# MAT116.1 - Programming with MatLab
# MOCK EXAM

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**Exercise 1** (2 P.) Sequence!

a) Write a script called `'sequence.m'` which:

- Given the recursive sequence $a_1 = 1$, $a_n = \frac{1}{1+0.5a_{n-1}}$, finds the first 10 values of the sequence;
- plots these values as discrete points (no lines between them);
- adds a title on the top of the plot;
- adds a label for the $x$ axis;
- saves automatically the plot in `'sequence_plot.fig'`;
- closes the figure.

b) The sequence $a_n$ converges to $a = \sqrt{3} - 1$. Build a function `'tolerance_sequence.m'` that takes as input a tolerance $\varepsilon$ and stops the sequence $a_n$ when the error $|a_n - a| \leq \varepsilon$. The output is the first $n$ such that $|a_n - a| \leq \varepsilon$.
INPUT: tolerance.
OUTPUT: first $n$ such that $|a_n - a| \leq \varepsilon$.

**Exercise 2** (2 P.) Mistery

a) Create a function called `'mistery.m'` that loads the structure `'mistery_vector.mat'`, which has a vector of integers called `mistery_vect`, and returns the number of 0 elements of the vector (how many times the value 0 appear in the vector) and the mode value of the vector.
INPUT:
OUTPUT: number of zero elements, mode value

b) Create a script called `'mistery_plot.m'`. The script should:

- load the file `'mistery_vector.mat'` and the vector as above;
- reshape it into a matrix $400 \times 640$;
- `spy` this matrix;
- save the plot into `'mistery_figure.fig'`;
- close the figure.

**Exercise 3** (2 P.) Functions

a) Given the sequence of functions $f_k(x) = k\sqrt{2}e^{-kx}\cos(\pi/4+kx)$, do a script `'plotting_functions.m'` that

- plots on $[0, 1]$ all the functions in one figure for $k = 1, \ldots, 5$;
- uses colors red, blue, green, yellow and magenta in this order;
- adds also a legend and a title;
- saves the figure as `'plotted_functions.fig'`;
- closes the figure.

b) Code a function called `'symbolic_integration.m'`. Use the symbolic tool of MATLAB to compute $\int_0^1 f_k(x)dx$. The function receives $k$ as input, and returns the value (a double, not symbolic) of the integral.
INPUT: $k$
OUTPUT: $\int_0^1 f_k(x)dx$ (as double).

**Exercise 4** (2 P.) Factorial!

a) Build a function `'my_factorial.m'` that, given a big number $M$, finds the first natural number $n$ such that $n! > M$.
(Hint: remember that $n! = 1 \cdot 2 \cdot 3 \cdot \cdots \cdot n$)
INPUT: $M$
OUTPUT: $n$

b) In a function `'factorial_matrix.m'`, build a matrix $A$ of dimension $n \times n$, with $n$ given as an input, where

$$A_{ij} = \begin{cases} (j \bmod i)! & \text{if } i < j \\ (i \operatorname{div} j)! & \text{if } i \geq j \end{cases}$$

for $i, j \in \{1, \ldots, n\}$, where div is the integer division and mod is the remainder of the integer division. Return the mean value of the whole matrix.
INPUT: $n$
OUTPUT: $\frac{1}{n^2}\sum_{i,j=1}^{n} A_{ij}$