

UNIVERSAL ROBOTICS CHALLENGE 2023

Real Robotics

Advanced Division Rulebook

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Table of Contents

Overview.....	2
1. The Competition.....	2
2. The Field	3
3. The Rules	8
4. Scoring.....	13
5. Preliminary Video Rules	16
6. Competition Robots	17
7. Disqualification	18
Appendix 1. Building the Stacking Area and Packages	19
Appendix 2. Scoring Examples	25
Appendix 3. ArtecRobo Parts.....	32
Appendix 4. Artec Blocks	33

Overview

Stacking Packages

In our society, you don't have to look very far to find robots that do work in place of humans. This includes carrying things! While robots that transport objects are already sold and used in factories, there's lots of research and discussion around robots that can deliver packages right to your house and even serve meals in restaurants! In this competition, your goal is to make a robot that can pick up block packages from specific locations on the field. These packages are different shapes and sizes, and the higher you stack them, the higher your score!

1. The Competition

○ Competition Guidelines

◇ The Mission

The robot will carry block packages from different points around the field and stack them in the Stacking Area. You will get points based on how high you can stack the packages within the time limit.

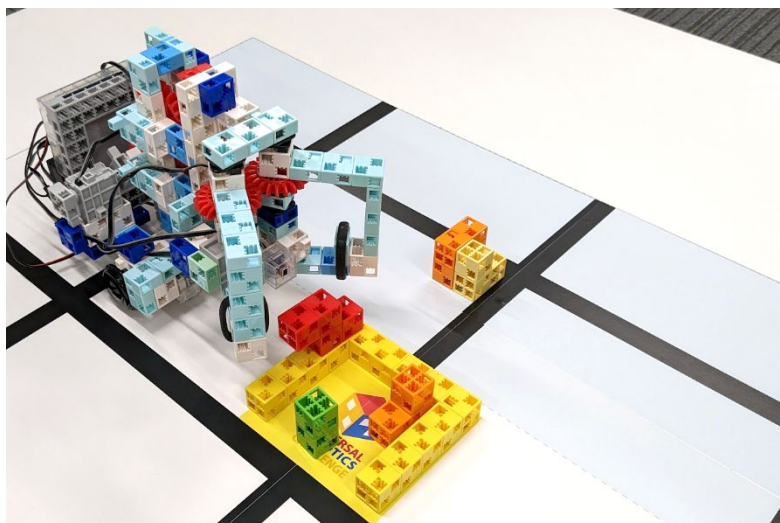


Fig 1. Stacking Packages

2. The Field

○ Layout and Placement

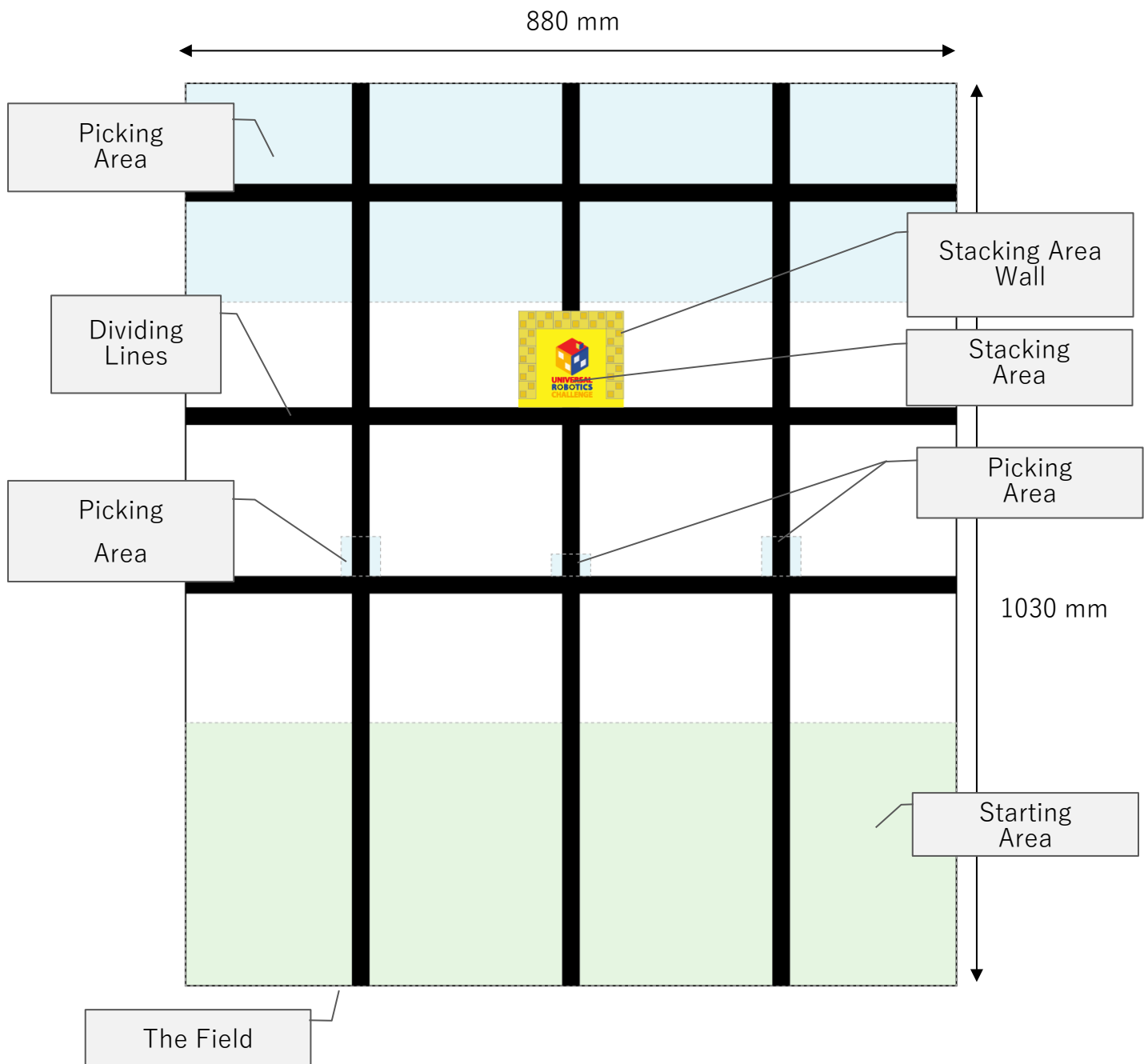


Fig 2. Competition Field

◇ The Starting Area

Start by setting down your robot inside of this light green rectangle. The Starting Area includes the black Dividing Lines shown inside of the red box in Figure 3.

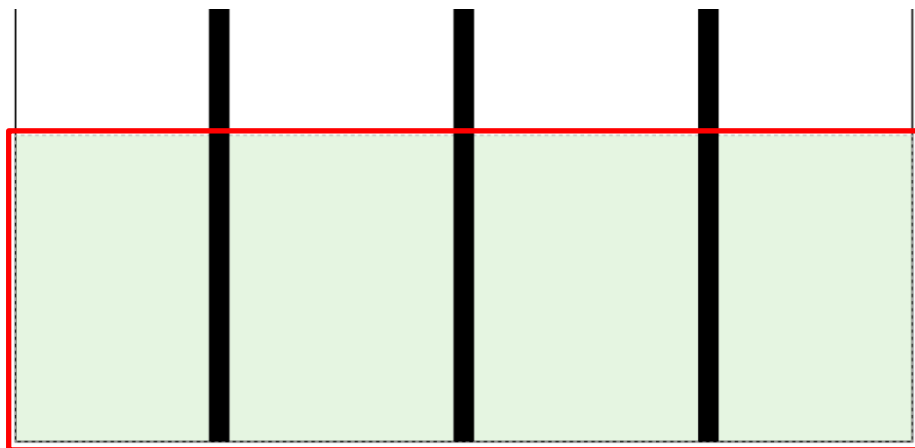


Fig 3. The Starting Area

◇ The Stacking Area

The Stacking Area is a yellow square on the field enclosed by a wall made of Artec Blocks. This wall is five cubes high and six cubes wide. Follow the instructions in Appendix 1 to build this wall. Be sure to use tape to keep the wall from moving outside of the Stacking Area.



Fig 4. The Stacking Area Wall

The wall you make for your preliminary video submission can be any single color you wish.

★ The wall in the World Finals will be yellow.

◇ Packages A-F

Packages are made of multiple Artec Block cubes. Your robot's job is to transport them from different points around the field. There are six types of packages, and the shape, color, and quantity of each package is shown in Figure 6. Follow the instructions in Appendix 1 to build these packages.

