

Figure 1: Sketch of track layout. The grid is in meters. The numbers refer to the sections below. Green lines indicate a fence (of at least 8 cm height).

# Track description 2025

The Danish version has priority if there are contradictions.

## 1 Introduction

The track is located in the DTU library building 101. The layout will generally be as shown on the sketch (figure 1), but minor variations may occur, the other figures do not all relate to the current track.

The track is designed on the basis that the vehicle can follow a tape line, and if you follow the right edge of the line you will reach the goal, but in this way only achieve relatively few points.

### 1.1 The floor

The track is located on a plateau that is raised above the library floor level.

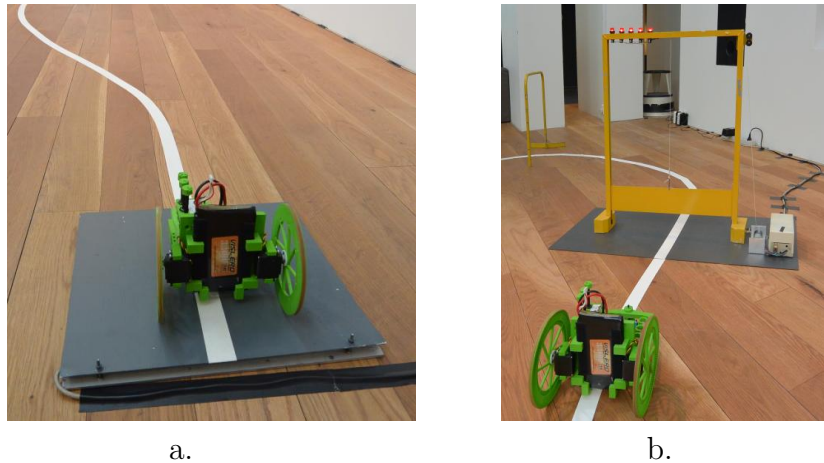


Figure 2: Start plate and guillotine, the two first and mandatory challenges. Both are replaced by a proximity detector and a boom respectively, but the floor is the same.

The raised floor below the track are of two types, a wood surface (oak) see figure 2, which is the yellow area on the track sketch, and a central area that is black. The black area (approximately 5.5 x 6.8 m in the middle of the area) is shown darker on the track sketch - see figure 3 (the area is usually at floor level, but is filled with black panels for the occasion). There may be small differences in level between the wood and the black panels - we have seen up to 5mm. The panels are framed with a narrow aluminium edge of approx. 5 mm, two aluminium edges thus give a transition of 10-15 mm, since there can also be a small distance between the panels (see also figure3).

## 1.2 Canvas tapes and power cables

The tape lines are made with 38 mm wide white tape (type Tesa-4651). The tape will be placed roughly as shown on the track sketch. Electrical items will be connected by cables. They will be taped to the floor (with black tape) and may be passed by the robot

## 1.3 Line sensor

The wooden floor is very bright with an infrared line sensor and can, therefore, be difficult to distinguish from the white canvas tape. It is therefore recommended to use visible light for the line sensor.

## 1.4 Navigation aid markers

At different places on the track, there will be ArUco markers. Each marker has a 4x4 code.

ArUco codes can be detected by e.g. OpenCV, see e.g. [https://docs.opencv.org/3.4.15/d5/dae/tutorial\\_aruco\\_detection.html](https://docs.opencv.org/3.4.15/d5/dae/tutorial_aruco_detection.html) and generated on-line by

e.g. <https://chev.me/arucogen/>.

## 1.5 Satellite robots

If the robot consists of several units, then all units must pass the boom-gate. After the boom each units (satellite robots) can earn points independently.

## 1.6 Reliability point

The team may, before the start, state the expected number of points collected. If this number of points are reached, then an extra reliability point is added to the score.

## 1.7 Gates

The gates are all 45 cm wide (+/- 2 cm) with 47-50 cm free height. The wall thickness of the gates is approx. 16 mm (this does not apply to the tunnel or the race track). The gates are shown as yellow lines in the sketch (figure 1).

Each correctly passed yellow gate gives 1 point.

# 2 The Start

The start area is a marked square. A sensor detects when the robot has left the square, initiating a mission timer.

Just after the start there is an electronic boom. The robot must pass the boom before it closes. The boom is open for at least 15 seconds after the robot has left the start area.

Passing the boom gives 1 point.

# 3 Time limit switches

The time limit for the mission is 200 seconds. This limit can be extended if the robot passes each of the two switches marked with 3 and a red ellipse in figure 1. Each switch can only extend the time limit by 90 seconds once. The two time limit switches is (most likely) formed as a small bump with a build-in switch.

If the time limit is passed (time runs out) no more points can be earned and the mission ends.

There is no points associated with the time limit switches.

# 4 The goal

When the robot activates the sensor at the goal, the mission ends. The goal sensor is most likely activated by a push.

Ending in this way gives 2 points.



Figure 3: The figure shows the ramps, the see-saw and the stairs. The orange golf-balls and the yellow gates are visible too. Notice also the aluminium edge of the floor-plates.

