Name: _____

Date: _____

Collaborators: _____

(If applicable, collaborators submit their individually written assignments together)

Question:	1	2	Total
Points:	45	15	60
Score:			

Instructor/grader comments:

Matlab

1. The goal of this exercise is (a) to write a matlab function that uses **for** loop and preallocates an array, and (b) to write a matlab script that plots graphs of functions.

   Consider the following integral:

$$y(n) = \int_0^1 x^n e^{-x} \mathrm{d}x, \qquad (A)$$

   where n is non-negative integer, $n = 0, 1, 2, \ldots$

   The integral (A) has the following properties:

   1. All $y(n)$ are positive, $y(n) > 0$ for $n = 0, 1, \ldots$
   2. $y(n)$ is monotonously decreasing function of n, i.e. $y(n) < y(n-1)$ for $n = 1, 2, \ldots$.

   To evaluate the integral numerically, we integrate (A) by parts to obtain the following relation:

$$y(n) = n\,y(n-1) - \frac{1}{e}. \qquad (B)$$

   The value of the integral (A) for $n = 0$ is

$$y(0) = \int_0^1 e^{-x} \mathrm{d}x = 1 - \frac{1}{e}. \qquad (C)$$

   Using (C) and (B) for $n = 1$ we can find that

$$y(1) = y(0) - \frac{1}{e} = 1 - \frac{2}{e}. \qquad (D)$$

   We now can repeat the steps to calculate $y(2)$, $y(3)$, ...

   (a) (15 points) Write matlab function `hw02p1integral` (place the code in the file named **hw02p1integral.m**) that accepts a positive integer parameter k and returns a vector containing the values of the integral (A) for $n = 1, 2, \ldots, k$. The function must use the relation (B) and the value of $y(1)$, (D). Your function must preallocate the array that it returns. Use `for` loop when writing your code. Provide the help text for the function.

(b) (10 points) Write matlab script (place it into a file **hw02p1.m**) that uses your function to calculate the values of the integral (A) using the recurrence relation (B), $y(n)$ for $n = 1, 2, \ldots 18$.

The very first two command in your script must be

```
clear
clf
```

(c) (10 points) Add the following code to your script to calculate the values of the integral by direct numerical integration.

```
N = 18;
fun = @(x, k) x.^k.*exp(-x);
z = zeros(N, 1);
for n = 1:N
    z(n) = integral(@(x) fun(x, n), 0, 1);
end
```

To compare the results of your calculations, plot the graphs of $y(n)$ and $z(n)$ in the same figure. Provide meaningful title and axis labels and graphs legend, as well as draw the grid. Use a linestyle that marks the data points and connects them with a line.

(d) (10 points) modify the code of your script to measure the time of calculations by the algorithm you implemented and by the matlab generic integration function. Run your matlab scrip several times to get a reliable timing. How much faster is your specialized algorithm vs matlab's generic one?

Hints:

1. If you wrote your function correctly, the results of the calculations will clearly contradict the properties 1. and 2. of the integral. We'll learn later in this class why correct programs produce wrong results.
2. Your script should produce a graph similar to the one shown in Fig. 1 or 2.

2. (15 points) Create a gitlab project called **hw02** (name it exactly as shown). Upload **all** matlab files that are required to run your code. **Do not** upload other types of files (e.g. no graphics files). Create README.md file and write your answer to Question (d). Share the project with the instructor (gitlab user name `m3510_21f_in`) and the TA (gitlab user name `m3510_21f_ta`) and grant them the **Reporter** privileges.

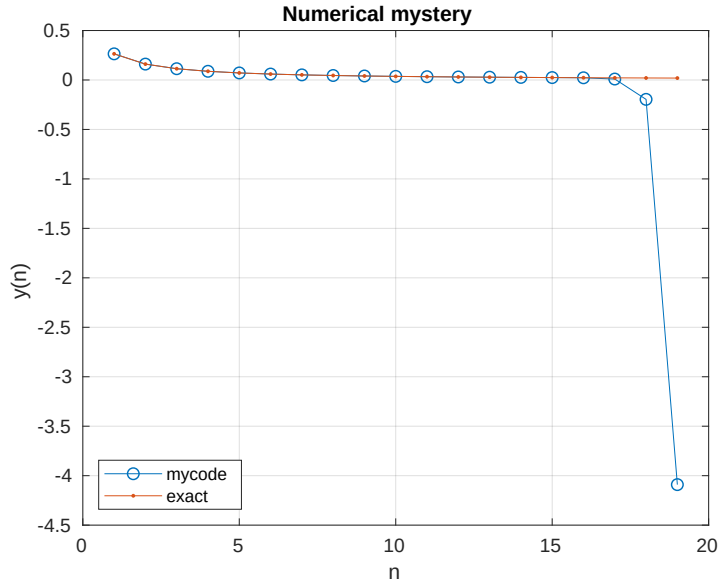

Figure 1: Posible graph in Problem 1

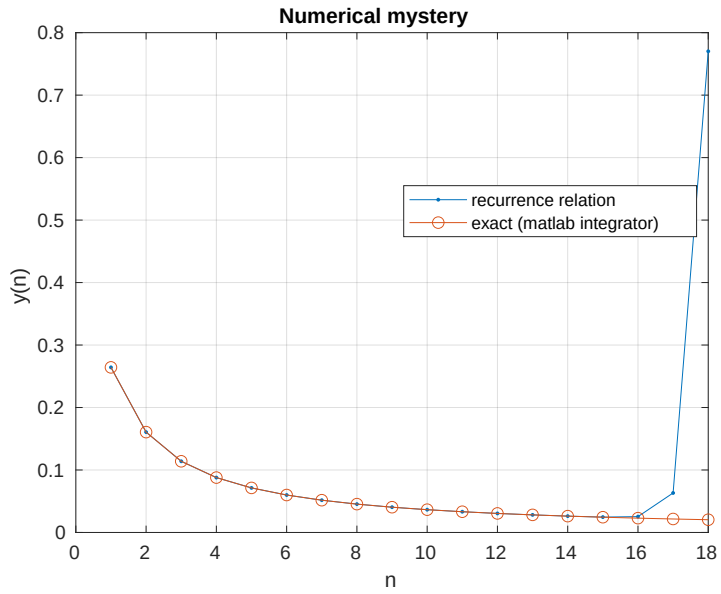

Figure 2: Another possible graph in Problem 1