
## SETTING THE SCENE

A new rapid personal transport system (RPT) has been put into service in your city. It connects the main centres of interest and allows you to move about efficiently while protected from bad weather. You avoid the roads in pods hanging from a rail network.

Your city has opted for the latest generation of this system, in which the pods use lithium batteries as a power source, avoiding constraints related to electrification of the rail network. In addition, vehicles communicate with each other to optimize travel and continuously transmit their operational status.

You have been mandated to monitor the operation of the RPT by performing routine maintenance on the pods. You must ensure that they are in perfect condition and then put them back on the rail.

## GENERAL FUNCTION OF THE ROBOT

You will need to design a robot capable of picking up the pods from the ground, moving them and then attaching them to the rail so that they can return to service. However, you must take into account the alerts you have received:

- You have received an alert that the battery temperature of one of the pods is abnormally high and needs to be replaced. Your robot will have to retrieve the pod whose battery is overheating and go to the electrical maintenance area for repair. The pod will have to stay in the electrical maintenance area for at least 5 seconds to allow the battery to be repaired. The pod will then be able to be installed on the rail.

- A passenger has forgotten a bag containing his hockey equipment in one of the pods. It is heavier than normal. You will need to recover it and go to the area for lost items. A team member there will be able to remove the bag from the pod. The pod can then be installed on the rail.

**For the Senior White level**, you will know in advance the location of the pod that is too heavy and the location of the pod whose battery is overheating.

**For the Senior Black level**, the robot will have to identify which pod is too heavy and which pod has a battery that is overheating. This one will be marked in red.

**For the Senior+ level**, the robot will have to determine which pod is too heavy and, with the aid of a temperature sensor, identify which pod has a battery that is overheating. You can design your sensor yourself.

## DESCRIPTION OF THE ROBOT:

The dimensions of robots participating in this challenge must not exceed the following limits:

A. Length at the start: 30 cm
B. Width at the start: 30 cm
C. Height: no limit
D. Mass: no limit

The challenge for Black or White levels can be achieved using only LEGO pieces. **However, the following elements are allowed in the challenge:**

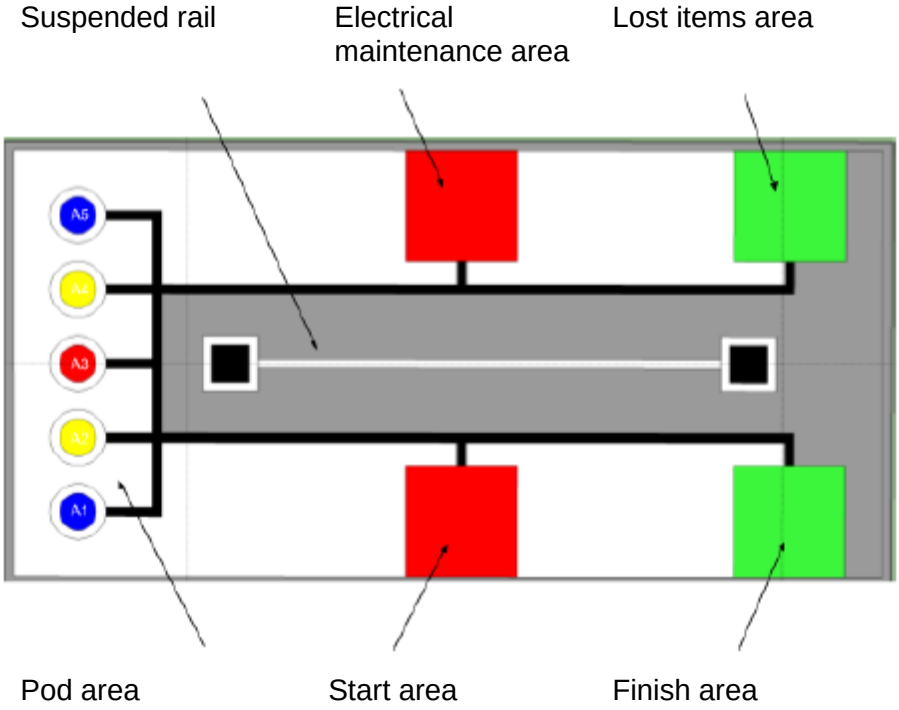
1. Replace the LEGO EV3 or NXT brick with another microcontroller card (Arduino, Raspberry PI, home card, etc.) and its software.
2. Use 3D printing to make the clamp used to pick up the pods. However, the mechanism for raising the pod must use a LEGO engine.