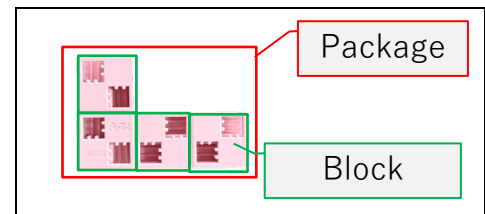

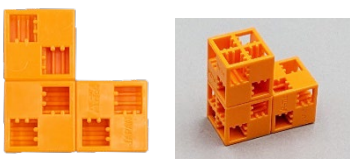
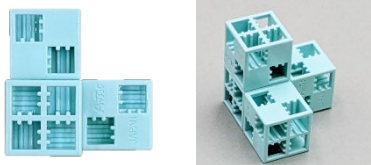


Fig 5. Packages and Blocks

		
Package A	Package B	Package C
Yellow	Orange	Light Aqua
4 each	4 each	4 each

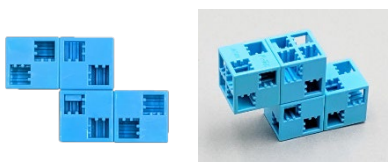
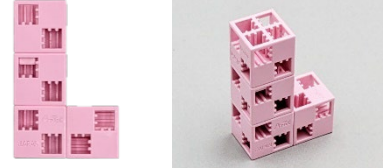
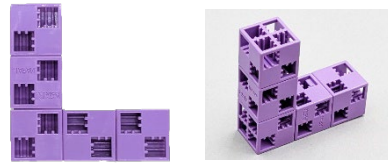
		
Package D	Package E	Package F
Aqua	Light Pink	Light Purple
4 each	4 each	4 each

Fig 6. Packages

The packages you make for your preliminary video submission can be any single color you wish, but each package must be a different color. For example, you could make Package A pink, Package B gray, Package C red, and so forth.

★ Packages in the World Finals will be the colors shown in Figure 6.

◇ Picking Areas

Place your packages in the light blue Picking Areas before the round starts. There are four of these on the field. Picking Areas include the black Dividing Lines shown inside of the red boxes in Figure 7.

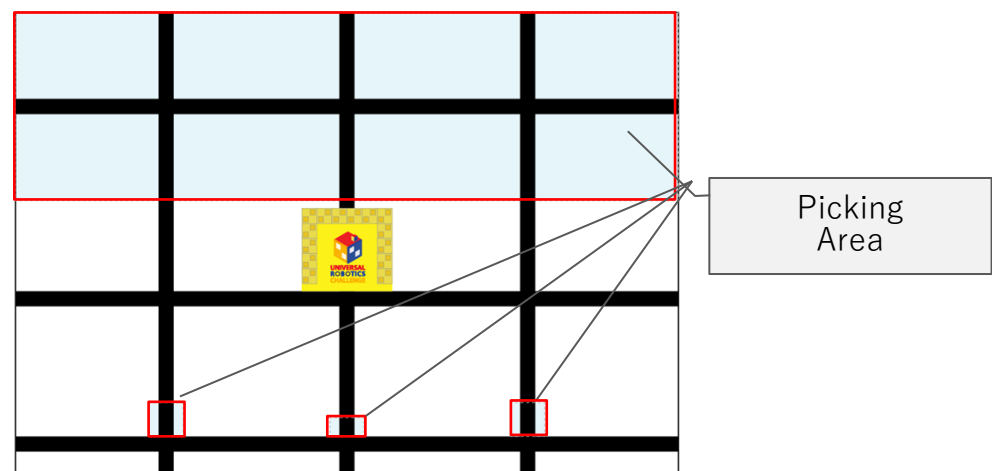


Fig 7. Picking Areas

◇ Dividing Lines

These lines are used as guides on the competition field.

◇ The Field

Set your Stacking Area wall, packages, and robot on the field.

○ Placement Rules (Preliminaries)

- 1) You can make your field for the preliminaries by printing out the field PDF on 15 sheets of A4 paper.
 - 2) Add tape to the bottom of the Stacking Area wall to keep it from sliding out of the Stacking Area.
 - 3) Use any quality of paper to print out the field.
 - 4) Do not place any other robots, walls, or objects which change the height of the field on the field. Changes in height caused by overlapping tape or paper are acceptable.
 - 5) The floor beneath the competition field should be perfectly level with no angles that cause changes in height.
 - 6) You can also lay the field on plywood, styrene, or other material to keep it level.
 - 7) There are multiple ways to deal with white margins caused by printing the course:
 - Proceed with the round leaving the margins intact.
 - Use markers of similar colors to fill in the margins on the Dividing Lines, Picking, and Stacking Areas and cover the remaining margins with extra paper.
- ★ There will be no white margins on the fields in the World Finals.



Fig 8. Filling in Margins

3. The Rules

○ Before the Round

1) Placing Packages

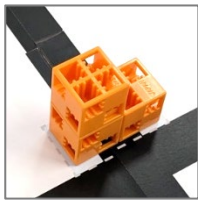
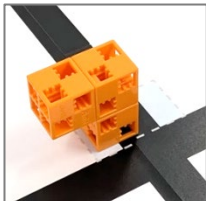

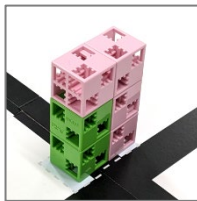
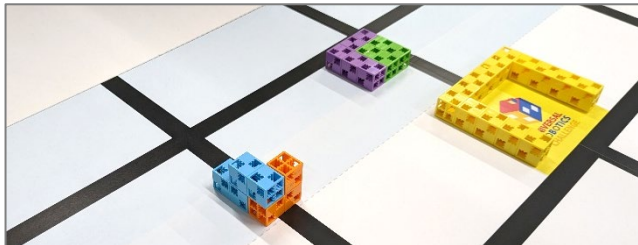
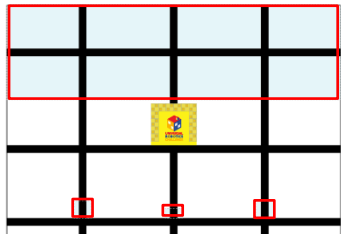
Place one package in each Picking Area. The time limit to do this is **one minute**.

The rules for placing packages are as follows:

- Each packaging must be touching the Picking Area.
- The bottom of each package must be completely within the Picking Area.
- The packages shouldn't touch the Stacking Area or the Stacking Area wall.
- You don't have to place every package. Set your leftover packages away from the field. These packages shouldn't be used, including for retries.
- You aren't allowed to touch pieces after placing them or resetting them for a retry.

The below show examples of correct and incorrect placements.

Placing Packages

				
				
<p>Correct</p>				
<p>The bottom of each package is touching the Picking Area. The top of the packages can stick out of the area and the Dividing Lines are considered a part of the Picking Area.</p>				

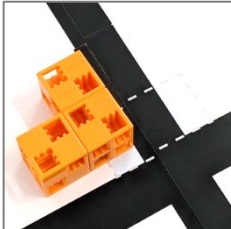



		
Incorrect	Incorrect	
Package is sticking out of the Picking Area	One or more Packages is not touching the Picking Area.	
		
Incorrect		
Package is touching the Stacking Area and wall.		

Fig 9. Package Placement

2) Placing the Robot

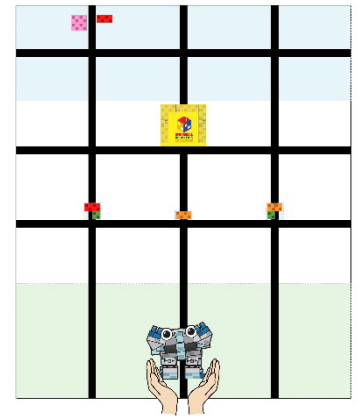
One participant sets the robot at any point inside of the Starting Area. The robot must be completely inside of the Starting Area. This includes the parts of the robot not touching the ground. The time limit to do this is **one minute**. The same participant can place the robot and packages.

○ The Round

1)

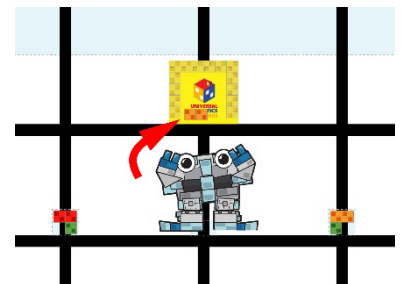
Starting the Round

Turn your robot on. You're allowed to control your robot using buttons or touch it to adjust its position as long as it stays in the Starting Area.



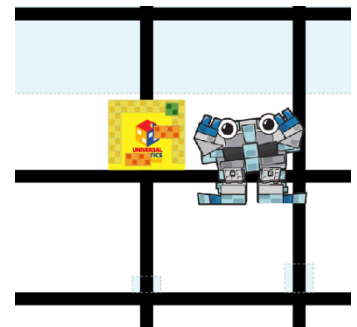
Leaving the Starting Area

The robot picks up and stacks packages in the Stacking Area until it returns to the Starting Area.



Ending the Round

The round is over once the participant declares that the round is over or **180 seconds** have passed. You won't be allowed to touch your robot or packages until the judge finishes scoring.



- 2) Participants aren't allowed to touch the robot if any part of it is outside of the Starting Area. This includes parts not touching the ground. Touching the robot will count as a retry and will result in a **40-point** deduction each time this happens.
- 3) The robot is allowed to handle any packages in the Stacking Area.
- 4) The robot can handle any packages it has already moved.
- 5) The round will end in the event of any of the following:
 - The participant declares the round over. The time of the declaration will be the time for the round.
 - **180 seconds** have passed.
 - The judges determine that there has been a serious rule violation.

