

FLL INTO ORBITSM – RULES & ROBOT GAME

At the FLL Robot Game, the FLL teams compete with robots they have built in advance out of LEGO[®] parts and programmed by themselves. Within 2½ minutes they try on the approximately 2 m² large playing field, to get as many points. The robot must act autonomously, all movements must be performed independently by the program. Remote controls are not allowed.

At all tournaments of a season, the same playing fields and missions are used worldwide. The way in which the objects are achieved and the order in which they are dissolved, are not prescribed. Accordingly, the robots of the teams look completely different, even though they are all built from LEGO[®].

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1. RULES

1.1 Guiding Principles

GP01 – Gracious Professionalism®

- The FLL Tournament should be driven by fairness.
- You compete hard against problems, while treating all people with respect and kindness.
- If you joined FIRST® LEGO® League with a main goal of “winning a robotics competition,” you’re in the wrong place!

GP02 – Interpretation

- **If a detail isn’t mentioned, it doesn’t matter.**
- The Robot Game text means exactly and only what it plainly says.
- If a word isn’t given a game definition, use its common conversational meaning.

GP03 – Benefit of the Doubt

- If the referee feels something is a “very tough call,” and no one can point to strong text in any particular direction, you get the “benefit of the doubt.”
- This good-faith courtesy is not to be used as a strategy.

GP04 – Variability

- Our partners and volunteers try hard to make all fields correct and identical, but you should always expect little defects and differences.
- Top teams design with these in mind.
- Examples include border wall splinters, lighting changes, and field mat wrinkles.
- Questions about conditions at a particular tournament should be directed to that tournament’s officials, the contact dates you can find at the [FLL Regional Websites](#).

GP05 – Information Superiority

- If two official facts disagree, or confuse you when read together, here’s the order of their authority (with 1 being the strongest):
 - 1 = [Current Robot Game updates \(FAQ\)](#)
 - 2 = [Missions and Field Setup](#)
 - 3 = [Rules](#)
 - 4 = Local head referees – in unclear situations, local head referees may make good-faith decisions after discussion, with rule GP03 in mind.
- Pictures and videos have no authority, except when talked about in one, two or three.
- Emails and forum comments have no authority.

1.2 Definitions

D01 – Match

- A “match” is when two teams play opposite each other on two fields placed north to north.
- Matches last 2½ minutes, and the timer never pauses.
- Your robot launches one or more times from base and tries as many missions as possible.

D02 – Mission

- A “mission” is an opportunity for the robot to earn points.
- Requirements are written in the form of
 - Results that must be visible to the referee at the **end of the match**.
 - Methods that must be observed by the referee **as they happen**.

D03 – Equipment

- “Equipment” is everything you bring to a match for a mission-related activity.

D04 – Robot

- Your “robot” is your LEGO® MINDSTORMS® controller and all the equipment you’ve combined with it by hand which is not intended to separate from it, except by hand.

D05 – Mission Model

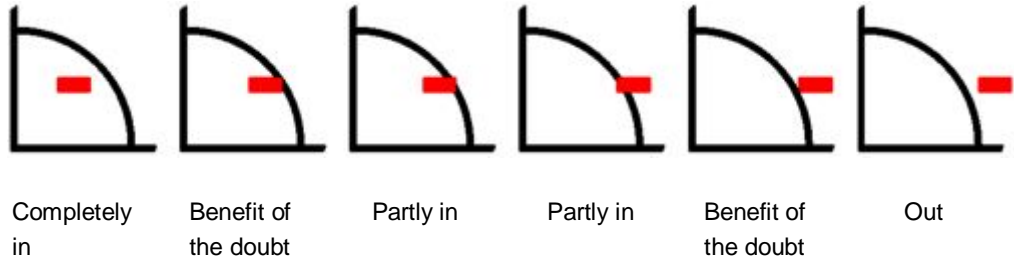
- A “mission model” is any LEGO® element or structure already at the field when you get there.
- Mission models are not the same as “equipment”.

D06 – Field

- The “field” is the robot’s game environment, consisting of mission models on a mat, surrounded by border walls, all on a table.
- “Base” is part of the field.
- For full details, see 2.2 Field Setup & Placement.

D07 – Base

- “Base” is the space directly above the field’s quarter-circle region, in the southwest.
- It extends southwest from the outside of the thin curved line to the corner walls (no further).
- The thin line around any scoring area counts as part of that area.
- When a precise location related to a line is unclear, the outcome most favorable for the team is assumed.



D08 – Launch

- Whenever you’re done with handling the robot and then you make it go, that’s a “launch.”

D09 – Interruption

- The next time you interact with the robot after launching it, that’s an “interruption.”

D10 – Transporting

When a thing (anything) is purposefully/strategically being ...

- taken from its place, and/or
- moved to a new place, and/or
- being released in a new place,

it is being “transported.” The process of being transported ends when the thing being transported is no longer in contact with whatever was transporting it.

1.3 Equipment, Software, and People

R01 – All Equipment

All equipment must be made of LEGO®-made building parts in original factory condition.

- Except: LEGO® string and tubing may be cut shorter.
- Except: Program reminders on paper are okay (off the field).
- Except: Marker may be used in hidden areas for identification.

R02 – Controllers

- You are allowed to use only one individual controller in any particular match.
- It must exactly match a type shown below (except color).