3. Use sensors other than LEGO or homemade ones, however do so without exceeding a total of four sensors on the robot (the rotation sensors integrated into the engines are not counted).

**The rest of the robot must be made of LEGO pieces and must use LEGO motors (NXT or EV3).**

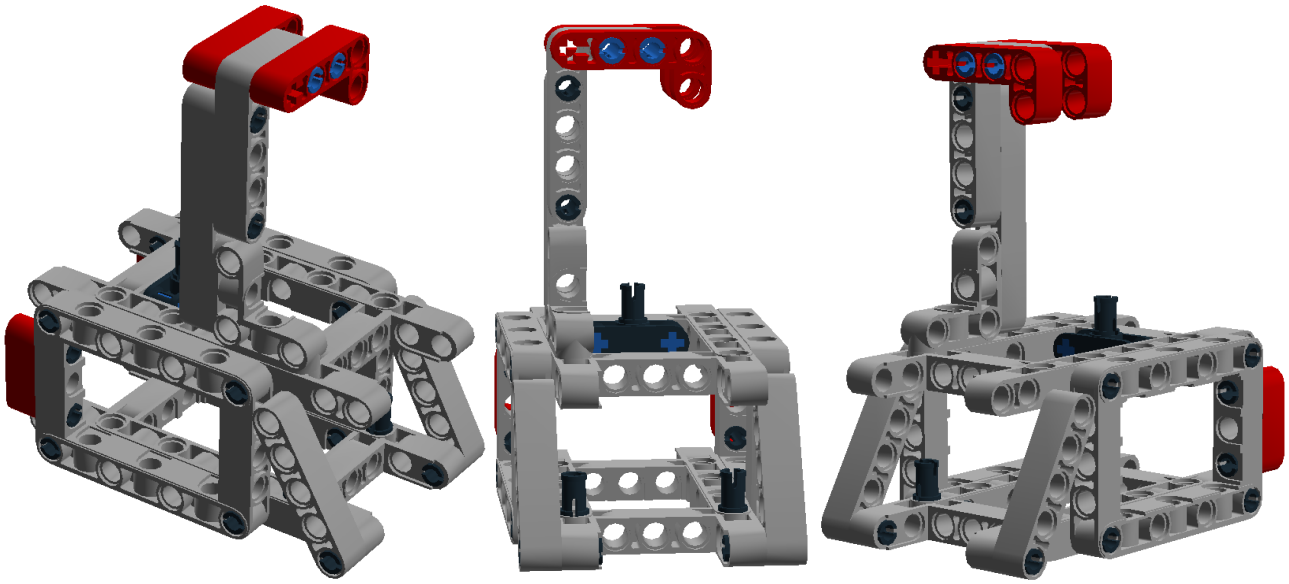
## DESCRIPTION OF THE SURFACE AREA:

### Surface used: Z01-F mat



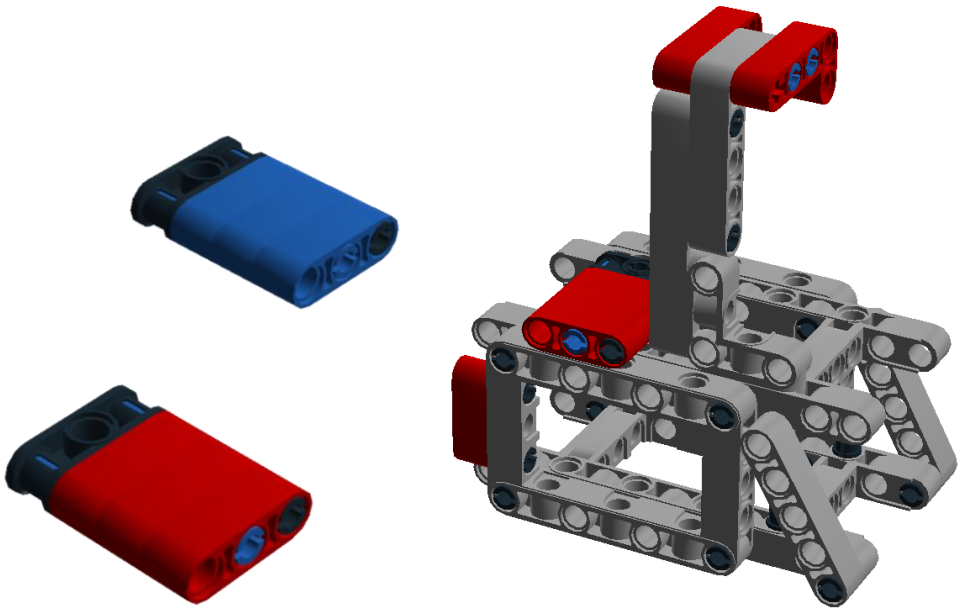

## Description of accessories:

**a. Aerial pods**



There are 3 pods. Each pod weighs 50 grams. One pod contains an additional weight of about 69 grams representing the hockey bag. The weight is made of a non-ferromagnetic metal material, copper. It is made from 3 plumbing sleeves of 19mm in diameter (¾" coupling). The sleeves are flattened with a hammer and held with tape.