○ Retries

- 1) If a robot malfunctions and stops moving after it leaves or the packages are placed in unexpected ways, participants can declare a retry and move their robot back to the Starting Area.
- 2) Each retry will result in a **40-point** deduction.
- 3) The timer for the round will keep running during a retry.
- 4) Participants must notify the judges when the retry is over.
- 5) The robot must be completely inside of the Starting Area before the retry is over.
- 6) Participants are allowed to do the following during a retry:
 - Handle their robot.
 - Move the robot back to the Starting Area.
 - Touch the packages and move them to Picking Areas of their choosing.
- ★ This is limited to packages which have already been placed on the field.
- 7) There is no limit to the number of retries allowed.

○ Ending the Round

- 1) The round is over once the participants declare it's over or **180 seconds** have passed.
- 2) Judges may handle the robot and packages to determine the final score.
- 3) Once the round is over, the judge will calculate your final score to determine rankings.

4. Scoring

- 1) Preliminary scores will be calculated by judges based on submitted videos.
- 2) At the World Finals, the highest score out of two rounds will be your final score.
- 3) Scores will be calculated at the end of each round.
- 4) Scores are calculated based on the number of packages touching the valid parts of the Stacking Area and inner wall.

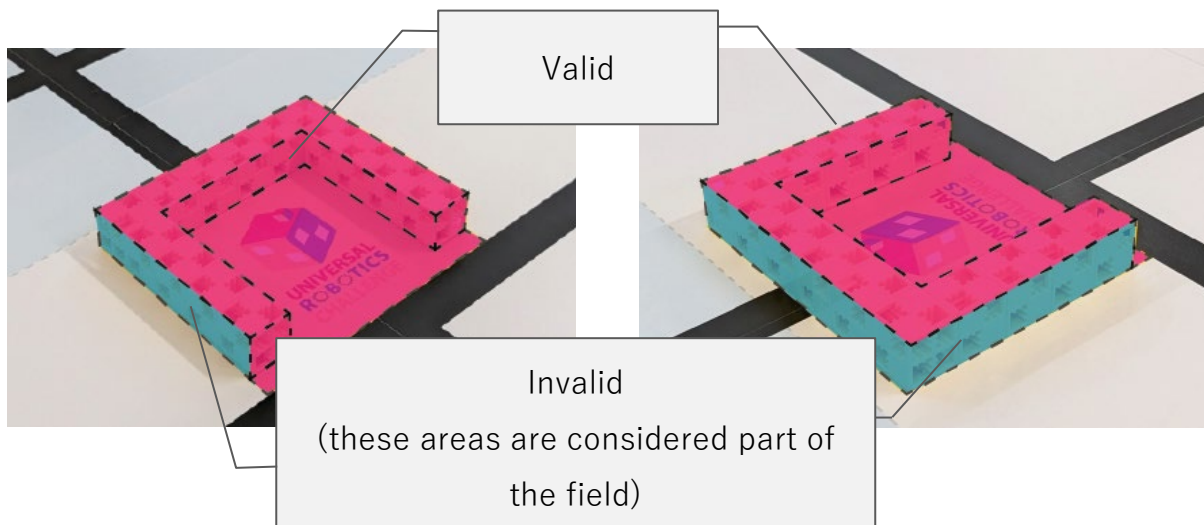


Fig 10. Scoring Areas

- 5) A package is valid and receives points if it satisfies the following three conditions:
 1. The package is touching the Scoring Area.
 2. The package is touching only the Stacking Area and not any other part of the field.
 3. The package is not touching the robot.
- 6) Fallen packages are valid packages which are not lying flat inside of the Scoring Area.
- 7) Packages which are touching fallen packages are also considered fallen packages.

8) Valid packages are scored according to the following criteria:

- $(\# \text{ of blocks}) \times (\text{height multiplier}) = \text{points}$
- As shown in Figure 11, one block height is a multiplier of 10, two block heights is 20, three is 30, and four is 40.
- Fallen packages get a multiplier of 10 regardless of height.

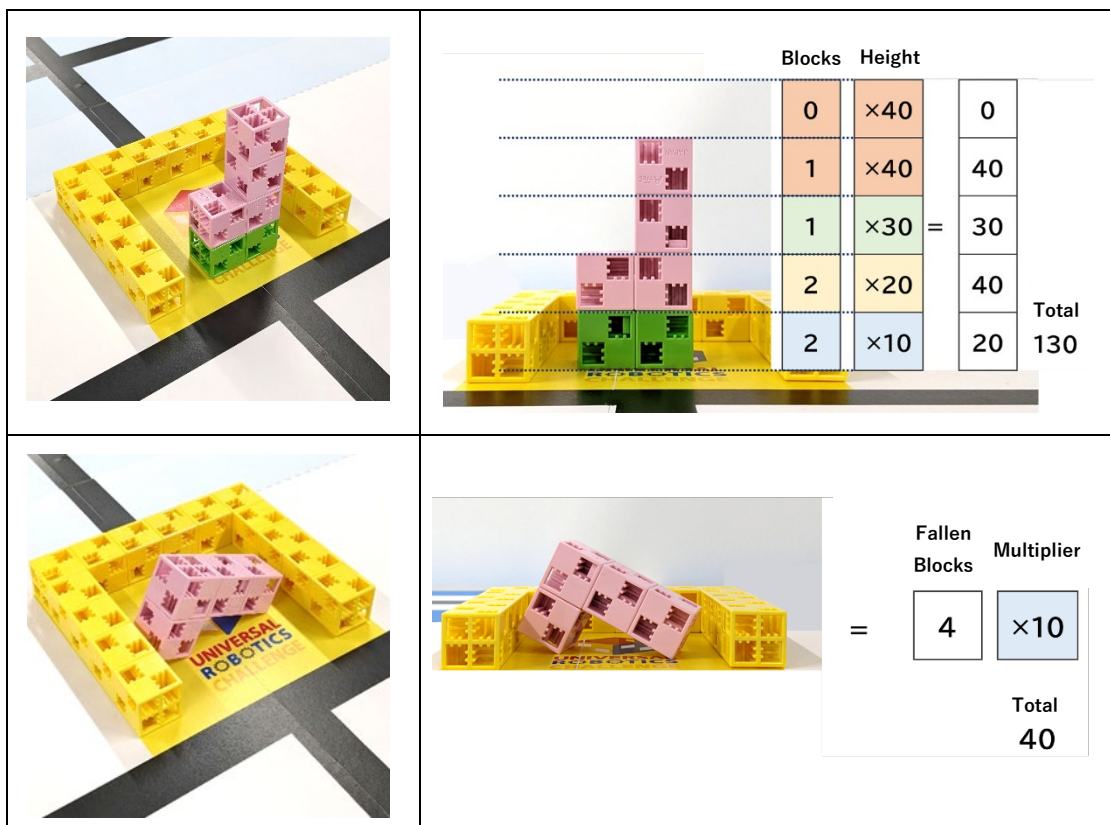


Fig 11. Scoring Packages

You can find more specific examples of stacked packages in **Appendix 1. Scoring Examples.**

9) Points will be deducted based on your number of retries to get your final score.

○ Ranking

Ranks in the competition are determined as follows:

- 1) The highest-scoring team.
- 2) In the event of multiple teams with the same score, ranks are determined as follows:
 1. The height of the team's stack.
 2. The number of blocks at the top level.
 3. The number of blocks at the next highest level.
 4. Steps 1-3 are repeated until height 1 is reached.
 5. The number of packages.
 6. The smallest number of retries.
 7. The shortest round time.