EV3



NXT



RCX

- All other controllers must be left in the Pit Area for that match.
- All remote control or data exchange with robots (including bluetooth) in the competition area is illegal.
- This rule limits you to **only one individual robot** in any particular match.

R03 – Motors

- You are allowed to use up to four individual motors in any particular match.
- Each one must exactly match a type shown below.
- You may include more than one of a type, but again, your grand total may not be greater than FOUR.
- ALL other motors must be left in the Pit Area for that match, **no exceptions**.



EV3 "LARGE"



EV3 "MEDIUM"



NXT



RCX

R04 – External Sensors

- Use as many external sensors as you like.
- Each one must exactly match a type shown below.
- You may include more than one of each type.



EV3 TOUCH



EV3 COLOR



EV3 ULTRASONIC



EV3 GYRO/ANGLE



NXT TOUCH



NXT LIGHT



NXT COLOR



NXT ULTRASONIC



RCX TOUCH



RCX LIGHT



RCX ROTATION

R05 – Other Electric/Electronic Things

- No other electric/electronic things are allowed in the competition area for mission-related activity.
- Except: LEGO® wires and converter cables are allowed as needed.
- Except: Allowable power sources are one controller’s power pack or six AA batteries.

R06 – Non-electric Elements

- Use as many non-electric LEGO® elements as you like, from any set.
- Except: Factory-made wind-up/pull-back “motors” are not allowed.
- Except: Additional/duplicate mission models are not allowed.

R07 – Software

- The robot may only be programmed using LEGO® MINDSTORMS® RCX, NXT, EV3, or RoboLab software (any release).
- No other software is allowed.
- Patches, add-ons, and new versions of the allowable software from the manufacturers (LEGO® and National Instruments) are allowed, but tool kits, including the LabVIEW tool kit, are not allowed.

R08 – Technicians

- Only two team members, called “technicians,” are allowed at the competition field at once.
- Except: Others may step in for true emergency repairs during the match, then step away.
- The rest of the team must stand back as directed by tournament officials, with the expectation of fresh technicians being able to switch places with current technicians at any time if desired.

1.4 Robot Game

R09 – Before the Match Timer Starts

- After getting to the field on time, you have at least one minute to prepare.
- During this special time only, you may also ...
 - ask the referee to be sure a mission model or setup is correct, and/or
 - calibrate light/color sensors anywhere you like.

R10 – Handling During the Match

- Only the robot is allowed to interact with any part of the field that's not COMPLETELY in base.
 - Except: You may interrupt the robot any time.
 - Except: You may pick up equipment that broke off the robot unintentionally, anywhere, any time.
- You are not allowed to cause anything to move or extend over the base line, even partly.
 - Except: Of course, you may **launch** the robot.
 - Except: You may move/handle/**store** things off the field, any time.
 - Except: If something accidentally crosses the base line, just calmly take it back – no problem.
- Anything the robot affects (good or bad!) or puts completely outside base stays as is unless the robot changes it. Nothing is ever repositioned so you can “try again.”

R11 – Mission Model Handling

- You are not allowed to take mission models apart, even temporarily.
- If you combine a mission model with something (including the robot), the combination must be loose enough that if asked to do so, you could pick the mission model up and nothing else would come with it.

R12 – Storage

- Anything completely in base may be moved/stored off the field, but must stay in view of the referee, on a stand.
- Everything in off-field storage “counts” as being completely in base and may be placed on an approved holder.

R13 – Launching

A proper launch (or re-launch) goes like this:

- Ready situation
 - Your robot and everything in base which is about to move or use is arranged by hand as you like, all fitting completely in base and measuring no taller than 12 inches (30.5 cm).
 - The referee can see that nothing on the field is moving or being handled.
- Go!
 - Reach down and touch a button or signal a sensor to activate a program.

- If first launch of the match – in this case, accurate fair timing is needed, so the exact time to launch is the beginning of the last word/sound in the countdown, such as “Ready, set, GO!” or BEEEEEP!

R14 – Interrupting

- If you interrupt the robot, you must stop it immediately, *then calmly pick it up for a re-launch (*if you intend one).
- Here’s what happens to the robot and anything it was transporting, depending on where each was at the time:
 - Robot
 - Completely in base: re-launch.
 - NOT completely in base: re-launch + penalty.
 - Transported thing which came from base during the most recent launch
 - Always: keep it.
 - Transported thing which did not come from base during the most recent launch
 - Completely in base: keep it.
 - NOT completely in base: give it to the referee.
- The “penalty” is described with the [missions](#).
- If you do not intend to re-launch – in this case, you may shut the robot down and leave it in place. (See also section “1.6 Changes for 2018/19”.)

R15 – Stranding

- If the uninterrupted robot loses something it was transporting, that thing must be allowed to come to rest. Once it does, here’s what happens to that thing, depending on its rest location ...
- Transported thing
 - Completely in base: keep it.
 - Partly in base: give it to the referee.
 - Completely outside base: leave as is.

R16 – Interference

- You are not allowed to negatively affect the other team except as described in a mission.
- Missions the other team tries but fails to get because of illegal action by you or your robot will count for them.

R17 – Field Damage

- If the robot separates Dual Lock or breaks a mission model, missions obviously made possible or easier by this damage or the action that caused it do not score.

R18 – End of the Match

- As the match ends, everything must be preserved exactly as-is.
 - If your robot is moving, stop it as soon as possible and leave it in place. (Changes after the end don’t count.)
 - After that, hands off everything until the referee has given the “okay” to reset the table.

