RoboCupJunior Soccer Rules 2013

RoboCupJunior Soccer Technical Committee 2013:

> *José Dias (Portugal), jatdias@sapo.pt*
> *Gerard Elias (Australia), elias.gerard@gmail.com*
> *Luis José López (Mexico), CHAIR, llopez@TecnoVanguardia.com*
> *Katsumi Masaoka (Japan), k-mac@sea.plala.or.jp*
> *Sebastian Polly (Germany), Sebastian.Polly@gmx.de*
> *Gio Spina (Canada), profspina@gmail.com*

These are the official rules for RoboCupJunior 2013. They are released by the RoboCupJunior Soccer Technical Committee for Soccer. These rules have priority over any translations.

Preface:

In the RoboCupJunior soccer challenge, teams of two autonomous mobile robots compete against another team in matches. They must look for an infrared-light-emitting ball, trying to score into a color-coded goal in a special field built in a way that resembles the actual field for human soccer. Robots are required to have full autonomy from humans, technical designs, and ingenious programming by their developers.

Participants of this challenge are required to give the best of their abilities in programming, robotics, electronics and mechatronics, but also to contribute on teamwork and knowledge sharing with other participants, regardless of culture, age or result in the competition. All are expected to compete, learn, have fun and grow up.

The changes determined by the Technical Committee for this year's rules aimed to favor skills over brute force in the games, with safer conditions for both robots and humans. The rules better work out situations of aggressive robots that cause damage to IR balls, robots and fields; control unrealistic kicker force that cause damage to IR balls and referees; and reduce the excessive need for human intervention in a stressful attempt to maintain game continuity.

1. TEAM

1.1 Regulations

A **team** consists of two or more members.

Each team must have a **captain**. The captain is the person responsible for communication with referees. The team can replace its captain during the competition. Team is allowed to have only the fewest possible members beside the field during game play: they will usually be the captain and an assistant team member.

1.2 Violations

Teams that do not abide by the rules are not allowed to participate.

Any person close to the playing field is not allowed to wear any yellow or blue clothes that can be seen by the robots (to avoid interference with the goal colour). A referee can require a team member to change clothes or to be replaced by another team member if interference with goal colour is suspected.

The referee can interrupt a game in progress if any kind of interference from spectators is suspected (colour clothing, IR emitters, camera flashes, mobile phones, radios, computers, etc.).

2. ROBOTS

2.1 Number of robots / substitution

Each team is allowed to have at most two robots. The substitution of robots during the competition within the team or with other teams is forbidden.

2.2 Interference

Robots are not allowed to be coloured yellow or blue in order to avoid interference with the goal colours. Yellow or blue parts used in the construction of the robot must either be occluded by other parts from the perception by other robots or be taped/painted with a neutral colour.

The robot must not emit infrared light. However, optical sensors (e.g. infrared-distance-sensors) may be used as long as they do not affect other robots. This needs to be proved by a referee or an OC member if a claim is placed by the other team.

Infrared light reflecting materials must not be used on the outside. If robots are painted, they must be painted matte. Minor parts that reflect infrared light could be used as long as other robots are not affected. A team claiming that their robot is affected by the other team's robot reflecting infrared light has to show the proof/evidence of the interference.

2.3 Control

The use of remote control of any kind is not allowed. Robots must be started manually by humans and be controlled autonomously.

2.4 Communication

Robots are not allowed to use any kind of communication during game play unless the communication between two robots is via Bluetooth class 2 or class 3 (range shorter than 20 meters) or via ZigBee. Teams are responsible for their communication. The availability of frequencies cannot be guaranteed.

2.5 Agility

Robots must be constructed and programmed in a way that their movement is not limited to only one dimension (that means one axis). They must move in all directions, for example by turning. Robots must respond to the ball in a direct forward movement. For example, it is not enough to basically just move left and right in front of their own goal, but also to move directly towards the ball in a forward movement. At least one team robot must be able to seek and approach the ball anywhere on the field, unless the team has only one robot on the field at that time.

Robots must be constructed and programmed in a way that they do not enter the goal. Robots are allowed to use the cross-bar.

2.6 Handle

All robots must have a stable handle to hold and to lift them. The handle must be easily accessible, for example on top of a robot. The dimensions of the handle may exceed the 22 cm height limitation, but the part of the handle that exceeds this 22 cm limit cannot be used to mount components of the robot.