In the White and Black levels, the top of two of the pods will be Blue (battery at the right temperature) and the other will be Red (battery that is overheating).



In the Senior+ category, instead of coloured Lego pieces, a non-ferromagnetic metal part of the same size will be deposited on top of each pod by the judge at the beginning of the test. This piece represents the battery. The temperature of one of the metal parts at the beginning of the test will be greater than 50 degrees (heated to 60 degrees). This temperature will gradually decrease because the heat will dissipate.

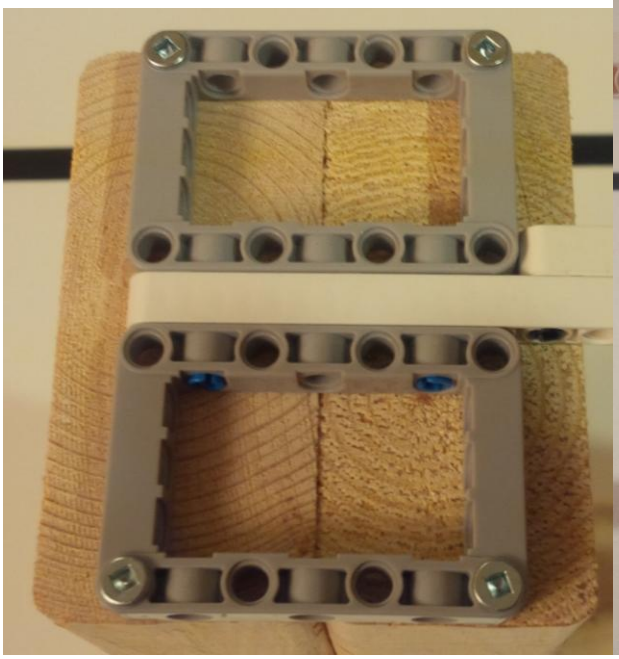
The metal part may be manufactured from a plumbing sleeve of 19 mm in diameter (¾" coupling), flattened with a hammer, folded in half and pierced with a 4.8 mm diameter hole (3/16”).

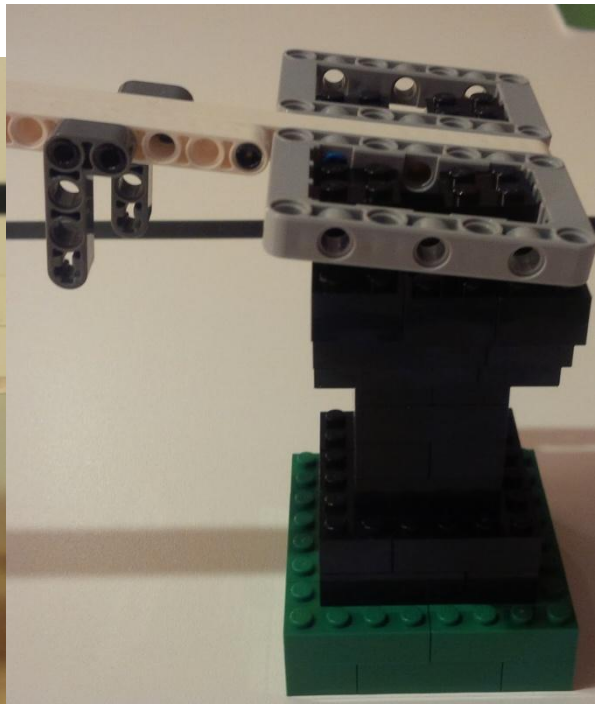
The battery that overheats will not be on the pod containing the hockey bag.

