Campus Ciudad de México **Escuela Ingeniería y Ciencias** **Computación**	**Course: CS4015** **Applied Computing** **Professors: Manuel Valenzuela Rendón** **Roberto Alejandro Cárdenas Ovando** **<u>Midterm evaluation</u>** **Date: March 7th, 2019** **Name:** Bruno González Soria **Student ID:** A01169284
	Grade:

"By adhering to the Code of Ethics of the Students of Tecnológico de Monterrey, I promise that my performance in this exam will be governed by academic honesty. Consistent with the commitment acquired by signing this code, I will carry out this examination in an honest and personal way, to reflect, through it, my knowledge and accept, subsequently, the evaluation obtained. "

I agree: Bruno González Soria

Rules: At the beginning of the R script, the team must explicitly specify the exercises done to achieve 100 points. If there are exercises that were not explicitly written at the beginning of the file, these will not be graded. If more than 100 points are specified to be graded, the grade will be void. If the exercise requires a justification, it must be done in a commentary either at the beginning or the end of your solution.

First section (40 points)
Linear Models. In this section the exercises must have a justification with the model used and the reasons why it was selected: Simple regression, ANOVA, ANCOVA or logistic regression.

Statistical tests. The use of the test must be justified. Why did you selected the test to be parametric or non-parametric, one-tailed or two-tailed test, the p-value threshold to accept or reject the null hypothesis.

The databases may have missing values or outliers. Thus, you may have to clean them and filter them. Justify what you did to get the database to be analytical data.

NOTE: It is not necessary to do both subsections of the same database.

Database: Chocolate

a) Dependent variable: Chocolate
   Choose only the most significant variables to model the dependent variable. (10 points)

b) Do a statistical test to see if there is a significant difference in the sugar percentage in the chocolate candies vs the other candies. (10 points)

Database: Weather

a) Dependent variable: rain or no rain
   Independent variables: Month, minimum and maximum temperature. But they can be filtered afterwards. (10 points)

b) Do a statistical test to see if there is a significant difference in the minimum temperatures of July vs December (10 points)

Second section (100 points)
Algorithm Coding. All algorithms must be coded by yourself. The only libraries accepted for this part are the ones that already come with the R language. Do not use any package that already have the algorithm coded. Also, the code must be commented with the instructions to use your code and at least one function to demonstrate its functionality. It is recommended to do a flow chart to explain the logic of the algorithm.

TIPs for subsection a and b. Use the functions: expression, D, parse and paste within a loop to get the desired output.

a) Lagrange polynomials. This algorithm receives a nx2 matrix, where the first column represents the x coordinate while the second column represents the y coordinate. The code must provide as output the Lagrange polynomial interpolation expression in terms of “x”. (30 points)

b) Taylor series: The algorithm receives an expression or a string with the function to do and the number of terms to get. The output will be an expression containing all the Taylor series about 0. (30 points)

c) Runge-Kutta. The algorithm will receive an ODE, initial values for x and y, the step size and the upper bound. The output will be the plot of the second, third and fourth order RK approximations. To demonstrate the functionality of your code, use the analytical answer of the ODE to compare all the approximations (30 points)

d) Coupled Runge-Kutta. Modify the fourth order RK algorithm to receive two ODEs. The output will be the plot of both ODEs approximations. (10 points)

Third Section (120 points)
Applied Computing. In this section you will use your fourth-order coupled Runge-Kutta algorithm code to solve different problems. Compare your answers with the “ode” function from the “deSolve” R package. Plot your answer vs the deSolve answer. Justify if the problem is stiff or not, the chosen step size, and the time units that the step size represent (seconds, minutes, hours, days, etc).

a) Competition model. Two populations compete for the same resources. Thus, one population grows while the other dies. The behavior of these two populations is modeled by the next two ODEs:

$$\frac{dx}{dt} = x(a_1 - b_1x - c_1y)$$
$$\frac{dy}{dt} = y(a_2 - b_2y - c_2x)$$

Where a, b and c are positive natural numbers bigger than zero. Initial values $x_0 = 4; y_0 = 4$. Choose the best step size to model the first 10 years of both populations. (30 points)

b) RLC series-circuit in DC. The Voltage function is given by

$$V = L\frac{d^2Q}{dt^2} + R\frac{dQ}{dt} + \frac{Q}{C}$$

The circuit constants are: $L = 0.1H;\ R = 20\Omega;\ C = 10^{-3}F;\ V = 1.5V$. Choose the best step size to model the first 10 seconds of the Inductance and the Capacitance. Assume that both elements are discharged at the start of the simulation (30 points)

c) Lotka-Volterra equations / predator-prey equations. The following ODEs describe the interaction between foxes and bunnies.

$$\frac{dx}{dt} = -16x + 0.08xy$$
$$\frac{dy}{dt} = 4.5y - 0.9xy$$

At the start of the model there are 4 foxes and 4 bunnies. Choose the best step size to model the first 2 years of the ecosystem (30 points)

d) Coupled water tanks. Two water tanks are joined as depicted in the Figure 1.

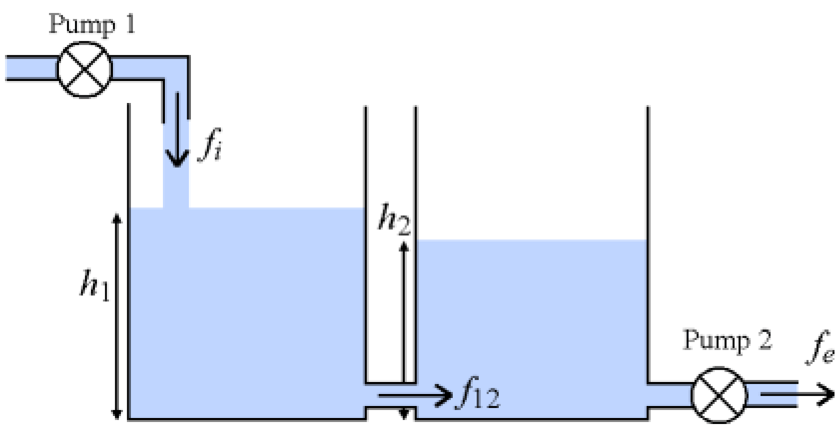

Figure 1. Coupled water tanks

The model that describes the water flow from one tank to the other [gallon/minute] is given by the following ODEs:

$$\frac{dx_1}{dt} = -\frac{2}{25}x_1 + \frac{1}{50}x_2$$
$$\frac{dx_2}{dt} = \frac{2}{25}x_1 - \frac{2}{25}x_2$$

Choose the best step size to model the first 60 minutes. Assume that the first tank has 25 gallons and the second tank is empty before the h2 door is opened. (30 points)