



university of
 groningen

faculty of science
and engineering

PROGRAMMING, MODELLING AND SIMULATION

FINAL EXAM

Groningen, November 3, 2023

The exam is closed book, thus no helping material is allowed in the exam hall. Please:

- write your answers on the paper provided
- mark all individual answer sheets with your student number and your full name
- write clearly, otherwise your answers cannot be assessed. It is a good idea to draft your answers before you write the version you hand in
- follow the coding conventions, if you are asked to write code, write it exactly as you would do in Matlab, including comments and correct indentation.
- you will be evaluated on your MATLAB solutions to the problems, your use of the coding conventions and the clarity of your explanations

This exam contains 2 problems with several subquestions

The number of points per question are stated

In total you can obtain 40 points

Good luck!
(and don't forget to enjoy)

Problem 1: Filling water tanks

24 points

Question 1) A function

10 points

For the last week of PMS (FESTO) your Teaching Assistants had to fill up several water tanks using a small watering can. The following information is given to you:

- The large water tank's volume in Liters is calculated as:

$$\text{volume (Litres)} = 1000 \cdot \text{length} \cdot \text{width} \cdot \text{height}$$

where distances are assumed in metres.

- The smaller watering can holds up to x Liters of water.

For example, if the large tank's measurements are length=0.1, height=0.1, and width=0.17, the volume is 1.7 Liters. If the watering can holds 0.4 Liters, the TA needs to fill the watering can 5 times (4.25 before rounding up).

Write a function called `fill_water_tank` that outputs the volume of the tank (`tank_volume`) and the number of times a TA needs to refill their watering can in whole numbers (`refill_count`) using the dimensions of a water tank and the volume of the smaller watering can.

Question 2) Using the function

10 points

The DTPA lab actually has several different types of water tanks, all are assumed to be cuboid/rectangular solid (as before in Question 1.1). The following data is given to you (see Figure 1, the spreadsheet data is loaded into Matlab as a matrix of size 5×3 , using

```
1 water_tank_data = csvread("water_tank_data.csv");
```

	A	B	C
1	0.1	0.1	0.17
2	0.3	0.12	0.4
3	0.4	0.25	0.35
4	0.6	0.1	0.1
5	0.15	0.33	0.33

(a) Spreadsheet

```
water_tank_data =  
  
    0.1000    0.1000    0.1700  
    0.3000    0.1200    0.4000  
    0.4000    0.2500    0.3500  
    0.6000    0.1000    0.1000  
    0.1500    0.3300    0.3300
```

(b) In MATLAB

Figure 1: The CSV data for the tanks in a spreadsheet and as a 5×3 matrix in MATLAB.

Write a Matlab script that uses the `fill_water_tank` function for each of the five tanks. The smaller watering can (x) is assumed always to contain 0.4 Liters. Make sure to store the output data from the function for each water tank, and do not overwrite previous outputs. Finally, adequately display your results.

Question 3) Code improvement**4 points**

A) Explain what would happen if we use the following inputs:

$$\text{length} = -0.3, \quad \text{width} = 0.5, \quad \text{height} = 0.1, \quad x = 1$$

to the function *fill_water_tank*. Comment on the output result and explain how you could circumvent this.

B) Currently, our Excel sheet only has 5 tanks. In the future, the number of tanks may be higher or lower. How could you ensure your script handles any number of tanks in the Excel sheet without changing the script each time before running it?

Problem 2: Car rolling down a slope

16 points

Question 1) Simulation

2 points

We want to create a Matlab script to simulate a stress test for a car (a 3-door Renault Clio). But before diving in, the following information is given regarding time (all in seconds):

$$\text{start time} = 0, \quad \text{time step/dt} = 0.1, \quad \text{end time} = 12$$

In our simulation, the car will have an acceleration, velocity and position at each moment of our defined time. Taking into consideration that timestep stands for the difference between the subsequent moments of time, what is the length (number of indexes) of these lists? *Explain how you obtained your answer.*

Q2) Flowchart

14 points

For this question, you are asked to create a flowchart for simulating the following scenario:

A car (3-door Renault Clio) of mass 1500 kg is rolling down a hill due to gravity as shown in Figure 2. The hill has a gradient of 30° ($\theta = 30$). In your flowchart, you will have to prepare a code that updates the position of the car using velocity, which is in turn updated by acceleration. Velocity and position are calculated with the same formulas we used in the bouncing ball assignment in Week 4. Specifically, the acceleration is obtained using Newton's Second law ($F = ma$). For our car, the force F is given as the forward force minus the friction force, as seen below. The coefficient of friction between the wheels and the road is assumed to be 0.4.

$$F_{\text{forward}} = mg \sin(\theta), \quad F_{\text{friction}} = 0.4mg \cos(\theta)$$
$$\text{acceleration}_i = \frac{F_{\text{forward}} - F_{\text{friction}}}{m}$$
$$\text{velocity}_i = \text{velocity}_{i-1} + \text{acceleration}_i \cdot dt$$
$$\text{position}_i = \text{position}_{i-1} + \text{velocity}_i \cdot dt$$

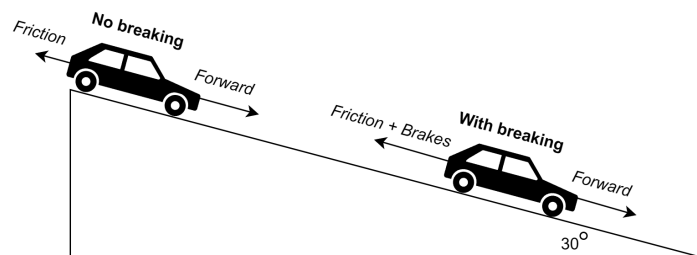


Figure 2

Lastly, we want the car to stay at constant speed once it has reached a velocity of 15m/s . To achieve this, the driver breaks as much as the car accelerates. In code, we simply set the acceleration to zero. Create a flowchart of the car rolling down a slope with the given equations and time. Use everything you have been taught about flowcharts, and draw clearly. Additionally, use the following information:

$$\text{start time} = 0, \quad \text{time step/dt} = 0.1, \quad \text{end time} = 12, \quad m = 1500\text{kg}$$

$$\text{position}_1 = 0, \quad \text{velocity}_1 = 0, \quad \text{acceleration}_1 = 0$$