## 5 The ramps

The ramp leads up to a platform at a height of approximately 55 cm (see figure 3). The ramp starts at least 3.5 m before the platform (horizontal distance). The decent ramp is steeper.

The ramps are 60 cm wide. There are 2 gates on the ramps, each 1 point.

## 6 Up and down the stairs

The stairs (see figure 3) has 4 steps and therefore 5 level jumps, each approximately 11 cm. The steps are 40 cm long and 60 cm wide. There are two gates on the stairs, each 1 point for passage. Going up the stairs gives additional points for each passed gate.

Maximum 4 points for the stairs.

## 7 The seesaw

On the upper part of the ramp, there is mounted a seesaw. The normal position of the seesaw is horizontal and it is supported by the ramp. This means that the seesaw will remain horizontal when a vehicle moves from the ramp to the seesaw until the vehicle passes the support point. A yellow gate is located at the outer end of the seesaw. When driving from ramp to the seesaw, there will be up to 6 cm height difference (the seesaw is lower than the ramp).

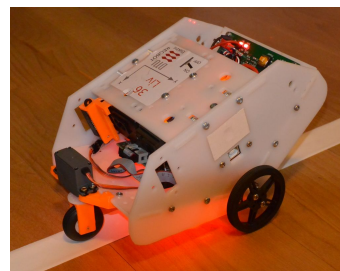
The gate at the seesaw must be passed by using the seesaw and gives 1 point.



Figure 4: The platform with golf ball and hole for the ball.



a.



b.

Figure 5: The tree-gate (a) is a circular 25 mm high disk with 3 gates and no tape lines. (b) Autonomous guard robot protecting the 3-gate.

## 8 Golf Ball

On the seesaw about 20 cm from the seesaw support point and on the ramp platform are placed golf balls (red circle in figure 1).

These balls must be placed in the hole on the platform (see figure 4) to obtain points. The diameter of the standard golf ball is 43 mm and the colour is orange.

The hole diameter is 52mm. Each golf ball in the hole gives 2 points.

## 9 The three gate

The 3-gate has 3 gates placed on a circular plate – see figure 5 a. The gates are placed readily on the plate and form an angle of 120 degrees. The plate is approximately 25 mm thick and has a diameter of 120 cm. The plate is painted on the top in a dark colour, the edge is (largely) vertical and in a lighter colour.

Each passed gate gives 1 point.

A robot is guarding the 3-gate. It runs right (clockwise) along the shown tape line (formed as an infinity symbol). The robot is approx. 17cm wide and 25cm long (see figure 5 b).

The robot must not be touched and it gives -1 point for each touch (up to a maximum of -2 points). The speed will not be constant but be within the range of

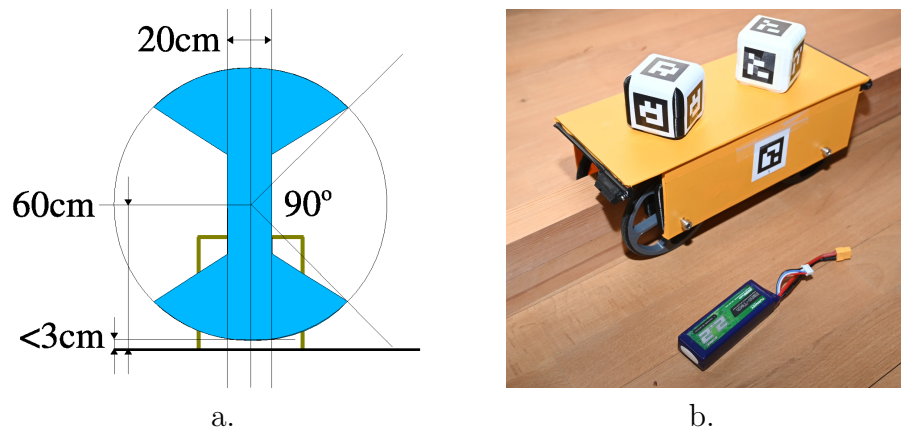


Figure 6: Axe gate (a.), with a gate shown beyond. (b.) The yellow shuttle with the two of luggage cubes.

0 to 50 cm/sec with an average speed of approximately 30 cm/sec over 20 seconds. If the robot is pushed, or for some reason loses the line, it will stop, but still, it should not be touched.

Placement of an obstacle or other actions that prevent the guard robot from driving counts as a touch.

Each of the two gates on the guard path gives 1 point.

## 10 The axe gate

The axe gate is a rotating axle that periodically blocks the passage of 2 gates. The axe is made of plywood, with dimensions as shown in figure 6 a. The axe rotates with approx. 1 rotation in 10 seconds. There is a gate just before and one just after the axe, the distance between these gates is approx. 10 cm. The frame shown on the track drawing is a steel frame (90 x 60 cm), with one leg in each corner (a frame from an examination table - clearance height 67 cm).

Each of the 2 gates gives 1 point.

## 11 Luggage delivery

A yellow luggage shuttle is moving back and forth with two boxes (see figure 6b). The shuttle has a flat top surface with the luggage. The top surface is about 13 cm above ground and has a size of 13 x 30 cm.

