Return as an email attachment to taneli.kalvas@jyu.fi no later than 28 February at 12:15 (before lecture). The email title should include FYSY115/Harjoitus 5. If the exercises are made with a partner include the names of the team.

Make each exercise to its own script/function file.

1. Write a script file, which sets a variable as one. Divide the number by two repeatedly until the number becomes zero. Print the last non-zero number to screen. Do the same also in other direction: set a variable as one. Multiply it by two until it becomes infinite. Print the last number before infinite.

2. Write a function file with two functions: a main function and a subfunction. The subfunction takes at most three arguments: a, b and c. If the subfunction is given a single argument it should print "One argument: a" in which a is the value of the argument. Similarly if two arguments are given it should print "Two arguments: a and b" and if three it should print "Three arguments: a, b and c". Use `fprintf` and `nargin` methods. The main function calls the sub function three times. Once with arguments $(1, 2, 3)$, then with arguments $(4, 5)$ and last with only a single argument (6).

3. Calculate the volume of a circle based cone. Assume that the axis of the cone is z-axis and the base of the cone is at plane $z = 10$ and the apex is at origin. The radius of the base circle $r = 2$. Create all points in the box $\vec{x} \in ([-2, 2] \times [-2, 2] \times [0, 10])$ using a 0.1 mesh density. Form the 3D points using three for loops within each other. Each point corresponds to a cube with volume $V = 0.1 \times 0.1 \times 0.1$. If the point is within the cone (check it with an if-clause) the volume of the cube should be added into a summing variable. After all points are processed the summing variable contains an approximation of the volume of the cone. Check by comparing to an analytical value.

4. Similarly calculate the moment of inertia of a two dimensional object. The object is a rectangular thin plate with length $L = 20$ cm and width $W = 30$ cm. There is a circular hole with radius $R = 5$ cm at the center of the plate. The mass density of the plate is 1.3 g/cm^2. The axis of rotation is oriented along the normal of the plate and goes through one of the corners. Chop the plate into $h \times h$ squares and calculate the contribution of each point into the moment of intertia according to $J = \sum m_i r_i^2$. Try how small h must be to get a correct

result within two significant digits.

5. The data file `data51.txt` has emittance data from the Linac4 ion source at CERN (which means that the file contains ion beam current in a two-dimensional phase space). The data file has 300 columns (x coordinates) and 300 lines (y coordinates). Each matrix element in the file $I(i, j)$ is the current measured at each point in phase space. The columns and lines correspond to x and y coordinates linearly. The extreme values for the coordinates are $x_{\min} = -29.5$ mm, $x_{\max} = 30$ mm, $y_{\min} = -87.3$ mrad, $y_{\max} = 89.7$ mrad. Don't worry about units. The current values I have to be filtered. All negative and values smaller than I_s are replaced by zero, where $I_s = 0.05 I_{\max}$. In other words the the filter level is 5 percent of the largest current value in any element.

Calculate emittance

$$\epsilon = \sqrt{\langle y^2 \rangle \langle x^2 \rangle - \langle xy \rangle^2},$$

from the data, where

$$\begin{aligned}
\langle x^2 \rangle &= \sum_{i,j} x_i^2 I(i,j) / \sum_{i,j} I(i,j) \\
\langle y^2 \rangle &= \sum_{i,j} y_i^2 I(i,j) / \sum_{i,j} I(i,j) \\
\langle xy \rangle &= \sum_{i,j} x_i y_j I(i,j) / \sum_{i,j} I(i,j).
\end{aligned}$$

This exercise is worth two points!