# Location and design of the track

(The Danish version has priority if there are contradictions)

The course is located at DTU in the library building 101.

The layout of the track will generally be as shown on the track sketch (figure 1), but minor variations may occur, the other figures do not all relate to the current track layout.

The track is designed on the basis that the vehicle can follow a tape line on the floor, and if you keep to the right of this line you will reach the goal, but in this way only achieve relatively few points.
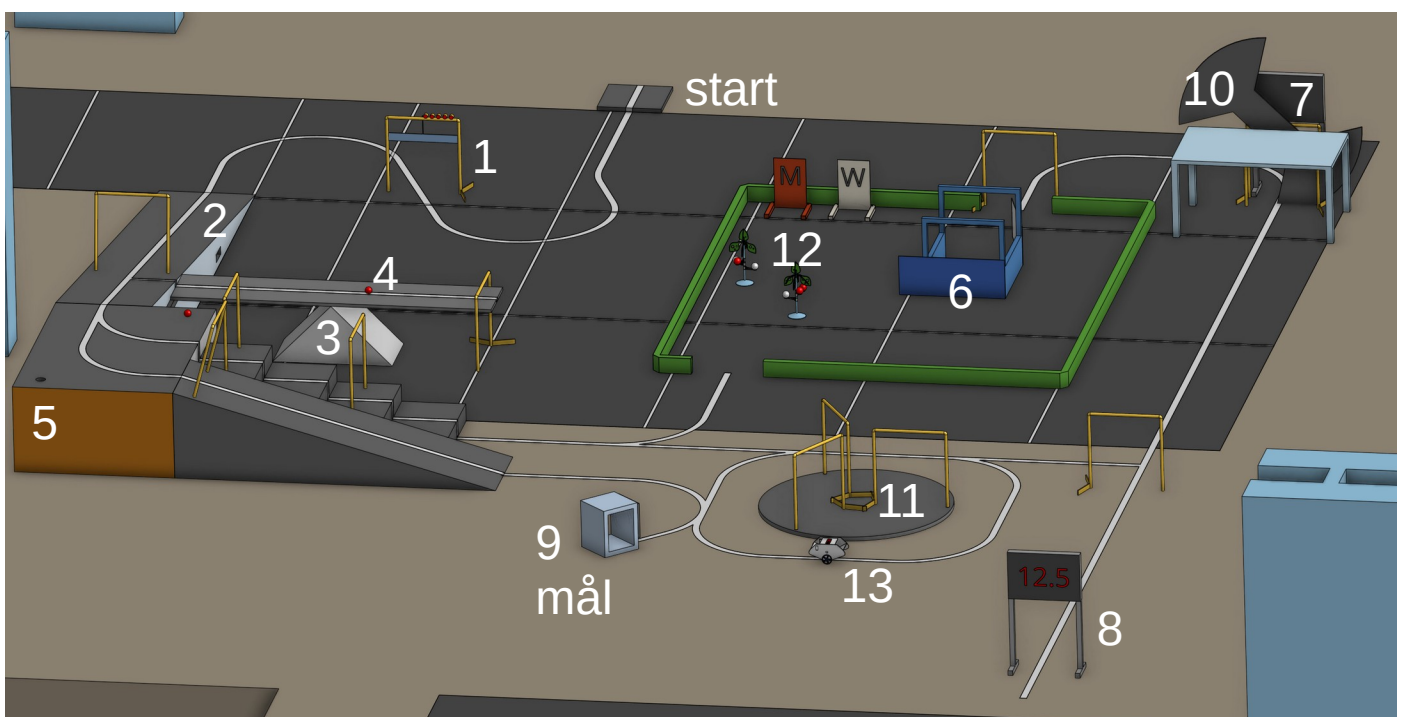
Figur 1: Sketch of the track. There is also a planar view of the track available on the DTU Robocup page. The image is from a 3D model from onshape :
https://cad.onshape.com/documents/a82458cb775129e90636dc5f/w/f5f322ebee2618fd0f24fbcf/e/25a83c5f130dc230b778f579

• **The floor**

The track is located on a plateau that is raised approx. 42 cm above floor level.

The floor below the track has two types of coating, a wood covering (oak) - see figure 2, which is the bright area on the track sketch, and a central area that is black. The black area (approx. 5.5 x 6.8 m in the middle of the area) is shown darker on the track sketch - see figure 4 (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 figure 4).

• **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. No curve will be sharper than a circle with a radius of 50 cm. Electrical obstructions will be connected to cables. They will be taped to the floor (with black tape) and may be passed by the robot.

• 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.

• Other conditions

Except for the guillotine gate and goal, all the remaining challenge may be completed in any order.

It is not a requirement that all challenges have to be completed.

If the robot consists of several units, then all these units must pass the guillotine. Then, these units (satellite robots) can earn points independently.

Figure 2: guillotine gate and example of a white line on the wooden floor.

• 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).

Each correctly passed yellow gate gives 1 point.