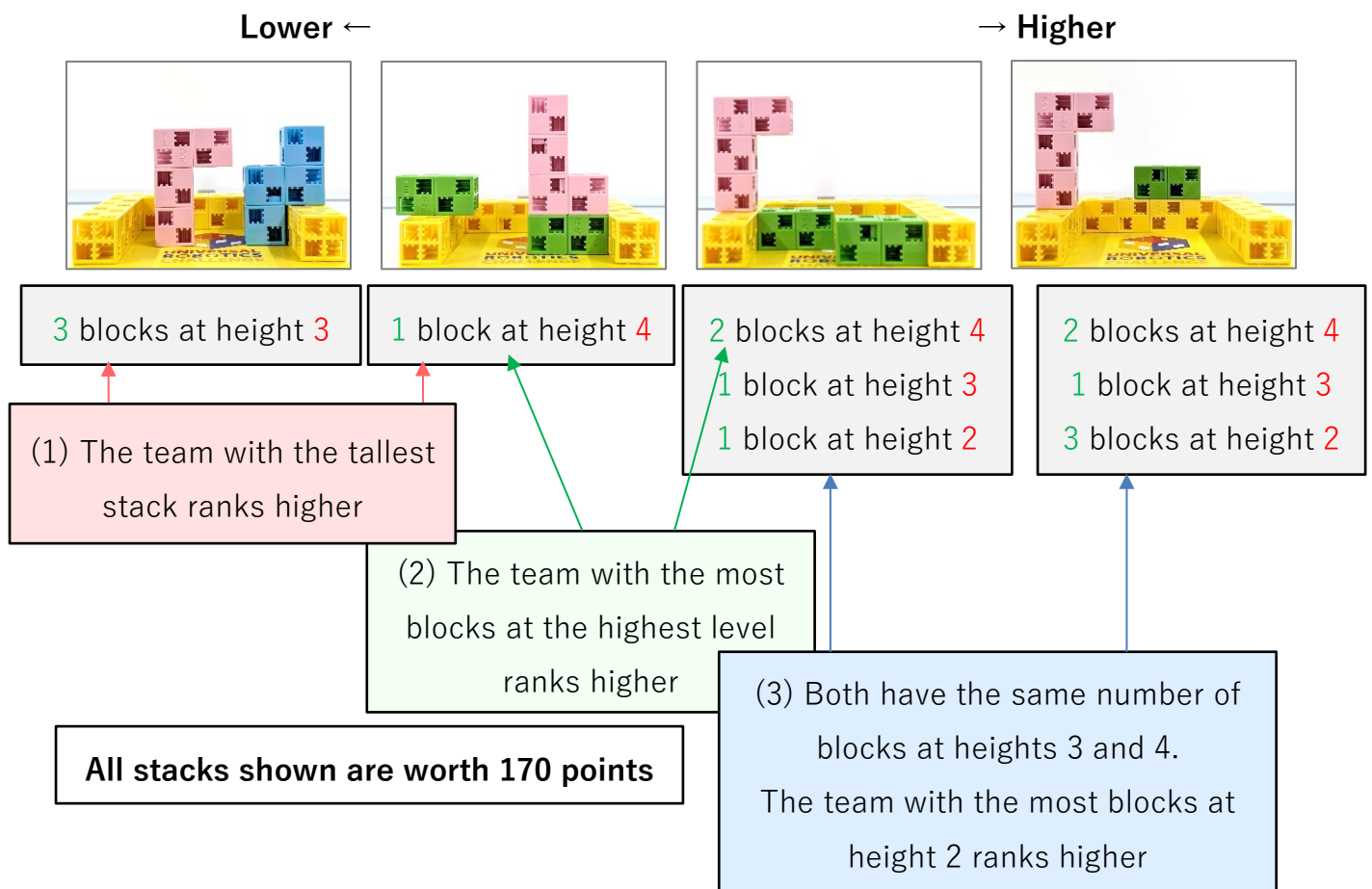


Figure 12. Ranking Identical Scores

5. Preliminary Video Rules

- 1) In order to ensure the robot meets the size requirements of the competition, participants must include a clip or images in their video of them measuring the length, width, and height of the robot using a tape measure or ruler. The camera must be still for at least three seconds for each dimension.
- 2) In order to measure the time for the round, include a stopwatch or clock with a second hand in the video.
- 3) After the round is over, take a video or image of the Stacking Area that clearly shows the packages. Include this at the end of the video.
- 4) You do not need to include the placement of the robot or packages. The video of the round can start with these already placed on the field.
- 5) There should be no cuts between the start and the end of the round. You should not move the camera as it films.

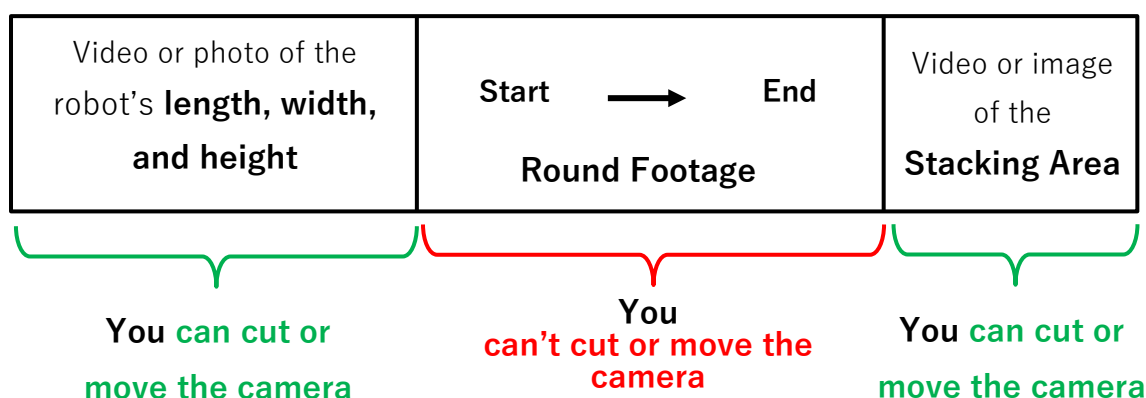


Fig 13. Video Content

6. Competition Robots

- 1) Only one robot is allowed per team.
- 2) See Appendix 3 and Appendix 4 for the ArtecRobo parts and Artec Blocks competitors can use to build their robots.
- 3) Robots may use only one Studuino, Studuino:bit Core Unit, or micro: bit. There are no restrictions on the number of other parts.
- 4) Any parts from 2) can't be modified.
- 5) Participants are not allowed to reinforce their robots using zip ties, rubber bands, or adhesives. You are, however, allowed to bundle cables together.
- 6) Robots must not exceed **25 cm in width, 30 cm in length**, and **25 cm in height** at the start of the round.
- 7) There are no weight restrictions on robots.
- 8) While robots are allowed to transform at the start of the round, they must stay in one piece.
- 9) Robots should move completely on their own once the round has started. They must not be remote controlled.
- 10) Robots must not use any power sources aside from those allowed in Appendix 3.

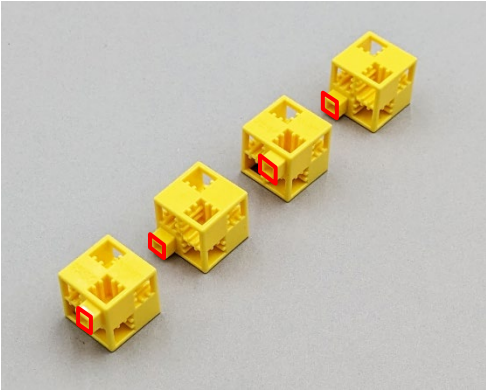
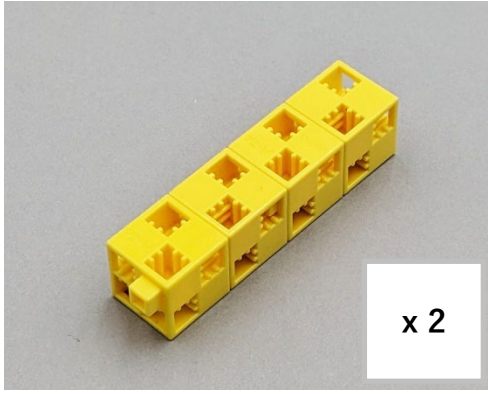
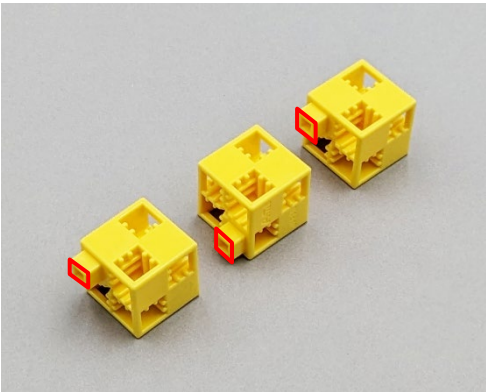
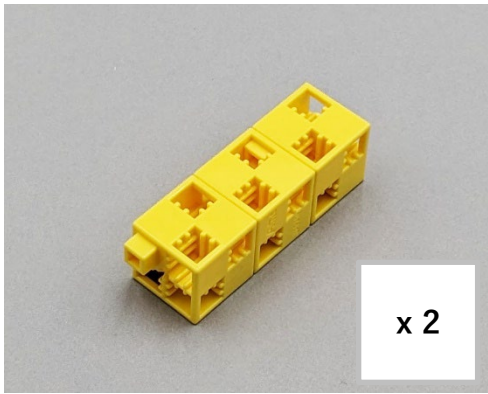
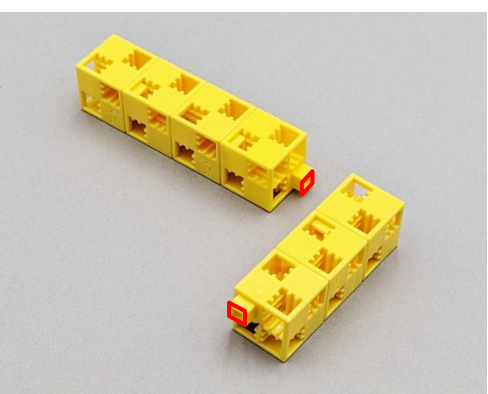
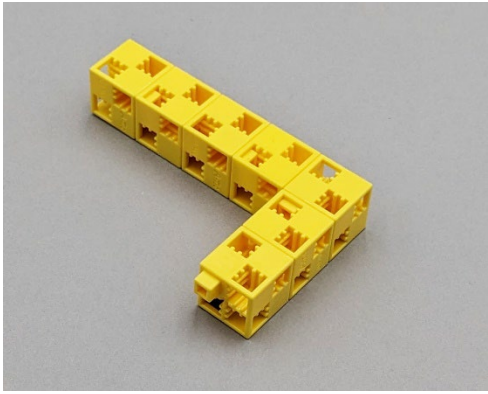
7. Disqualification