2.7 Additional regulations of the sub-leagues

A tournament may be organized in different sub-leagues. Each sub-league (e.g. "Open League" and "Light Weight League") may have its own additional regulations, including regulations affecting the construction of robots. Such regulations will be published by the RoboCupJunior Soccer Technical Committee and become a part of this rule.

2.8 Violations

Robots that do not abide by the specifications/regulations are not allowed to play. If violations are detected during a running game the team is disqualified for that game. If similar violations occur repeatedly, the team can be disqualified from the tournament.

3. FIELD

3.1 Kind of field

There is only one kind of field for all sub-leagues.

3.2 Dimensions of the field

The playing-field is 122 cm by 183 cm. The field is marked by a white line which is part of the playing field. Around the playing-field, beyond the white line, is an outer area of 30 cm width. Total dimensions of the field, including the outer area, are 182 cm by 243 cm. It is recommended that the field be positioned 70 to 90 cm off the ground.

3.3 Walls

Walls are placed all around the field, including behind the goals and the out-area. The height of the walls is 14 cm. The walls are painted matte black.

3.4 Goals

The field has two goals, centered on each of the shorter sides of the playing field. The goal inner space is 60 cm width, 10 cm high and 74 mm deep, box shaped. It has a cross-bar on top (to prevent robots from entering the goal and to allow checking if the ball scored). The goal "posts" are positioned over the white line marking the limits of the field. The cross-bar is exactly over the white line. The interior walls and the cross-bar of each goal are painted, one goal yellow, the other goal blue. The exterior is painted black.

3.5 Floor

The floor consists of green carpet on top of a hard surface. The carpet should be of a quality that will resist the wear and tear of spinning wheels. All straight lines on the field should be painted and have a width of 20 mm.

3.6 Neutral spots

There are five neutral spots defined in the field. One is in the center of the field. The other four are adjacent to each corner, located 45 cm along the long edge of the field, aligned with each goal post towards the middle of the field (from the goal post). The neutral spots can be drawn with a thin black marker.

3.7 Center circle

A center circle will be drawn on the field. It is 60 cm in diameter. It is a thin black marker line. It is there for Referees and Captains as guidance during kick-off.

3.8 Penalty areas

In front of each goal there is a 30 cm wide and 90 cm long penalty area.

The penalty areas are marked by a black line of 20 mm width. The line is part of the area.

A robot is considered inside the Penalty Area when it is completely inside.

3.9 Lighting and Magnetic Conditions

The fields should be placed in a way that the influence by external infrared light is as low as possible and that the magnetic field of the earth is disturbed as little as possible. Perfect conditions cannot be guaranteed, however. Teams must come to tournaments being prepared to calibrate their robots based on the lighting and magnetic conditions at the venue.

4. BALL

4.1 General ball specification

A well-balanced electronic ball shall be used. The ball will emit infrared (IR) light set to pulsed mode.

4.2 Official suppliers for pulsed balls

Currently, there is one ball that has been approved by the RoboCupJunior Soccer Technical Committee:
- RoboSoccer RCJ-05 ball operating in MODE A (pulsed)
  made by EK Japan/Elekit (www.elekit.co.jp)

Technical details are in the Appendix: "Technical Specification for Pulsed Soccer Ball".

4.3 Tournament balls

Balls for the tournament must be made available by the organizers. Organizers are not responsible for providing balls for practice.

5. GAMEPLAY

5.1 Game procedure and length of a game

The game will consist of two halves. The duration of each half is 10-minutes. There will be a 5-minute break in between the halves.

The game clock will run for the duration of the halves without stopping (except if or when a referee wants to consult an official). The game clock will be run by a referee or a referee assistant (see Rule 7.1 for the description of a referee assistant).

Teams are supposed to be at their field table 5 minutes before their game starts. To be at the inspection table

does not count in favor of this time limit. Teams can be penalized one goal per minute at the referee's discretion if they are late for the game start. If a team does not report within 5 minutes of the game start, it forfeits the game and the winning team is awarded a 5-0 win.

5.2 Pre-match meeting

At the start of the first half of the game, a referee will toss a coin. The team mentioned first in the draw shall call the coin. The winner of the toss can choose either which end to kick to, or to kick off first. The loser of the toss will settle for the other option. After the first half, teams will switch sides. The team not kicking off in the first half of the game will kick off to begin the second half of the game.