• The Start

The start is on a starting plate (figure 3). When the plate is left, a countdown of the guillotine gate starts (Figure 2). Timing and distance to the guillotine are determined so that an average speed of 25 cm/s will be sufficient for passage. Passage of the gate gives 1 point.

Figure 3: starting plate – here shown on a wooden floor.

• The ramp

The ramp (at 2) leads up to a platform at a height of approx. 55 cm (see figure 4). The ramp starts at least 3.5 m before the platform (horizontal distance) and with the same incline all the way. The width is 60 cm. The ramp is like the platform, staircase and descent made of wood and painted in a dark colour. The ramp also has a rough surface for increased friction during the run-up.

On the upper part of the ramp, there is mounted **a seesaw** (at 3). The normal position of the seesaw is horizontal and it is supported by the ramp. This

Figure 4: Ramp, plateau, staircase and seesaw. the orange golf balls on the platform and seesaw are just visible. The floor is dark with narrow aluminium edges.

means that the seesaw will remain horizontal when a vehicle moves from the ramp to the seesaw until the vehicle passes the support point. It will require approx. 200 g of impact 20 cm from the support point before the seesaw tilts. 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.

• Golf Ball

On the seesaw (at 4) 30 cm from the seesaw support point and on the ramp platform are placed golf balls.
These balls must be placed in the hole on the platform (at 5 and in figure 5) to obtain points. The diameter of the ball is standard 42.7 mm, but for vision-based solutions, golf balls are used for winter

Figure 5: Platform with a hole for the golf balls

golf with an orange colour. To ensure that the ball's position is uniform at each pass, a small metal ring (key ring) is mounted under the tape in which the ball is placed.

Each ball triggers one point (maximum 2 points). The hole diameter is 52mm.

• Downhill from the plateau

The descent from the platform can take place via 2 alternative roads. The ramp is 60 cm wide and ends at least 2 m from the platform (horizontal distance). On the ramp, there is a gate that gives 1 point for passage.

• Up and down the stairs

The second option for descent is the staircase (see figure 4), which 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 giving 1 point for passage.

Passage for going up the stairs gives additional points for each passed gate (ie up to 4 points for going down and back up the stairs).

• Closed Tunnel

The tunnel (at 6) is mounted with an outward going door at each end. The doors are 25 cm high (see figure 6). The front door is the widest - so it can be pushed open from the outside. The doorways have the same dimensions as a gate, but they are not yellow. It gives 1 point to open and pass through each of the doors. This gives an additional 1 point per door if the doors are subsequently closed. The door is only considered closed if the opening is less than 2 cm (4 points in total).

The tunnel is taped to the floor.

• The racetrack

The race track (from 7 to 8) starts and ends with an

Figure 6: Tunnel with the wide door open. The doors are 1.5mm iron plates and both open outwards.

electronic gate. The gates are aluminium profiles, with internal dimensions similar to the other gates. When a light beam is broken in the starting gate, timing starts and it stops when a corresponding light beam is broken in the end gate. The light rays are located approx. 7.5 cm above floor level. 0, 1, 2 or 3 speed points are given. It will require an average speed of more than 1 m/s to achieve maximum points on this challenge.

It must be the same (satellite) robot to activate the start and end gate.
Less than 0.5 m from the start gate is the rotation axe challenge.

Figure 7: Axe gate, with a gate shown beyond.

• The axe gate

The axe gate (at 10) is a rotating axe that periodically blocks the passage of 2 gates.
The axe is made of plywood, with dimensions as shown in figure 7. The axe rotates with approx. 1 turn 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 for an examination table - clearance height 67 cm). Each of the 2 gates gives 1 point.

• The three gate

The 3-gate (at 11) has 3 gates placed on a circular plate – see Figure 8. The gates are placed radialy on the plate and form an angle of 120 degrees. The plate is approximately 25mm thick and has a diameter of 120cm. 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.
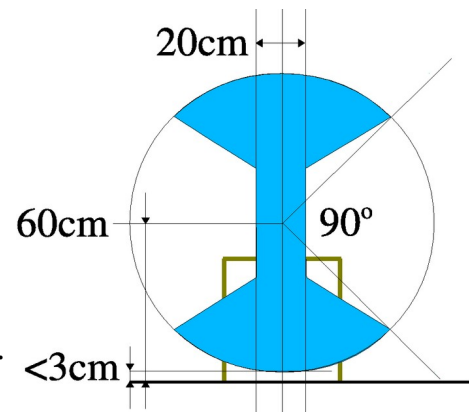
Figure 8: Treport er en cirkelformet forhindring uden tape linjer. Der kan opnås 3 point for denne forhindring.

• Apple picking

Two "apple" trees (at 12) each carry 3 apples, 3 white and 3 red/orange. These are to be sorted and placed in the two barskets. The apples are golf balls.
The apple trees (see figure 9) has a foot that is 11 cm in diameter (green) a stem (a black 8 mm carbon fiber tube) and some plastic leaves on the top. The apple branches ends in a small ring (about 6 cm from the stem) that carry the apple. The lowest apple is about 10 cm from the ground level. The trees are fairly easy to overturn – and that is allowed.
The trees are in a field fenced with a

Figure 9: Apple tree details.

