PH 3120 - Computational Physics Laboratory I

Introduction to data analysis with Python

This week we will explore some data analysis techniques using Jupiter and Python, Numpy, and Matplotlib.pyplot.

1. Define two variables a = 15 and b = 6. Calculate the following quantities.
    a. a+b
    b. a – b
    c. a*b
    d. a/b
    e. a^b

2. A ball is dropped from a tower of height *h* with initial velocity zero. Write a program that asks the user to enter the height in meters of the tower and then calculates and prints the time the ball takes until it hits the ground, ignoring air resistance. Use your program to calculate the time for a ball dropped from different heights. Study the relationship between height and falling time.

3. Perform the following trigonometric operations.
    a. Evaluate $\sin\theta$ and $\cos\theta$ for $\theta = 0°, 30°, 45°, 60°, 90°$.
    b. Evaluate $\sin\theta$ and $\cos\theta$ for $\theta = 0, \frac{\pi}{6}, \frac{\pi}{4}, \frac{\pi}{3}, \frac{\pi}{2}$

4. Two vectors a and b are defined as follows. $\vec{a} = 3\hat{\imath} - 2\hat{\jmath} + k$, $\vec{b} = 2\hat{\imath} - 4\hat{\jmath} - 3\hat{k}$. Write a python program to input the x,y,z components of the vectors and calculate the following.
    a. Magnitude of each vector
    b. $\vec{a} + \vec{b}$
    c. $\vec{a} - \vec{b}$
    d. $\vec{a} * \vec{b}$
    e. $\vec{a}/\vec{b}$
    f. $C\vec{a}$, where C is a scalar
    g. Angle between two vectors
    h. Cross product of two vectors

5. Given a scalar field by $\phi(x, y, z) = 3x^2z - xy^3 + 5$, write a code to calculate the value of ϕ at points (0,0,0), (1, -2,2), (-1, -2, -3).

6. From an original mass N_0 of radioactive material, the remaining mass after a time t (in seconds) is given by the equation for radioactive decay:

$$N(t) = N_0 e^{-t/\tau}$$

where τ is the 'mean lifetime' of the radioactive material. Carbon-11 has a mean lifetime of 1760 s.

   a. Write a program to calculate how much remains of an original mass of 4.5 kg of carbon-11 after 10 minutes.

   b. The relation between the mean lifetime and the half-life is given as;

      $\tau = \frac{t_{1/2}}{\ln(2)}$.

      The half-life of carbon-11 is 1220 s. Rewrite your program such that it first calculates the mean lifetime from the half-life, and then calculates the remaining mass, just like in exercise a. Check that you get the same results as in exercise a.

7. Write a program that asks the user to enter the password and let the user in if the password is correct if not, ask it again. Modify the above code to give only 3 attempts to enter the password then, deny access.

8. The Fibonacci numbers are the sequence of integers in which each is the sum of the previous two, with the first two numbers being 1, 1. Thus the first few members of the sequence are 1, 1, 2, 3, 5, 8, 13, 21. Write a program to print the Fibonacci sequence up to 500. Using your program Find the sum of all the Fibonacci numbers below 500.

9. Download the file "distance.dat" and plot data with error bars.

10. Download the file al-marks.dat. This contains marks obtained by a set of students for physics, mathematics and chemistry. Plot histograms of the mark distributions for the three subjects. Calculate their Z scores and plot a histograms of the Z scores.

$$z = \frac{x - \mu}{\sigma}$$

$\mu =$ Mean
$\sigma =$ Standard Deviation