Location and design of the track

(Translated to English, the Danish version has priority if there are contradictions)

The course is located at DTU in the library room in 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.

Note that the tape stripe is white on a relatively dark floor covering.

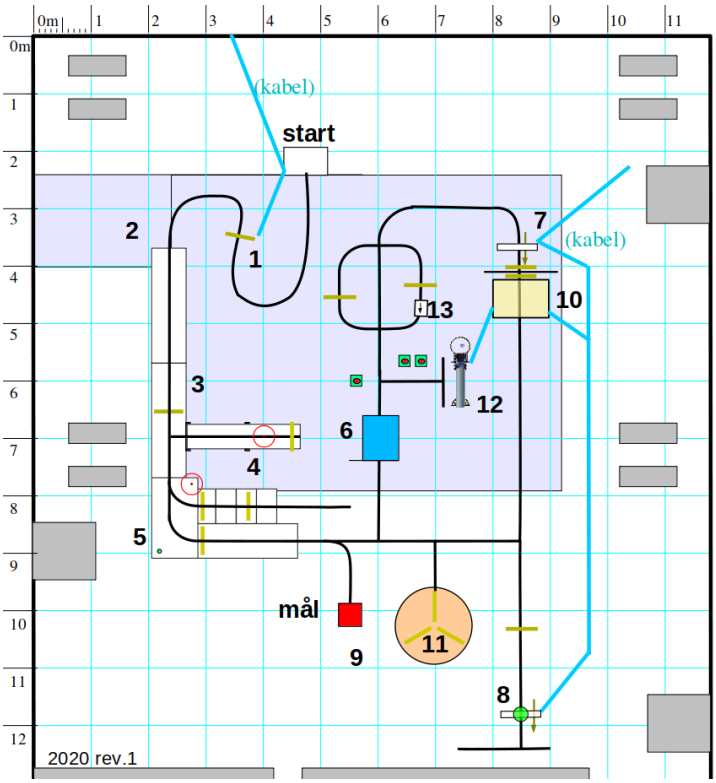


Figure 1: Track sketch 2019. Each challenge is marked with a number, which is referenced in the text.

• 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 (bluish) 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 angular 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 smaller distance between the panels (see also figure 4).

The other grey areas are either column, stairs or floor level, and should not be considered as navigable.

Figure 2: guillotine gate (Marked as 1 on the track sketch) and example of a white line on the wooden floor.

• Canvas tapes and power cables

The line is made with 38 mm wide white tape of the type (type Tesa-4651).
The tape will be placed roughly as shown with black lines 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, roughly as shown on the sketch as blue lines. 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.

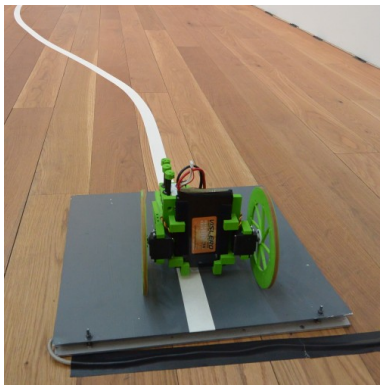


Figure 3: starting plate – here shown on a wooden floor.

• Other conditions

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

There is no 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.

• 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, countdown to start 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 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.

• The ramp

The ramp (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** (3). 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. 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

At the position (4) 30 cm from the seesaw support point and on the ramp platform is placed golf balls, both marked with a red circle on the track sketch. These balls must be brought with the robot and placed in the hole on the platform (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 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.

At (5) there are mentioned golf holes - see figure 5, in which the golf balls must be placed to obtain points for these. Each ball triggers one point (maximum 2 points). The hole diameter is 52mm.

Figure 5: Platform with a hole for the golf balls

• 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 on each approx. 11 cm. Each step is approx. 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).