The luggage boxes are 6 cm on each side (cubes) with rounded corners and weighs about 100g. The packages are marked with an ArUco marker (on 6 sides) with ID 20 and 53. Each marker is 3.5 cm.

The shuttle moves back and forth along the green fence at a constant speed of 20 cm/s.

The shuttle itself has an ArUco marker on its side, with ID 5 and size of 3.5 cm.

The luggage marked 20 is to be placed at “A” in the sorting center (marked 13 in figure 1). The luggage marked 53 is to be delivered at “D” in the sorting



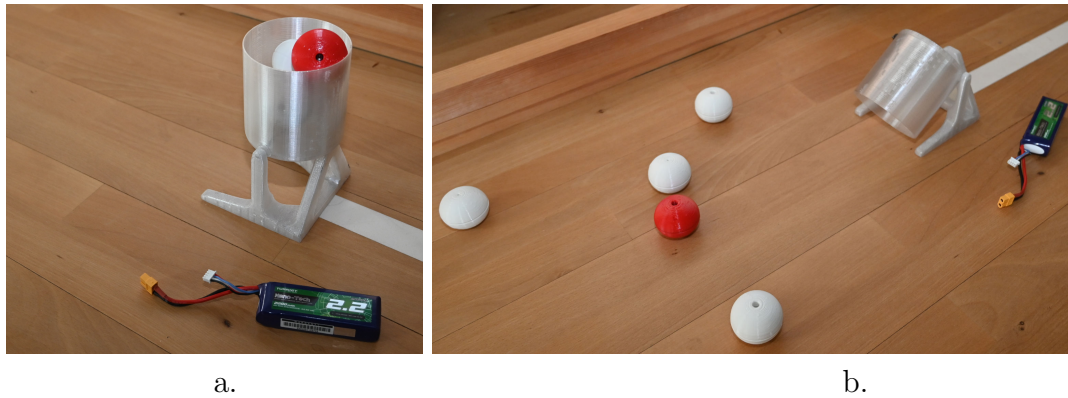


Figure 7: The ball dispenser (a) height is 18 cm. The dispenser holds 5 balls and can be activated by a push.

center.

One only of these possibilities gives points:

- The right luggage delivered to “D” gives 4 points.
- The right luggage delivered to “A” gives 3 points.
- Any luggage delivered to the sorting center gives 1 point.

## 12 Ball sorting

A ball dispenser can release 5 balls, each ball is 3D printed with a weight of about 30g. The balls are not spherical and are partially filled with screws that limits the roll distance. The balls has a height of about 43 mm on the flat side.

The dispenser is activated by pushing the top of the container(see figure 7). The top of the container is approximately 18 cm above the ground.

The dispenser holds one red, one light blue, and 3 white balls.

The balls are to be placed in the sorting center (12) and gives points in this priority order:

- Blue ball placed at “C” gives 4 points,
- Red ball placed at “B” gives 3 points,
- Any ball placed at the sorting center gives 1 point.

## 13 Sorting center

The sorting center is the destination for luggage delivery and the ball sorting challenge. The sorting center is an about 25cm high X shape. A labeled area is marked in each quadrant of the X as shown in figure 1. The size of the quadrant is at least 25 x 25 cm. An item is delivered if it is inside the area or touches the tape marking.

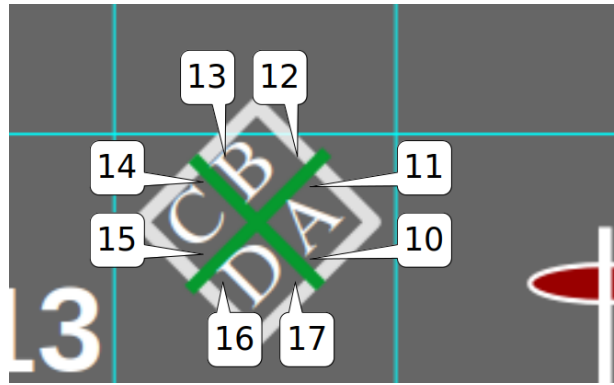


Figure 8: Each side of the four quadrants of the sorting center are marked with an ArUco code, this gives 8 markers, and the ID of the markers will be as shown.

Each surface of the X is marked with an Aruco code. The code is, from the A-quadrant counter clockwise: 10, 11, 12, 13, 14, 15, 16, and 17 as shown in figure 8. The marker size is 10 cm.

The points given is described in the Luggage delivery and ball sorting section.

## 14 Summary of points

Table 1 gives an overview of the number of points achievable.

Table 1: Summary of points. Numbers in brackets refer to numbers in figure 1.

Challenge	max points	note
Boom (2)	1	passed
Goal (4)	2	activating
Ramp up (5)	1	one gate
Ramp down (5)	1	one gate
Stairs (6)	4	2 for going down, 2 going up.
Seesaw (7)	1	for passing the gate
Golf balls (8)	4	2 points for each ball
3-gate (9)	5	including the guard gates
Axe (10)	2	two gates
Luggage delivery (11)	4	3 or 1 point possible
Ball sorting (12)	4	3 or 1 point possible
Reliability	1	achieving stated score
Total	30	