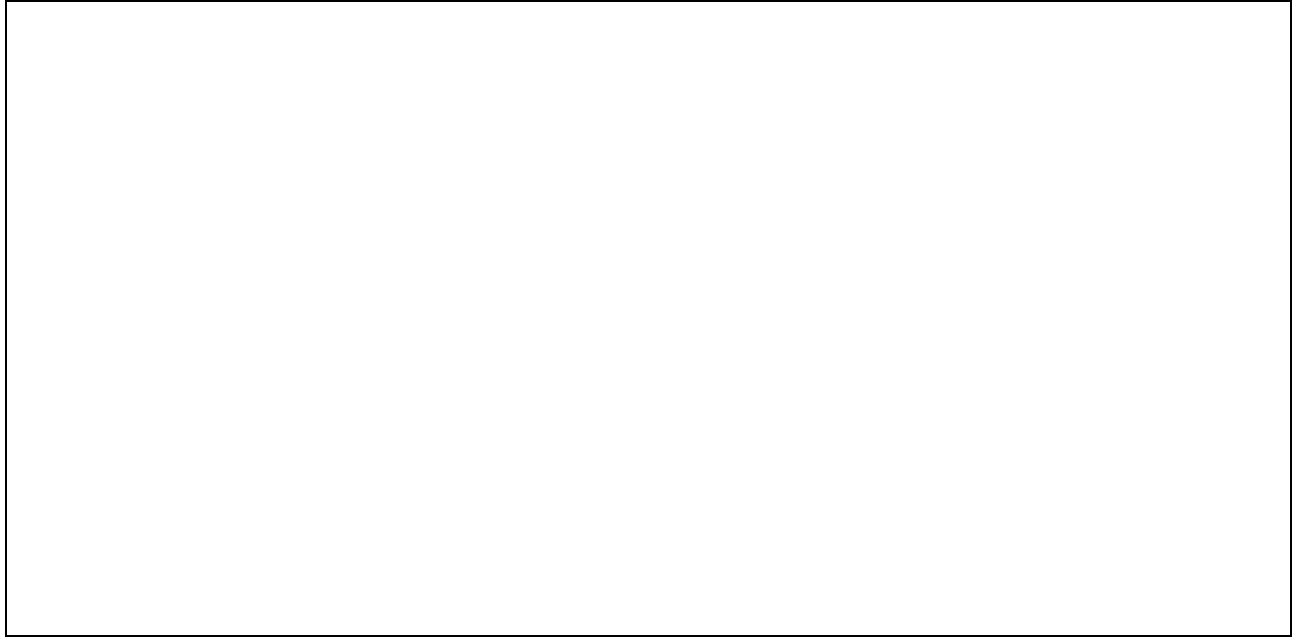
In this formula, M is the magnification ratio and ϕ is the phase lag defined by

$$M = \frac{1}{\sqrt{(1 - \omega^2/\omega_0^2)^2 + 4\zeta^2(\omega/\omega_0)^2}}, \quad \phi = \tan^{-1} \left[\frac{2\zeta(\omega/\omega_0)}{1 - (\omega/\omega_0)^2} \right],$$

where $\omega_0 = \sqrt{k/m}$ is the natural frequency and $\zeta = b/(2\sqrt{km})$ is the damping ratio. Write a Python program that uses the Matplotlib `Axes` class method `plot` to plot the magnification ratio M over the interval of frequency ratio ω/ω_0 from 0 to 2.0 for damping ratio $\zeta = 0.1, 0.2, 0.4, 0.6$, and 0.8 , respectively, on the same graph. You should label your graph with proper axis labels, title, and legends. From your graph, you can observe how the peak value of M depends on ζ , i. e. the effect of damping on the resonance frequency of the block.