R19 – Scoring

- Scoresheet/Scoringsoftware: The referee discusses what happened and inspects the field with you, mission by mission.
 - If you agree with everything, you sign the sheet, and the scoresheet is final.
 - If you don't agree with something, the head referee makes the final decision.
- Impact: Only your best score from regular match counts toward awards/advancement.

1.5 Questions Regarding Rules, Robot Game & Field Setup

- Important questions are published at the “[FAQ](#)” section for all teams.
- For official answers to questions send an email to HANDS on TECHNOLOGY e.V. fill@hands-on-technology.org.
- Questions will be answered in due time.

1.6 Changes for 2018/19

Major

- If you interrupt the robot while it is transporting something it took from base during the most recent launch, you can now keep that object.

Minor

- Border lines are always part of the area they define.
- Disputes related to the thickness of thin lines (such as the border of base) always settle in favor of the team.
- You need to conform to local event standards regarding the style and size of your storage trays and carts.
- It is okay to shut off the robot and leave it in place without penalty if it is done with intended missions.

2. ROBOT GAME 2018/19 – INTO ORBITSM

2.1 General FLL Field Set up & Placement

Overview



The field is where the FLL Robot Game takes place. It consists of a field mat on a table, with mission models arranged on top. The mat and the LEGO® pieces for building the mission models are part of your challenge set. The instructions for building the mission models are not part of the challenge set but available online:

www.first-lego-league.org/en/season/robot-game/building-instructions.html.

The instructions how to build the FLL Tournament Table is online:

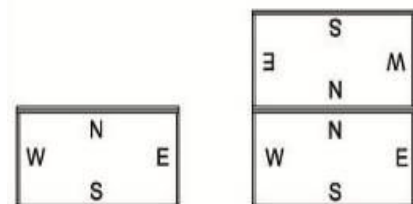
www.first-lego-league.org/en/general/participation.html#4.

How to arrange the mission models on the playing field is explained in this document.

Field Mat Placement

Step 1: Remove any obvious splinters, and cover any obvious holes. Vacuum the table top carefully. Even the tiniest particle under the mat can give the robot trouble. After vacuuming, run your hand over the surface and sand or file down any producing imperfections you find. Then vacuum again.

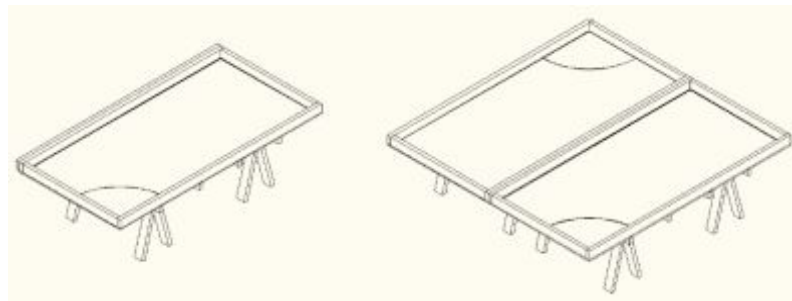
Step 2: Place the mat on a smooth surface (for example, the FLL Table) and clearly mark it with a corresponding pitch limit (band), as it is common to FLL Tournaments. On the vacuumed surface (never unroll the mat in an area where it could pick up particles), unroll the mat so the image is up and its north edge is near the north/double border wall (note the location of the double wall in each table sketch below). Be very careful not to let the mat kink from bending in two directions at once.



Step 3: The mat is smaller than the playing surface by design. Slide and align it so that there is no gap between the south edge of the mat and the south border wall. Center the mat east-west with equal gaps at left and right.

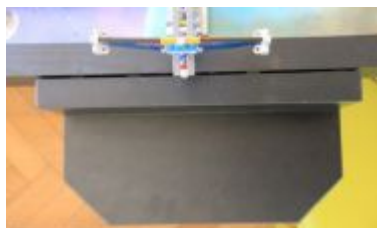
Step 4: With help from others, pull the mat at opposite ends and massage out any waviness away from the center and re-check the requirement of step three. It is expected that some waviness will persist, but that should relax over time. Some teams use a hair dryer to speed the relaxation of the waviness.

Step 5 – OPTIONAL: To hold the mat in place, you may use a thin strip of black tape at the east and west ends. Where the tape sticks to the mat, it may cover the mat's black border only. Where the tape sticks to the table, it may stick to the horizontal surface only, and not the border walls. You can also fix the mat with double faced adhesive tape you stick under the mat to fix it on the table.



Step 6: For a competition setup, secure two tables north-to-north. The total span of border between two tables must measure between 76 mm and 100 mm. At a tournament, two tables are placed back to back, but you only operate on one table, so you only need to build one table to practice on.

Dummy Wall: Most Robot Games have a “shared” mission for both teams, whose mission model(s) rest partly on your table, and partly on the other team’s table, which is connected to your table’s north side. You don’t need to build a second table, but you do need to build the necessary part of the other team’s table, so the shared mission model(s) can be positioned correctly. In the photo you can see, how a dummy wall can look like. In this season, a dummy wall is not mandatory.



Mission Model Construction

Build the mission models

Use the LEGO® elements from your challenge set, and instructions from this page: www.first-lego-league.org/en/season/robot-game/building-instructions.html.