5.3 Kick-off

Each half of the game begins with a kick-off. All robots must be located on their own side of the field. All robots must be halted. The ball is positioned by a referee in the center of the field.

The team kicking off places their robots on the field first. Robots cannot be placed nor remain behind the goal line or in the outer area. Robots cannot be repositioned once they have been placed.

The team not kicking off will now place their robots on the defensive end of the field. All robots on the team not kicking off must be at least 30 cm away from the ball (that means outside the center circle).

The referee may adjust the placement of the robots to make sure that the robots are placed properly within the field positions.

On the referee's command (usually by whistle), all robots will be started immediately by each captain. Any robots that are started early will be removed by the referee from the field and treated as a damaged robot.

5.4 Human interference

Except for the kick-off, human interference from the teams (e.g. touching the robots) during the game is not allowed unless explicitly permitted by a referee. Violating team/team member(s) can be disqualified from the game.

The referee or a referee assistant can help robots to get unstuck, but only if the ball is not being disputed near them, and also if that situation was created from the interaction between robots (i.e. it was not a design or programming flaw of the robot alone). The referee or a referee assistant will pull back the robots just enough for them to be able to move freely again.

5.5 Ball movement

A robot cannot hold a ball. Holding a ball means taking full control of the ball by removing all of its degrees of freedom. Examples for ball holding include fixing a ball to the robot's body, surrounding a ball using the robot's body to prevent access by others, encircling the ball or somehow trapping the ball with any part of the robot's body. If a ball stops rolling while a robot is moving or a ball does not rebound when rolled into a robot, it is a good indication that the ball is trapped.

The only exception to holding is the use of a rotating drum that imparts dynamic back spin on the ball to keep the ball on its surface. Such a device is called a dribbler.

Other players must be able to access the ball.

5.6 Scoring

A goal is scored when the ball strikes or touches the back wall of the goal. Goals scored either by an attacking or defending robot have the same end result: they give one goal to the team on the opposite side. After a goal, game will be restarted with a kick-off from the team who received the goal against.

5.7 Goalie

The robot moving first into the penalty area on a team's defending side completely (with every part of it) is designated as goalie until a part of it leaves the penalty area.

5.8 Pushing

Within the penalty area, the goalie has priority. Attacking robots are not supposed to push the goalie in any way.

If the attacker and the goalie touch each other and at least one of them has physical contact with the ball, the ball will be moved to the nearest unoccupied neutral spot immediately.

If a goal is scored as a result of this pushed-situation, it will not be granted.

5.9 Lack of progress

Lack of progress occurs if there is no progress in the gameplay for a reasonable period of time and the situation is not likely to change. Typical lack of progress situations are when the ball is stuck between robots, when there is no change in ball and robot's positions, or when the ball is beyond detection or reach capability of all robots on the field. After a visible and loud count, (usually a count of five, the length of the count could be decided by the OC before a competition as long as it's the same length within a sub-league) a referee will call "lack of progress" and will move the ball to the nearest unoccupied neutral spot. If this does not solve the lack of progress, the referee can move the ball to different neutral spots.

5.10 Out of bounds

If a robot's entire body moves out beyond the white line of the field completely, it will be called for being out of bounds. When this situation arises, the robot is given a one-minute penalty, and the team is asked to remove the robot from the field. The robot out time starts once the robot is removed. There is no time stoppage for the game itself.

After the penalty time has passed, robot will be placed on the unoccupied neutral spot nearest to where it has been taken off, and not directly aiming towards the ball.

A referee can waive the penalty if the robot was accidentally pushed out of bounds by any other robot. In such a case, the referee may have to slightly push the robot back onto the field.

The ball can leave and bounce back into the playing field. If it remains outside the playing field too long or any of the robots are unable to return it into the playing field (without their whole body leaving the field), after a visible and loud count the referee will call "out of reach" and will move the ball to the nearest unoccupied neutral spot.

5.11 Damaged robots

If a robot is damaged, it has to be taken off the field and must be fixed before it can play again. A damaged robot must remain off the field for at least one minute.

A robot is damaged especially when:
- it does not respond to the ball, or is not able to move (it lost pieces, power, etc.).
- it continually moves into the goal or out of the playing field.
- it turns over on its own accord.