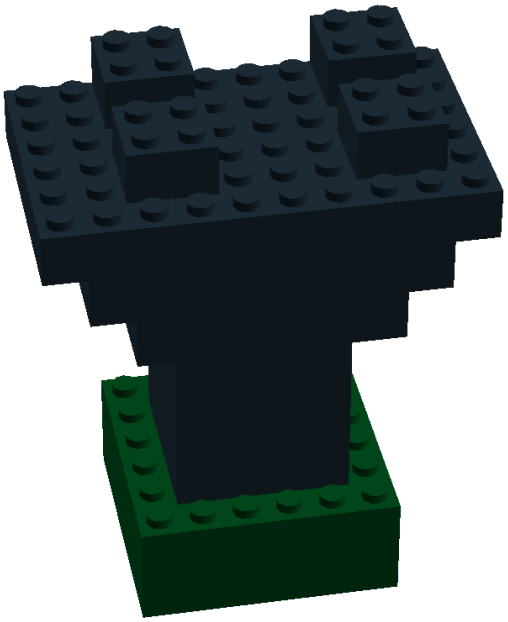
### b. Rail et supports

The rail is made of 24 15-hole beams and frames at the ends. The frames at the ends are firmly attached (screwed) to a wooden support. The other end is placed on a support made of LEGO bricks.

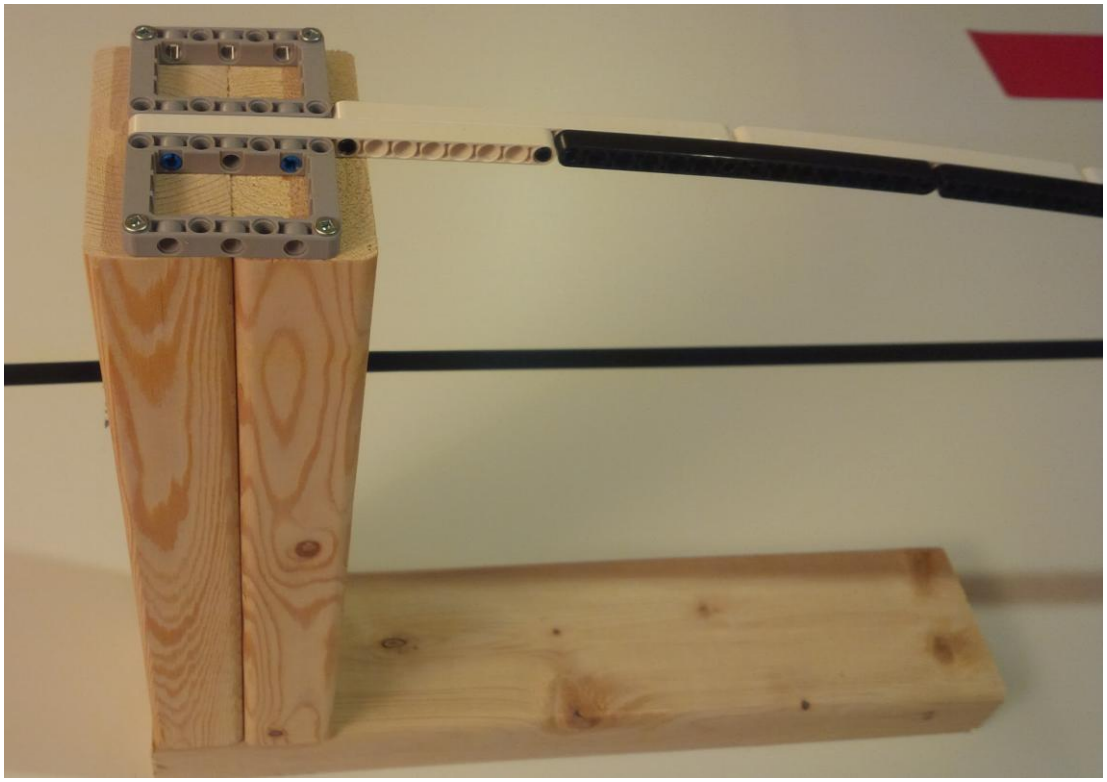
The black section of the rail defines the place where the robot can hang the pods.







The wooden base is made of three pieces of 1 ½" x 3 ½" (2X4) wood screwed together. Two 30 cm pieces form the vertical part and a piece of 40 cm is attached horizontally below. The latter extends beneath the rail in the area for fastening the pods.



It is intended that the rail creates a slope on which the pods will slide.

**Alternative supports for classroom practice**

Instead of the long rail of 25 beams, a simpler assembly can be achieved in class with only 14 15-hole beams or with available beams without the sloping section.

## DETAILED DESCRIPTION OF THE CHALLENGE

| WHITE level | BLACK level |
|---|---|
| The White level of this challenge is for teams of beginners. The challenge is kept as simple as possible by keeping the problems to solve to a minimum. For students with more experience, we recommend the Black level. | The Black level of this challenge is for teams with more experience. Students encounter the challenges of designing and programming at their level. |
| **Time allowed** | |
| 3 minutes | |
| WHITE level | BLACK level |
| Programming: □□□<br>Design:□□□<br>Strategy:□□□ | Programming: □□□<br>Design:□□□<br>Strategy: □□□ |
| **Recommended hardware** | |
| 1. Colour sensor<br>2. Temperature sensor<br>Other sensors (force, temperature) as needed | |
| **The challenge step by step** | |
| WHITE level | BLACK AND SENIOR+ levels |
| 1. The team presents itself with its robot, which it places in the start area (red square). | |
| 2. The judge places each of the 3 pods in the A2, | 1. The judge places each of the 3 pods in the A1, |

| | |
|---|---|
| A3 and A4 locations. He adds the red battery in A3, the blue batteries in A2 and A4 and the weights in A4. The orientation of the pods is up to the team. | A3 and A5 locations. He randomly adds to the pods 1 red battery and 2 blue batteries (1 hot battery and 2 cold batteries for Senior+), then randomly, the weight in a pod with a blue battery (cold battery for Senior+). The orientation of the pods is up to the team. |
| 3. At the signal, the judge starts the timer and the team starts its robot. | |
| 4. The robot then moves towards the pods it must check before hanging them one by one on the overhead rail. The robot cannot possess or touch two capsules at the same time. | |
| 5. If the pod is heavier than normal, the robot must bring it to the lost items area where a team member can remove the weight (hockey bag). The robot can then attach the pod to the rail. | |
| 6. If the pod contains a battery that is overheating, the robot must bring it to the electrical maintenance area for it to be replaced. The pod must remain in the maintenance area at least 5 seconds to simulate the replacement. | |
| 7. The robot earns extra points if it manages to remove the pods from the rail in the unhooking area (lower area of the rail) and place them on the ground. | |
| 8. The timer is stopped when the robot is completely in the arrival area (green) or when the team says STOP. If the robot leaves the area before the timer stops, a penalty will be applied. | |

## SCORING

| | MAX PTS |
|---|---|
| 10 points per pod brought to the rail area, the gray area (3) | 30 |
| 25 points per pod hooked to the rail (3) in the upper section of the rail | 75 |
| 20 points for having recovered the hockey bag in the lost items area | 20 |
| 20 points for having repaired the battery that overheated in the electrical maintenance area | 20 |
| 5 points for each pod that moves on the rail until the unhooking area (3) | 15 |
| 10 points for each capsule unhooked from the rail by the robot in the unhooking area (3), the lower section of the rail | 30 |

| | |
|---|---|
| 5 points for finishing in the arrival area (green) | 10 |
| **Total** | **200** |

## PENALTIES

| | |
|---|---|
| If the hockey bag is mounted on the rail | -10 |
| If the battery that is overheating is mounted on the rail | -20 |
| If the rail or a support is damaged | -40 |
| If the robot leaves the surface BEFORE the stopwatch is stopped | -10 |

## SUGGESTED STRATEGIES

| WHITE | BLACK | SENIOR+ |
|---|---|---|
| 1. Go step by step and decide the order<br>2. Use the markings on the mat | 1. Be sure to identify the colour of the pods<br>2. Find a way to weigh a pod | 1. Find a way to weigh a pod<br>2. Create your temperature sensor |

## EDUCATIONAL CONCEPTS

Thermal capacity
Force and torque
Battery technologies

## FAQ

**Q1: Are the rail supports attached to the surface?**

Answer: The support made of wood is attached to the game mat using double face tape. The LEGO support is not attached.

**Q2: When removing the weight from the pod in the lost items area, can the team take the pod, remove the weight, put the pod back on the robot and press a button to restart the robot?**

Answer: Yes, this is allowed.

**Q3: The pods do not slide very well on the rail. Is an action from the robot allowed to make sure they slide?**

Answer: Yes, this is allowed. Once the pod has been pushed out of the black rail by the robot, a team member may help the pod moving if it does not slide by itself to the bottom of the rail.

**Q4: Is there a specific unhooking area?**

Answer: The 8 last 15-hole beams are considered as the unhooking area or lower section of the rail. The pods can be unhooked in this area and placed on the ground in any orientation.

**Q5: What is considered a damaged rail or support?**

Answer: The rail is considered as damaged if it cannot perform its intended function anymore (ex: rail broken, rail out of its support, support no more standing up or broken). It is not considered as damaged only moved from its original position (LEGO support).

**Q6. Is there a mandatory orientation for the pods on the rail?**

R6. You can choose any orientation but the pod has been designed to slide easily when facing forward.