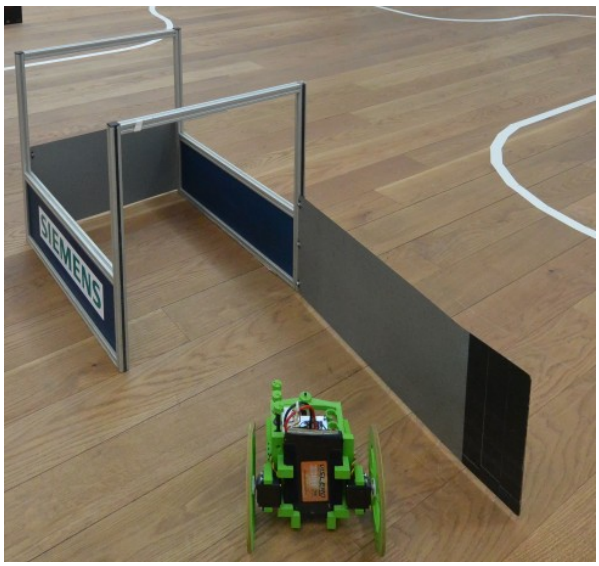


Figure 6: Tunnel with the wide door open. The doors are 1.5mm iron plates and both open outwards.

• Closed Tunnel

The tunnel (6) is mounted with an outward door at each end. The doors are 25 cm high (see figure 6). The front door is the widest - so it can be pushed up 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 2cm (4 points in total).

• The racetrack

The race track (7-8) starts and ends with an 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 first 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.

The starting gate (7) must be passed in the direction of the arrow. It must be the same (satellite) robot to activate the start and end gate.
Less than 0.5m from the start gate is the rotation axe challenge.

• The axe gate

The axe gate (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 (90x60 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.

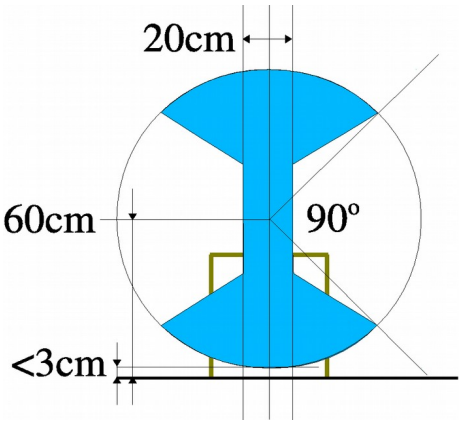


Figure 7: Axe gate, with a gate shown beyond.

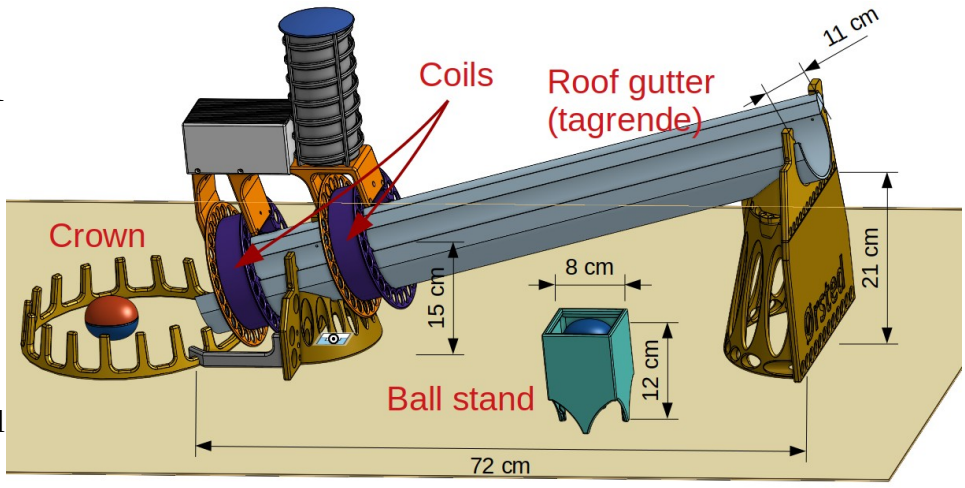
• The 3-gate

The 3-gate (11) is 3 gates placed on a round plate – see Figure 8. The gates have an angle of 120 degrees. The plate is 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.