Computers and repair equipment are not permitted in the playing area during gameplay. Usually, a team member will need to take the damaged robot to an "approved repair table" near the playing area, located inside the competitors working area. A referee may permit robot sensor calibration, computers and other tools in the playing area, only for the 5 minutes before the start of each half.

After a robot has been fixed, it will be placed on the unoccupied neutral spot nearest to where it has been taken off, and not directly aiming towards the ball. A robot can only be returned to the field if the damage has been repaired. If the referee notices that the robot was returned to the field with the same original problem, s/he could ask the robot to be removed, and proceed the game as if the robot had not been returned.

Only the referee decides whether a robot is damaged. A robot can only be taken off or returned with the referee's permission.

If both robots from the same team are deemed damaged during gameplay, the clock continues and the remaining team gets one initial goal and rests while waiting for the opponent's return to play. The remaining team will also get one additional goal for each minute the opponent's robots remain damaged. After five minutes of absence, the team with no functional robots forfeits the game. However, these rules only apply when none of the two robots from the same team were damaged as the result of the opponent team violating the rules.

5.12 Multiple defense

Multiple defense occurs if more than one robot from the defending team enters its penalty area with some part and substantially affects the game. The robot farther from the ball will be moved to the center neutral spot.

If multiple defense happens repeatedly, the robot will be deemed damaged.

5.13 Interruption of Game

In principle, a game will not be stopped.

A referee can stop the game if there is a situation on or around the field which the referee wants to discuss with an official of the tournament or if the ball malfunctions and a replacement is not readily available.

When the referee has stopped the game, all robots must be stopped and remain on the field untouched. The referee may decide whether the game will be continued/resumed from the situation in which the game was stopped or by a kick-off.

6. CODE OF CONDUCT

6.1 Fair Play

It is expected that the aim of all teams is to play a fair and clean game of robot soccer. It is expected that all robots will be built with consideration to other participants.

Robots are not allowed to cause deliberate interference with or damage to other robots during normal game play.

Robots are not allowed to cause damage to the field or to the ball during normal game play.

Humans are not allowed to cause deliberate interference with robots or damage to the field or the ball.

6.2 Behavior

All participants are expected to behave themselves. All movement and behavior is to be of a subdued nature within the tournament venue.

6.3 Help

Mentors (teachers, parents, chaperones, and other adult team-members including translators) are not allowed in the student work area unless it is explicitly but temporarily permitted by a member of the organizing committee. Only participating students are allowed to be inside the work area.

Mentors must not touch, build, repair or program any robots.

6.4 Sharing

The understanding that any technological and curricular developments should be shared among the RoboCup and RoboCupJunior participants after the tournament has been a part of world RoboCup competitions.

6.5 Spirit

It is expected that all participants, students, mentors and parents alike, will respect the RoboCupJunior mission. *It is not whether you win or lose, but how much you learn that counts!*

6.6 Violations / Disqualification

Teams that violate the code of conduct can be disqualified from the tournament. It is also possible to disqualify only single person or single robot from further participation in the tournament.

In less severe cases of violations of the code of conduct, a team will be given a warning by showing it a yellow card. In severe or repeated cases of violations of the code of conduct a team can be disqualified immediately without a warning by showing it the red card.

7. CONFLICT RESOLUTION

7.1 Referee and referee assistant

All decisions during the game are made by the referee or the referee assistant who are in charge of a field, and the persons and the objects surrounding the field. <u>During gameplay, the decisions made by the referee and/or the referee assistant are final.</u>

Any argument with the referee or the referee assistant can result in a warning. If the argument continues or another argument occurs, this may result in immediate disqualification from the game.

At the conclusion of the game, the referee will ask the captains to sign the score sheet. By signing the score sheet the captains accept the final score on behalf of the entire team.

7.2 Rule clarification

Rule clarification may be made by members of the RoboCupJunior Soccer Technical Committee and Organizing Committee, if necessary even during a tournament.

7.3 Rule modification

If special circumstances, such as unforeseen problems or capabilities of a robot occur, rules may be modified by the RoboCupJunior Soccer Organizing Committee Chair in conjunction with available Technical Committee and Organizing Committee members, if necessary even during a tournament.

