Mathematical Modelling - assignments Week 3: Functions in Matlab & Numerical integration

For the following assignments you have to make several functions. For each function you have to make a separate MATLAB file. The scripts, which call these functions, should be collected in one single assignment file. This assignment file has to be submitted together with The MATLAB files of the functions.

Assignment 1

Make a function file for the function `squaredSum`.
The function has as input variable a vector x.
The output variable is the number y, which is the sum of the elements of x squared.
Don't forget to add a few comment lines, to explain what the function does.
Hint: you are allowed to use the command `sum` (see help).

Test your function with a script with x a vector of the integer numbers 1 to 10.

```
sum_of_squared =
   385
```

Assignment 2

Make a function file of the function `replacementResistance`
That function has the input variable: the vector R of resistances R1, R2, ... Rn.
The output variable should be Rv, which should be equivalent to the circuit in which all resistors R1 to Rn are in parallel.

Hence, the following formula applies: $\frac{1}{Rv} = \frac{1}{R1} + \frac{1}{R2} + \cdots + \frac{1}{Rn}$

Don't forget to add a few comment lines to explain what the function does.

Test your function for R = [20, 24, 27, 50, 32].

```
Rv =
    5.5570
```

Assignment 3 polynomial function

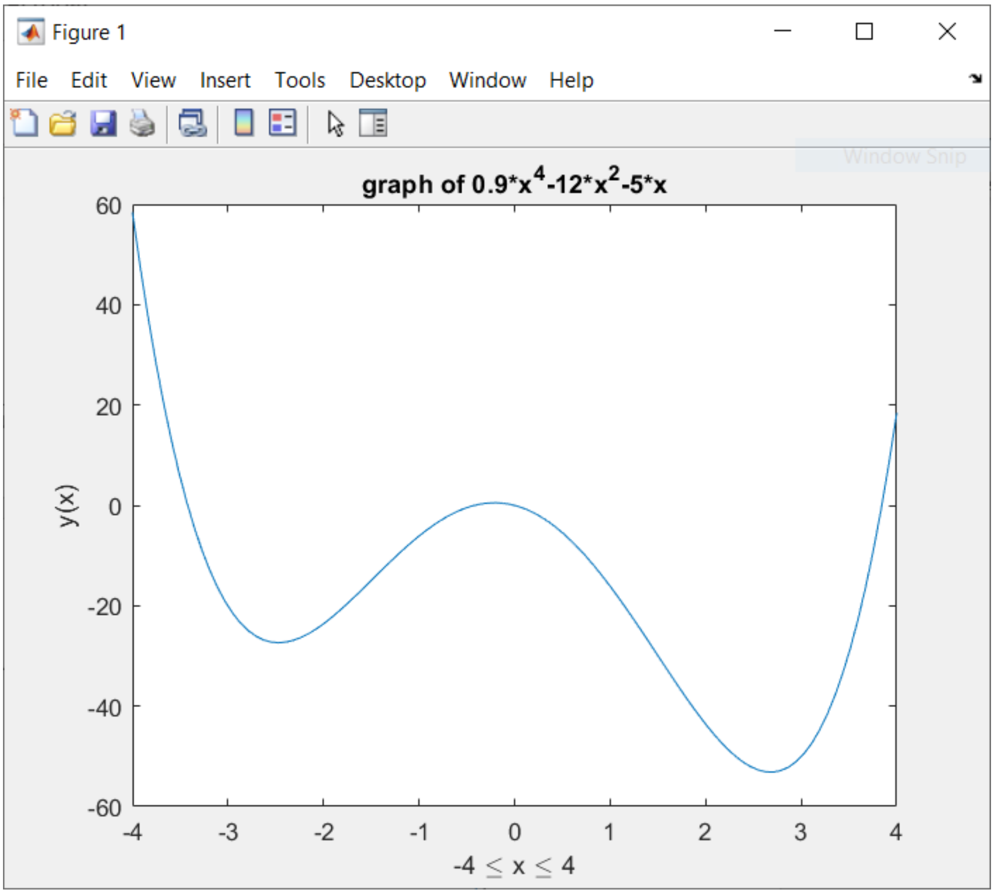
Make a function file of a function with input variable x and output variable y, in which y is defined as the function $y(x) = 0.9x^4 - 12x^2 - 5x$

Write the function in such a way that input `x` could also be a vector.
Don't forget to add a few comment lines, to explain what the function does.

Calculate with this function the function-values for `y(-3)` and `y(5)`.
Then make a plot of `y` as a function of `x`, when x has 100 values between −4 and 4.

```
y_minus_3 =
  -20.1000

y_5 =
  237.5000
```



Assignment 4

Make a function file of the function `calculateAngle`. Since already a function with the name `angle` exists, a different name has been chosen.
The function `calculateAngle` has two input variables: the vectors a and b.
Also it has two output variables: the real number y and the text txt.
In the function you should first check if the variables a and b have the same dimensions.
If that is the case, the text txt will get the value 'OK', and y will get the value of the angle (in rad) between the vector a and b.
If the dimensions do not agree txt should get the value 'Error', and y should become the value 'NaN'.
Don't forget to add a few comment lines, to explain what the function does.

