Exercise Sheet 1

Deadline: October 13, 2025 @ 07:00 am

Exercise 1: Write a program that asks for and reads a number (from 1 to 7) from the keyboard, and that gives as output the corresponding day of the week (MON, TUE, etc.), using a `CASE` statement. In case that the input is not in the correct range (1 – 7), give a corresponding error message.
Expand and change the example above with a `GOTO` statement: In case that the input number is not in the range 1 – 7, give an error message and start again with asking for the input. This can also be solved with a loop, use the `REPEAT` statement to implement the same functionality.

Exercise 2: Define two vectors: $x = 0, 0.05, 0.1, \ldots 5$ and $f(x) = x^{0.5}$.
a) Make a graph of f as function of x (use the routine `PLOT, x, y`).
b) Calculate for which entries of x the function f has a value larger than 1.5 (use the `WHERE` function). Print the corresponding x values and check the obtained results against the graphics.
c) For how many data points is $f(x)$ larger than 1.5? (Hint: check the IDL help or online IDL search for the `WHERE` function and for `N_ELEMENTS`.)

Exercise 3: Write a program that calculates the exponential function of a number x by using its Taylor series expansion:

$$exp(x) = 1 + x1/1! + x2/2! + x3/3! + x4/4! + x5/5! \ldots \tag{1}$$

a) Implement such Taylor series using a FOR loop. Test the program first for $x = 1$ (as you know the result) and vary the number of elements of the series used for the calculation. Compare the accuracy of the result for different number of terms used in calculating the series (e.g., 5, 10, 100, 1000). You can compare your results with the one from the IDL function `EXP`. When the program works, test it also for other values of x.
Note 1: Make sure you use floating point numbers and not integers in the calculation.
Note 2: For the calculation of the series you could use the IDL function `FACTORIAL`. But this will lead to some problems – which ones? why? Implement and test it for different x.
b) You can implement a better solution which does not need the `FACTORIAL` function. Looking into the series, one can see that each new (i) term can be

written as a product involving the preceding $(i-1)$ term. This means, saving at each step the new term in a variable as well as the sum of the series so far in a separate variable, allows us to calculate the series more efficiently.
Implement, test and discuss these two different approaches and their pro's and con's.

Exercise 4: Use an implementation for calculating the exponential function based on variant b) above. But now use a `WHILE` loop. The calculation shall stop when the new term that is calculated is smaller than a given accuracy, say $\epsilon = 10^{-6}$. (In IDL the command for this assignment would be, e.g., `eps = 1E-6`). At the end of the program print as output the result, the number of terms that were needed in the calculation as well as the difference between the result from your Taylor series calculations and the IDL function `EXP`. Test the program for different values of x. Discuss how the results behave for different values of x in terms of accuracy and number of terms needed.

Exercise 5: Calculate the sine function of a number x by using its Taylor series expansion. Use an implementation with a `REPEAT` loop. Do the same analysis as in exercise no. 4.