7.4 Regulatory statutes

Each RoboCupJunior competition may have its own regulatory statutes to define the procedure of the tournament (for example the SuperTeam system, game modes, the inspection of robots, interviews, schedules, etc.). Regulatory statutes become a part of this rule.

Field diagram
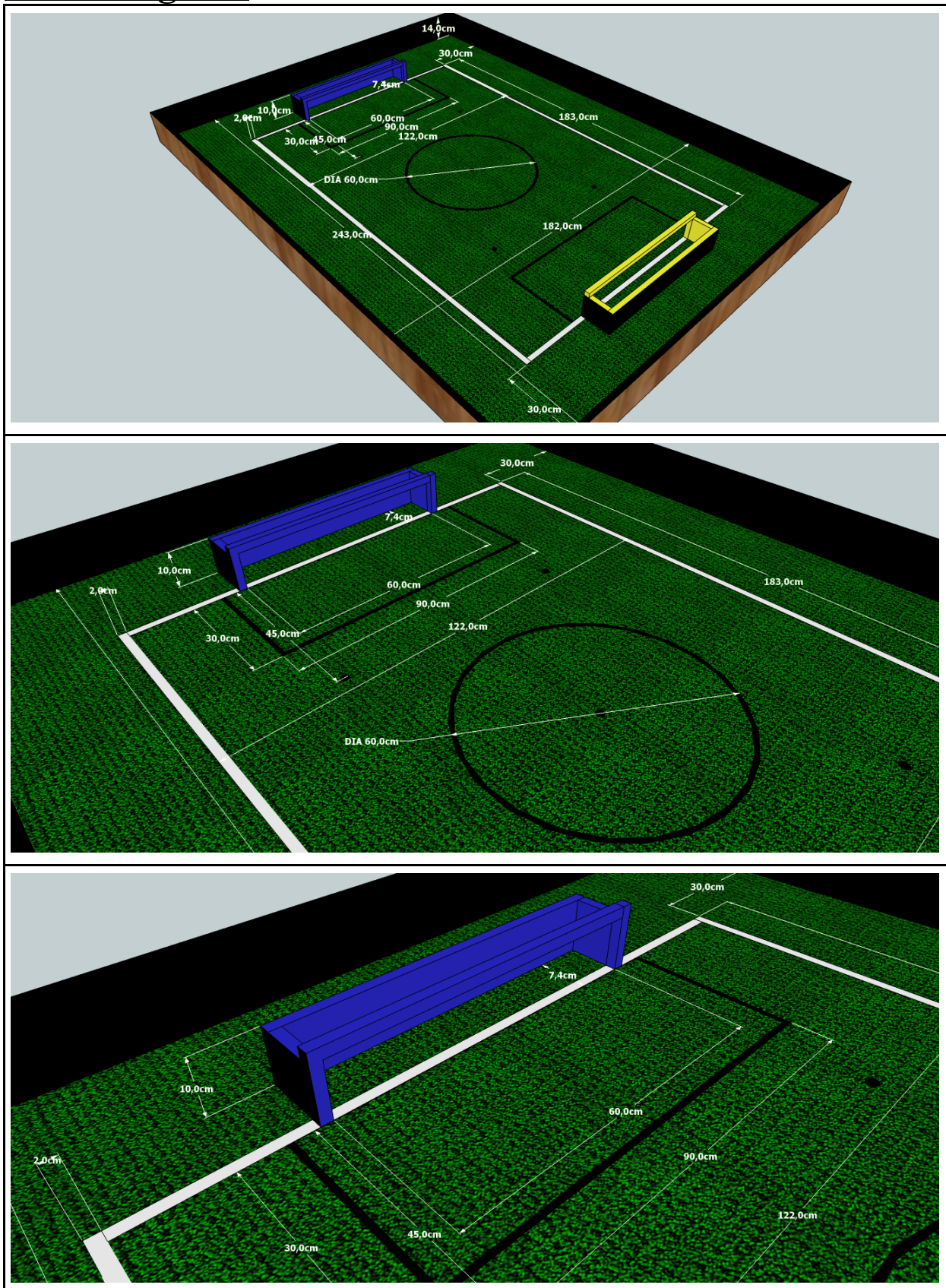
Graphics designed by José Dias

League Regulations 2013

1. Preamble

According to rule 2.7 of the RoboCupJunior Soccer Rules, each league has its own additional regulations. They become a part of the rules.