~10 cm high wodden fence. The field is ~2.5 m x 3 m and the openings are ~45 cm wide.
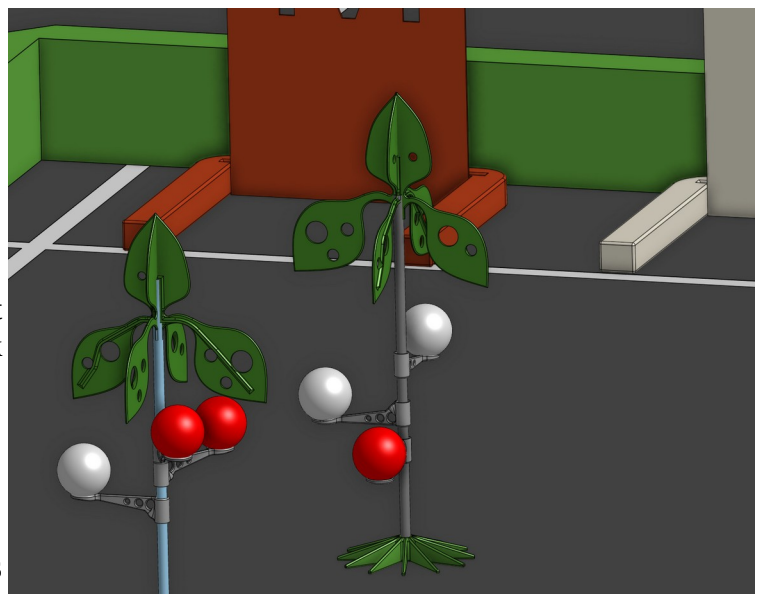
The two baskets are U-shaped frames in the far end of the field. The opening of the barskets is 20x20cm (red and white in figure 1 and 9).

An apple is in the barsket if it is fully within the 20x20cm barsket area. 1 point is given for each apple in a barsket up to 4 points. An additional point is given if the apple is in the right barsket, i.e. red/orange apples in the red barsket and white apples in the white barsket, up to a maksimum of 4 additional points. Maksimum for this challenge is 8 points.

A vertical panel is marking each of the two barskets with an ArUco code (not with a W and M as in figure 1). The ArUco mark is 15x15cm and has number 19 for the red and 5 for the white barsket, as shown in figure 10.

Figure 10: ArUco markes on the apple barskets. The markers are generated by: https://chev.me/arucogen/.

The ArUco markers can be detected by e.g. OpenCV code, see e.g.
https://docs.opencv.org/3.1.0/d5/dae/tutorial_aruco_detection.html
The fence and the barskets are taped to the floor. The trees will be at a marked position at the start of the run, but the relative position of the apples can not be garantied to be at the same position.
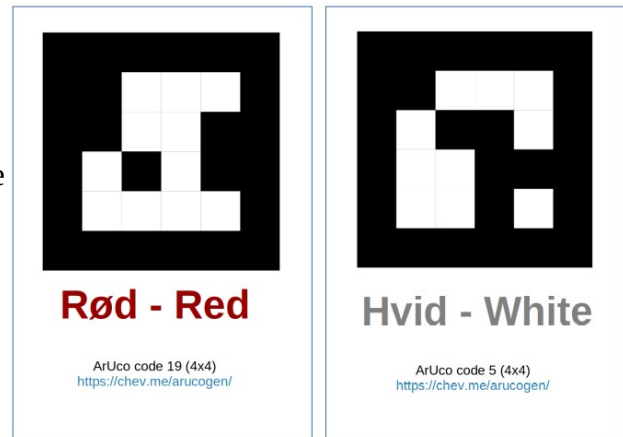
• Autonomous robot at roundabout

A robot is trapped in a roundabout (at 13). It runs right (clockwise). The robot is approx. 17cm wide and 25cm long (see Figure 11). 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 0 to 50 cm/sec. If the robot is pushed, or for some reason loses the line, it will stop, but still, it should not be touched.

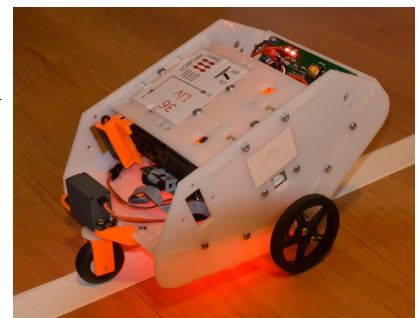Placement of an obstacle or other actions that prevent the robot from driving counts as a touch.

Figure 11: Autonomous robot

• The siren

The goal siren (at 9) is activated by pressing the front plate (which mechanically activates a switch). The front plate is approx. 15 cm wide, 10 cm high and recessed approx. 1 cm in relation to the frame. 2 points are scored to get to the goal (and activate the siren).

When the goal is activated, the run is over.

• Reliability

There is two runs on the track, and if the same score is acheived in both runs, one extra point is given.