With this lab, you will start becoming familiar with the Matlab environment and some of its facilities. You will learn:
- How to perform basic arithmetic operations
- How to assign values to variables
- How to use control structures (do and if)
- How to generate graphics

Exercise 1: Basic Arithmetic calculations within Matlab

Evaluate the following expressions by hand and use Matlab to check the answers:

a) \(1+2+3\)
   
   \(\text{ans} = 6\)

b) \(\cos\left(\frac{\pi}{6}\right)\)
   
   \(\text{ans} = 0.866\)

\(3^{2^2}\)
   
   \(\text{ans} = 81\)

c) \(\log(e^3)\) (lookup the functions \texttt{exp} and \texttt{log})
   
   \(\text{ans} = 3\)

d) \(\sin^2\left(\frac{\pi}{6}\right) + \cos^2\left(\frac{\pi}{6}\right)\)
   
   \(\text{ans} = 1\)

e) \(2 + \text{floor}(6 / 9 + 3 * 2) / 2 - 3\)
   
   \(\text{ans} = 5\)
Exercise 2: assign values to variables; basic operations on arrays

a) Create an array of the even whole numbers between 31 and 99.

```matlab
>> a = 32:2:99;
```

b) Create a vector x with the elements,

\[ x_n = \frac{(-1)^{n+1}}{2n-1} \]

Add up the elements of the version of this vector that has 100 elements.

```matlab
>> n = 1:100;
>> x = (-1).^(n+1)./(2*n-1);
>> sumx = sum(x)
sumx = 0.7829
```

c) Let \( x = [3 \ 2 \ 6 \ 8]' \) and \( y = [4 \ 1 \ 3 \ 5]' \) (NB. x and y should be column vectors).

i) Add each element in x to the corresponding element in y.

```matlab
>> z1 = x + y;
```

ii) Raise each element of x to the power specified by the corresponding element in y.

```matlab
>> z2 = x.^y;
```

iii) Divide each element of y by the corresponding element in x.

```matlab
>> z3 = y./x;
```

iv) Multiply each element in x by the corresponding element in y.

```matlab
>> z4 = x.*y;
```

d) Create the \( 3 \times 3 \) matrix whose entries in the first row and first column are all equal to 1 and all the other entries are equal to e \((=\exp(1))\).

```matlab
>> a = ones(1,1)*exp(1);
>> a(1,:) = 1;
>> a(:,1) = 1;
```
Exercise 3: Control structures

a) The 3*n+1 sequence
We consider a famous unsolved problem in number theory, the “3n+1” sequence. Start with any positive integer n and repeat the following step:
- If n = 1, stop
- If n is even, replace it with n/2
- If n is odd, replace it with 3n+1

For example, starting with n = 7, we get:
7,22,11,34,17,52,26,13,40,20,10,5,16,8,4,2,1
The sequence terminates after 17 steps. The unanswered question is, does this process always terminate?

The following Matlab code generates the sequence starting with any specified n:

```matlab
y = n;
while n > 1
    if rem(n,2) == 0
        n = n/2;
    else
        n = 3*n+1;
    end
    y = [y n];
end
```

We do not know ahead how long the resulting vector y is going to be. But the statement `y = [y n];` automatically increases `length(y)` each time it is executed.

i) Implement this matlab code and test it for n = 7
ii) Modify this Matlab code so that for a given starting value n, it computes L(n), the length of the sequence after termination.

```matlab
function L = length3n(n)
% LENGTH3N computes the length of the sequence 3*n+1
L=1;
while n > 1
    if rem(n,2) == 0
        n = n/2;
    else
        n = 3*n+1;
    end
    L = L + 1;
end
end
```
iii) Compute \( L(n) \) for all values of \( n \) between 1 and 1000. What is the maximum value of \( L(n) \) for \( n \) in this range?

\[
\text{max}(L(n)) = 179
\]

\( b) \) Compute the sum of the series

\[
1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \frac{1}{6} \ldots
\]

Up to an even number of terms:
- using a for loop
- without using a for loop

Compare the efficiencies of these two approaches using the functions \texttt{tic} and \texttt{toc}.

\[
N = 1000;
\]

\[
\text{sum1} = 0;
\]

\[
\text{for } i = 1:N \\
\quad \text{sum1} = \text{sum1} - (-1)^i/i;
\]

\[
\text{end}
\]

\[
\text{idx1}=1:2:N; \\
\text{val1}=1./\text{idx1}; \\
\text{suma} = \text{sum(\text{val1});}
\]
idx2 = 2:2:N;
val2 = 1./idx2;
sumb = sum(val2);

sum = suma - sumb

Exercise 4: graphing

Biorhythms

Biorhythms were very popular in the 1960s. They are based on the notion that three sinusoidal cycles influence our lives. The physical cycle has a period of 23 days, the emotional cycle has a period of 28 days, and the intellectual cycles has a period of 33 days. For an individual, the cycles are initialized at birth. The figure below shows my biorhythm, which begins on October 26, 1961, plotted for an eight-week period centered around the date this is written, April 7, 2014.

The following code segment is part of a program that plots a biorhythm for an eight-week period centered on the date April 7, 2014:

```matlab
t0 = datenum('Oct. 26, 1961');
t1 = datenum('Apr. 7, 2014');
t = (t1-28):1:(t1+28);
y = 100*[sin(2*pi*(t-t0)/23)
        sin(2*pi*(t-t0)/28)
        sin(2*pi*(t-t0)/33)];
plot(t,y,'LineWidth',2);
```
a) Complete the program above, using your own birthday, and the `line`, `datetick`, `title`, `datestr`, `legend`, and `xlabel` functions. Your program should produce something like the figure above.

b) The three rhythms are periodic functions, with periods 23, 28, and 33 days. There will be a day in your life when all three rhythms will be zero again (“resetting” the rhythms): it will occur $23*28*33$ days after your birth, i.e. on day 21252, i.e. when you will be 58 years old! Can you find which day this will be?

c) In between your birthdate and that day, is there a day where all your 3 biorhythms will be maximum? The answer is no…. but can you find a “near perfect” day, i.e. a day where the three biorhythms will be close to 1?
- Consider finding the maximum of the sum of the three functions $y_1$, $y_2$, and $y_3$

**Download program biorhythm.m from website!**