Soccer will consist of two sub-leagues. These sub-leagues are called "**Open League**" and "**Light Weight League**" (See 2.1 Dimensions). Each sub-league can be further divided into primary and secondary.

For RoboCupJunior 2013, there are three sub-leagues as follows:
- Light Weight League – Primary
- Light Weight League – Secondary
- Open League

2. Regulations

2.1 Dimensions

Robots will be measured in an upright position with all parts extended. A robot's dimensions must not exceed the following limits:

sub-league	**Open League**	**Light Weight League**
size / diameter	Ø 22.0 cm	Ø 22.0 cm
height	22.0 cm *	22.0 cm *
weight	2400 g **	1100 g **
ball-capturing zone	3.0 cm	3.0 cm
voltage	15.0 V	12.0 V

* The handle of a robot may exceed the height.
** The weight of the robot includes that of the handle.

Ball-capturing zone is defined as any internal space created when a straight edge is placed on the protruding points of a robot. This means the ball must not enter the concave hull of a robot by more than 3 cm. Furthermore, it must be possible for another robot to take possession of the ball.

2.2 Limitations

Voltage pump circuits are permitted only for a kicker solenoid drive. All other electrical circuits inside the robot cannot exceed 15.0 V for Open League and 12.0 V for Light Weight League. Each robot must be designed to allow verifying the voltage of power packs and its circuits, unless the nominal voltage is obvious by looking at the robot, its power packs and connections.

Pneumatic devices are allowed to use natural air only.

Kicker strength is subject to compliance check at any time during the competition. During gameplay, a referee can ask to see a sample kick on the field before each half, when a damaged robot is returned to the field, or when the game is about to be restarted after a goal. If the referee strongly suspects that a kicker exceeds the power limit, he can require an official measurement with the 'Kicker Power Measure Device'. (See the Appendix 'Kicker Power Measure Device' for details.)

2.3 Construction

Robots must be constructed exclusively by the student members of a team. Mentors, teachers, parents or companies may not be involved in the design, construction, and assembly of robots.

For the construction of a robot, any robot kit or building block may be used as long as the design and construction are primarily and substantially the original work of a team. This means that commercial kits may be used but must be substantially modified by the team. It is neither allowed to mainly follow a construction manual, nor to just change unimportant parts.

Indications for violations are the use of commercial kits that can basically only be assembled in one way or the fact that robots from different team(s), build from the same commercial kit, all basically look or function the same.

Robots must be constructed in a way that they can be started by the captain without the help of another person.

Since a contact with an opponent robot and/or dribbler that might damage some parts of robots cannot be fully anticipated, robots must have all its active elements properly protected with resistant materials. For example, electrical circuits and pneumatic devices, such as pipelines and bottles, must be protected from all human contact and direct contact with other robots. When batteries are transported or moved, it is recommended that safety bags be used. Reasonable efforts should be made to make sure that in all circumstances robots avoid short-circuits and chemical or air leaks.

2.4 Programming

Robots must be programmed exclusively by student members of the team. Mentors, teachers, parents or companies should not be involved in the programming and debugging of robots.

For the programming of the robots, any programming language, interface or integrated development environment (IDE) may be used. The use of programs that come together with a commercial kit (especially sample programs or presets) or substantial parts of such programs are not allowed. It is not allowed to use sample programs, not even if they are modified.

2.5 Inspection and Interviews

Robots must be inspected and certified every day before the first game is played. The Organizing Committee may request other inspections if necessary. The routine inspections include:
- Weight restrictions for the particular sub-league (see 2.1).
- Robot dimensions (see 2.1).
- Voltage restrictions (see 2.1 and 2.2).
- Kicker strength limits, if the robot has a kicker. (See the Appendix 'Kicker Power Check Device'.)

Proof must be provided by each team that its robots comply with these regulations, for example, by a detailed documentation or log book. Teams may be interviewed about their robots and the development process at any time during a tournament.

During an interview, at least one member from each team must be able to explain particularities about the team's robots, especially with regards to its construction and its programming. An interviewer may ask the team for a demonstration. The interviewer may also ask the team to write a simple program during the interview to verify that the team is able to program its robot.