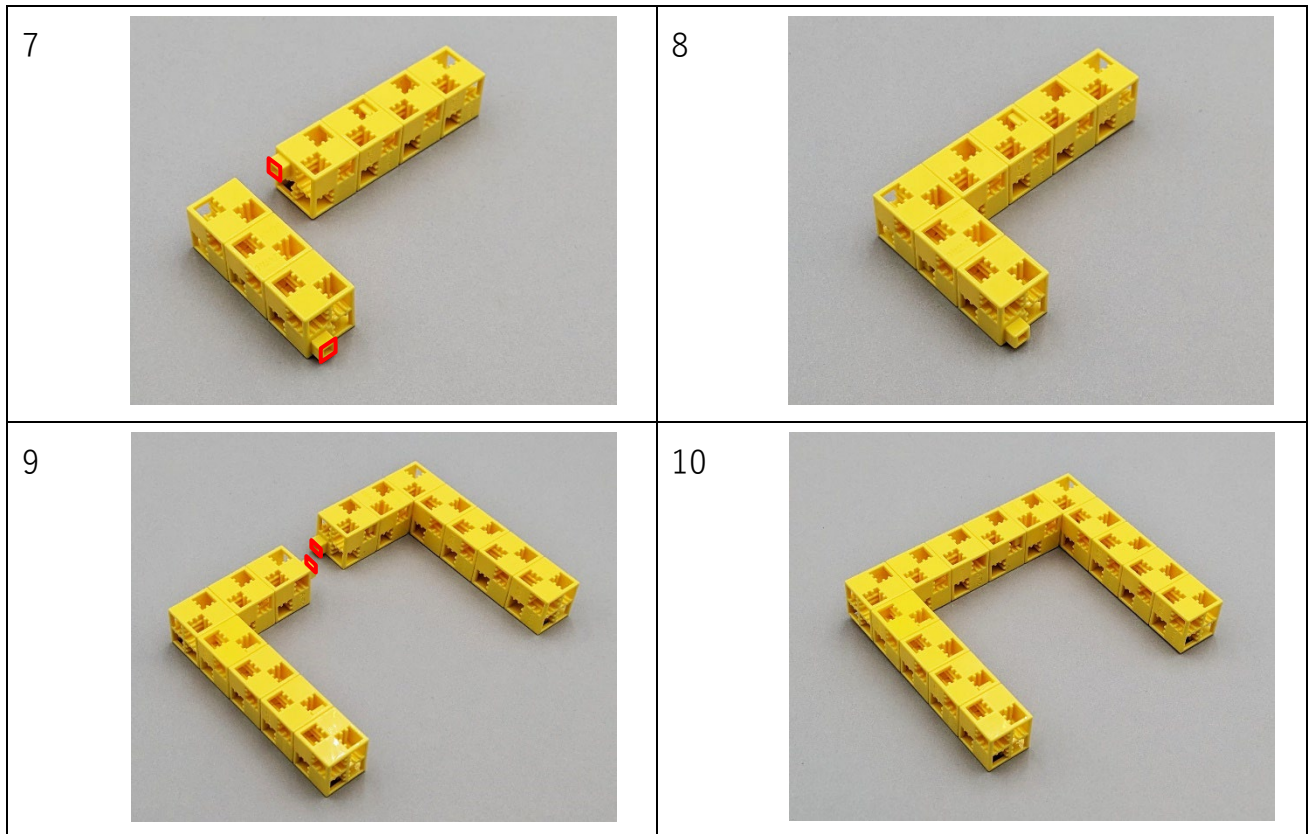
Preliminary submissions will be disqualified in the event:

- 1) It has been determined that the video was fast-forwarded, fabricated, clipped, or otherwise edited
- 2) The Stacking Area moves or breaks apart during the round
- 3) The robot does not meet the specifications in section 6.
- 4) Participants move or touch the packages outside of a retry.

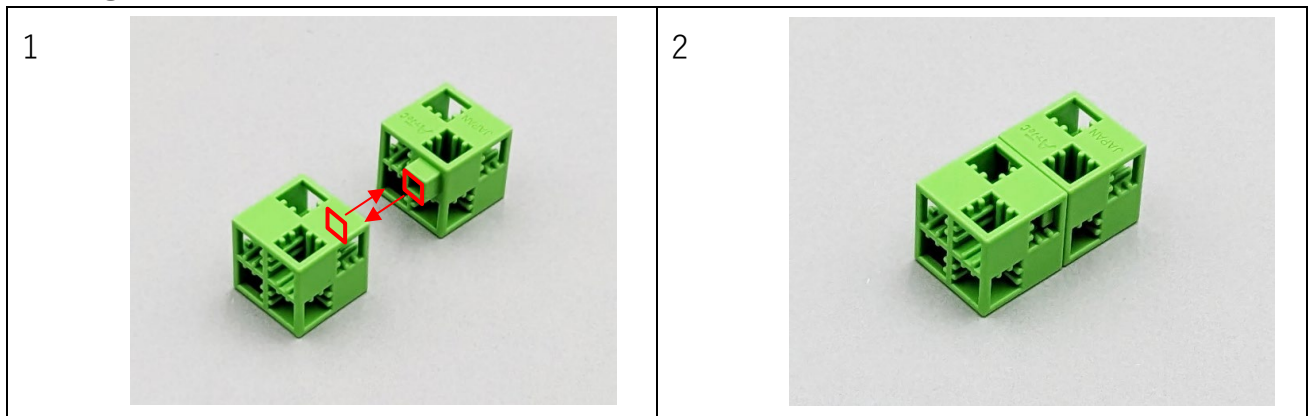
Appendix 1. Building the Stacking Area and Packages

The Stacking Area

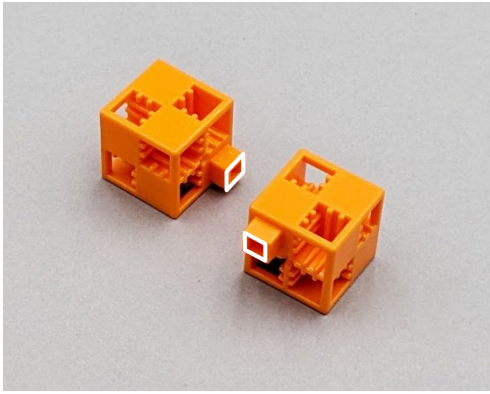
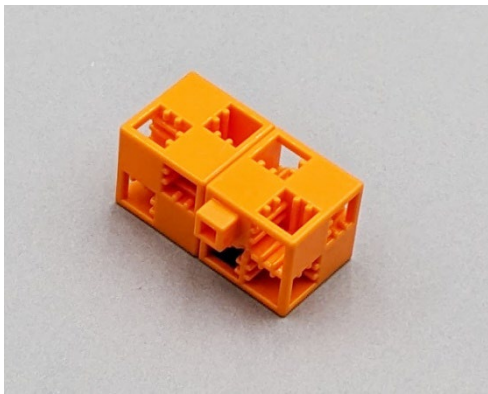
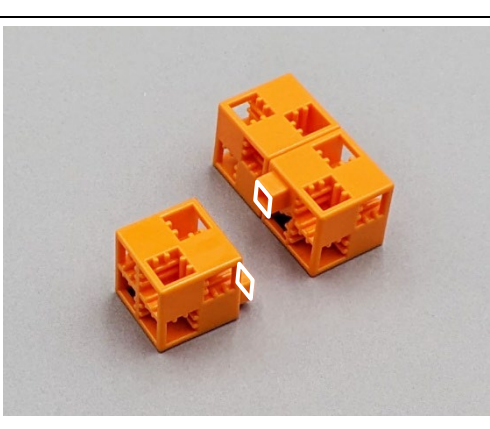
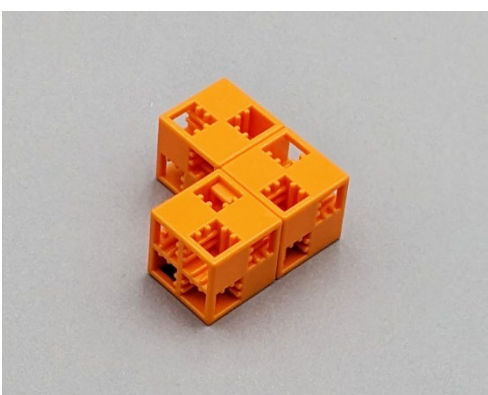
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<p>3</p> 	<p>4</p> 
<p>5</p> 	<p>6</p> 