It will take one person at least six hours to do this, so it's best done in a work party. For any team members with little or no experience building with LEGO® elements, mission model construction is a great way to learn. This step is also a nice time for new team members to get to know each other.

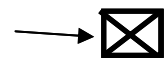
Quality

The models must be built PERFECTLY. "Almost perfect" is NOT good enough. Many teams make several building errors and practice all season with incorrect models. When these teams later compete on fields with correct models, the robot fails. The team incorrectly blames the technicians, the robot, the tournament organizers, or bad luck for the failure. Best practice is to please have several people check for correctness.

Dual Lock

Some models are "secured" to the mat, others are simply "placed" on the mat. Each place on the mat where a model needs to be secured has a white box with an X in it. The connection is made using the re-usable fastening material from 3M called Dual Lock, which comes in the flat clear bag with the LEGO® elements in your challenge set. Dual Lock is designed to stick or "lock" to itself when two faces of it are pressed together, but you can unlock it too, for ease of transport and storage. The application process for the Dual Lock is only needed once. Later, the models can simply be locked onto the mat or unlocked. To apply Dual Lock proceed one model at a time as follows:

Step 1: Stick one square, adhesive side DOWN, on each box you see on the mat with an "X" in it. For half-sized boxes, cut the squares in half.



Step 2: Press a second square on top of each of those, "locking" them on, adhesive side UP. Instead of using your finger, use a bit of the wax paper the squares came on.

Step 3: Align the Model exactly over its marks, and lower/press it onto the squares.



Step 1



Step 2



Step 3

Hints: Pay attention. Some models look symmetrical, but do indicate a directional model feature somewhere. Be sure to place each square precisely on its box, and each model precisely over its marks. When pressing a model down, press down on its lowest solid parts instead of crushing the whole model. Pull on that same structure if later you need to separate the model from the mat.

For large and/or flexible models, apply only one or two pairs at a time. There's no need to do them all at once.

Field Maintenance

Border Walls

Remove any splinters, and cover holes.

Field Mat

Don't clean the mat with anything that will leave a residue. Any residue, sticky or slippery, will affect the robot's performance. Use a vacuum and/or damp cloth for dust and debris (above and below the mat). To remove marks, try a white plastic eraser. When moving the mat for transport and storage, don't let it bend into a sharp kink point, which could affect the robot's movement. For control of extreme curl at the east or west edges of the Mat, black tape is allowed, with a maximum of 6 mm overlap. Foam tape is not allowed. Do NOT put Dual Lock nor any other tape nor adhesive under the mat.

Mission Models

Keep the mission models in original condition by straightening and tightening solid connections often. Ensure that spinning axles spin freely by checking for end-to-end play and replacing any that are bent. Frequently check for and fix any loop distortion.



u-loop → good



droop-loop distortion → bad



bell-loop distortion → bad

2.2 Missions: Field Setup & Placement, Tasks Description, Constraints & Evaluation

BASE

Place these six models anywhere in base:

- supply payload
- crew payload
- 1 meteoroid
- satellite V
- satellit C
- tube module



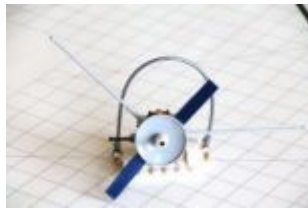
supply payload



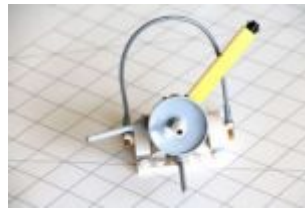
crew payload



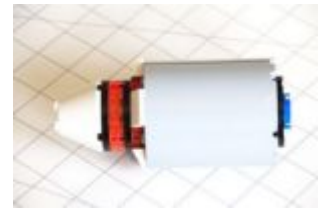
meteoroid



satellite V



satellite C



tube module

FIELD



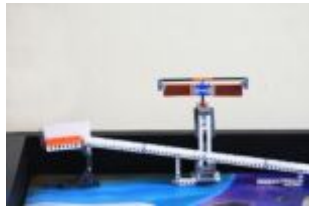
M01. SPACE TRAVEL

BACKGROUND

Incredible engineering accomplishments like space travel come about in steps. And many huge, progressive sub-goals need to be met before we can forever leave earth and live to tell about it!

FIELD SETUP & PLACEMENT

- **Space travel ramp + your team's solar panel:** These models are built as one piece and secured to the mat on their marks. Move your team's solar panel into the middle-click position, not angled.



space travel ramp and your team's solar panel



your team's solar panel

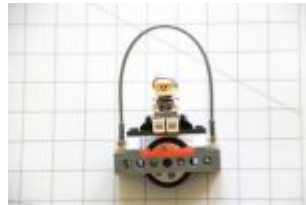


your team's solar panel

- **Space travel payloads:** Place the supply and crew payloads anywhere in base, and place the vehicle payload on the orange section of the space travel ramp, facing east, and leaning west.



supply payload



crew payload



vehicle payload

MISSION

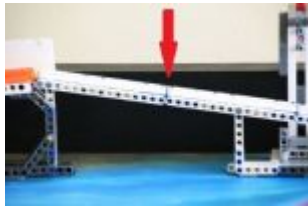
The robot needs to send payload rockets (carts) rolling down the space travel ramp. The first cart is pre-set and ready to go, but the robot needs to load the other two from base.