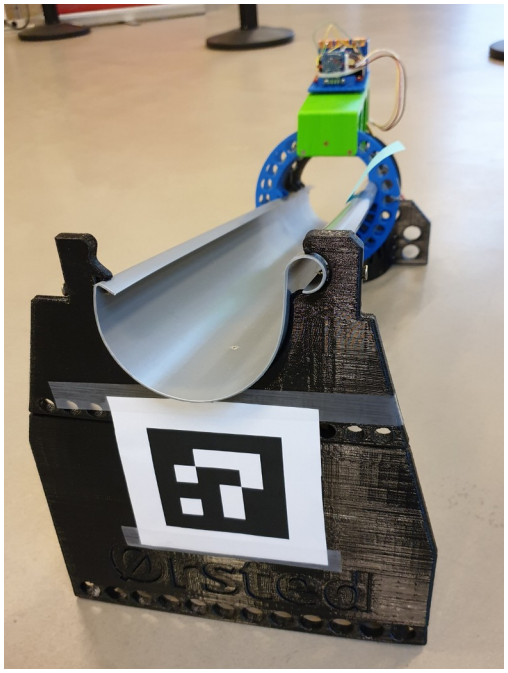
• Ørsted

At (12) is the Ørsted challenge and 3 magnetic balls - see Figure 9. This challenge gives 1 point for each ball placed in the Crown.
If the ball passes through the Ørsted coils, it can give up to 3 points depending on the speed. It typically gives 1 point to roll from the low end and 2 points from the high end of the gutter. The balls are slightly ellipsoidal (5cm diameter on the short axis and 6cm on the long) with a built-in rod magnet along the short axis.



Figur 9: Ørsted challenge. Rolla a magnetic ball from the ball stand down the gutter and get points for speed and that the ball remains within the crown.

Red and blue colours could indicate the north and south poles of the magnet shown in Figure 9. The shape promotes the ball rolling in a way the coils can detect. However, it is possible that the ball slides with the magnet across the coils and may therefore not be detected.
Speed points are given after the fastest ball.
There are 3 balls on the course, each placed in a square ball holder (Ball stand in Figure 9), these are located on the course as outlined in Figure 1 (green square with red ball).
In total, the challenge can give up to 6 points.
An ArUco code will be placed on the high end (see Figure 10), a 4x4 code with the frame size of 8cm (**http://chev.me/arucogen/** , For ArUco application see, for example,



Figur 10: ArUco code ID is 4.

https://docs.opencv.org/3.1.0/d5/dae/tutorial_aruco_detection.html).
The gutter slopes 15 degrees from the horizontal. The magnet in the spheres is cylindrical with 10mm diameter and length 4cm, neodynium N40 (S-12-40N from https://www.supermagnete.dk), each pole is thus approx. 0.5cm from the ball surface. The ball can easily be lifted out of the ball holder with a corresponding magnet.
The Ørsted challenge is essentially 3D printed from Onshape drawings (**https://cad.onshape.com/documents/6c25144fb6b5ecc925149214/w/343c2e2cc8b54c4f216126ad/e/cac34d0bc25742f49a12635d**), to get relevant STL files email jca@elektro.dtu.dk.

• Autonomous robot at roundabout

A robot (white square at 13) is trapped in a roundabout. It runs right (clockwise). The robot is approx. 17cm wide and 25cm long (see Figure 10). The robot must not be touched and it gives -1 point for each touch (but maximum -2 points). The speed will not be constant but be within the range of 0 to 50 cm/second. 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.

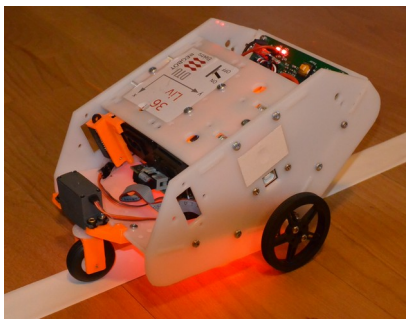


Figure 11: Autonomous robot

• 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.