2.6 Violations

Robots that do not comply with the above regulations are not allowed to play. If violations are detected during a game play, the team is disqualified for that game. If similar violations occur repeatedly, the team can be disqualified from the tournament.

Technical Specification for pulsed Soccer Ball

1. Preamble

Answering to the request for a soccer ball for RCJ tournaments that would be more robust to interfering lights, less energy consuming and mechanically more resistant, the RCJ Soccer Technical Committee defined the following technical specifications with the special collaboration from EK Japan and HiTechnic.

Producers of these balls must apply for a certification process upon which they can exhibit the RCJ-compliant label and their balls used in RCJ tournaments.

Balls with these specifications can be detected using specific sensors from HiTechnic (IRSeeker - information on distance and angle) but also common IR remote control receivers (TSOP1140, TSOP1240, GP1UX511QS, ... - on-off detection with a possible gross indication of distance).

2. Specifications

2.1 IR light

The ball emits infra-red (IR) light of wavelengths in the range 920nm - 960nm, pulsed at a square-wave carrier frequency of 40 KHz. The ball should have enough ultra-bright, wide angle LEDs to minimize unevenness of the IR output.

2.2 Diameter

The diameter of the ball is required to be 74mm. A well-balanced ball shall be used.

2.3 Drop Test

The ball must be able to resist normal game play. As an indication of its durability, it should be able to survive, undamaged, a free-fall from 1.5 meters onto a hardwood table or floor.

2.4 Modulation

The 40 KHz carrier output of the ball shall be modulated with a trapezoidal (stepped) waveform of frequency 1.2 kHz. Each 833-microsecond cycle of the modulation waveform shall comprise 8 carrier pulses at full intensity, followed (in turn) by 4 carrier pulses at 1/4 of full intensity, four pulses at 1/16 of full intensity and four pulses at 1/64 of full intensity, followed by a space (i.e. zero intensity) of about 346 microseconds. The peak current level in the LEDs shall be within the range 45-55mA. The radiant intensity shall be more than 20mW/sr per LED.

2.5 Battery Life

If the ball has an embedded rechargeable battery, when new and fully charged it should last for more than 3 hours of continuous use before the brightness of the LEDs drops to 90% of the initial value. If the ball uses replaceable batteries, a set of new high-quality alkaline batteries should last for more than 8 hours of continuous use before the brightness of the LEDs drops to 90% of the initial value.

2.6 Coloration

The ball shall be neutral in color. In particular, it must not have any green, blue or yellow coloration (to avoid confusion with the colors of the field and goals).

Kicker Power Measuring Device

1. Preamble

This Kicker Power Measuring Device can measure the power of a robot's kicker. It is easy to build with commonly accessible materials.

This device can measure the power of a robot's kicker up to a length of 22cm.

2. Materials

Plastic Board	A4 paper size
M3 Spacers (40mm length)	5
M3 Screw	10

3. Device schematics

The device schematics can be printed out from the diagram located at the end of the document. Please be advised to check that the software you use to print the schematic does not have a "scale to fit" option activated (i.e. check that it is configured to print at 100% or "actual size" scale).

Note: The device schematics shows a straight line past the 22cm mark, while the photo shows the line at that point to be curved. Either straight or curved lines are acceptable, but a curved line will request more difficult cutting and the attached device schematic is simple enough for quick construction.

4. Example of device construction

    a.   Print out the device schematics.
    b.   Paste the paper on a plastic board. The incline line (red lines) should be straight.
    c.   Cut out along the lines, and drill the holes.
    d.   The two boards should be connected using the 40mm spacers.

5. Inspection

    a.   Place a ball at the bottom of the ramp run of the device, and put the robot in front of the ball, aiming the kicker towards the top of the ramp.
    b.   Activate the robot's kicker for a single shot.
    c.   Measure the distance that the ball travelled on the device. The distance should not exceed 22 cm.

Kicker Power Measuring Device

RoboCupJunior Soccer Technical Committee

NOTE: You might need to set up to the magnification ratio "100%" of this print.

$37-\sqrt{969}\,\cos20° \approx 0.77\,cm$

20 degrees

20 degrees

0

5

10

15

20

22

0

5

10

15

20

22

28.0 cm

7.0 cm

RoboCup 2013

RoboCup Junior

RoboCup

RoboCup 2013

RoboCup Junior

RoboCup