ALGORITHM:

PROGRAM:



OUTPUT:



Exercise 4: Employees in Hong Kong's Construction Industry

AIM:

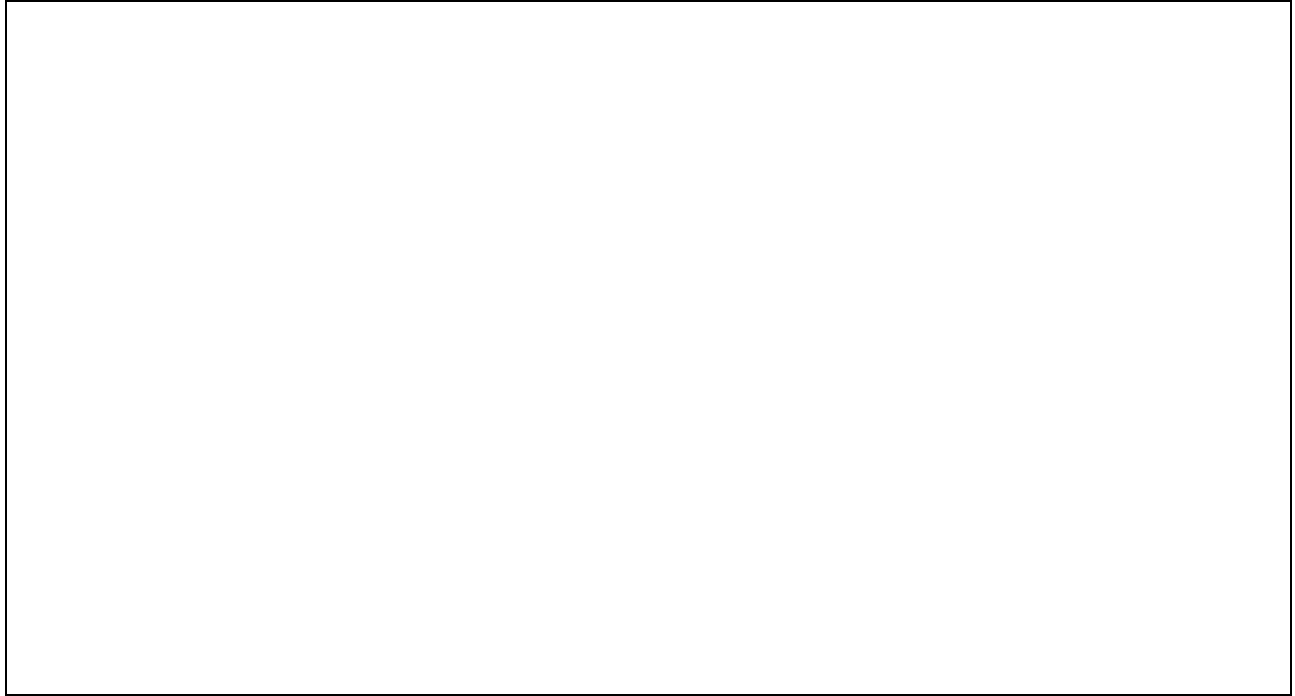
Below is the table of the employment statistics in Hong Kong's construction industry from 2011 to 2020 (source: <https://www.censtatd.gov.hk/tc/scode200.html> by Census and Statistics Department, HKSAR).

Year	Number of Employees in Thousands	Share of the Employees in the Labour Force
2011	277.0	7.75 %
2012	290.1	7.93 %
2013	309.0	8.30 %
2014	309.7	8.27 %
2015	316.7	8.39 %
2016	328.4	8.67 %
2017	342.0	8.95 %
2018	351.6	9.09 %
2019	337.5	8.77 %
2020	310.0	8.47 %

Write a Python program that uses Matplotlib `Axes` class method `twinx` to produce a bar chart of the number of employees in Hong Kong's construction industry and a line plot of the percentage share of these employees in the labour force as a function of year on the same graph. You should label your graph with proper axis labels, title, and legends.

ALGORITHM:

PROGRAM:



OUTPUT:

