## 0.1 Brainstorming (21.09.2015)

***Time frame:*** 21.09.2015 17:00-21:00
***Preview:*** Since this year FTC rules were published, every member of our team had carefully read them. Today we gathered together to discuss all the aspects of this year gameplay and think of how to get on with the most significant features of the game.

***General aspects:***

| Features | Solutions | Label |
|---|---|---|
| Moving to the ramp is essential to achieve high score. | Robot's wheel base should be good at moving on the ramp. | chassis |
| Space between each two bars in 3-rd zone is wider than the standard TETRIX wheel diameter. | Using tracks or 3-4 wheels from each side of the robot will prevent robot from getting stuck. | chassis |
| It will take a lot of time to climb to the 3-rd zone of the ramp. | It is possible to deliver debris to the highest goal with elevator standing on the 2-nd zone instead of climbing to the 3-rd. | elevator |
| Goals for debris have a very little capacity. | It is more preferable to collect cubes than balls. That's why we need mechanism to prevent balls from collecting. | gripper |
| Pulling up costs 80 points. It's not difficult to realise then. | At least 1 DC motor should be reserved for pulling up. It is possible to grasp the pull-up bar with hook and lift to it by reeling the cable. | pull up |
| Moving over the inclined plane and pulling up require high moment on motors. However, the number of motors is limited. | Robot should be light enough to decrease the moment required for moiving and, as a result, increase speed of moving. | weight |
| All the zones of red alliance are the mirror reflection of blue alliance's zones. | Robot should be symmetrical and capable of playing on both sides of field. | concept |
| Robot can grip 5 debris at once, when the maximal capacity of one bucket is 24 cubes. So, to fill one bucket robot has to repeat collecting and taking cubes to the goal 5 times per 1,5 minutes | Gripper for debris should be at the front side of the robot and extractor for scoring elements - from the back side. It will allow robot to go to the ramp backwards, so it won't need to turn around on the ramp before going down to collect debris. It will save some time. | concept |
| It's quite unconvenient to exchange ramps with your ally during the game. | We will negotiate with our ally about spheres of influence before each game. Additionally, there should be two autonomus programs for climbing onto both ramps. | strategy |
| The only main difficulty of this year autonomus period is that both robots in alliance have to fulfil the same tasks at the same place. So, there is a high risk of collisions between them. | A number of different programs for autonomus period are needed for easier adjustment to the ally's strategy. | strategy |
| It's not restricted to collect debris in autonomus period. | It will be useful to realise automatic collection of 5 cubes in autonomus period. At the conclusion of autonomus period the robot will remain on the ramp with 5 cubes and we will put them to the goal immediately | strategy |

***Detailed explaination:***

1. As we know from our previous FTC seasons experience, there are strict constraints for wheel bases can be used for climbing mountains. Firstly, omni and mechanium wheels are completely not suitable, because mechanium wheels can ride only on plain surface (when 2-nd and 3-rd zones have cross hurdles) and omni wheels have ability of undependable movement on small rollers so they behave very unstable on mountain. Various conbinations of standard and omni wheels can't be used too, as in the 2-nd zone there are obstacles which can cause some wheels lose contact with ground and if the rest of wheels will behave differently, the whole robot would be unstable. In conclusion, we can use only standard wheels or tracks.

   Additionally, wheel base should be symmetrical against central axis for stable climbing to the mountain.

   If we decided to climb 3-rd zone with standard wheels, we will have to put 3-4 wheels at the each side to avoid getting stuck on hurdles (the space between two hurdles is for about 14 cm, when the diameter of big TETRIX wheels is only 10 cm).

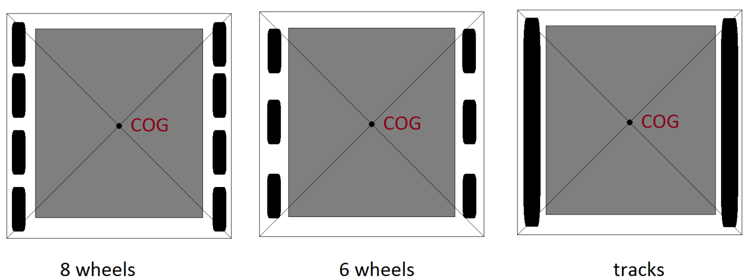



Рис. 1: possible wheel bases

2. To score in high zone goal from 2-nd zone robot should have a mehanism for delivering debris to the distance of 40 cm or more. Shooting debris is entirely unsuitable approach, because it's impossible to realise enough accuracy for stable scoring cubes and especially balls. Another way is elevator. There are three types of lifts which familiar to us: they're crank lift, scissor lift and retractable rails.

   Scissor lift is not suitable for this year competition, because despite it's main advantage - the ability of extracting the longest distances of all - it's too difficult in development.

   Crank lift allows to vary the angle of turning of each segment. However, it requires at least one DC motor of strong servo for every joint.

   Retractable rails can only move along one axis. However, they require the least space and can be equipped by one DC motor (as all the motors are connected to the only reel, which winds the cable).

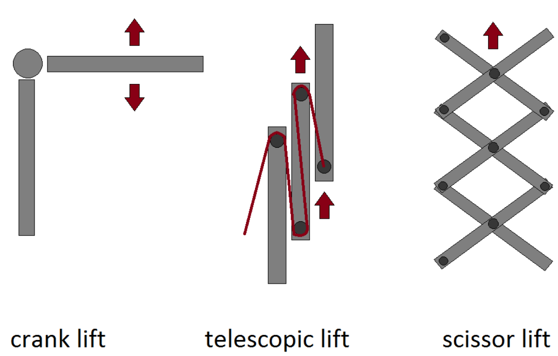



Рис. 2: types of elevators

3. The parameters of the box are $9 \times 5.75 \times 6.25$. So, it can contain at most 24 cubes (4 in length, 2 at width and 3 in depth). As for balls, there can't be scored over approximately 10 of them because of their unconvenient shape and ability of top balls to roll out of the box (especially from the upper box, which is turned on $50°$ from horisontal position).
   This is the reason to implement mechanism for separating debris into cubes and balls. However, there are only 50 cubes on field (12.5 for one robot), so they will run out quickly, so the ability of collecting balls is required as well.
   Additionally, we need to think of how to put cubes into boxes gently so as they will settle down in straight lines. It will allow entire filling boxes with cubes.

4. Solid constructions for pulling up will be too bulky because they have to be strong enough to withstand full weight of the robot. The more reliable and simple solution is steel cable with hook for grasping the bar on it's tail.
   In second case the most difficult objective is to deliver hook to the bar, which can be solved by creating secondary lift for it (the main one is a lift for debris). Mechanism for shooting hook towards the bar is not suitable as it can be dangerous for operators and spectators (if the it will be accidentally activated during the match).

5. The main weight of the robot goes the battery and motors. The weight of the battery is 570g. We have two types of motors: standard TETRIX motor (207g) and "NeveRest 40"motor by AndyMark (334g). The complete control system (phone + controllers + power distributor) weigh about 700g.
   Therefore, total weight of essential components varies from 2926g to 3942g (with 8 motors). With several beams (166g the longest), wheels (117g each) and other construction elements robot will weigh from 6 to 10kg.
   In our primary calculations robot's weight will be accepted as 10kg. However, it is preferable to make robot as light as possible.

6. Wheel bases which are good at climbing mountains are usually less manevrous, than carriages with omni and mechanium wheels. This way, the less robot will turn, the more effective it will compete.
   Accordind to this, it will be more convenient to realise construction that will allow robot to score debris without turning around. Robot can collect debris with gripper on it's front side while moving forward and then go backward to the ramp and score debris with the mechanism on it's back side.
   Furthermore, it will be useful to attach one robot to one ramp in order to prevent them from commiting extra movement. Although it seems that two robots can fill the top goal together two times faster, in fact they will just interfere with each other. So, it will be a good tactical step to negotiate with our ally before the mach which robot will operate with each mountain.

7. This year field is symmetric with respect to the diagonal. It means that all zones of one alliance are the mirror reflection of another. Consequently, the gameplay depends on which alliance you are playing for. So, the robot should be capable of executing equal tasks playing for each alliance. The major unconvenience cause releasing alpinists, as it requires two similar mechanisms from both sides, that will take 2 servos instead of 1. Mechanism For scoring debris should be summetrical to provide filling boxes from both sides of the ramp. Besides, autonomus program should be twoside as well.

***Additional comments:*** For the next meeting we need to think of two issues:

1. which tasks our robot should be able to execute without loss of efficiency
   and
2. to set the priorities of performing tasks during the game.

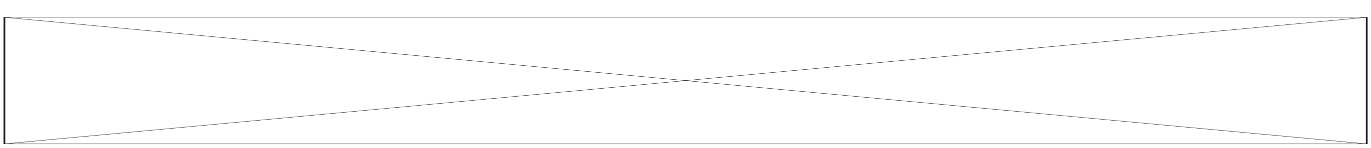
## 0.2 Strategy discussing (22.09.2015)

***Time frame:*** 22.09.2015 17:00-21:00
***Preview:*** Today we put the priorities during the building of the robot and performing tasks of the game.

***Detailed explaination:***

1. The tasks which robot must complete (We assume that robot can do everything. Tasks located in order of priority) :
   - 1.1. Autonomous period:
     - 1.1.1. Push the button and score climbers. It give 60 points (20 - button 10x2 - climbers in autonomous 10x2 - climbers in tele op).
     - 1.1.2. Ride to opposite mountain and collect balls and bricks. It help us to save a time because when start tele op we already have 5 bricks.
     - 1.1.3. Go to middle or high zone of the mountain. It give 40 (or 20) points. Additionally, we start driver control period near the top box. So we can put 5 bricks there immediately.
   - 1.2. Driver control period:
     - 1.2.1. Put elements that we collected in autonomous period to the top box.
     - 1.2.2. Go from the mountain and collect 5 bricks. We decided to collect only bricks because the balls take up much space in the box. So if we collect only bricks we can put more elements to one goal and get more points.
     - 1.2.3. Put 5 bricks to the top box. After that the top box most likely will be full. So we won't be able to put another five bricks.
     - 1.2.4. Collect and put 5 bricks to the middle box.
     - 1.2.5. Start moving to the crossbar and score climbers.
     - 1.2.6. Turn "all clear"signal.
     - 1.2.7. Pull-up.
2. Implementation of robot that can perform following tasks (tasks are in order of priority)
   - 2.1. Stable scoring to the middle box. This task is very simple and give a lot of points.
   - 2.2. Scoring to the high box. This task is more complex but gives more points.
   - 2.3. Releasing the climbers on the rope in driver control period. We can do it very fast and get 60 points but for scoring the top climber we must be able to climb to high zone.
   - 2.4. Scoring climbers in autonomous period. It is very easy task that give 40 points (as 4 bricks in the middle box).
   - 2.5. Riding to the high zone. It can give 40 points in autonomous period and 40 points in tele op.
   - 2.6. Pulling up. This task give the most number of points.
   - 2.7. Turning "all clear"signal. It gives us 20 points and our opponent lose 20 points.
   - 2.8. Pushing button. This task is difficult in terms of programming and gives only 20 points.

***Additional comments:***Task for the next meeting: to elaborate concept of the robot.



## 0.3 Concept discussing (24.09 - 02.10)

**Description:** The main purpose the following number of meetings was to develop a concept of the robot. It is an essential step before creating models and developing construction.

***Modules:***

| Modules | Conclusive solutions | Label |
|---|---|---|
| Wheel base | Six standard wheels | wheel base |
| Lift | Retracktable rails with the bucket on it | lift |
| Bucket for debris | Bucket mounted on rails that can overturn backwards to put debris into the box | bucket |
| Gripper | Rotating brush ahead of the bucket | gripper |
| Scoring autonomous climber and pushing button | F - shaped beam | climbers + button |
| Scoring climbers in tele op | Retracktable slat | climbers |
| Pulling up | A hook with the winch | pullup |
| Push the clear signal | Servo with beam | clear signal |

**Separation tasks between collaborators:**

| Collaborator | Modules | Label |
|---|---|---|
| Gordei Kravtsov | Wheel base | chassis |
| Aleksandr Iliasov | Bucket | bucket |
| Anton Ponikarovskiy | Elevator | elevator |
| Andrei Nemov | Gripper and slopes | gripper |
| Timur Babadjanov | Beam for alpinists | alpinists |

**Days inside section:**

### 0.3.1 24.09.15

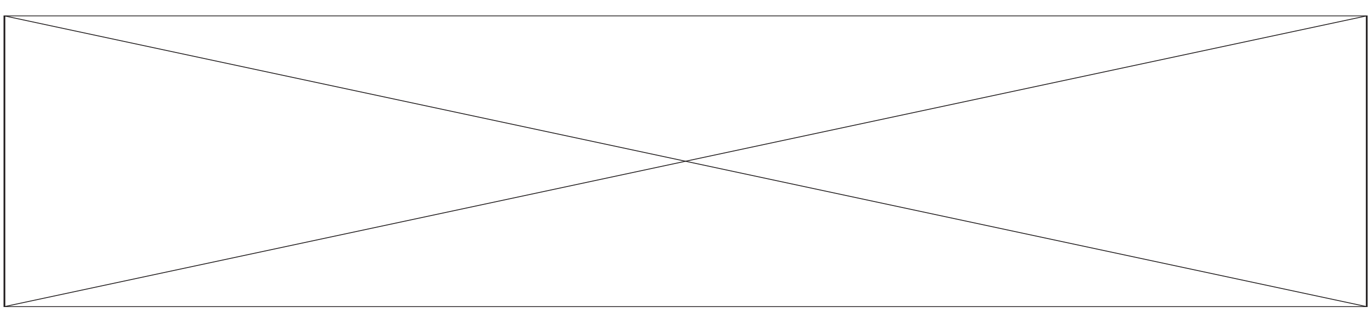
***Time frame:*** 17:00 - 21:30
***Preview:*** The main purpose for current meeting was to figure out how the modules of the robot should look and how they will be developed.

***Modules:***

| Modules | Solutions | Label |
|---|---|---|
| Wheel base | Six standard wheels with leaf suspension | wheel base |
| Lift | Scissor lift | lift |
| Gripper | Rotating brush and bucket | gripper |
| Scoring autonomous climber and pushing button | F - shaped beam | climbers + button |
| Scoring climbers in tele op | Retracktable slat | climbers |
| Pulling | Motor that reel the rope | pullup |
| Push the clear signal | Servo with beam | clear signal |

***Detailed explaination:***

1. Wheel base will consists of six standard wheels which rotates with help of six DC motors. It allows to climb to low and middle zone fast enough. The leaf suspension ensure stability in the middle zone.
2. We decided to use the lift in our robot. It help us to score elements to high goal from low or middle zone. So we don't need climb to the high zone. We choosed the scissor lift because it is compact and extend to a big height .
3. The robot will collect elements with help of rotating brush which pull them to the special bucket which connected with the lift. This method is the most simple and fast. After collecting elements the bucket rises by the lift. Then it overturns to the side and elements fall to the box.
4. We decided to make one mechanism for scoring autonomous climbers and pushing the button. It is the F-shaped beam. In the top beam is the bucket for climbers, in the bottom - axle which push button. When we turn this mechanism the axle push the button and in the same time climbers fall to the goal.
5. For scoring climbers in tele op we decided to use horizontal retracktable slat that move to the both sides by the whhel that rotate with help of servo of continuous rotation. When the slat extract it push to the hook that fix zip line.
6. The pulling mechanism is the 2 DC motors that reel the rope which connected with the hook that fixed on the lift. Also this motors rise the lift. When lift is rising the rope is extracting. When the robot pull up rope is reeling and lift is lowering.
7. For pushing clear signal we decided use the servo with beam that fixed on the lift.



### 0.3.2 26.09.2015

***Time frame:*** 17:00-21:00

***Tasks for current meeting:*** To improve the concept of the robot.

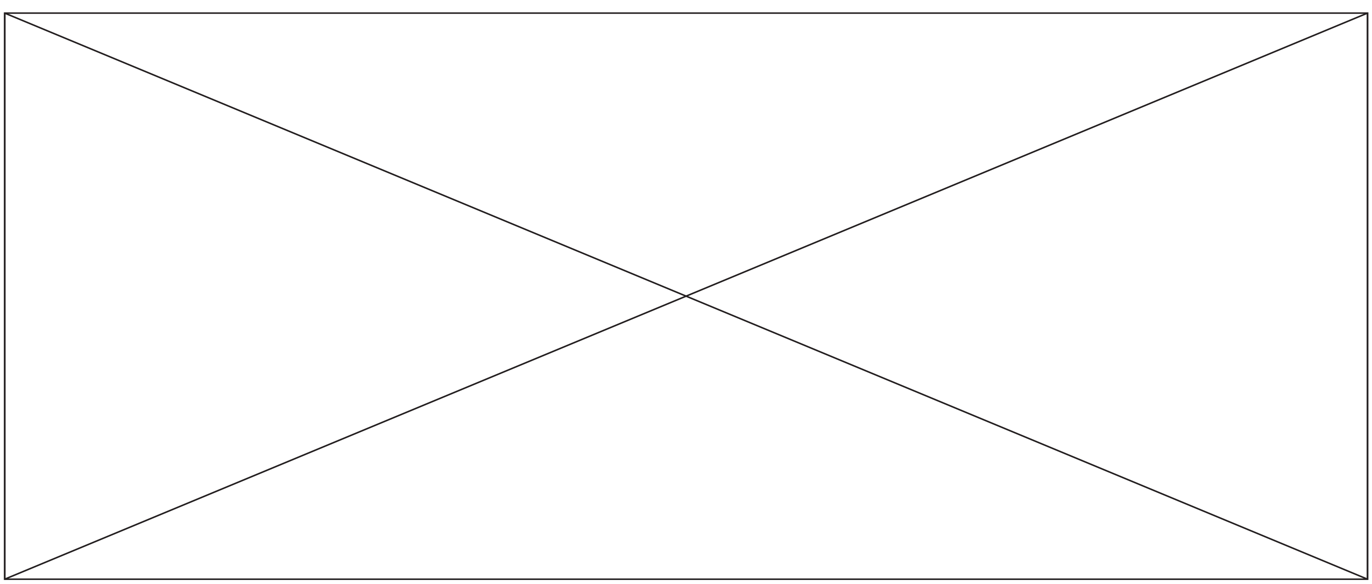
| Module | Solutions | Label |
|---|---|---|
| Wheel base | 6 standard wheels without suspension | wheel base |
| Lift | Retracktable slats | lift |
| Scoring elements | Bucket overturns back | gripper |

***Detailed explaination:***

1. We decided to refuse from suspension on wheel base because it is too complex and reduse reliability of the robot.
2. We decided to use lift that consists of retracktable construction profiles. This system is more reliable.
3. We decided to overturn the bucket back and turn the robot because when we overturn it to the side we need ride to the ramp very accurate. In addition when we overurn it to the side we need very long bucket.
4. We decided to score climbers in tele op with help of the servo which turn the beam (one servo on each side of the robot). This mechanism is more compact.
5. Also we thought that for scoring elements and pulling we need different angle of inclination of the lift. So we need the mechanism that turn it.

***Additional comments:*** What to do the next meeting.

1. To think of the mechanism that turn the lift.



#### 0.3.3 30.09.2015

***Time frame:*** 16:00-21:00
***Tasks for current meeting:*** To think about mechanism for turning lift.

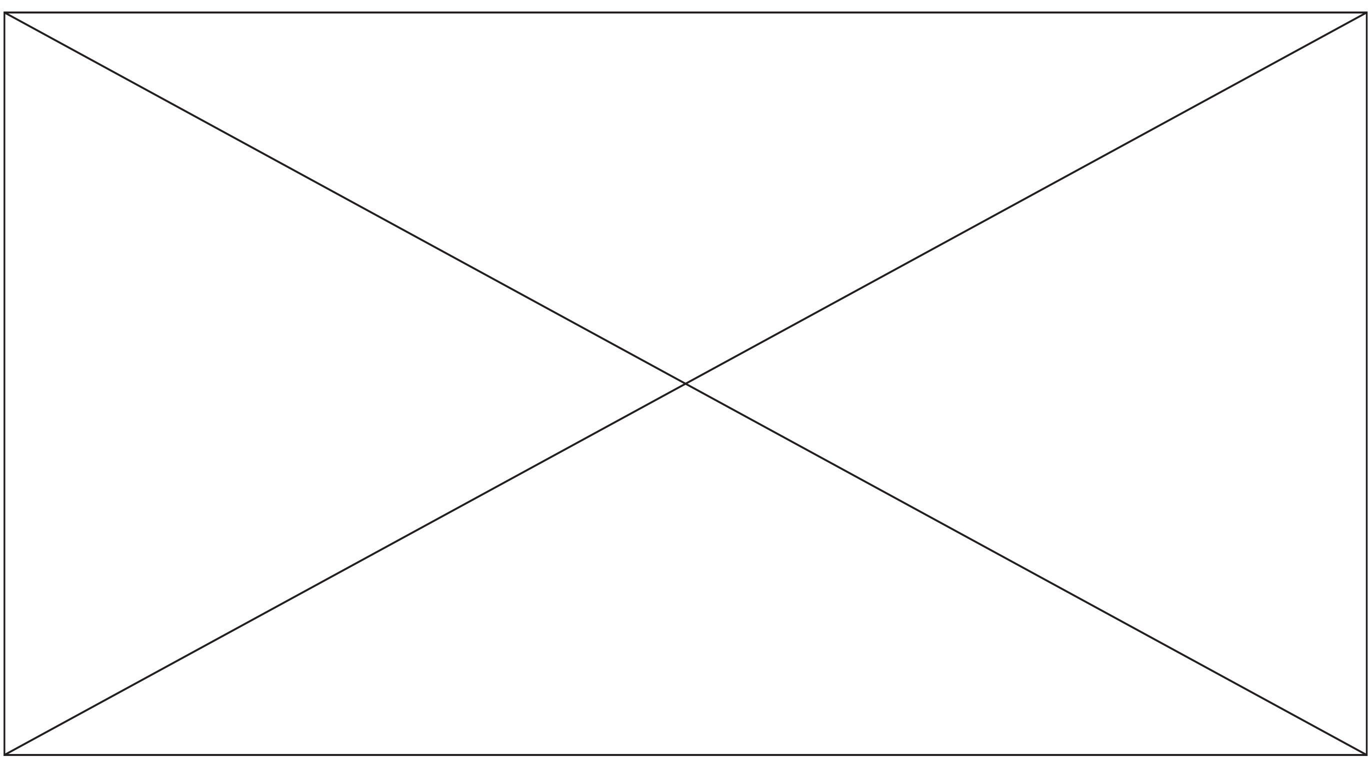
| Tasks | Solutions | Label |
|---|---|---|
| To elaborate mechanism for turning lift | Servo of continuous rotation with worm gear | robot |

***Detailed explaination:***

1. We made a drawing in GeoGebra where were estimated angles of inclination of the lift for scoring elements and pulling.
2. We looked the variant with DC motor and transmission for power but it take up much space.
3. We decided use the servo of continuous rotation with worm gear. The worm gear esure power and allow to keep position.

***Additional comments:***
Tasks for the next meeting:

1. To make a schematic model of the robot
2. To devide the robot into modules.
3. To make a technical task for each module and start parallel elaborating models of each module.



### 0.3.4 02.10.2015

***Time frame:*** 17:00-19:30
***Preview:*** The purpose of this meeting was to divide all construction works into 4 groups (one group for one teammate) to elaborate modules in parallel. After that, we wrote the technical specifications for each group of modules to help collaborators follow the requirements.

***Technical specifications for modules:***

1. Chassis
   1.1. Carriage consists of two lengthwise beams 41.5cm connected at the back. All other modules will be mounted to this base.
   1.2. Wheel base consists of 3 pairs of standard wheels. All wheels at one side are linked to each other and move together.
   1.3. Wheel base is powered by 4 dc motors (2 at one side).
   1.4. Motors should not interfere with the bucket, which will be placed in the front half of the robot.
   1.5. While the robot is climbing the ramp, no construction elements but the wheels should be touching the surface of the ramp.
2. The mechanism that turns the elevator
   2.1. A continuous rotation servo will turn the worm gear.
   2.2. It should be mounted on the side beam of the base.
3. Elevator
   3.1. Elevator consists of retracktable construction profiles which connected with help of special elements. The shape and size of these elements should be fit with grooves in profiles.
   3.2. It should be mounted on the turning mechanism.
   3.3. Length of the elevator should be enough for scoring debris into high and middle boxes from low zone and starting pullup from the middle zone.
   3.4. A thread and block system will provide lifting of elevator.
   3.5. The servo that turn clear signal should be fixed on the top of the elevator.
   3.6. The hook for pulling the robot up will also be mounted on the top of the elevator.
4. Bucket
   4.1. The bucket will be fixed to a beam turned by a servo on the top of the lift.
   4.2. Free space inside the bucket should be 10-14cm at width, 15-17cm in length and 7cm in height. It should be spacious enough to contain 5 cubes of 3 balls.
   4.3. To prevent gathering more than five cubes at once, the bucket will narrow down to the back (cubes will settle as $2+2+1$).
   4.4. The bucket's movement should not interfere with debris gripper.
   4.5. The entrance hole of the bucket should have the same height and width as the internal space.
   4.6. Bucket should have a turning flap above the entrance which can prevent balls from scoring not on demand. Additionally, the flap will stop debris from falling out of the bucket when it is be flipped over.
5. Gripper
   5.1. Gripper consists of 2 rotating blades which form a 180° angle.
   5.2. Gripper is powered by 1 or 2 continiously rotating servos.
   5.3. Gripper is placed in front the bucket. Blade width should match the bucket entrance.

- 5.4. Space between axis and field is enough for unhindered passage of balls.
- 5.5. Gripper should not pose any obstacle for bucket motion.
- 5.6. At both sides of the blade's working area placed slopes, which are tapering to the bucket.

6. Scoring autonomous climbers + pushing button

- 6.1. The mechanism for scoring autonomus alpinists will be placed at the front right side of robot. It's definite position will be determined after discussion of autonomus strategy.
- 6.2. Mechanism consists of F-shaped beam powered by standard servo.
- 6.3. At the end of top beam is a bucket for 2 alpinists. The bottom beam pushes the button.
- 6.4. Module should not interfere with gameplay after the autonomus period ends.

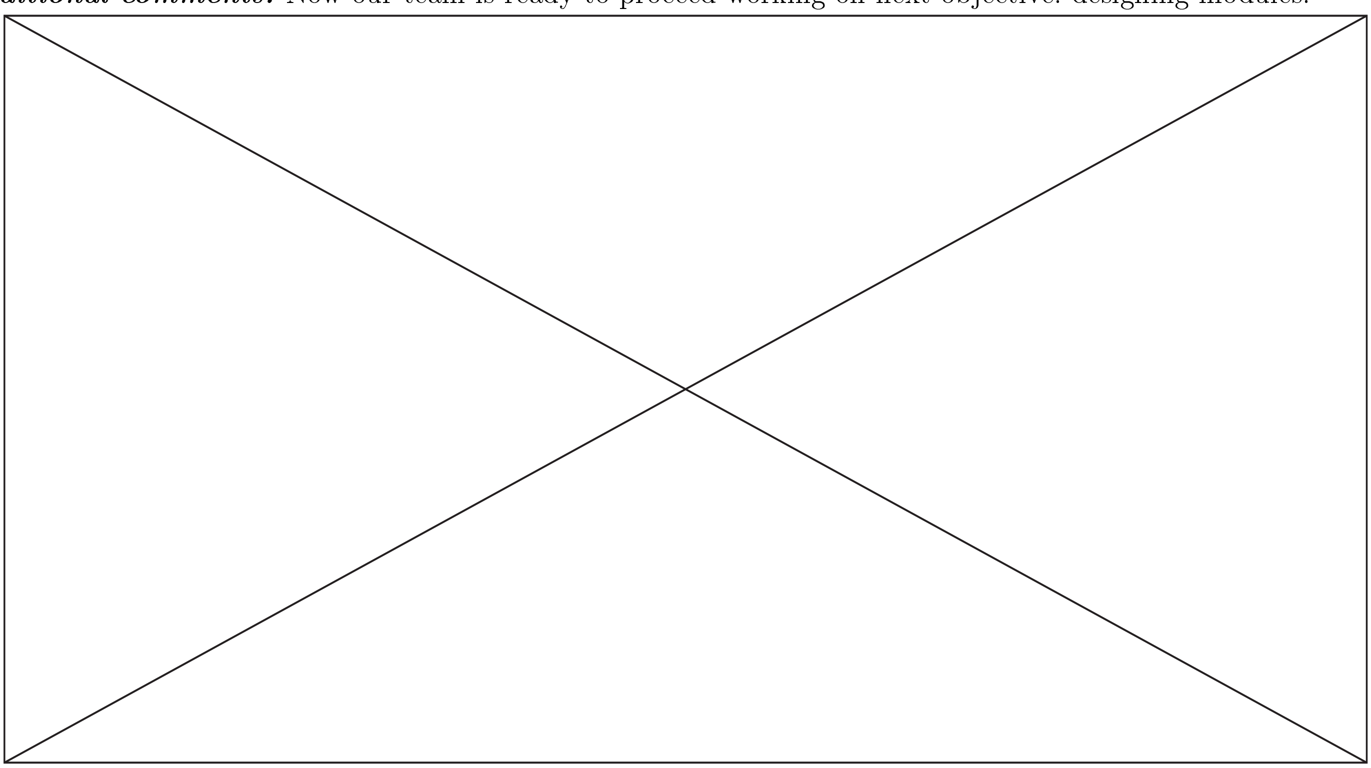
7. Mechanism for extracting lift and pulling

- 7.1. Two reels that are rotated by 4 DC motors.
- 7.2. The rope for pulling and line for extracting lift are in different reels. When the line wound the rope unwound and in other way.
- 7.3. It should be mounted on the back beam of the base.

***Responsibilities for each module:***

1. Carriage and wheel base - Gordei Kravtsov
2. Bucket - Aleksandr Iliasov
3. Elevator - Anton Ponikarovskiy
4. Gripper with slopes - Andrei Nemov
5. Mechanism for scoring alpinists - Timur Babadjanov

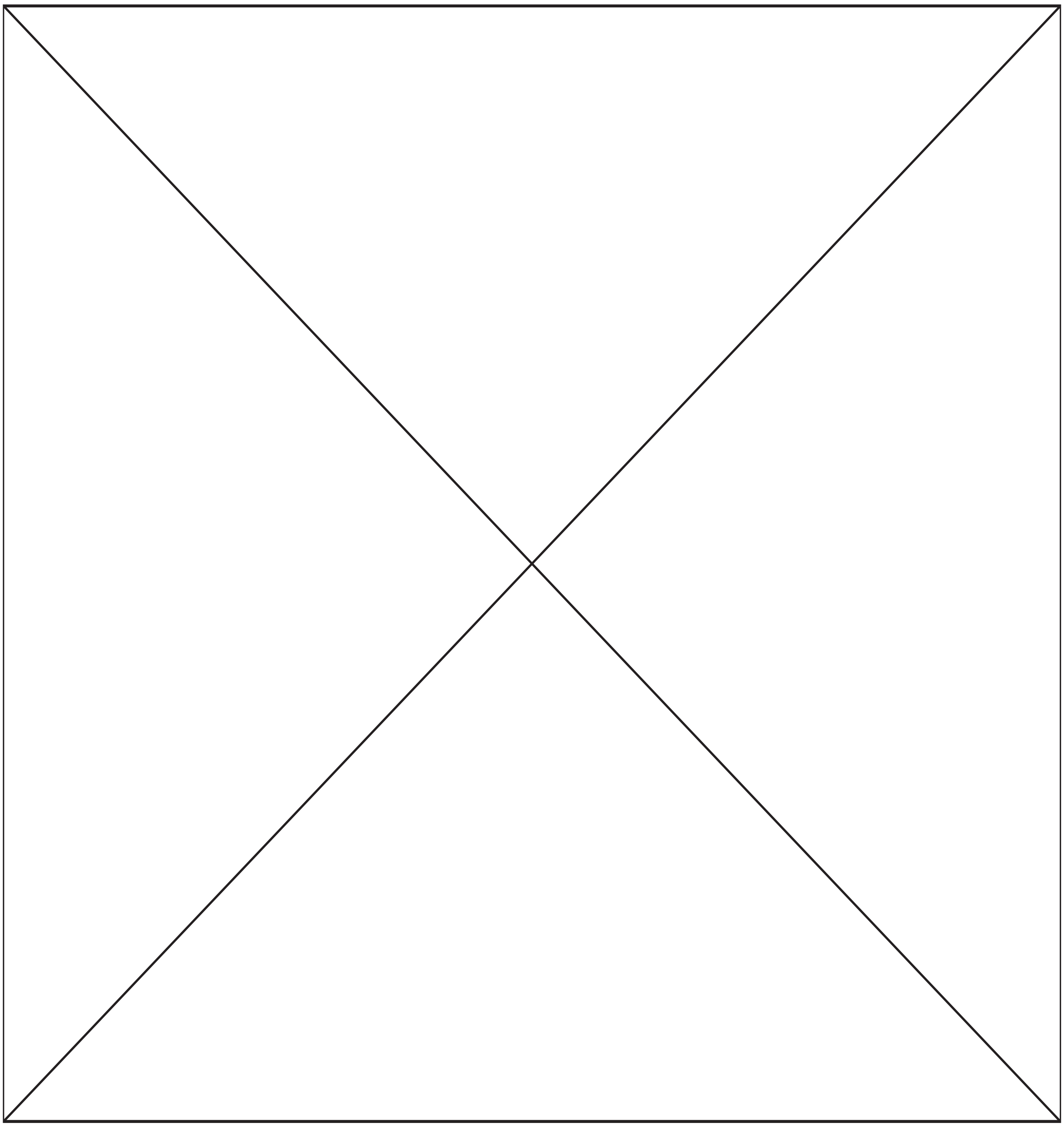
***Additional comments:*** Now our team is ready to proceed working on next objective: designing modules.



## 0.4 Designing modules (03.10 - 09.11)

**Description:** During this period there were pondered the main aspects in implementation of each module and were developed primary CAD models of modules. In the following section there are mentioned only results of this work. Further clarifications about the process of engineering are available in section "specifications for modules".

### 0.4.1 Wheel base



## 0.5 Team meetings (10.11 - 03.12)

**Description:** The following section contains a consequence of team meetings with short descriptions. The purpose of this is to present the elaboration of the robot in it's progress. You can find the full information about modules and program in sections "specifications of modules"and "specifications of programs"correspondingly.
**Days inside section:**

### 0.5.1 10.11.2015

***Time frame:*** 17:00-21:00
This day there were discussed the results of design work. All the models of modules were finished and we were able to start creating the robot.

### 0.5.2 12.11.2015

***Time frame:*** 17:00-21:30


Рис. 3: two sides of the carriage

### 0.5.3 12.11.2015

***Time frame:*** 17:00-21:30


Рис. 4: two sides of the carriage

### 0.5.4 12.11.2015

***Time frame:*** 17:00-21:30


Рис. 5: two sides of the carriage

### 0.5.5 17.11.2015

***Time frame:*** 17:00-21:30


Рис. 6: two sides of the carriage

### 0.5.6 18.11.2015

***Time frame:*** 17:00-21:30


Рис. 7: two sides of the carriage

### 0.5.7 19.11.2015

***Time frame:*** 17:00-21:30


Рис. 8: two sides of the carriage

### 0.5.8 21.11.2015

***Time frame:*** 17:00-21:30


Рис. 9: two sides of the carriage

### 0.5.9 23.11.2015

***Time frame:*** 17:00-21:30


Рис. 10: two sides of the carriage

### 0.5.10 24.11.2015

***Time frame:*** 17:00-21:30


Рис. 11: two sides of the carriage

### 0.5.11 25.11.2015

***Time frame:*** 17:00-21:30


Рис. 12: two sides of the carriage

### 0.5.12 27.11.2015

***Time frame:*** 17:00-21:30
Today we created two sides of the carriage. There were mounted 6 motors that will be applied for drive.


Рис. 13: two sides of the carriage

### 0.5.13 28.11.2015

***Time frame:*** 17:00-21:30
Today we created two sides of the carriage. There were mounted 6 motors that will be applied for drive.


Рис. 14: two sides of the carriage

### 0.5.14 29.11.2015

***Time frame:*** 17:00-21:30
Today we created two sides of the carriage. There were mounted 6 motors that will be applied for drive.


Рис. 15: two sides of the carriage

## 0.6 Specifications for modules

**Description:** This section contains detailed information the process of elaboration of each module in particular.

## 0.7 Lift and bucket for debris

### 0.7.1 Lift

The lift consists of two beams. One beam is stationar and it is fixed vertically on the back part of the robot. The second beam turns by DC motor that mounted at the top of stationar beam. The length of beams must allow to score debris to the high goal from the middle zone and to middle goal from low zone.
For estimating optimal length of beams it was made drawing in GeoGebra.

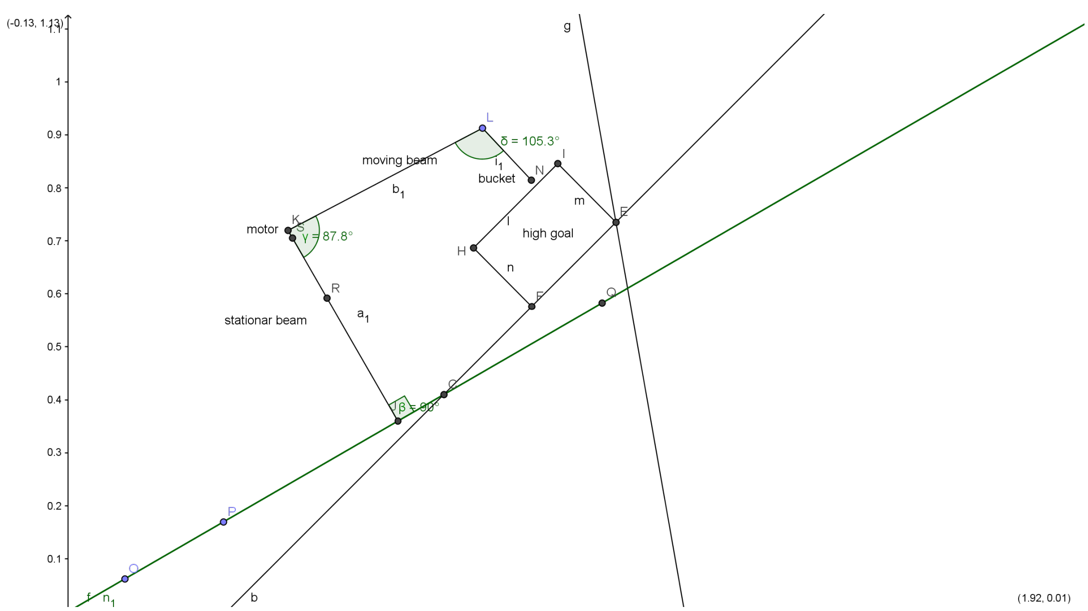



Рис. 16: Drawing of the lift

### 0.7.2 Bucket

The bucket's size allow to fit 3 cubes and 2 balls. So we can collect 5 cubes (because size of cube is smaller than size of ball) or 3-4 balls. It is enough for us because we want to concentrate on collecting cubes.
For estimating optimal size and form it was made drawing in GeoGebra. During designing model of the bucket for all sizes were made dimention tolerances 2cm.

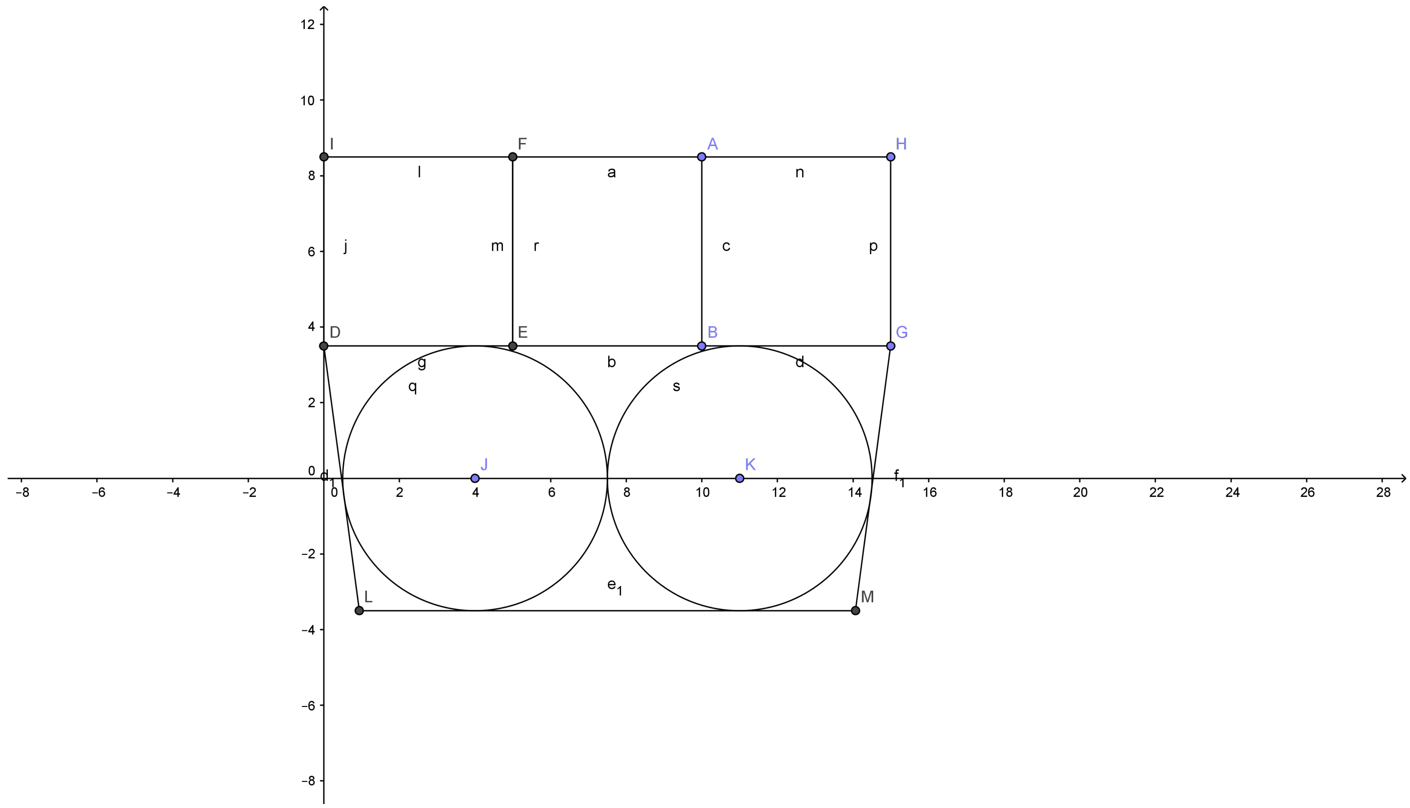



Рис. 17: Drawing of the bucket

But after that it was decided to change size of the bucket. The width entrance hole and width of the scoring box should be the same. It ensure maximal accuracy of scoring debris. It was decided to make bucket that can fit 5 cubes or 3 balls.

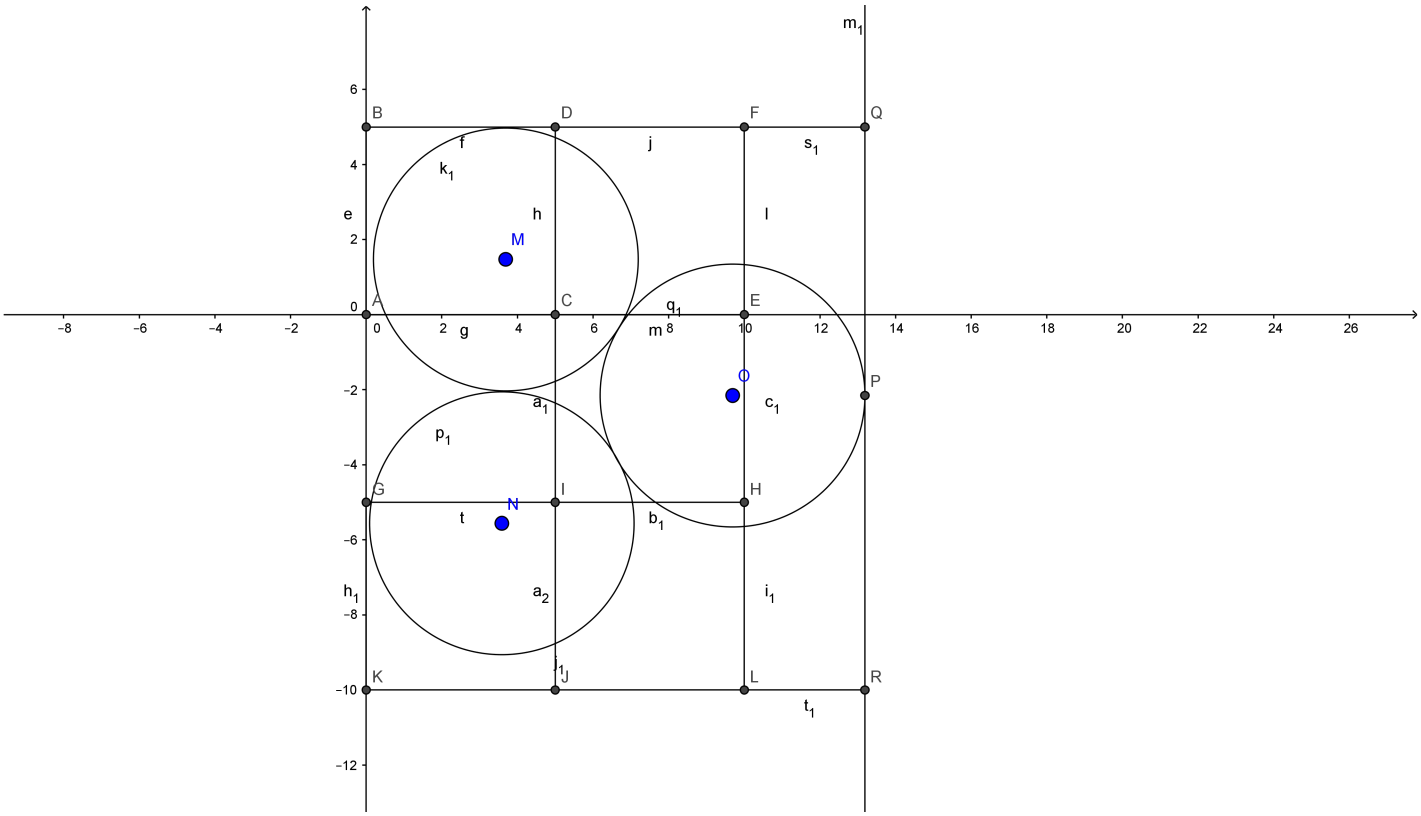
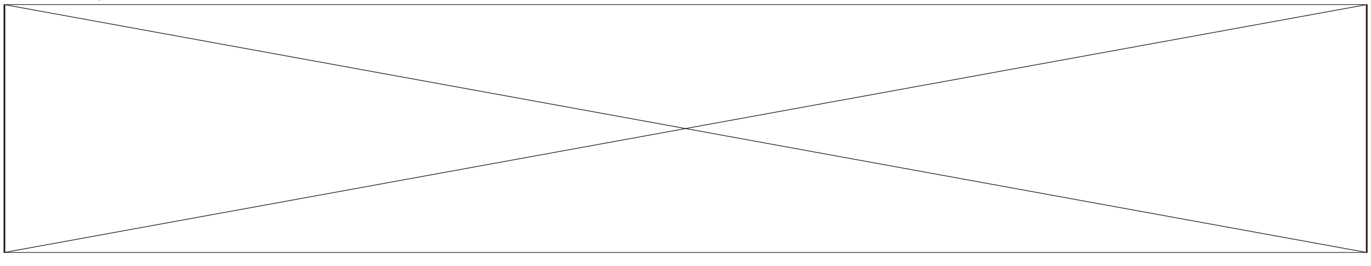



Рис. 18: Changed bucket

For building bucket it was decided use plastic PET 0.5mm. It is easy to cut it, it light, cheap and clear that allow us to see how much elements are incide the bucket.

The bucket mounts to beam that turns by the servo which fixed on the lift. It need because else we have to make detail that fix bucket to the elevator on the defined angle. It require high accuracy. So it will be difficult to make this detail. In addition the mount with servo extend operational window of the lift.

The bucket equped by the cover that turn by the servo and close entrance hole of the bucket. It prevent to falling debris out it during turning of the moving beam of lift. Also it can to prevent balls get into the bucket when we collect only cubes. When it closed not fully (so that distance between bottom edge of cover and floor is about 6cm) the cube can get into the bucket but the ball is not. When we open cover the balls can get to the bucket.
The cover fix on 14cm beam that turn by the servo. It was decided use so long beam as the most optimal variant when cover move vertically because otherwise it can to prevent rotating gripper for debris. When it turn around the circle with big radius trajectory of cover's moving is close to vertical.
Also they were calculated moments of force that acts to servos (for servo that turn bucket and for servo that move cover).



### 0.8 Specifications for programmes

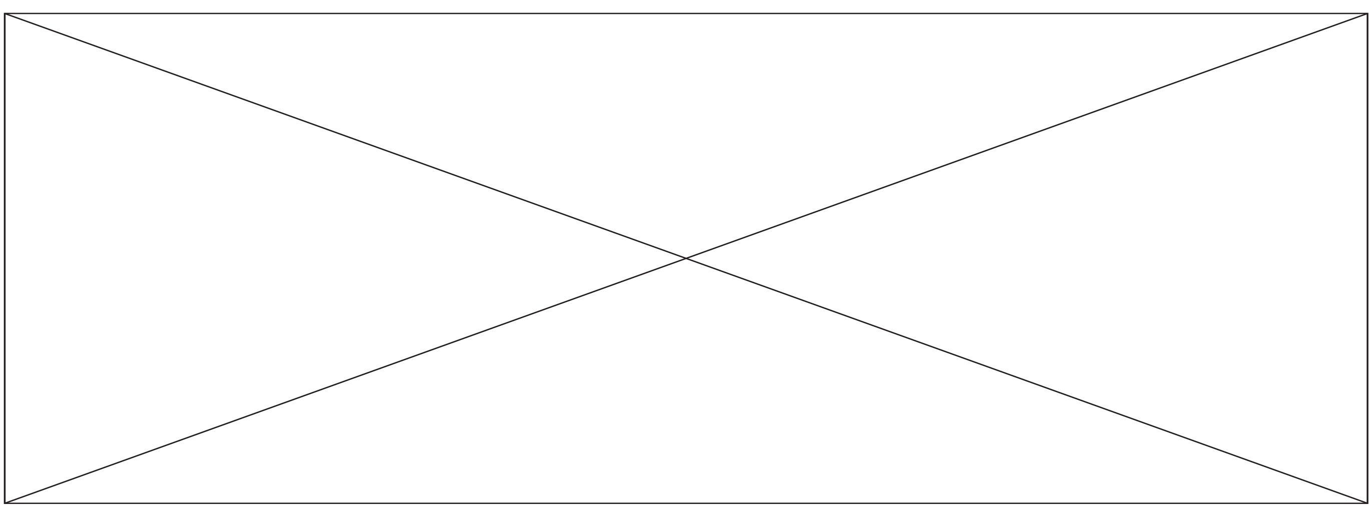
**Description:** This section contains detailed information about elaboration of remote-control program and autonomus program.

#### 0.8.1 Driver control program

As soon as the first prototype of the wheel base was assembled on November 12th, it was elaborated a program for test-drive. It included straight movement and turning around in 4 grades of speed. With this program, there were tested the abilities of the present wheel base. Here is the source code of first version. Results of the test drive were analysed so as develop a convenient control system. At first, turning around on high speed is unaccurate. So, the speed of turn was reduced proportionally to speed of straight movement. There also were added extra active buttons for accurate movement. Main drive control was moved from TopHat to a left stick. The operating area of the stick was divided into 8 zones. Zones 3 and 5 (fig. 1) are not used because of unconvenience of back semi-turns. Here is the source code of second version. Due to testing it was discovered, that optimal course speed to turn speed proportion varies nonlinearly from one speed mode to another. So, it's more preferable to set speed mode by exact values of both speed parameters instead of common coefficient. In addition, it was decided to reduce the number of sectors on main stick's from 8 to 6 because 2 sectors were not in use (fig. 2). Here is the source code of third version.


Рис. 19: robot


Рис. 20: robot

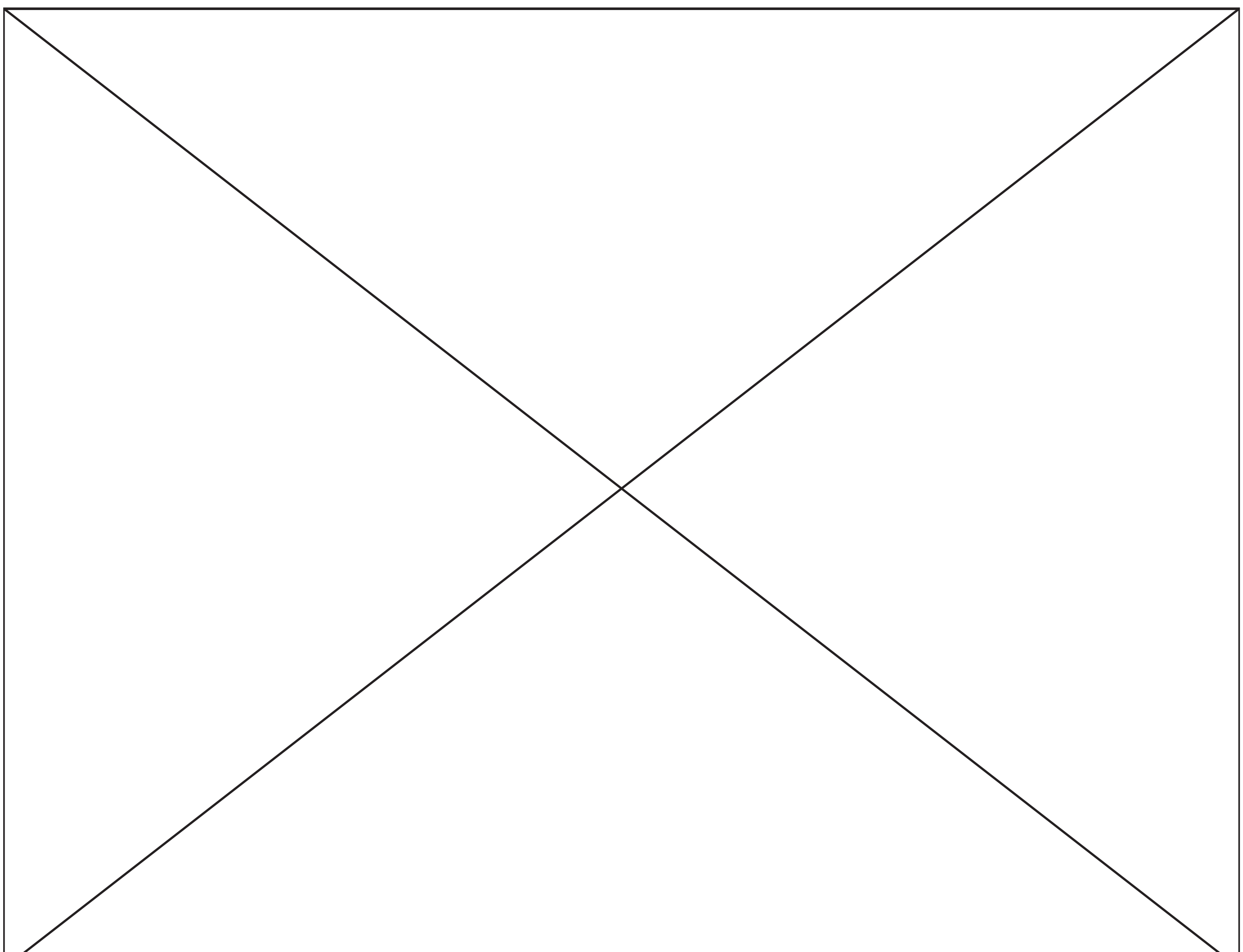


### 0.8.2 Autonomus program

.......


Рис. 21: robot


Рис. 22: robot



## 0.9 Key summary

**Description:** Here are marked the tactical and technical characteristics of the final version of the robot.