SCORES

- Vehicle payload rolled down the space travel ramp: **22**
- Supply payload rolled down the space travel ramp: **14**
- Crew payload rolled down the space travel ramp: **10**
- Possible scores: 0, 10, 14, 22, 24, 32, 36, 46

SCORING REQUIREMENTS

- For each roll, the cart must be independent by the time it reaches the first track connection ramp. → Note: Only allowed method. Must be observed by the referee.
- Start each payload clearly rolling down the space travel ramp. → Note: Only allowed method. Must be observed by the referee.
- As a mission requirement in any mission, the word “independent” means “not in contact with any of your equipment.” → As long as the cart clearly rolls independently past the first track connection, it’s okay if it doesn’t roll all the way east.



first track connection

M02. SOLAR PANEL ARRAY

BACKGROUND

Solar panels in space are a great source of energy for a space station in the inner solar system, but since things in space is always moving, aiming the panels takes some thought.

FIELD SETUP & PLACEMENT

- **Your solar panel:** See field setup & placement M01.





MISSION


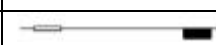

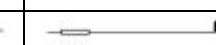
Solar panels need to be angled toward or away from you, depending on strategy and conditions.

SCORES

- Both solar panels are angled toward the same field: **22 (for both teams)**
- Your solar panel is angled toward the other team's field: **18**
- Possible scores: 0, 18, 22, 40 as shown below and seen from above your north border, facing north.

In the diagrams below, as on your practice field, "your" solar panel is the one on your west end of the table.

OTHER TEAM: 22 	OTHER TEAM: 18 	OTHER TEAM: 0 	OTHER TEAM: 22+18 
YOUR TEAM: 22+18	YOUR TEAM: 18	YOUR TEAM: 0	YOUR TEAM: 22

OTHER TEAM: 0 	OTHER TEAM: 18 	OTHER TEAM: 0 	OTHER TEAM: 0 
YOUR TEAM: 18	YOUR TEAM: 0	YOUR TEAM: 0	YOUR TEAM: 0



angled solar panel

SCORING REQUIREMENTS

- Results must be visible at the end of the match.

M03. 3D PRINTING

BACKGROUND

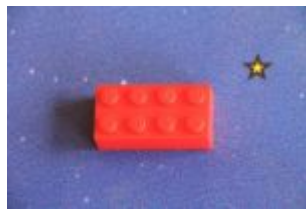
It is amazingly expensive to send heavy stuff like construction material into space, so scientists and engineers are instead learning how to print what they need in space, using available extraterrestrial elements.

FIELD SETUP & PLACEMENT

- **3D printer + 2 x 4 brick:** These models are built as one piece and secured to the mat on their marks and the 2 x 4 brick with its studs upwards.



3D printer



2 x 4 brick



3D printer ready

MISSION

The robot needs to get a regolith core sample and place it into the 3D printer, which will cause the 2 x 4 brick to pop out. The ejected 2 x 4 brick can then be delivered elsewhere for more points.

SCORES

- The 2 x 4 brick ejected and completely in the northeast planet area: **22 OR**
- The 2 x 4 brick ejected and not completely in the northeast planet area: **18**
- Possible scores: 0, 18, 22



northeast planet area



22 points



18 points

SCORING REQUIREMENTS

- Results must be visible at the end of the match.
- Eject the 2 x 4 brick by placing a regolith core sample into the 3D printer. → Only allowed method. Must be observed by the referee.

M04. CRATER CROSSING

BACKGROUND

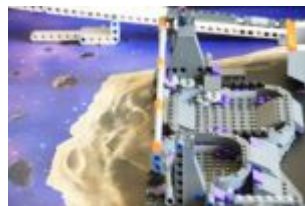
For rovers in other worlds, getting stuck is definitely not okay! Teams of rovers can help each other, but a lone rover needs to be very careful.

FIELD SETUP & PLACEMENT

- **Craters:** Secure the craters model to the mat on its marks and raise the gate as high as it will go.



craters



gate



craters ready

MISSION

The robot or whatever agent-craft it sends out needs to cross the craters model completely, by driving directly over it. Not near it. Not around it.

SCORES

- Robot or agent-craft crossed the craters model completely: **20**
- Possible scores: 0, 20



between the towers



past the gate

SCORING REQUIREMENTS

- All weight-bearing features of the crossing equipment must cross completely between the towers. → Only allowed method. Must be observed by the referee.
- Crossing must be from east to west, and make it completely past the flattened gate. → Only allowed method. Must be observed by the referee

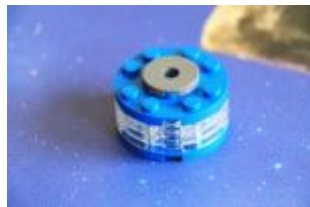
M05. EXTRACTION

BACKGROUND

To live away from earth, it would help if we were good at detecting and mining resources under the surfaces of other planets, moons, asteroids, and even comets.

FIELD SETUP & PLACEMENT

- **Core site:** Secure the core site to the mat on its marks, with its axle pointing east.
- **Regolith core samples + gas core sample + water core sample:** Load core samples onto the axle with their studs facing east, in the order shown: regolith, gas, water, and regolith last.