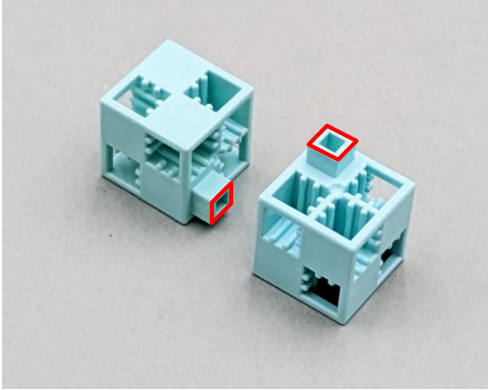
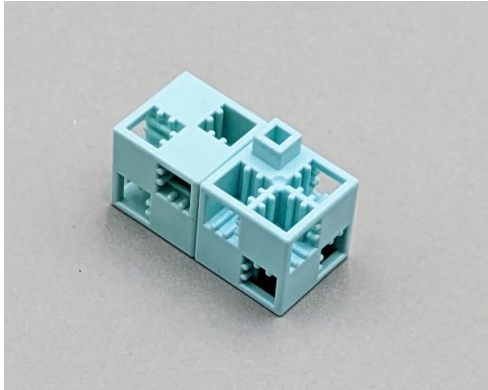
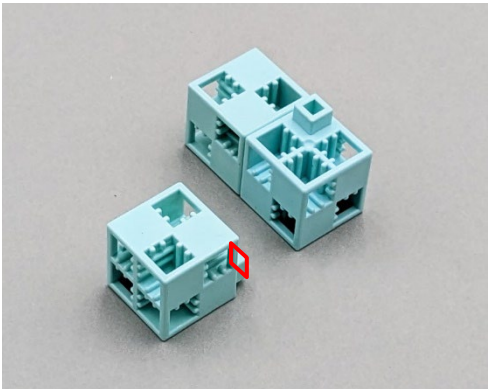
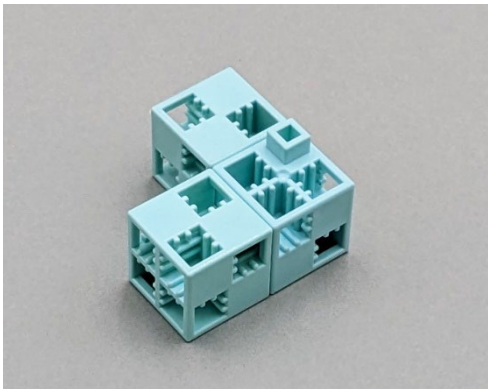
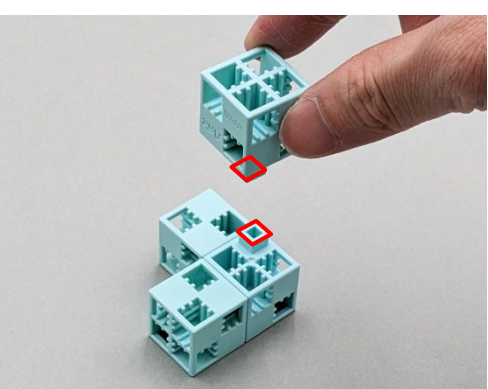
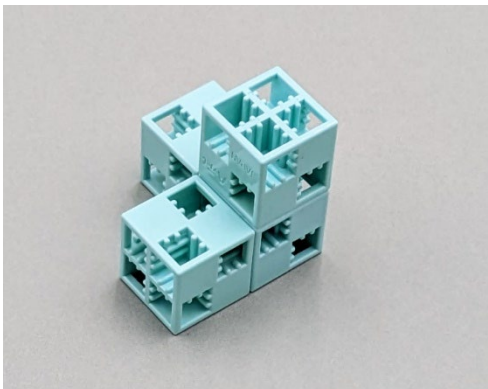
Package A



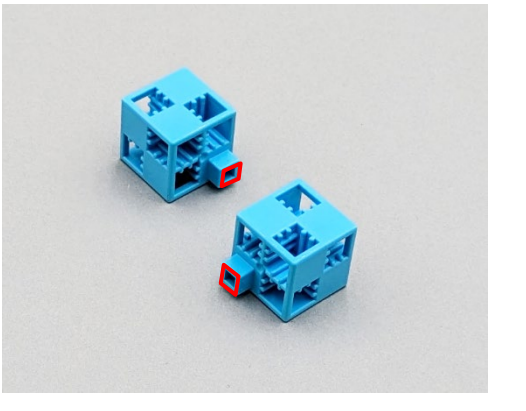
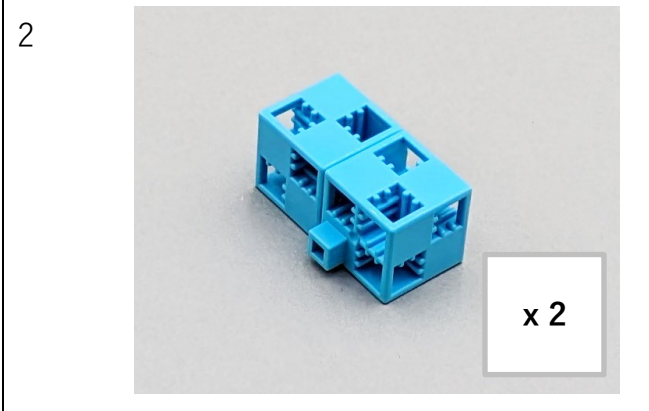
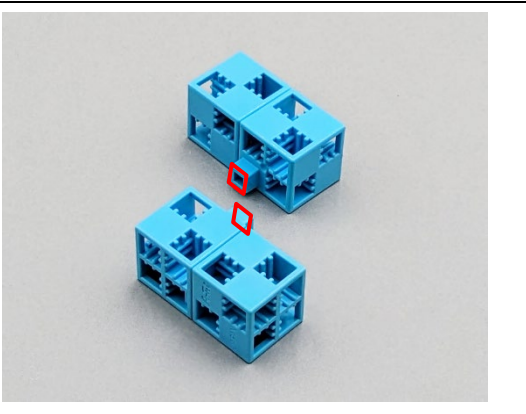
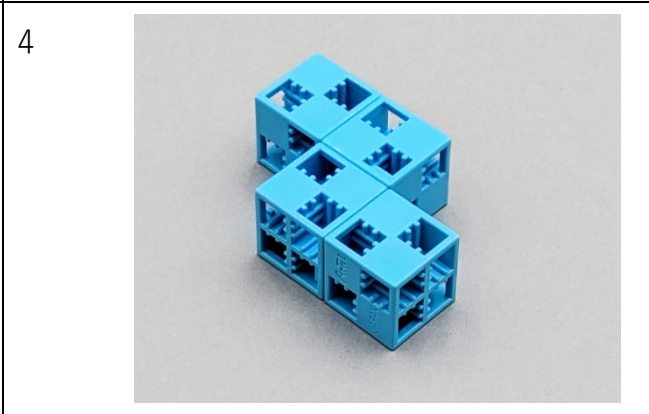
Package B

<p>1</p> 	<p>2</p> 
<p>3</p> 	<p>4</p> 

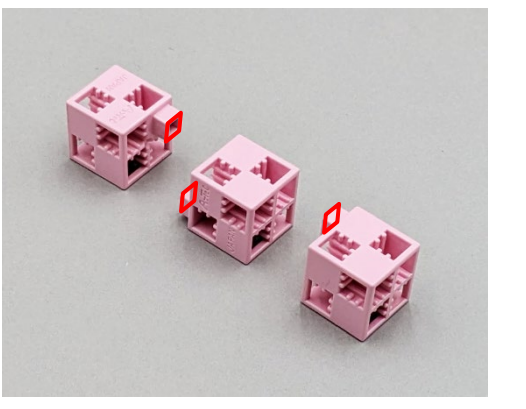
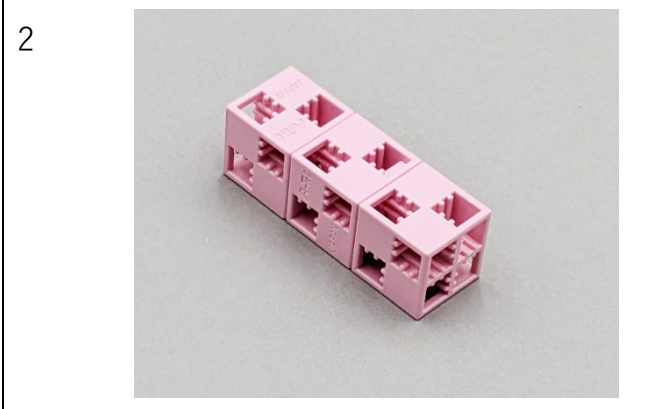
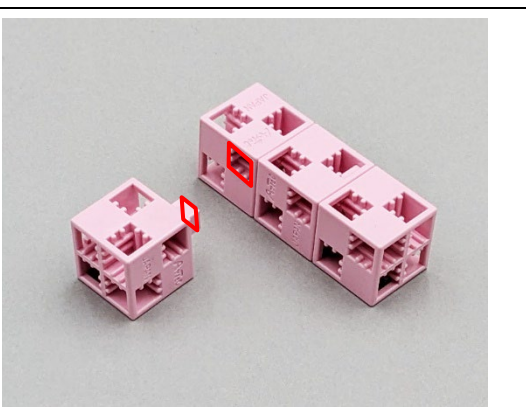
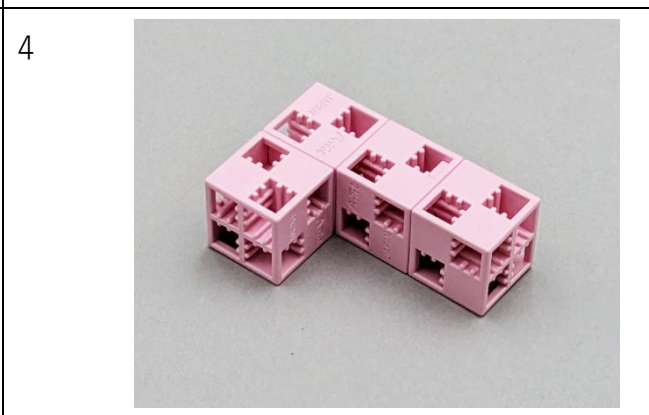
Package C

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<p>3</p> 	<p>4</p> 
<p>5</p> 	<p>6</p> 

Package D

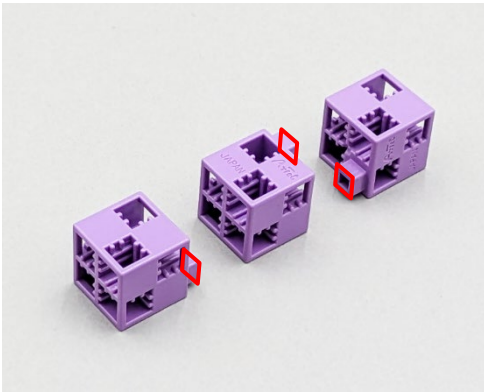
1		2	
3		4	

Package E

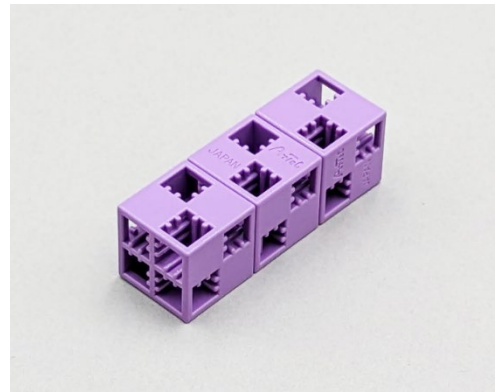
1		2	
3		4	

Package F

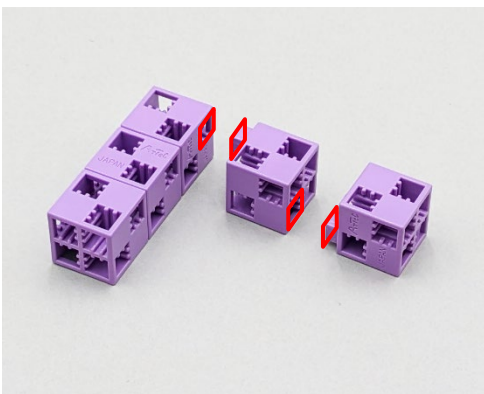
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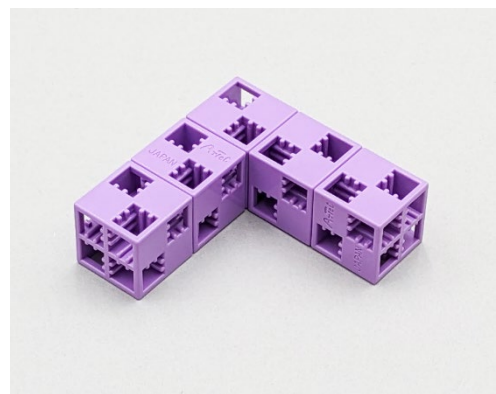
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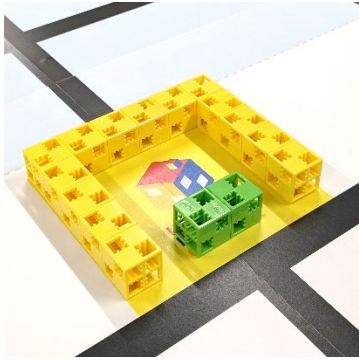
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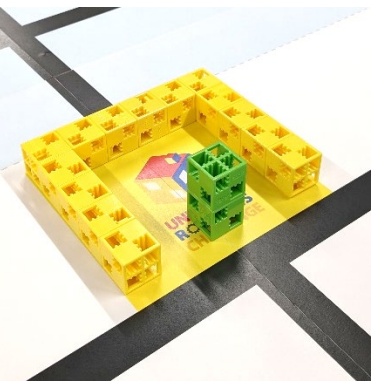
Appendix 2. Scoring Examples

The following section shows example scores.

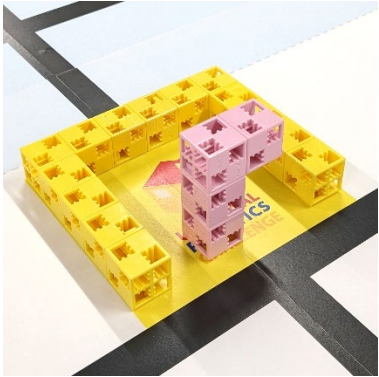
Example 1) Setting down one package

	Blocks Height			
	0	×40	0	=
	0	×40	0	
	0	×30	0	
	0	×20	0	
	2	×10	20	
			Total	20
$2 \times 10 = 20$ points				

Example 2) Standing the package on one end for more points

	Blocks Height			
	0	×40	0	=
	0	×40	0	
	0	×30	0	
	1	×20	20	
	1	×10	10	
			Total	30
$(1 \times 10) + (1 \times 20) = 30$ points				

Example 3) Standing the package on one end for more points

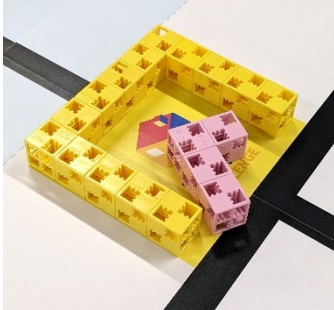
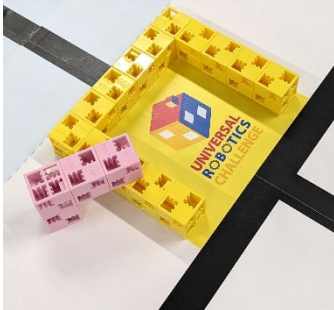


	Blocks	Height		
	0	×40		0
	0	×40		0
	2	×30	=	60
	1	×20		20
	1	×10		10
				Total
				90

$$(1 \times 10) + (1 \times 20) + (2 \times 30) = 90 \text{ points}$$

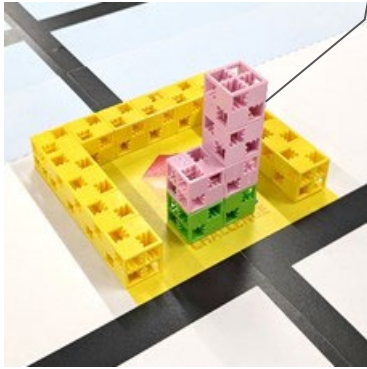
Example 4) Invalid package

No points are given to packages if they aren't completely inside of the Stacking Area





0 points

Example 5) Stacking multiple packages



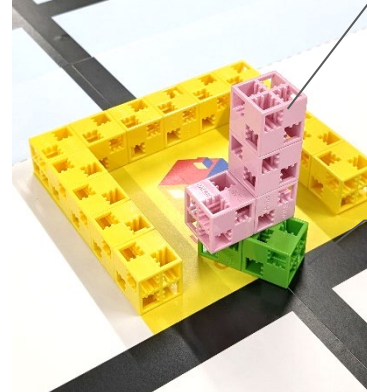
Points are given to packages stacked on top of valid packages



Blocks	Height		
0	×40		0
1	×40		40
1	×30	=	30
2	×20		40
2	×10		20
			Total
			130

$$(2 \times 10) + (2 \times 20) + (1 \times 30) + (1 \times 40) = 130 \text{ points}$$

Example 6) Invalid stacking



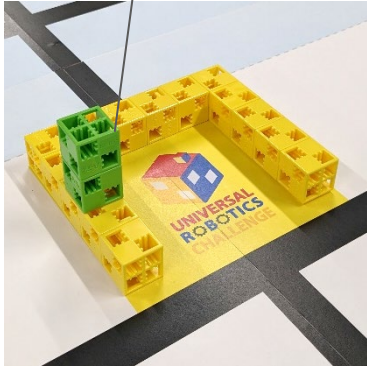
No points are given to packages stacked on top of invalid packages

No points are given to packages if they aren't completely inside of the Stacking Area

