**PHZ4151C, Fall 2019**
**Homework 2**
**Due Tuesday Sep 24th, 11.59PM**

**Instructions:** Solve all four problems. Every problem is worth 10 points. Write your codes following the strategy discussed in the "Structure of the program and program design" video and the format used in the sample programs discussed in the class and lecture videos. Make sure that your code is clear, readable for users other than yourself, and properly commented. Once finished, include all your program files and figures into a zip file named after your last name and homework number (e.g. "Ullah_HW2.zip") and submit it through canvas. Submitting individual files for each problem or part of the problem will not be accepted and disregarded. There is no need to include big data files generated by your programs unless the data files are read by your programs (that is the program reads data from the file and uses that data). Email me any questions or concerns about the homework either through canvas or directly my email address.
**Note:** You are allowed to submit incomplete codes for partial credit.

**Problem 1:** When a satellite orbits the Earth, the satellite's orbit forms an ellipse with the Earth located at one of the focal points of the ellipse. The satellite's orbit can be expressed in polar coordinates as

$$r = \frac{p}{1 - \varepsilon\cos(\theta)} \qquad (1)$$

Where $r$ and $\theta$ are the distance and angle of the satellite from the center of the Earth, $p$ is the size and $\varepsilon$ is the eccentricity of the orbit. A circular orbit has $\varepsilon = 0$, and an elliptical orbit has $0 < \varepsilon \geq 1$. If $\varepsilon > 1$, the satellite follows a hyperbolic path and escapes the earth's gravitational field.

Consider a satellite with $p$ = 15000km. Calculate and create a table (using WRITE statement) of the height of this satellite versus $\theta$, where $\theta$ runs from 0 to 360$^{o}$ in increment of 30$^{o}$ (Note: You will have to convert $\theta$ from degrees to Radian) if (a) $\varepsilon = 0$; (b) $\varepsilon = 0.2$; (c) $\varepsilon = 0.7$. How close does each orbit come to the center of the Earth? How far away does each orbit get from the center of the Earth? The Radius of the earth is 6371km.

**Problem 2:** If Matrix $A$ is an $N$ *by* $L$ matrix and $B$ an $L$ *by* $M$ matrix, then the product $C = A \times B$ is an $N$ *by* $M$ whose elements are given by the equation

$$c_{ik} = \sum_{j=1}^{L} a_{ij} \bullet b_{jk} \qquad (2)$$

Write a program that computes the product of $A$ and $B$ using *Nested Do Loops* where

$$A = \begin{pmatrix} 2.0 & 3.0 \\ 19.0 & -3.0 \end{pmatrix} \quad and \quad B = \begin{pmatrix} 13.0 & -4.0 \\ 10.0 & 3.0 \end{pmatrix}$$

Here $a_{11} = 2.0$, $a_{12} = 3.0$, $a_{21} = 19.0$, $a_{22} = -3.0$, and similarly for $B$. Hint: You will need 2 *by* 2 arrays for $A$, $B$, and $C$.

**Problem 3:** Write a function to determine the gravitational force ($F = Gm_1m_2/r^2$) on a 1500 kg satellite in orbit 45000 km above the center of the earth. Call this function in the main program to get the value of G using $m_1$, $m_2$, and $r$ as arguments.

**Problem 4:** Develop a Subroutine that will calculate slope m and intercept b of the least-squares line that best fit an input data set. The input data points (x,y) are passed to the subroutine in two input arrays X and Y. The equations describing the slope and intercept of the least-squares line are

$$y = mx + b$$

$$m = \frac{(\sum xy) - (\sum x)\bar{y}}{(\sum x^2) - (\sum x)\bar{x}} \qquad (3)$$

$$b = \bar{y} - m\bar{x}$$

Where $\bar{x}$ *and* $\bar{y}$ represent the mean of all x and y values respectively. Test your program on the x and y values given in xlsf.dat and ylsf.dat given on canvas.