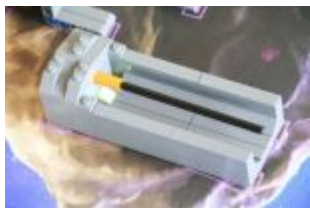
water core sample



regolith core samples



gas core sample



core site



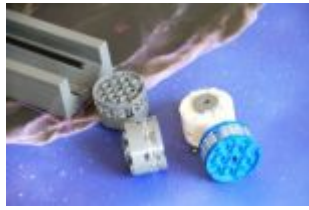
core site ready

MISSION

The robot needs to get all the core samples out of the core site model, then it has options for what to do with them as described here, and in mission M03.

SCORES

- Move all four core samples so they are no longer touching the axle that held them in the core site model: **16**
- Place the gas core sample so it is touching the mat, and completely in the lander's target circle: **12 OR**
- Place the gas core sample completely in base: **10**
- Place the water core sample so it is supported only by the food growth chamber: **8**
- Possible Scores: 0, 16, 24, 26, 28, 34, 36



16 points



Lander's target circle



12 points



10 points



8 points

SCORING REQUIREMENTS

- Results must be visible at the end of the match.

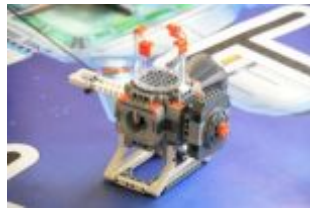
M06. SPACE STATION MODULES

BACKGROUND

Space stations allow us to learn about and even practice living in space, but improved technology and new international partners require modules to be easily interchangeable.

FIELD SETUP & PLACEMENT

- **Habitation hub:** Secure the habitation hub to the mat on its marks, with the white beam extension at the north side.
- **Astronaut “Gerhard”:** Insert the astronaut as shown, with his visor down, his feet down, his forearms level, and his loop vertical compared to the mat.
- **Dock modul:** Insert the dock module all the way into the port at the south side of the habitation hub, with its studs facing up.
- **Cone modul:** Insert the cone module all the way into the port at the east side of the habitation hub.
- **Tube model:** Place the tube module anywhere in base.



habitation hub



astronaut “Gerhard”



astronaut inserted



dock module



cone module



tube module



habitation hub ready

MISSION

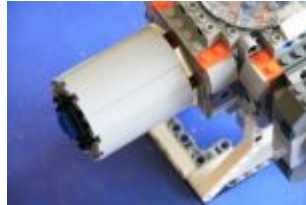
The robot needs to remove and insert modules among the habitation hub's port holes.

SCORES

- Move the cone module completely into base: **16**
- Insert the tube module into the habitation hub port, west side: **16**
- Transfer/insert the dock module into the habitation hub port, east side: **14**
- Possible scores: 0, 16, 32, 46



16 points



16 points



14 points

SCORING REQUIREMENTS

- Results must be visible at the end of the match.
- Inserted modules must not be touching anything except the habitation hub. → Needs to be visible at the end of the match.

M07. SPACE WALK EMERGENCY

BACKGROUND

Space is quiet and beautiful, but with almost no heat, air, nor air pressure, it could freeze, suffocate, and boil you all at once! Help our spacewalking astronaut “Gerhard” get to safety.

FIELD SETUP & PLACEMENT

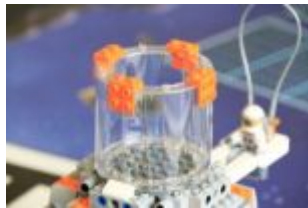
- **Astronaut + Habitation hub:** See field setup & placement M06.

MISSION

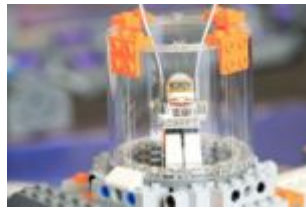
The robot needs to get Gerhard’s body into the airlock chamber.

SCORES

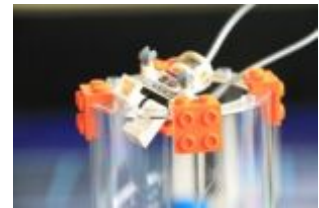
- Astronaut completely in the habitation hub’s airlock chamber: **22 OR**
- Astronaut partly in the habitation hub’s airlock chamber: **18**
- Possible scores: 0, 18, 22



airlock chamber



22 points



18 points

SCORING REQUIREMENTS

- For this mission, the word “body” includes all parts except the loop.
- Results must be visible at the end of the match.

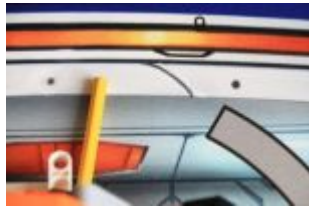
M08. AEROBIC EXERCISE

BACKGROUND

Though spacecraft travel crazy-fast, even the shortest trips involve a lot of time for the traveler's body away from labor and recreation, which is bad for the heart and lungs.

FIELD SETUP & PLACEMENT

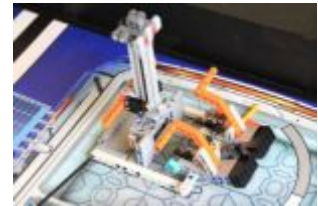
- **Exercise machine:** Secure the exercise machine to the mat on its marks. rotate the pointer northwest as far as it will go. Move the strength bar down as far as it will go.



pointer



strength bar



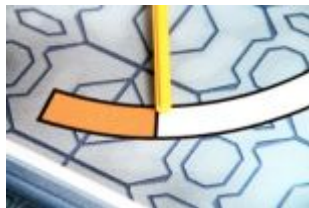
excercise machine ready

MISSION

The robot needs to repeatedly move one or both of the exercise machine's handle assemblies to make the pointer advance.

