EngBAM PYTHON BASICS WORKSHEET

Scenario application : Gravity

Considering the concept of gravity and gravitational forces, our planet earth exerts a gravitational force on everything within it and around it that has a mass. This is why when we jump, we always come back to the ground and why the moon stays at a certain distance away from the earth; it tries to move away but earth's gravity pulls it back.

Let us consider 5 bodies; a, b, c, d and e of mass 10, 120, 70, 40 and 5kg respectively. Try to complete the following tasks using python.

1. Create an array that contains the mass of all 5 bodies, you can call this array whatever you want.
2. Calculate the gravitational force that the earth exerts on these 5 bodies.
    The gravitational force acting on a body can be expressed as below:

$$F_g = m * g \qquad \textbf{equation 1}$$

F_g is the gravitational force a body experiences, measured in Newtons (N).
m is the mass of the body, measured in kilograms (kg).
g is the **gravitational constant**, otherwise known as **acceleration due to gravity**, with a value of **9.81** m/s^2 for our planet; Earth.

3. Select the gravitational force less than 500N, you can call this array whatever you like.
    Hint: can you combine a **for** loop, e**numerate** function and an **if** statement in python? Feel free to google how it works.

4. Select the mass of bodies that experience a gravitational force greater than 100N **but** less than 700N.
    Hint: can you combine a **for** loop, **enumerate** function, an **if** statement and an **and** function in python?

5. Can you plot the mass of the bodies (m) and the gravitational force (F_g) they experience, think about what should be on the x-axis and what should be on the y-axis.
    (1) Plot this graph as a scatter plot/graph.
    (2) Plot this graph as a line graph.

    Hint: can you replicate what was done in the plotting graphs in python tutorial, but for this scenario?

EXTENSION

As an engineer or scientist, you would almost always have to re-arrange your data in a manner that makes sense, so you can explore the relationship between two things. Re-arranging your data in a way that makes sense also helps you to present your data in a nice way such as graphs (data visualisation).

Consider an astronaut who recently landed on a newly discovered planet within our solar system and this astronaut is trying to understand the effect of gravity on this new planet. To do this, the astronaut decides to use experimental data below, which was gotten from a previous visit to this planet.

Table 1: Mass and gravitational force data from new planet

Mass of body (kg)	Gravitational force - F_g (N)
67	690
168	1566
205	2031
131	1362
90	848
35	333

1) Plot the data of the mass of the bodies and their gravitational forces.
    i)   Plot the data as a scatter plot graph
    ii) Plot the data as a line graph.

2) re-arrange the data in a way that makes sense.
    HINT: have a think of what the relationship between the mass of the bodies and the force should be. Then try to use the **sort** function in the **numpy** library.

3) Plot the graph of the newly re-arranged data
    i)   plot this new data as a scatter graph.
    ii) plot the data as a line graph.
    iii) **Do you notice a difference between this new graph and the old one in extension question 1?**

Now that you can re-arrange and order your data, the use of mathematical equations to describe the relationship between things is what scientist and engineers do a lot. This allows us to make sense of our result and predict values of things we did not test in experiment. The use of mathematical equations to describe things is known as **modelling**, using values we did not test in our experiment allows us to check how good our model is.

4) Apply the modelling technique explained in the "**simple python modelling**" video to your newly re-arranged data, to determine the mathematical model/ equation that describes the relationship between the mass and gravitational force experienced by these bodies.

    Hint: from the graphs plotted in question 3 (both the scattered and line graph), have a think of what the mathematical model that describes the relationship between the mass and gravitational force of the bodies should look like. Also try to incorporate the **polyfit** function from the **numpy** library.

5) The astronaut wants to calculate the value of the gravitational constant (g) of the planet from the data above to compare it with that of other planets as shown in the data below. How can this be achieved? What planet in table 2 below does this new planet have a similar gravitational constant (g) to?

Table 2: Planets and their gravitational constant

Planet	Gravitational constant-(g) (m/s²)
Mercury	3.70
Jupiter	24.79
Earth	9.81
Venus	8.87

Hint: You have developed a mathematical equation/ model that describes the relationship between the mass of the body and the gravitational force they experience. What does this mathematical equation represent? (Try to relate your model/equation to **equation 1**).

6) Now let us test your model: for two bodies that have masses of 80 kg and 300kg respectively, use your model to predict the value of the gravitational force they experience, are you confident in your answers? Explain why.

7) Using the data in table 2, who will experience the greatest gravitational force? An astronaut who has a mass of 95 kg on Venus or an astronaut that weight 50 kg on Jupiter?

   Hint: How think about how gravitational force is related to the mass of an object.