Test your function with a script for the vectors a = `[1,2,4] and b = [2,-3,1]`

Hint: the formula to calculate the angle between two vectors is $\cos^{-1}\left(\frac{a \cdot b}{|a|\,|b|}\right)$

```
angle =
    1.5708

result =
    'OK'
```

Assignment 5 dervivative

Make a function file with the name `derivative.m`

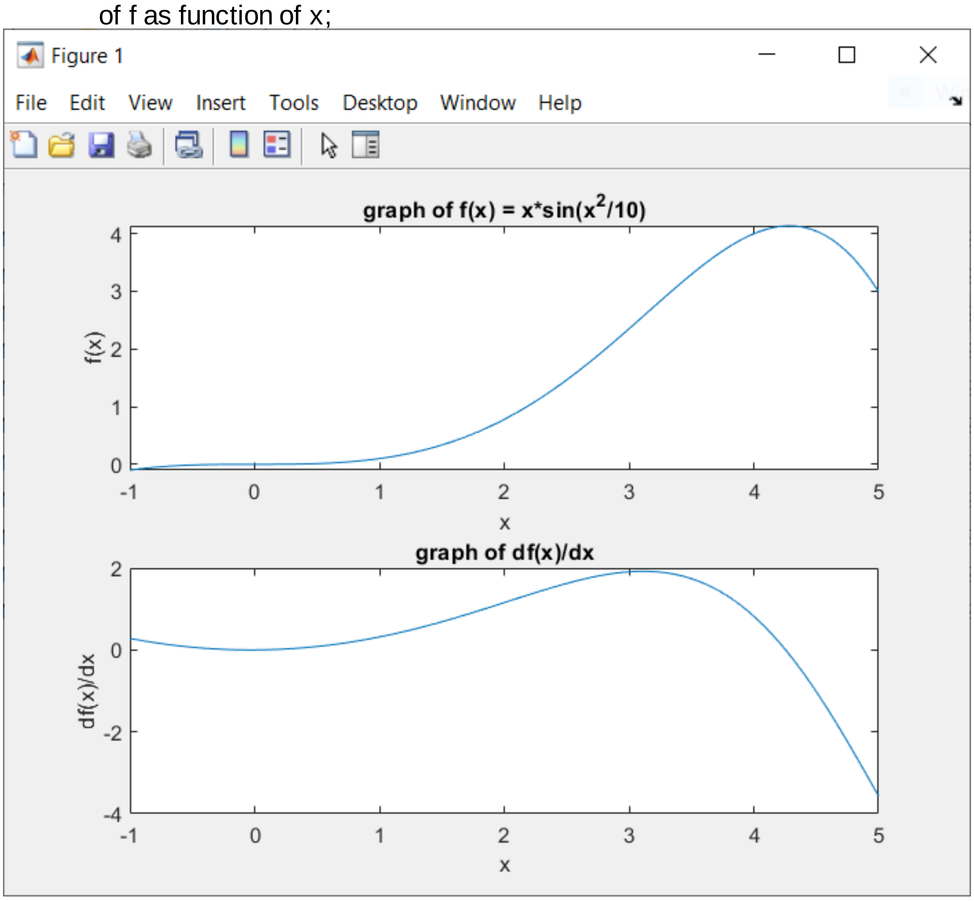
The function has two input variables and one output variable

- Input variable x is the vector of the x-values
- Input variable y is the vector of the output values of a certain function applied to x.
- Output variable dydx is the vector with the numeric calculated derivative of the input vector y of x (by using the command `diff`), with an added value at the end, to make the dimension (length) of dydx the same as the dimension of x. Think of a smart way to fill in this last value so that it fits in with the rest of the values.

The function is given $f : x \rightarrow x \cdot \sin\left(\frac{x^2}{10}\right)$

Make a script-file in which the following tasks are included:

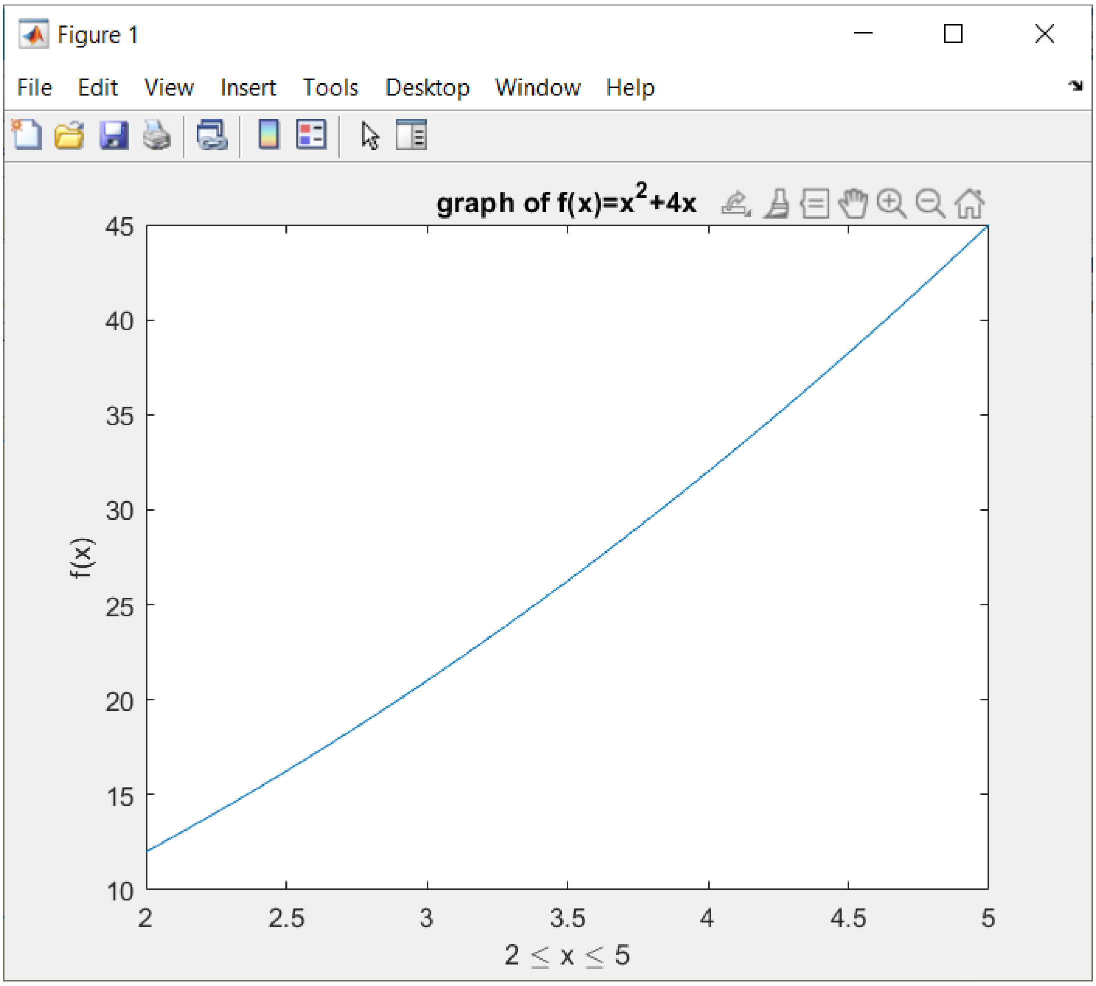
- Make a vector x with 100 numbers ranging from -1 to 5, with equal spacing.
- Calculate the function values for y = f(x)
- Calculate the differentiated values of the function f for the interval [-1,5]. For calculating the differentiated values, you should use your previously defined function `derivative`.
- Generate two plots using subplot: one subplot of f as function of x, and one subplot of the derivative of f as function of x;



There are more possibilities to think of a smart last value like the value of the previous point y(length(x)-1), or somewhat more advanced the previous value plus the direction coefficient times the step size (where the direction coefficient is based on difference of (y(length(x)-1)-y(length(x)--2))/ (x(length(x)--1)-x(length(x)--2)). Since the step size is 1, this simplifies even y(length(x)--1)-y(length(x)--2).
if you really don’t have a good idea, you could even use zero (but that is not really a good choice).

Assignment 6

Make a plot of the graph of the function $f(x) = x^2 + 4x$ on the interval of 2 to 5.



First manually calculate the outcome of the integral of $\int_2^5 \left(x^2 + 4x\right)dx$

Write your manual calculation as comment in the Matlab file; you should not only give the value, but also the calculation steps as comment.

Now we want to calculate the integral of $\int_2^5 \left(x^2 + 4x\right)dx$ using numerical integration by means of the built-in function `trapz` to estimate the numerical value of this integral.

First do this with 2 values for x, i.e. a single trapezium.
Is the result too big or too small, compared to the actual value of this integral? Give your answer in the form of Matlab comment.
Next do this with 3 values for x, i.e. two trapeziums.
Then do this with 100 values for x
And finally do this with 1000 values for x.

```
area2 = 85.5000
area3 = 82.1250
area100 = 81.0005
area1000 = 81.0000
```

Assignment 7

Estimate the value of the following integral by means of numerical integration with the help of `trapz`.
First, use 10 values for x to calculate the integral, then double the amount of values for x until the result is no longer changing for the first four decimal digits.

$$\int_0^2 \left(1+\cos\left(x^2+1\right)\right)dx$$

```
area =
    1.5721

amount =
   320
```

Assignment 8

Estimate the value of the following integral by means of numerical integration using the Simson rule (making use of the function `simpson` defined above).
Take for each integral first 10 trapeziums, then double the number of trapeziums until the result is no longer changing for the first four decimal digits.

$$\int_0^2 e^{1-x^2}\,dx$$

```
amount =
    20

area =
    2.3977
```

Assignment 9

Use the built-in function `integral` to calculate

$$\int_0^2 e^{1-x^2}\,dx$$

```
area =
    2.3977
```

Assignment 10

Use the built-in function `integral` to calculate

$$\int_2^5 \left(x^2+4x\right)dx \text{ d}$$

```
area =
    81.0000
```