SCORES

- Get the pointer tip completely in orange, or partly covering either of orange's end-borders: **22 OR**
- Get the pointer tip completely in white: **20 OR**
- Get the pointer tip completely in gray, or partly covering either of gray's end-borders: **18**
- Possible scores: 0, 18, 20, 22



22 points (benefit of the doubt)



18 points



18 points



handle assembly (it is part of the exercise machine, but it is shown by itself here for clarity)

SCORING REQUIREMENTS

- Advance the exercise machine's pointer along its dial by moving one or both of the handle assemblies. → Only allowed method. Must be observed by the referee.
- Results must be visible at the end of the match.

M09. STRENGTH EXERCISE

BACKGROUND

In zero-gravity, everything's easy to move, and you couldn't fall "down" even if you tried, so astronauts need movement resistance – two hours a day in fact, just to keep muscle and bone density.

FIELD SETUP & PLACEMENT

- **Exercise machine:** See field setup & placement M08.

MISSION

The robot needs to lift the strength bar to scoring height.

SCORES

- Lift the strength bar so the tooth-strip's 4th hole comes at least partly into view as shown:
16
- Possible scores: 0, 16



strenght bar



16 points



0 points

SCORING REQUIREMENTS

- Results must be visible at the end of the match.

M10. FOOD PRODUCTION

BACKGROUND

Gardening is easy, right? You just need a truckload of rich soil, some rain, sun, fertilizer, helpful bugs, CO₂ and a rake but what if you were orbiting Neptune, in a room the size of a minivan?

FIELD SETUP & PLACEMENT

- **Food growth chamber:** Secure the food growth chamber to the mat on its marks, with the push bar facing south and moved as far south as it will go.



food growth chamber push bar



food growth ready

MISSION

Move the push bar the right distance at the right speed, to get into the green scoring range.

SCORES

- Spin the food growth chamber's colors so the gray weight is DROPPED after green, but before tan, by moving the push bar: **16**
- Possible scores: 0, 16



16 points



16 points



0 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.
- Spin the food growth chamber's colors must be spun by moving the push bar. → Only allowed method. Must be observed by the referee.

M11. ESCAPE VELOCITY

BACKGROUND

Soon after a launch, rocket engines often separate away from spacecraft by design, but that's long before the spacecraft leaves the pull of gravity. So why doesn't the spacecraft fall back to earth?

FIELD SETUP & PLACEMENT

- **Launch platform + spacecraft:** Secure the launch platform to the mat on its marks, with its spacecraft fallen/down.



launch platform ready

MISSION

The robot needs to impact the strike pad hard enough to keep the spacecraft from dropping back down.

SCORES

- Get the spacecraft to go so fast and high that it stays up, by pressing/hitting the strike pad: **24**
- Possible scores: 0, 24



strike pad



24 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.
- Activate the spacecraft by pressing/hitting the strike pad. → Only allowed method. Must be observed by the referee.

M12. SATELLITE ORBITS

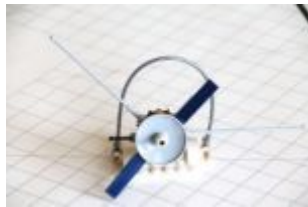
BACKGROUND

If a satellite doesn't have the correct velocity and distance from earth, it can fall, drift away, fail to function, or get destroyed by debris. Propulsive adjustments need to be performed with precision.

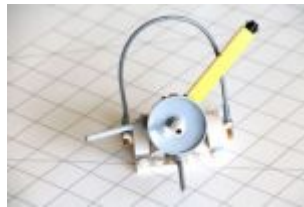
FIELD SETUP & PLACEMENT

- Satellite V
- Satellite C
- Satellite X

Place satellites V and C anywhere in base, and place satellite X loose on its marks as shown.



satellite V



satellite C



satellite X

MISSION

The robot needs to move one or more satellites to the outer orbit.

SCORES

- Move any part of a satellite on or above the area between the two lines of the outer orbit:
8 each
- Possible scores: 0, 8, 16, 24



Outer Orbit (only between these two lines)



8 points



0 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.

M13. OBSERVATORY

BACKGROUND

A space telescope is astonishing, but it can't beat the accessibility and simplicity of a college or science museum observatory – that is, if you know how and where to point it.

FIELD SETUP & PLACEMENT

- **Observatory:** Secure the observatory to the mat on its marks, and rotate it so the bottom of its pointer is centered over the black dot as shown.



observatory



observatory ready

MISSION

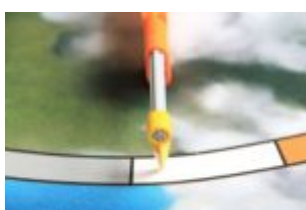
Rotate the observatory to a precise direction.

SCORES

- Get the pointer tip completely in orange, or partly covering either of orange's end-borders: **20 OR**
- Get the pointer tip completely in white: **18 OR**
- Get the pointer tip completely in gray, or partly covering either of gray's end-borders: **16**
- Possible Scores: 0, 16, 18, 20



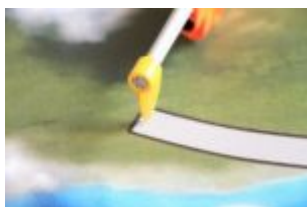
20 points



18 points



16 points



16 points



0 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.