0 points

Example 7) Package on top of the Stacking Area wall

Points are given to packages touching the Stacking Area




Blocks	Height			
0	×40		0	
0	×40		0	
1	×30	=	30	
1	×20		20	
0	×10		0	Total 50

$(1 \times 20) + (1 \times 30) = 50$ points

Example 8) Package on top of package outside of the Stacking Area

Points are given to packages touching the Stacking Area



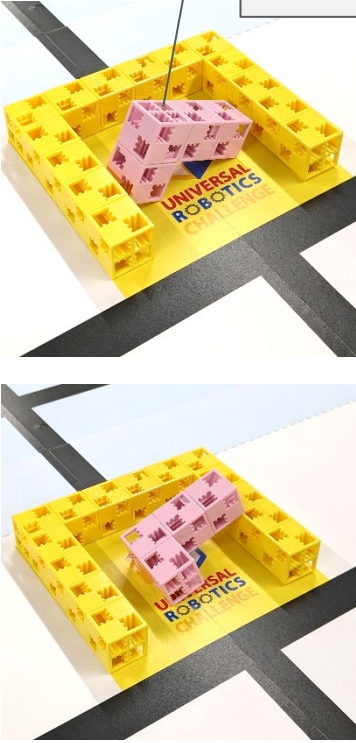
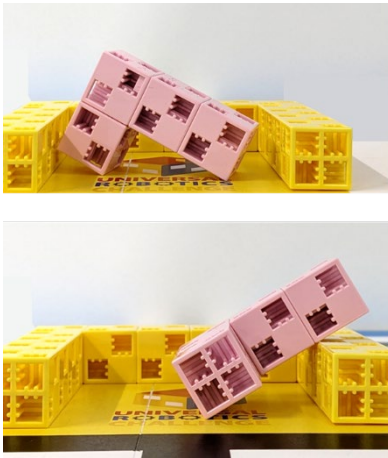
Blocks	Height			
0	×40		0	
1	×40		40	
1	×30	=	30	
2	×20		40	
0	×10		0	Total 110

No points are given to packages if they aren't completely inside of the Stacking Area

$(2 \times 20) + (1 \times 30) + (1 \times 40) = 110$ points

Example 9) Fallen package

This **fallen package** has 4 blocks and gets 10 points per block in the package to make 40 points





Fallen Blocks	Multiplier
4	$\times 10$
Total 40	

$4 \times 10 = 40$ points

Example 10) Fallen package on top of other packages

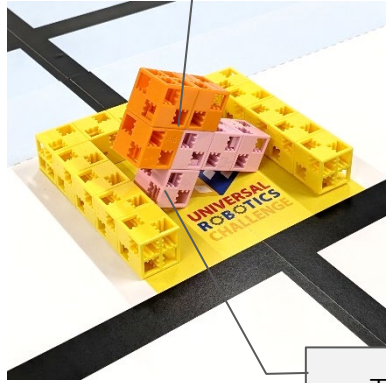
This **fallen package** has 2 blocks and gets 10 points per block in the package to make 20 points



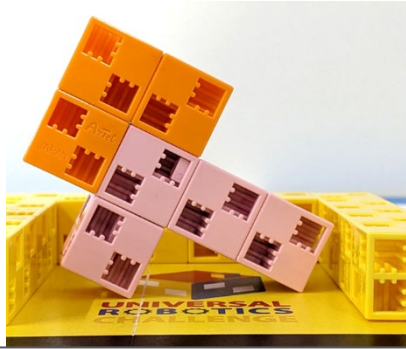
Blocks	Height	
0	$\times 40$	0
0	$\times 40$	0
2	$\times 30$	60
2	$\times 20$	40
3	$\times 10$	30
Fallen Blocks 2	$\times 10$	20
		Total 150

$(2 \times 10) + (3 \times 10) + (2 \times 20) + (2 \times 30) = 150$ points

Example 11) Multiple fallen packages



The surface of this package is touching another package. This **fallen package** has 3 blocks and gets 10 points per block in the package to make 30 points

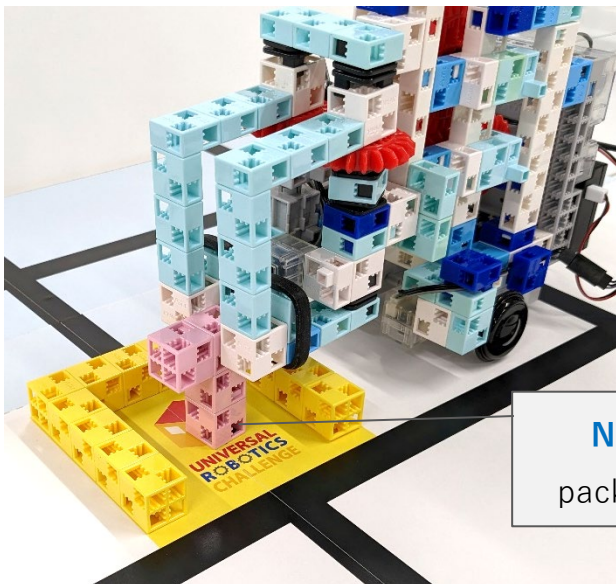


Fallen Blocks	Multiplier
7	$\times 10$
Total 70	

This **fallen package** has 4 blocks and get 10 points per block in the package to make 40 points

$7 \times 10 = 70$ points

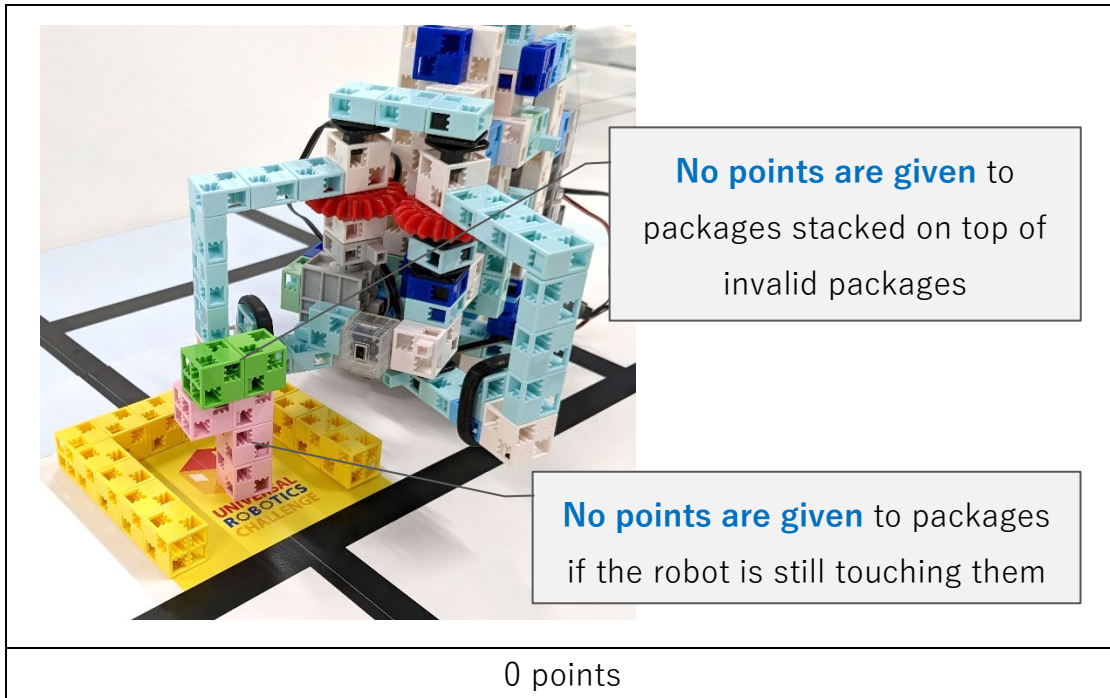
Example 12) Robot touching the package




No points are given to packages if the robot is still

0 points

Example 13) Robot a package on top of another package

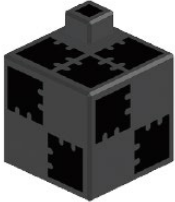
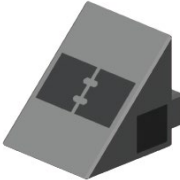
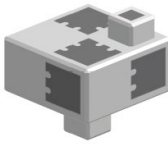
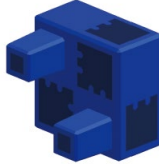






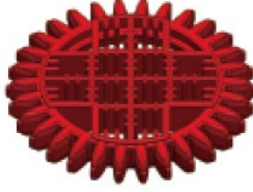



Appendix 3. ArtecRobo Parts

Studuino	Studuino Battery Box	LED (red, blue, green, white)	Buzzer
 ★ The Studuino may have a face plate sticker attached			
Touch Sensor	IR Photoreflector	Accelerometer	DC Motor
			
DC Motor Parts	Servomotor	Sensor Connecting Cable (any type)	Extension Cable for Servomotors
			
Studuino:bit Core Unit	Studuino:bit Battery Box	Robot Expansion Unit	ArtecRobo 2.0 Power Bank
			
Power Bank Cable	micro:bit	micro:bit Expansion Board	
			

Appendix 4. Artec Blocks

★ Blocks can be of any color.

Basic Cube	Triangle	Half A	Half B
			
Half C	Half D	Axle	Wheel
			
Beam	Disk	Gear (L)	Gear (S)
			
Gear Rack	O-ring	Tire	