M14. METEOROID DEFLECTION

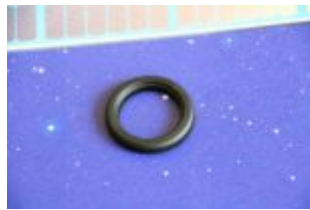
BACKGROUND

The chance of a “serious” meteoroid hitting earth in our lifetime is extremely low, but it’s not zero, and the devastation could truly wipe us out. How will scientists and engineers keep us safe?

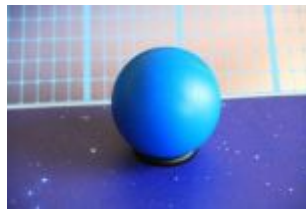
FIELD SETUP & PLACEMENT

- meteoroid ring
- 2 meteoroids
- meteoroid catcher

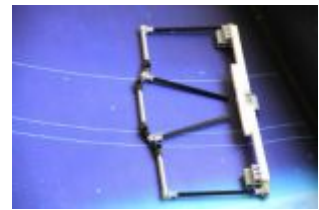
Place the meteoroid ring on its marks and place one of the two meteoroids on the ring. Place the other meteoroid anywhere in base. Secure the meteoroid catcher to the mat on its marks.



meteoroid ring



meteoroid on the ring



meteoroid catcher

MISSION

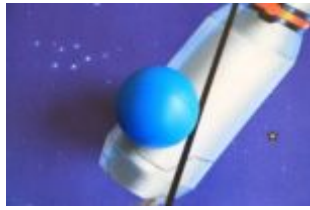
From west of the free-line, send one or both meteoroids independently to the meteoroid catcher. “Independently”: see also M01, Section “Scoring Requirements”.

SCORES

- Meteoroid(s) touch(es) the mat in the center section of the meteoroid catcher: **12 each**
- Meteoroid(s) touch(es) the mat in either side section of the meteoroid catcher: **8 each**
- Possible scores: 0, 8, 12, 16, 20, 24



free-line



meteoroid must be independent when it is no longer completely west of the free-line



24 points



20 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.
- The meteoroids need to be sent over the free-line to touch the mat in the meteoroid catcher → Only allowed method. Must be observed by the referee.
- The meteoroids must be hit/released while they are clearly and completely west of the free-line. → Only allowed method. Must be observed by the referee.
- While between hit/release and scoring position, the meteoroid must be clearly independent. → Only allowed method. Must be observed by the referee.
- If ever the ring-set meteoroid is off its ring, you may remove the ring from the field by hand. This is a special exception to the rules.

M15. LANDER TOUCH-DOWN

BACKGROUND

Our Lander doesn't have working parachutes, thrusters, or cushions, but one important feature is realistic ... it's very fragile.

FIELD SETUP & PLACEMENT

- **Lander:** Secure the lander release to the mat on its marks. Assemble the lander parts as shown, with tan axles in gray holes. Clamp the lander into the lander release as shown (hint: diagonal), and push the lock lever all the way down/east.



lander release



lander parts



lander clamped



lander down/east



lock lever



lander ready

MISSION

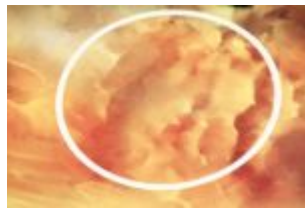
Get the lander to one of its targets intact, or at least get it to base.

SCORES

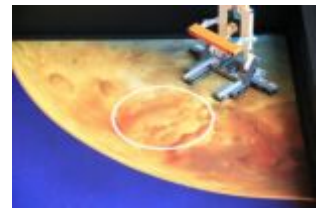
- Move the lander to be intact, touching the mat, and completely in its target circle: **22 OR**
- Move the lander to be intact, touching the mat, and completely in the northeast planet area: **20**
- Move both parts of the lander completely into base: **16**
- Possible scores: 0, 16, 20, 22



intact



lander's target circle



northeast planet area



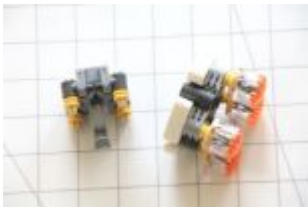
22 points



20 points



20 points



16 points



0 points



0 points

SCORING REQUIREMENTS

- Result must be visible at the end of the match.
- The lander is "intact" if its parts are connected by at least two of its four tan location axles

INTERRUPTION PENALTIES

FIRST® LEGO® League mission requirements need to be achieved by your robot through its programs and its use of equipment. You're allowed to hand-rescue your robot, but that does cause this penalty. Be sure to pay extra attention to the rules where they talk about "Interruptions" (D09, R10 and R14).

FIELD SETUP & PLACEMENT

- **Six penalty discs:** Before the match starts, the referee removes the 6 red penalty discs from the white triangle at the southeast of the mat, and holds on to them.



penalty discs

PENALTY

- If you interrupt the robot: **minus 3 each time**
- Possible penalty totals: -18, -15, -12, -9, -6, -3, 0

SCORING REQUIREMENTS

- Interruption needs to be observed by the referee.
- Upon penalty, the referee will place one penalty disc in the southeast triangle as a permanent interruption marker.
- You can get up to six such penalties.
- If a penalty disc comes off the triangle, it is simply returned, with no effect on score.